37th

CAA 2009

Computer Applications
and Quantitative Methods in Archaeology

Making History Interactive

Program and Abstracts

Williamsburg, Virginia
March 22-26, 2009

Published by CAA2009 Williamsburg.

Edited and written by Lisa Fischer, Bernard Frischer, and Sarah Wells, with contributions from Louise Wrike and Jane W. Crawford.

Front cover and logo designed by Joshua Muse and Peter Inker.

Table of Contents

Welcome

Dear Conference Participants,

The Colonial Williamsburg Foundation and the University of Virginia welcome you to Williamsburg and to CAA 2009!

Williamsburg served as the capital of Virginia from 1699 to 1780 and today is the site of the nation's largest outdoor living history museum. Founded in 1926, the Colonial Williamsburg Foundation seeks to engage the general public in an interactive exploration of the revolutionary events and ideals that led to the establishment of a new nation. Guests can explore the reconstructed town; interact with interpreters; and learn about early American life.

As an organization, CAA is dedicated to an analogous kind of engagement with the past on the level of scholarship: the application of the new digital technologies that make it possible to document, interpret, and reconstruct the historical record interactively. Both CAA and Colonial Williamsburg use interactivity—whether physical or virtual—to stretch the boundaries of interpretation and to further our understanding of the past. Holding CAA in this unique setting will allow attendees to explore, on many levels, how to "Make History Interactive."

CAA is also pleased to welcome the Electronic Cultural Atlas Initiative (ECAI). The two organizations last met jointly at CAA 2006 in Fargo, North Dakota, U.S.A. ECAI is sponsoring eight sessions open to all attendees throughout the conference.

We hope you will be able to take some time while you are here to explore Colonial Williamsburg. You will find a copy of the weekly schedule in your conference bag.

Your Conference Organizers,

Lisa Fischer and Bernie Frischer

About CAA

CAA is an international organization bringing together archaeologists, mathematicians and computer scientists. Its aims are to encourage communication between these disciplines, to provide a survey of present work in the field and to stimulate discussion and future progress. Membership is open to anyone on payment of a nominal fee.

The CAA conference started as a small annual conference at the University of Birmingham in 1973, followed for nearly twenty years by annually organized conferences at British universities. Conference attendance increased steadily over the years, with delegates from many European countries, North and South America, Japan, Australia and New Zealand.

At the first conference held outside the UK, at the University of Aarhus in Denmark in 1992, a policy was adopted of meeting in a different country each year. At the same time it was decided that national chapters could be established. CAAUK was the first local organization in 1995, since followed by CAANL, CAAEs, CAAIt, CAAPortugal, CAAIndia, CAAGermany, CAANA (North America) and CAANorway. In 2006 CAA left Europe for the first time in history and had a conference in Fargo (USA).

CAA Steering Committee

Nick Ryan (chair)
Stephen Stead (treasurer)
Guus Lange (secretary)
Mercedes Farjas (membership secretary)
Sascha Schmidt (students and low income)
Geoff Avern (students and low income)
Elisabeth Jerem (CAA 2008 organizer)
Bernard Frischer (CAA 2009 organizer)
Lisa Fischer (CAA 2009 organizer)
Graeme Earl (CAAUK)
Hans Kamermans (CAANL & UISPP C04 liaison)
Juan Barceló (CAAEs)
Franco Niccolucci (CAAIT)
Gonçalo Leite Velho (CAAPortugal)
Vinod Nautiyal (CAAIndia)
Axel Posluschny (CAAGermany)
Jeffrey Clark (CAANA)
Espen Uleberg (CAANorway)

CAA 2009

About the Theme

This year's theme, "Making History Interactive," reads on more than one level. The Colonial Williamsburg Foundation's interpreters strive to make history interactive for the millions of visitors who come to experience the look and feel of an eighteenth-century capital city in the American colonies. The visitor learn about early American clothing, tools, and foodways, and visit homes and shops to gain a more personal understanding of daily life more than two centuries ago. Recreations of major and minor historic events help visitors engage with the decisions and actions that shaped a particular time and place. In its eighty years of operation, Colonial Williamsburg has become a textbook case in the use of storytelling and acting for purposes of site interpretation.

As an organization, CAA is dedicated to applying digital technologies to accessing and investigating cultural heritage in new ways. A key element is the empowerment of the scholar to interact with the historical record in ways that were inconceivable ten or twenty years ago. The scholar is no longer the passive observer of what evidence happens to have survived from the past. Today we can digitally reconstruct long-lost buildings and run experiments to help us understand how—and how well—they functioned. We can take known data about a building or city and build up a picture of daily life. These virtual interactions can be extended to parallel the work of the interpreters in Colonial Williamsburg, helping scholars and visitors alike to gain a human-level understanding of history.

Sponsors

Institutional Sponsors

The Colonial Williamsburg Foundation
http://www.history.org/

University of Virginia
http://www.virginia.edu/

Gold Corporate Sponsors

Disney Research
http://www.disneyresearch.com/

PastPerfect Productions
http://www.pastperfectproductions.com

Silver Corporate Sponsors

Brueckmann GmbH
http://www.brueckmann.com

Accurex Measurement
http://www.accurexmeasure.com

General Information

Name Badges. Please wear your conference name badge at all times. Your badge will admit you to all CAA2009 programs. Only registered attendees may attend the lectures, coffee breaks, and special events. Special events may also require a separate ticket, which registered attendees will receive when registering.

Exhibitors. Please see the exhibitor guide in your conference bag for information on the conference exhibitors.

Computer Room. Several computers will be available for attendee use in the Governor Jefferson Board Room. If there are others waiting to use the computers, please limit your time on a machine to 15 minutes in order to allow others access. The computer room will be open the following hours:

Sunday (March 22)	12:00pm-4:00pm
Monday-Wednesday (March 23-25)	8:00am-5:30pm
Thursday (March 26)	8:00am-12:00pm

The hotel business center, located off the main conference center hallway, can also assist with additional computing needs.

Wireless Access. Wireless access is available throughout the Williamsburg Lodge Conference Center. If you experience any difficulties accessing the network, the conference volunteers in the Computer Room (Governor Jefferson Board Room) will be able to assist you.

ATM (Cash Machine). For your convenience, there is an ATM located opposite the hotel business center in the Williamsburg Lodge.

Bus Service. Special buses will run from the Woodlands Hotel and Suites to the Williamsburg Lodge from 8:00am-9:00am during the conference. Regular Colonial Williamsburg bus service begins at 9:00am at the Visitor Center, adjacent to the Woodlands, and continues on a 15-minute schedule until 10:00pm. A map of the regular bus route, which includes a stop in front of the Lodge, is located in *This Week*.

Admission Tickets to Colonial Williamsburg, Historic Jamestowne, and Yorktown Battlefield. The conference registration fee includes a Colonial Williamsburg ticket valid for admissions for the duration of the conference. This ticket provides admission to all Colonial Williamsburg museums and exhibition buildings during the conference period. Your admission ticket will also allow you to use the bus service that connects the Visitor Center to the Historic Area. Your conference badge will also provide entrance to both Historic Jamestowne and Yorktown Battlefield (operated by the National Park Service). Both sites can be reached via the Historic Triangle Shuttle, departing from the Colonial Williamsburg Visitor Center every 30 minutes. For further information on the shuttle, please see the section on "Getting Around Williamsburg."

Tours. A series of behind-the scenes tours of Colonial Williamsburg and its research facilities will be offered throughout the conference. These tours are free, but are limited in size. All of the tour options are included in the conference schedule. To sign up for one or more of these informative opportunities, please visit the conference registration desk to receive a ticket. Your ticket will provide information on where and when to meet.

A Colonial Williamsburg Dining and Shopping Guide is included in your registration packet. The guide has useful information about restaurants at Colonial Williamsburg and in Merchants Square; lists shops in the Historic Area and museums, Merchants Square, and the Visitor Center; and includes locator maps. Dining reservations for Colonial Williamsburg restaurants may be made at the Visitor Center, by calling extension 5000 at Colonial Williamsburg hotels or by calling 229-2141.

Getting Around Williamsburg. The conference venue is in the heart of historic Williamsburg, within easy walking distance of nearly all Colonial Williamsburg attractions. Colonial Williamsburg offers complimentary bus service in and near the Historic Area; shuttles travel between the Visitor's Center and the Historic Area and also circle the Historic Area from 9:00am to 10:00pm.

The Historic Triangle Shuttle connects the Historic Triangle of Jamestown, Williamsburg and Yorktown. Provided as a free service by the National Park Service, the two routes of the Historic Triangle Shuttle depart every 30 minutes from the Colonial Williamsburg Visitor Center, one traveling along the Colonial Parkway to Jamestown, the other following the Parkway to Yorktown.

Service to Jamestown departs from the Colonial Williamsburg Visitor Center daily on the half-hour between 9:00am and 3:30pm and upon arriving at Jamestown, makes stops at both Historic Jamestowne and Jamestown Settlement. Return service to Colonial Williamsburg departs every half-hour from 9:30am to 4:00pm and makes a final departure at 5:15pm.

Service to Yorktown departs from the Colonial Williamsburg Visitor Center daily on the half-hour between 9:00am and 3:30pm and makes stops at both the Yorktown Battlefield Visitor Center and the Yorktown Victory Center. Visitors can board for return service to Colonial Williamsburg from either the Yorktown Battlefield or the Yorktown Victory Center, with pickups every half-hour between 9:30am and 4:00pm, and a final pickup at 5:15pm. Visitors should note that the Historic Triangle Shuttle merely provides transportation to Yorktown; it does not provide interpretive tours or transportation to individual attractions around the Yorktown Battlefield.

Conference participants wishing to explore the greater Williamsburg area will be able to get around easily using local bus service, taxi cabs, or renting a car. Williamsburg Area Transport provides bus service to and from major area attractions and shopping centers. This service runs Monday-Saturday from about 6:00am to 8:00pm; fares are approximately $1.25 one-way. Several taxi companies operate in Williamsburg. Cars can be rented at all three airports, at the Williamsburg Transportation Center (less than a mile away from the conference venue), and at several locations in town.

Conference Events

Opening Remarks, March 22, 4:30pm-5:30pm, Virginia Room DEF, Williamsburg Lodge

Join us for the CAA 2009 welcome and keynote. The highlight will be the keynote address, "What's New in Old World Archaeology? A North American Perspective," to be given by Brian Rose, James B. Pritchard Professor of Archaeology, University of Pennsylvania and President, Archaeological Institute of America. Additional speakers will include James Horn, Vice President of Research and Historical Interpretation, The Colonial Williamsburg Foundation; Jeanne Zeidler, the Mayor of the City of Williamsburg; and Nick Ryan, Chair of the CAA Steering Committee.

Opening Reception, March 22, 6:00pm-8:00pm, Governor's Palace

Following the opening session, attendees are invited to a reception in the garden of the Governor's Palace. Reconnect with old colleagues and meet new ones in this special venue. Participants will be able to tour the Governor's Palace, the reconstructed home of seven of Virginia's royal governors. The Palace is a short walk (5-10 minutes) from the Williamsburg Lodge. For those participants who wish to take a bus, you may pick up a Colonial Williamsburg bus in front of the Lodge (or from the Visitor Center for those staying at the Woodlands Hotel & Suites) and take it to the Palace Shuttle stop from where it is a short walk to the Governor's Palace. Reception sponsored by The Colonial Williamsburg Foundation.

Tavern Dinner, March 23, 7:00-9:00pm, Shields Tavern (Separate Ticket Required)

For a truly unique dining experience, join your colleagues for dinner at Shields Tavern. Diners will enjoy the ambience of an eighteenth-century tavern while sampling foods based on eighteenth-century recipes. Alcoholic beverages are not included in the price of the dinner, but will be available for purchase. Participants who have signed up for this event should meet in front of Shields Tavern, located on Duke of Gloucester Street near the Capitol, at approximately 6:45pm.

Conference Dinner, March 24, 7:00-9:00pm, Virginia Room EF, Williamsburg Lodge (Separate Ticket Required)

The Conference Dinner will be held at the Williamsburg Lodge. Feast on a buffet of regional cuisine while strolling balladeers entertain you. A historic person from the past will also make an appearance. Attendees will receive two wine/beer tickets; there will also be a cash bar.

Closing Reception, March 26, 5:00-7:00pm, Historic Jamestowne

Join your colleagues for a reception to wrap up CAA 2009 at Historic Jamestowne, site of the first permanent English settlement in North America. In 1994, archaeologists discovered the remains of James Fort, which was established in 1607. Attendees will be able to visit the ongoing excavation site, hear about the most recent findings from the archaeologists, and tour the Archaearium, a new museum that houses many of the important artifacts that are clues to the lives of the earlier settlers. Buses will transport attendees to and from the reception site beginning at 4:30pm. Buses will pick up and drop off attendees at both the Williamsburg Lodge. This reception is included in the conference registration, but attendees will need a ticket, which will be provided when registering, to board the buses. This reception is sponsored by the Association for the Preservation of Virginia Antiquities and the Jamestown Rediscovery.

Excursions

Historic Triangle Architectural Tour: Learn more about early American architecture by visiting selected sites in the Historic Triangle region (Williamsburg, Jamestown, and Yorktown). After learning about Jamestown at the reception the evening before, join this informative tour led by the Colonial Williamsburg Foundation's expert architectural historians. In the morning, we will visit Shirley, a grand plantation on the James River with a fine brick mansion house and several surviving service buildings, including a colonial-era kitchen, laundry, and dovecote. Lunch will be in Yorktown, where the defeat of British General Lord Cornwallis by George Washington precipitated the end of the American Revolutionary War. In the afternoon, Colonial Williamsburg Foundation archaeologists and architectural historians will be at sites near Palace Green in Williamsburg to discuss recent research on material life in Virginia's colonial capital. The Robert Carter, Peyton Randolph, Thomas Everard, and James Geddy properties have all been the subject of intensive investigation over the past three decades. Archaeological investigations at the Peyton Randolph site guided the reconstruction of the service yard, beginning in the 1990s, and yielded important information about the material life of an elite colonial family and their enslaved servants. The Thomas Everard and James Geddy houses tell us much about the lives of Georgian-era tradespeople as well as the process of refinement. The Robert Carter is a rare opportunity to visit both the refined rooms of a genteel house as well as, in the attic, surviving slave spaces. This tour will depart at 8 am and will end in Williamsburg around 5:00pm. Participants who have signed up for this tour should have received an information sheet in their registration packet with further information. If you did not receive this sheet, please stop by the registration desk.

Washington, D.C.: For first-time visitors to the United States, or repeat ones, this tour will give participants a chance to visit the nation's capital. The tour will drop off at the Washington D.C. mall, the heart of the city. Sites around the mall include the Smithsonian Museums, the Capitol Building, the Washington Monument, and the Lincoln Memorial. Several optional tours/offerings will be organized for those who wish to participate, or you may explore the city at your leisure. Most of these sites, including all of the Smithsonian museums and the monuments, are free of charge but meals will be on your own. Participants will be provided with a map and other information on the sites as well as recommendations for dining options to help plan the day. This tour will depart at 7:00am and return to Williamsburg around 9:00pm. Participants who have signed up for this tour should have received an information sheet in their registration packet with further information. If you did not receive this sheet, please stop by the registration desk.

CAA 2009 Organizing Committee

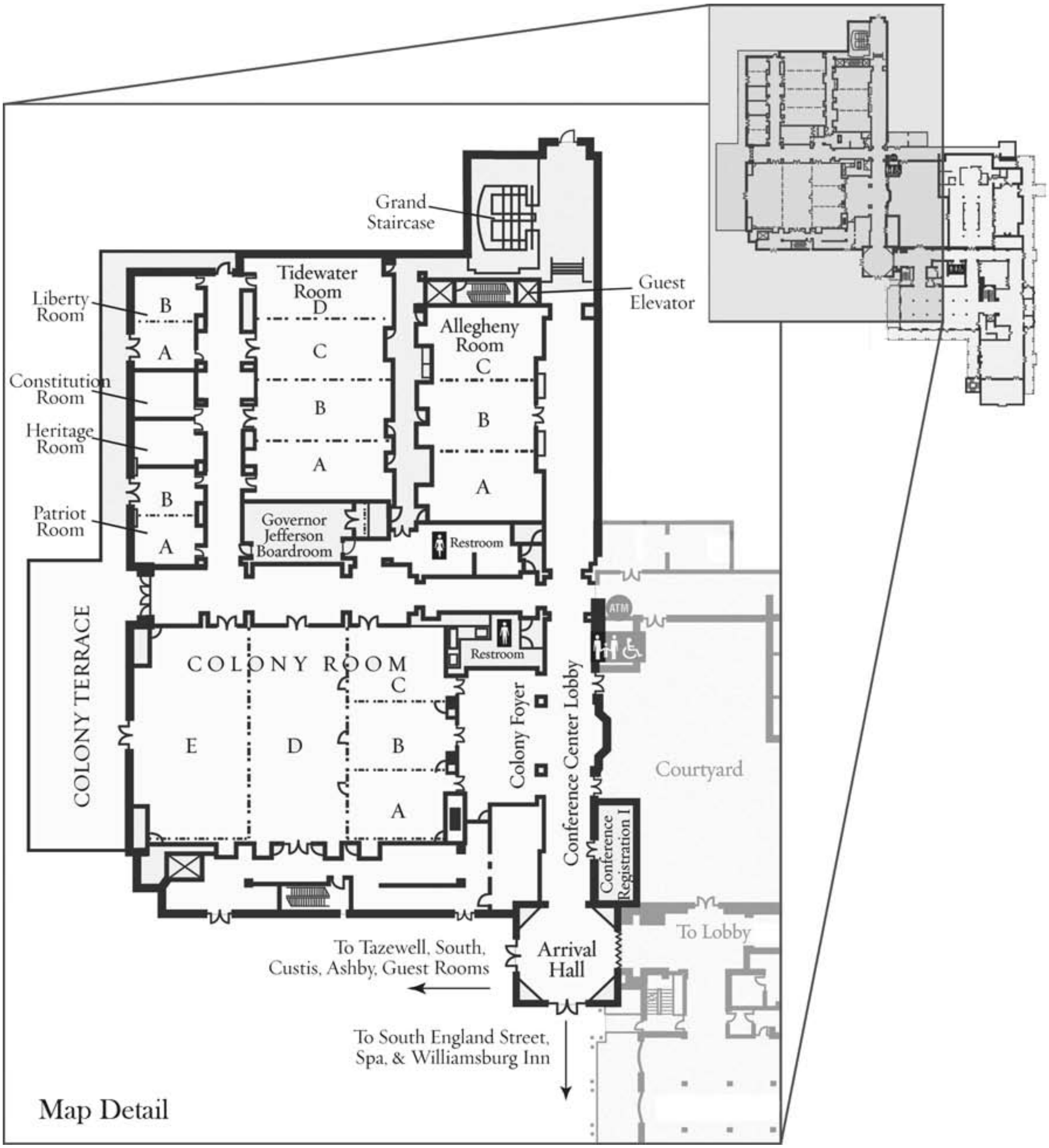
Lisa Fischer, The Colonial Williamsburg Foundation (chair)
Deborah Chapman, The Colonial Williamsburg Foundation (local arrangements chair)
Prof. Bernard Frischer, The University of Virginia
Prof. Alyson Gill, Arkansas State University
Prof. Lewis Lancaster, Electronic Cultural Atlas Initiative
Michael Raphael, Direct Dimensions Inc. (exhibitors and workshops chair)

CAA 2009 Scientific Committee

Prof. Bernard Frischer, The University of Virginia (chair)
Prof. Peter Bol, Harvard University
Dr. Wolfgang Börner, City of Vienna
Lisa Fischer, The Colonial Williamsburg Foundation
Prof. Arne Flaten, Coastal Carolina University
Prof. Maurizio Forte, University of California, Merced
Prof. Alyson Gill, Arkansas State University
Prof. Luc van Gool, Federal Technical Institute, Zurich
Prof. Gabriele Guidi, Politecnico di Milano
Prof. Elisabeth Jerem, Archaeological Institute of the Hungarian Academy of Sciences, Budapest
Prof. Ian Johnson, University of Sydney
Han Kamermans, University of Leiden
Prof. Kevin Kee, Brock University
Prof. Guus Lange, National Service for Archaeology, Cultural Landscape, and Built Heritage, Netherlands
Gary Lock, Oxford University
Prof. Scott Madry, University of North Carolina, Chapel Hill
Mark Mudge, Cultural Heritage Imaging
Prof. Fraser D. Neiman, Thomas Jefferson Foundation, Monticello

Dr. Daniël Pletinckx, Visual Dimension
Dr. Axel Posluschny, German Archaeological Institute, Frankfurt
Julian Richards, University of York
Prof. Nicholas Ryan, University of Kent, Canterbury
Stephen Stead, Paveprime LTD
John Tolva, IBM Corporation

Conference Center Map



About the Area

Williamsburg/Jamestown/Yorktown

Williamsburg is part of America's Historic Triangle, which also includes Jamestown and Yorktown. Jamestown, founded in 1607, was the site of the first English settlement in North America and first capital of Virginia. In 1699, the capital was moved to nearby Williamsburg, which would remain the seat of colonial government until 1780. Pivotal events that took place in Williamsburg, such as the Patrick Henry's protests against the Stamp Act in 1765, would help to lay the foundations for American Independence. Yorktown is best known for being the site of the last major battle of the American Revolution. In 1781, George Washington defeated British General Lord Cornwallis, which would lead to the signing of the Treaty of Paris two years later.

Colonial Williamsburg is the restored eighteenth-century capital of Britain's largest, wealthiest, and most populous outpost of empire in the New World. Here is interpreted the origins of the idea of America, conceived decades before the American Revolution. The Colonial Williamsburg story of a revolutionary city tells how diverse peoples, having different and sometimes conflicting ambitions, evolved into a society that valued liberty and equality. Americans cherish these values as a birthright, even when their promise remains unfulfilled.

Colonial Williamsburg is the nation's largest living history museum, encompassing 301 acres including 500 buildings, homes, stores and taverns reconstructed and restored to their eighteenth-century appearances; tradesmen practicing thirty historic trades and domestic crafts; historical interpreters and character actors; and ninety acres of gardens and greens; and now featuring the live action drama, Revolutionary City™, daily from mid-March to December. Please consult *This Week* for the current daily schedule of operations.

Charlottesville

The city of Charlottesville, named after Queen Charlotte Sophia (wife of British King Richard III), is about a two-hour drive west from Williamsburg. It was founded in 1762 along a trade route between Richmond (now the Virginia state capital) and the Blue Ridge (part of the Appalachian Valley). The city was the temporary capital of Virginia during the Revolutionary War, and was home to several important American figures, most notably Thomas Jefferson. Jefferson's Charlottesville estate, Monticello, and his "academical village," the University of Virginia, are UNESCO World Heritage sites. Jefferson founded The University of Virginia as a place of intellectual freedom and inquiry, independent of religious doctrine. Jefferson designed the architecture for the initial Grounds of the University, included the Rotunda (based on the Pantheon in Rome) and the Central Grounds, creating an architectural landmark that attracts visitors from all over the world.

Two other U.S. presidents, James Madison and James Monroe, had estates nearby, at Montpelier (about a 45-minute drive north of Charlottesville) and Ash Lawn-Highland (a few minutes' drive from Monticello). Montpelier recently recently finished a major restoration of the house, returning it to its nineteenth-century form. Both Montpelier and Ash Lawn are open to visitors and offer tours and programs.

Schedule

Sessions are marked in bold and have a page number for the full session description. All locations are in the Williamsburg Lodge unless otherwise noted. Tour tickets (marked with a T) will provide information on the starting location.

Sunday, March 22

10:00 – 7:00	Registration, Conference Registration 1
12:00 – 4:00	Computer Room open, Governor Jefferson Boardroom
1:00 – 2:00	Tour of the Archaeological Lab (free ticket required)[T]
2:00 – 3:00	Tour of the Archaeological Lab (free ticket required)[T]
2:00 – 3:00	Tour of the Reconstruction of Richard Charlton's Coffeehouse (free ticket required)[T]
4:30 – 5:30	Opening Remarks, Virginia Room DEF
6:00 – 8:00	Opening Reception Sponsored by the Colonial Williamsburg Foundation, Governor's Palace

Monday, March 23

8:00 – 5:30	Registration Desk open, Conference Center Lobby
8:00 – 5:30	Computer Room open, Governor Jefferson Boardroom
7:00 – 10:00	Exhibition and Poster set-up, Colony
8:30 - 3:00	**Reality-Based Modeling and Visualization of Large and Complex Archaeological Sites: Theoretical Achievements, Current Bottlenecks, and Technology Perspectives** (p. 27) Tidewater A
8:30 - 11:45	**The New ICOMOS Ename Charter (2008) on the Interpretation and Presentation of Cultural Heritage Sites: What Impact Can Digital Technologies *Really* Have on Public Heritage?** (p. 37) Tidewater B

8:30 - 3:00	**Archaeological Prospection Using High-Resolution Digital Satellite Imagery: Recent Advances and Future Prospects** (p. 43) Tidewater C
8:30 - 5:30	**Excavation to Publication: Developing and Applying Integrated Digital Technologies** (p. 54) Tidewater D
8:30 - 5:30	**Symposium on Digital Archaeology in North America** (p. 68) Patriot
8:30 - 10:00	**ECAI: Frontiers of Digital Culture** (p. 78) Liberty
10:00 - 5:00	Exhibition and Poster Room open, Colony
10:00 - 11:45	**Poster Session 1** (p. 80) Colony
10:15 - 11:45	**ECAI: Technology and Cultural History** (p. 89) Liberty
1:30 – 3:00	**CyArk Digital Preservation (Part 1)** (p. 91) Tidewater B
1:30 - 3:00	**Digital Approaches for Coins (General Session)** (p. 95) Constitution
1:30 - 3:00	**ECAI: Creating Digital Human Records** (p. 98) Liberty
3:15 – 5:30	**Workshop: Capturing and Publishing Information with the Heurist e-Research Framework** (p. 100) Tidewater B
3:15 - 5:30	**Workshop: Archaeological Site Prospection Using Google Earth** (p. 102) Bruton Heights School Computer Lab 209
3:30 - 4:30	Tour of the Archaeological Conservation Lab (free ticket required)[T]
3:30 – 4:30	Tour of Special Collections (Rare Books and Manuscripts) (free ticket required)[T]
3:30 – 4:30	Tour of the Reconstruction of Richard Charlton's Coffeehouse (free ticket required)[T]
7:00 – 9:00	Tavern Dinner, Shields Tavern (Separate Ticket Required, no late seating)

Tuesday, March 24

8:00 – 5:30	Registration Desk open, Conference Center Lobby
8:00 – 5:30	Computer Room open, Governor Jefferson Boardroom
8:30 – 5:00	Exhibition and Poster Room open, Colony
8:30 – 3:00	**Envisioning the Past: Virtual Reconstructions of Archaeological Sites** (p. 103) Tidewater A
8:30 – 3:00	**Close-Range 3D Laser Scanning: Recent Developments and Applications** (p. 114) Tidewater B
8:30 – 3:00	**Why Did It Take So Long? Spatio-Temporal Modeling and GIS** (p. 123) Tidewater C
8:30 – 3:00	**Integration and Sharing of Cultural Information Resources** (p. 135) Tidewater D
8:30 - 11:45	**Computational Intelligence in Archaeology** (p. 148) Patriot
8:30 - 10:00	**Short Paper Session on Research Projects Looking for Collaborators** (p. 156) Constitution
8:30 - 10:00	**ECAI: Digital Mapping as Communication** (p. 158) Liberty
8:30 - 10:15	**Poster Session 2** (p. 159) Colony
10:15 -11:45	**Short Paper Session for Presentation of Students' Research Projects** (p. 168) Constitution
10:15 -11:45	**ECAI: e-Resources—Space, Time, and Text** (p. 174) Liberty
1:30 – 3:00	**CyArk Digital Preservation (Part 2)** (p. 176) Patriot
1:30 - 5:30	**Workshop: The CIDOC Conceptual Reference Model—New Standard for Knowledge Sharing** (p. 180) Constitution

1:30 – 3:00	**ECAI: Inventing Paths in Digital Data** (p. 181) Liberty
3:15 - 4:15	Intrasis Demonstration, Tidewater A
3:15 - 5:30	**Workshop: New Dimensions in Profile Modeling: Rapid Digitization of Archaeological Objects** (p. 184) Tidewater B
3:15 - 5:30	**Workshop: ArchCamp 7** (p. 185) Tidewater D
3:15 - 5:30	**Workshop: Archaeological Site Prospection Using Google Earth** (p. 102) Bruton Heights School Computer Lab 209
3:30 – 4:30	Historic Area Architectural Walking Tour (free ticket required)[T]
3:30 – 4:30	Tour of the Archaeological Lab (free ticket required)[T]
3:30 – 4:30	Tour of the Ravenscroft Archaeological Site (free ticket required)[T]
7:00 – 9:00	Conference Dinner, Virginia Room EF (Separate ticket required)

Wednesday, March 25

8:00 – 5:30	Registration Desk open, Conference Center Lobby
8:00 – 5:30	Computer Room open, Governor Jefferson Boardroom
8:30 – 5:00	Exhibition and Poster Room open, Colony
8:30 – 3:00	**Visual Archaeologies for the Digital Age: Rethinking Representation in Archaeology** (p. 186) Tidewater A
8:30 – 3:00	**Three-Dimensional Surface Recording, Analysis, and Interpretation in Archaeology and Anthropology** (p. 197) Tidewater B

8:30 – 3:00	**Cell-Based Analysis and Landscape Archaeology: New Approaches and New Applications** (p. 211) Tidewater C
8:30 – 3:00	**The Semantic Web: Second Generation Applications** (p. 220) Tidewater D
8:30 – 3:00	**Digital Humanities and Pedagogy** (p. 232) Patriot
8:30 - 11:45	**Workshop: Practical Resources and Integrated Services for Preserving Cultural Heritage** (p. 245) Constitution
8:30 – 10:00	**ECAI: Technology for Recreating the Past** (p. 247) Liberty
10:15 – 11:45	**ECAI: Text, Artifact, and Narrative** (p. 249) Liberty
1:30 – 5:30	**CyArk Workshop: Web-based GIS for Data Management and Dissemination** (p. 251) Liberty
1:30 – 3:15	**Poster Session 3** (p. 252) Colony
3:15 – 5:30	**Workshop: High-Definition 3D-Surface Scanning in Arts and Cultural Heritage** (p. 262) Tidewater B
3:15 – 5:30	**Round Table. From Access to Collaboration and Synthesis: How Do We Get There?** (p. 264) Tidewater C
3:15 – 5:30	**Workshop: CIDOC Archaeological Sites Working Group Meeting** (p. 266) Tidewater D
3:30 – 4:30	Historic Area Architectural Walking Tour (free ticket required)[T]
3:30 – 4:30	Tour of the Archaeological Conservation Lab (free ticket required)[T]
3:30 – 4:30	Tour of Special Collections (Rare Books and Manuscripts) (free ticket required)[T]
5:30 – 6:30	CAA North America Meeting, Tidewater A

Thursday, March 26

8:00 – 12:00	Registration Desk open, Conference Center Lobby
8:00 – 12:00	Computer Room open, Governor Jefferson Boardroom
8:30 – 11:45	**3D Modeling and Scanning Applications (General Session)** (p. 268) Tidewater A
8:30 – 11:45	**Computational Intelligence in Archaeology: Quantitative Methods and Other Approaches (General Session)** (p. 276) Tidewater B
8:30 – 11:45	**GIS Applications (General Session)** (p. 284) Tidewater C
8:30 – 11:45	**Data Management (General Session)** (p. 291) Tidewater D
8:30 – 11:45	**Seeing Beneath the Surface: Remote Sensing and Other Applications for Finding and Assessing Archaeological Sites (General Session)** (p. 298) Patriot
8:30 – 11:45	**Computer Applications in Maritime Sites** (p. 306) Liberty
2:00 – 3:30	Annual General Meeting, Colony E
5:00 – 7:00	Closing Reception, Historic Jamestowne (Buses begin running at 4:30pm from the Williamsburg Lodge)

Friday, March 27

Post-conference excursions departure times:

7:00 am	Washington, DC (Separate Ticket Required)[T]
8:00 am	Historic Triangle (Separate Ticket Required)[T]

Sessions and Abstracts

Alphabetical List of Sessions

Session Summary

Sunday, 4:30 pm-5:30 pm, Virginia Room DEF

Opening Session

Keynote Address: What's New in Old World Archaeology? A North American Perspective

Brian Rose

James B. Pritchard Professor of Archaeology, University of Pennsylvania; President, Archaeological Institute of America

Additional Speakers:

James Horn, Vice President of Research and Historical Interpretation, The Colonial Williamsburg Foundation

Jeanne Zeidler, Mayor of the City of Williamsburg

Nick Ryan, Chair of the CAA Steering Committee

Session Summary

Monday, 8:30am-3:00pm, Tidewater A

Reality-Based Modeling and Visualization of Large and Complex Archaeological Sites: Theoretical Achievements, Current Bottlenecks, and Technology Perspectives

Chairs: Gabriele Guidi, Politecnico di Milano, Italy
Fabio Remondino, ETH - Zurich, Switzerland
Carlo Bianchini, Università degli studi di Roma la Sapienza, Italy

Several optical technologies are currently available for capturing the 3D digital shape of an archaeological site, based on satellite, aerial photogrammetry, GPS, laser scanning, and close-range photogrammetry with manual or automatic image matching. The results depend heavily on the intrinsic capability of each technology, in terms of its geometric resolution, accuracy, portability, and flexibility. Users can modulate the number of geometrical points by integrating several 3D technologies, matching different needs so as to properly describe a specific site or object. Using digital photography to add detailed textures and to control image resolution allows users to maximize archaeologically useful information. A project's final outcome may be the construction of 2D representations, comparable to "traditional" archaeological iconography, or 3D models, which can exploit the inner features of digital 3D representation. Either way, the lack of a sound and shared methodology as well as bottlenecks that can arise at different stages, frequently lead to delays in the production process. For example, it may be impossible to use active sensors in a particular condition or location, limiting acquisitions time during a field campaign and forcing a consequent reduction in the collected data. The difficulties in creating and cleaning meshes (sometimes even in producing conventional drawings from the acquired data) discourage some users from completing the process at all. A survey may end as point clouds, which are spectacular but not very useful in practical terms. The absence of powerful commercial image-processing tools that can derive automatically detailed and precise surface model from any data set pushes users more towards active sensors than towards image-based approaches.

Once the data have been collected, visualization of the 3D model is a relevant step, certainly, and it can be done by means of videos (with sophisticated but time-consuming off-line rendering tools) and fixed walk-through paths; or by real-time rendering (often in virtual reality environments), which allows users to freely navigate the model, possibly with links to complementary information. However, limitations in actual visualization packages may force users to simplify the geometric model with respect to the acquired high-resolution model because of the difficulty of managing and visualizing so many polygons. The difficulties that most 3D visualization systems have linking external information to a 3D model may forestall powerful and useful additions to the model. Last but not least, remotely managing the whole model through a web site is a project's feature more often claimed than delivered.

Session papers will focus on (i) discussing experiences in data acquisition and processing for archaeological site documentation by means of integrated approaches, possibly with polygonal modeling and texture mapping and (ii) reporting the specific steps for local and remote visualization with the possible ways of connection to geographic information systems or archaeological databases.

TOPICS: 3D data capture and modeling, photogrammetry and imaging, high-precision surveying, virtual reality

KEYWORDS: 3D recording, data acquisition, laser scanning, photogrammetry, texture mapping, 3D model visualization, 2D and 3D representation from real data

Schedule

8:30 - 8:40 "Introduction: Reality-Based Modeling and Visualization: Know How and Know Why," Gabriele Guidi

8:40 - 9:10 "Towards a Systematic Theoretical Approach in Survey and Modeling in Archaeology," Carlo Bianchini

9:10 - 9:40 "Digitizing the Pompeii Forum," Gabriele Guidi, Fabio Remondino, Michele Russo, Alessandro Rizzi

9:40 - 10:00 "Integrated Methodologies for the Study and the Restoration of the Byzantine Saint Nicholas Monastic Complex," Francesco Fassi, Federico Prandi, Raffaella Brumana, Luigi Fregonese, and Gianclaudio Macchiarella

COFFEE BREAK

10:15 - 10:35 "Research on 3D Reality-Based Modeling and 3D Virtual Walkthrough Based on WebGIS for Large Archaeological Sites, Taking the Small Wild Goose Pagoda in Tang-Dynasty as the Case Study, " Guo-hua Geng, Jun Liu and Xue-song Wang

10:35 - 11:05 "Virtual Rome VR webGIS, " Sofia Pescarin, Augusto Palombini, Valentina Vassallo, Luigi Calori, Carlo Camporesi, Bruno Fanini, and Maurizio Forte

11:05 - 11:25 "Multi-Resolution Three-Dimensional Models for Archaeological Complex Documentation," Caterina Balletti and Flora Gaetani

11:25 - 11:45 "Time Constraints Effects in 3D Acquisition and Data Processing: The Case of 'Villa delle Vignacce,'" Michele Russo and Darius A. Arya

LUNCH

1:30 - 2:00 "The Tools to Operate Reconstructions: An Investigation on the Vault Systems of the Small Thermal Baths in Villa Adriana," Giorgio Verdiani, Sergio Di Tondo, and Filippo Fantini

2:00 - 2:20 "Real-Time Visualization of the Forum of Pompei," Alice Pignatel, Fausto Brevi, and Sebastiano Ercoli

2:20 - 3:00 Round Table with all speakers and audience discussion

Abstracts

Towards a Systematic Theoretical Approach in Survey and Modeling in Archaeology

Carlo Bianchini

Università degli studi di Roma la Sapienza Italy

About a decade has passed since the first commercial laser scanning systems appeared and by now everybody can recognize in this event a real revolution in documentation and survey. Even if at a slower rate, in this same period archaeology has experimented with increasing utilization of laser scanning and related 2D and 3D modeling. Quick transformations, though, often move faster than theoretical systematizations, and after this extraordinary decade it's time to try to transform the initial pioneering applications into a mature methodology. First of all a comparison will be made between traditional surveying (direct, instrumental, photogrammetric, etc.) and 3D scanning: *speed* (thousands of points per second), *accuracy* (few millimeters' error) and *economy* are the major key points of this technology. None among the traditional methods can count on all three features. Furthermore we have to consider *recognizability*: the density of surveyed points is so high that point-cloud browsers actually produce images that can immediately represent the 3D characteristics of the studied object. This feature relies on the same principle of photography but in this case the images produced are *real time* relative to the position of the model adding *interactivity* to recognizability. The hoary problem of the *apparent contour* appears to be suddenly solved: if photogrammetric break lines and contours strictly depend on the original point of view, a point cloud preserves the overall spatial configuration, actually a solid net wrapping the object. Finally, 3D scanning output is perfectly digital and so available for perfect replication.

In this paper we will discuss all these aspects trying also to present a systematic operational approach to pass from the 3D clouds to 2D conventional models (plan, sections. etc.) as well as to 3D advanced models. A number of examples will be given referring to last RADAAR researches on Hagia Sophia (Istanbul, Turkey), Foro Romano, Tempio del Divo Claudio (Rome, Italy) and the Roman complex in Merida (Augusta Emerita, Spain).

Keywords: modeling theory, laser scanning, survey, advanced modeling

Digitizing the Pompeii Forum

Monday

Gabriele Guidi[1], Fabio Remondino[2], Michele Russo[1], and Alessandro Rizzi[3]

1. Politecnico di Milano, Italy
2. ETH, Zurich, CH; FBK, Trento, Italy
3. FBK, Trento, Italy

Acquiring a huge archaeological site means dealing with different scales of representation, and therefore different level of detail. This article reports on a multi-resolution approach developed for 3D modeling of the entire Roman Forum in Pompeii, Italy. The archaeological area, approximately 150x80m, contains more than 350 finds spread over the forum, as well as larger mural structures of previous buildings and temples. The interdisciplinary 3D modeling work consists of a multi-scale image- and range-based digital documentation method developed to fulfill all the surveying and archaeological needs and to exploit all the potential of actual 3D modeling techniques. Data resolution spans from decimeters down to millimeters. The surveying methodologies employed have pros and cons, which will be addressed and discussed. The preliminary results of the integration of the different 3D data in a unique and seamless textured 3D model will be presented, as well as the heavy processing needed for obtaining a texturized digital model, suitable for virtual reality, or its adaptation to standard online platforms such as Google Earth.

Keywords: multi-resolution, sensor fusion, mesh processing, texture mapping, 3D models

Integrated Methodologies for the Study and the Restoration of the Byzantine Saint Nicholas Monastic Complex

Francesco Fassi[1], Federico Prandi[1], Raffaella Brumana[1], Luigi Fregonese[1], and Gianclaudio Macchiarella[2]

1. Politecnico di Milano, Italy
2. Università Ca'Foscari Venezia, Italy

Usually, when organizing a survey of a complex archaeological site, a hierarchical information structure is imposed. The huge dimensions and the complexity of data require classification of the information from the general down to the detailed. 3D geometrical measurements can be done traditionally with a combination of classical topography and manual survey. In many cases, this approach is intricate, time-consuming, and in some cases impractical. Several technologies are now available to generate geometrical information, such as laser scanning, GPS, and photogrammetry. All these technologies are full-grown from the technological point of view, but the large amount of data they create and the complex elaboration phase reduce their potential diffusion. This paper describes the full workflow of a complete survey of the Byzantine Saint Nicholas Church and monastery near Mesopotam (Albania), with an integration of data from several different sources. The archaeological site is near Mesopotam, in the province of Delvina (Rrethi i Delvinës), a short distance from archaeological site of Phoinike. The Saint Nicholas church rises in the middle of a large fortification wall

(80x120m) on the top of the hill. According to our recent research, the church was probably rebuilt in the first quarter of the thirteen century under the imperial patronage of the Despotate of Epirus, but apart from the monumental four-dome church itself and some scattered ruins, no other elements belonging to the monastery complex are visible today. The joint UNESCO-CISB (Centre for Balkan Studies, University of Venice) mission has provided an opportunity for an Italian-Albanian study, restoration, and site valorization project, partially financed by the Region of Puglia. Over the course of this effort, people with different skills have worked with and acquired new data for the interpretation of the site. The data acquisition is particularly complex and time consuming; but in this case it is impossible to renounce different kinds of data: photography is essential for certain details, while other parts of the complex require the topographic accuracy and a great detail of laser scanning.

For these reasons, efficient data integration is crucial, from acquisition through processing. The possibility of large amounts of redundant data increases post-processing difficulties. There is also a substantial separation between laser scanning and photogrammetry, not only because of the different approach of these technologies but also because the resulting data are different. Survey work has used different methodologies, from traditional survey to high-density laser scanning, and all the different disciplines need to be integrated to obtain a complete 3D geometric documentation of the site. Particular attention was given to a final product obtained from the single kind of data and to the possibility of general site 3D models as well as of detailed views.

Keywords: data acquisition laser scanning 2D and 3D representation from real data

Research on 3D Reality-Based Modeling and 3D Virtual Walkthrough Based on WebGIS for Large Archaeological Sites, Taking the Small Wild Goose Pagoda in Tang-Dynasty as the Case Study

Guo-hua Geng, Jun Liu, and Xue-Song Wang
Institute of Visualization Technology, Northwest University, People's Republic of China

Large archaeological sites provide very important material data for the research of the ancient history, culture, art and the development of science and technology. However, with the passage of time, ancient historical and cultural sites are suffering considerable damage, which makes digital protection of these sites urgent. On the other hand, reality-based digital technologies are needed that can disseminate information about the sites and enhance their value for cultural use and for tourism. Therefore, capturing accurate 3D data without damaging the ruins of ancient buildings and relics, creating a 3D reality-based model from real data, and creating a 3D internet-based virtual walkthrough are worthwhile undertakings.

Taking the Small Wild Goose Pagoda in Tang-Dynasty as a case study, this paper examines key technologies of digital data acquisition, 3D reality-based modeling from real data, and 3D virtual walkthroughs. Firstly, we put forward a method of 3D digital data acquisition at large archaeological sites by way of combining

Monday

3D laser scanning of large scene and digital photography technologies, enabling prompt and accurate digital data acquisition without damaging the sites. Then, based on the geometrical key points of the ruins of ancient buildings, we offer a method of 3D reality-based modeling from real data with the adoption of local texture mapping. Finally, we introduce systematic architecture, a technology roadmap, and all the key technologies of the 3D desktop virtual walkthrough system based on WebGIS for large archaeological sites. Implementation of the methods proposed here can create a reality-based 3D digital model of the Small Wild Goose Pagoda, providing digital protection of this important cultural site built in 707 C.E., and generate a digital object of the Pagoda with 3D virtual walk-through functionality, so that people can enjoy its unique historical, cultural and tourist value on the Internet.

Keywords: digital archaeological, capture the 3D digital shape of an archaeological site, nondestructive data acquisition, 3D reality-based modeling from real data, 3D virtual walk-through

Virtual Rome VR webGIS

Sofia Pescarin[1], Augusto Palombini[1], Valentina Vassallo[1], Luigi Calori[2], Carlo Camporesi[3], Bruno Fanini[1], and Maurizio Forte[3]

1. CNR Instituto per le Tecnologie Applicate al Beni Culturali, Italy
2. CINECA, Italy
3. University of California, Merced, United States of America

Virtual Rome (http://www.virtualrome.net) is a project started and carried out by the Virtual Heritage Lab of the Institute for Technologies Applied to Cultural Heritage of the Italian National Research Council (CNR ITABC), in collaboration with CINECA, Seat Yellow Pages, Chamber of Commerce, and the Superintendency of Rome. The project aims at reconstructing the archaeology and past (potential) landscape of Rome in the second century C.E.., and at building a development and visualization platform, a double-sided tool consisting of a back end (VR webLAB) and a front end (VR webGIS). The back-end collaborative system was developed to enable the integration of a reconstructed 3D terrains data set, high-resolution 3D models, vectors, vegetation information, and metadata. It allows users to manage points of view and paths, customize every application feature, and build any virtual world and historical landscape. The VR webLAB creates a 3D interactive environment for online exploration of large archaeological landscapes (thus connecting the GIS functions to the virtual reality capabilities). The system is web-based, geospatial, and Open Source. At present it allows users to navigate and switch between two different terrain models: the archaeological actual landscape and the early Imperial period. Thanks to a realistic navigation tool, users can fly through the second century, visiting Roman landscape, querying its archaeological sites, and walking inside its monuments. Such a goal is achieved via the development of a specific plug-in for web browsers (Internet Explorer and Mozilla Firefox). The Open Source software is based on the OpenSceneGraph library and has been published under the GPL license, while contents are available under the Creative Commons license. The actual Virtual Rome terrain has

been created by the hi-res DEMs and aerial photographs provided by Seat Yellow Pages-Nuova Telespazio (20cm resolution). The second-century terrain has been built through a careful reconstruction of the ancient environment and monuments, as a result of sustained interdisciplinary research by the Virtual Heritage Lab in cooperation with geologists, paleobotanists, and archaeologists of principal Roman institutions. The result is a very powerful tool, which can provide an open laboratory for scholars and professionals to interact over the web, share data, build common digital libraries (architectures, vegetation, terrain textures, materials, etc.), and test hypothesis on past landscapes through simulation sessions. At the same time it may function as an innovative dissemination and teaching instrument, a feature which recently helped the project to win the E-content Award, in the e-learning section.

Keywords: virtual archaeology, VR webGIS, collaborative environments, Open Source

Multi-Resolution Three-Dimensional Models for Archaeological Complex Documentation

Caterina Balletti[1] and Flora Gaetani[2]

1. Università IUAV di Venezia, Italy
2. Politecnico di Milano, Italy

Cultural heritage is one of the main sectors for the application of "virtual systems" dedicated to education, dissemination, and use of museums. The virtual reconstruction of an archaeological area is a good basis for the consultation of a heterogeneous multimedia geo-database: images, text, movie, and VR models. In this way the user can have access to cultural, historical, artistic, and archaeological information of a site by moving inside a virtual space and asking questions about objects that are around him. This paper describes a case study developed within the research project, "New integrated methods and technologies for documentation and restoration of Mediterranean archaeological and monumental complexes." The project was focused on the production of an interactive navigation system of three-dimensional digital models that can be explored on- and off-line with varying level of detail. The case study is the virtual model of the *templum Claudianum* (54 C.E.) archeological complex that was located in Rome on the Caelian Hill facing the Colosseum valley, in honor of the Roman emperor Claudio. Today only some ruins remain. Because of the amount of data, it is necessary to reduce the calculation quantity executed by the computer and to assure a high three-dimensional detail. For this reason we decided to use multi-resolution models that change with reference to the point of view. Therefore the three-dimensional model was managed with manual and automatic methods of LOD (Level Of Detail). Manual LOD consists of the realization of some models with the same geometrical structure, but with different level of complexity, to be used in function of the distance between the point of view of the user and all the geometrical model or a part of it. This technique was developed using oFusion, a toolset for developing game content for Ogre (Object-Oriented Graphics Rendering Engine). Ogre is a scene-oriented, flexible 3D engine written in C++ designed to make it easier and more intuitive for developers to produce applications utilizing hardware-accelerated 3D graphics. In automatic LOD, models with different

Monday

level of complexity are generated and visualized automatically by the software. It means that the input model has to be built in a different way, with different tools but, even more, with a different theoretical approach. This phase, partially still in progress, has been carried out with different commercial software to do a wider comparison with the manual LOD technique.

Keywords: level of detail, virtual reality, 3D model visualization

Time Constraints Effects in 3D Acquisition and Data Processing: The Case of "Villa delle Vignacce"

Michele Russo[1] and Darius A. Arya[2]

1. INDACO, Politecnico di Milano, Italy
2. American Institute for Roman Culture, Rome, Italy

A 3D model of an archaeological excavation represents an innovative application of well-established methodologies and existing instruments. Despite these technological and scientific advances, some bottlenecks remain in the process leading from the physical object to its digital copy. A key step in the whole process is the initial survey planning, in which the main acquisition parameters (resolution, accuracy, uncertainty, work distance, field of view, etc.) are determined in relation to object geometry and dimension, survey logistics and applications, and intended application of the 3D model. Choices made in this first step directly affect the acquisition method, instruments applied in the project, data processing, and the amount of time necessary to complete the whole modeling project. In fact, time becomes a serious constraint when survey restrictions or time limitations in data processing are introduced in the project. Translated into practice, a resolution-driven time-frame can be applied only to projects with unlimited resources. Most projects, however, are not so fortunate, and so the constraint of time becomes a key factor.

For all these reasons, a realistic evaluation of what results can be obtained is essential in order to take best advantage of the time available. The case study presented in this paper is from the "Villa delle Vignacce" excavation, a well-known though unexplored second-century C.E. structure in the area now called the "Parco degli Acquedotti." The site was investigated by a scientific group of the American Institute for Roman Culture. Logistical and conservation requirements created a need to finish this important suburban excavation project as soon possible, which led to application of a particular compressed 3D acquisition and processing procedure. As a result, a different 3D survey and modeling approach was applied for the creation of a 3D model of a big portion of this case study. The aim of the paper is to suggest a different planning approach for 3D acquisition and data processing in order to optimize a project in which time constraints represent a real bottleneck for the creation of the final 3D model. In particular, we try to point out how the 3D digital model of "Villa delle Vignacce" represents a good compromise between the need to coordinate the best survey set-up coherent with the physical model's characteristics and the presence of time constraints, in order to obtain the best model resolution in a pre-assigned time-frame.

Keywords: 3D scanning, archaeological excavation, process optimization, project timing

The Tools to Operate Reconstructions: An Investigation on the Vault Systems of the Small Thermal Baths in Villa Adriana

Giorgio Verdiani, Sergio Di Tondo, and Filippo Fantini
Università degli Studi di Firenze, Italy

Villa Adriana is one of the most famous and visited Italian archaeological sites. It is a UNESCO World Heritage site and still the object of excavation and research in numerous unknown or neglected parts of the Villa. The site introduces original formal solutions, audacious in some cases, and represents a major advance in the forms of the Roman imperial architecture. This research project focuses attention on the vault structures. The object of the analysis will be the Small Thermal Baths, where the presence of a various and conspicuous abacus of vault solution, makes this ruined architecture one of the most interesting pavilions in Hadrian's Villa. The aim of this project is to comprehend the geometrical and formal building logic on which the vault solutions are based, in order to propose a reasonable reconstruction. The data from a laser scan digital survey provide precise information on the shape of the vault intrados, which makes the structural conception of the covering system explicit. The intrados provides information about the centre of the arches used during the building construction. This information gives a clear reading about the design of the vault systems. Moreover this research meshes the analysis of masonry and the study of formal and metric features of the plan. The entire set of hypotheses is informed by technological knowledge of the second century C.E. and is well-documented by literary sources. Digital applications allow cutting-edge investigations on vault shape, and the operative environment allowed us to visualize quickly the final result. So the research adds to knowledge of the site, creating reconstructed images which are able to show the original configuration.

Keywords: archaeology, 3D models, reconstructions, archaeometric, digital, Villa Adriana, scanner laser, vault systems, archaeological monument

Real-Time Visualization of the Forum of Pompeii

Alice Pignatel, Fausto Brevi, and Sebastiano Ercoli
Politecnico di Milano, Italy

This paper describes the process for creating a single realistic 3D digital model of a large archeological site (the Forum of Pompeii) for virtual reality application. The incoming data are texturized models coming from an accurate 3D survey of the entire area: the ground, buildings, and finds were acquired with active

and passive sensors and converted into polygonal models. Afterwards, the models were assembled in a single virtual scene that reproduces the Forum as it would actually appear to a tourist. The scene can be visualized by means of stereoscopic devices to increase the feeling of immersion. During the data conversion process we had three main categories of problems: database optimization, correction of digital objects' positions in the scene, and the realism of the displayed model. The main challenge was to optimize the digital database in order to obtain satisfactory real-time rendering performances without decreasing the high quality and level of detail of the polygonal models of both environment and buildings. This problem depends mainly on the large dimension of the Forum area (about 150x80m): the survey output is a set of models with a large, fixed polygon number that cannot be dynamically varied according to observer distance from the scene. To manage this wide database within a real time rendering system, it was necessary to balance the quality of texture images and the model's level of detail in order to maximize both detail quality and visualization frame rate. In fact, the main challenge of this project was to manage an highly detailed and realistic-looking database within an immersive and interactive virtual environment. The second problem that we had to face is connected to the right placement of all the digital objects into the virtual scene. In fact, objects were scanned singularly and processed as separate models, so it was necessary to place all the models in a single reference system by aligning 3D models of buildings and finds with the ground model. Finally, to add realism to the scene, light and real-time shadows were added. The lack of lighting effects in the real-time virtual environments decreases the realistic effect of the overall scene. To have a lighting condition that was consistent with the applied textures, we build a light set based on geographical information. We used a single directional light that could reproduce the sun's position at the moment of the survey, according to Pompeii's latitude and the survey time. The real-time rendered model of the Forum was displayed on a large screen with stereoscopic technology, as a platform for archeological studies.

Keywords: virtual reality, 3D visualization, real-time rendering

Monday

Session Summary

Monday, 8:30am-11:45am, Tidewater B

The New ICOMOS Ename Charter (2008) on the Interpretation and Presentation of Cultural Heritage Sites: What Impact Can Digital Technologies *Really* Have on Public Heritage?

Chairs: Neil Silberman, University of Massachusetts Amherst, United States of America
Elizabeth Chilton, University of Massachusetts Amherst, United States of America

Heritage professionals in the humanities and social sciences have turned their attention in recent years to questions of contemporary social significance and context as well as to documentation and research. This has become increasingly important to the conduct of economically sustainable, community-based heritage activities. Such international documents as the 2003 UNESCO Intangible Heritage Convention, the 2005 Council of Europe Faro Framework Convention for the Role of Heritage in Society, and the 2008 ICOMOS Ename Charter on the Interpretation and Presentation of Cultural Heritage Sites (http://www.enamecharter.org) have provided guidelines for action. This session will present new approaches and methodologies that go far beyond the traditional aims of academic research and tourist promotion toward a new, more socially conscious heritage of the twenty-first century. This session will bring together technologists, humanities scholars, and social scientists to examine the potential role of cultural heritage ICT in the following areas of emerging interest:

- *Intangible Heritage and Collective Memory*. The domain of heritage has today moved from a primary involvement with the physical preservation of built structures and historical sites to a wider focus on evolving urban landscapes, cross-cultural routes, vernacular architecture, intangible heritage, minority and indigenous heritage, and collective memory. In a word, public reflection on the significance of the past for contemporary society has become as important as the conservation of its physical remains. What role will cultural heritage ICT play in the coming years?
- *Community Participation*. Through community-based initiatives and innovative public programs, growing numbers of people from all walks of life have been become involved—not only as passive consumers and visitors, but as active partners—in the development and support of historic sites and heritage-related activities. In what practical ways can cultural heritage ICT facilitate this emerging trend?
- *Heritage Conflict and Consensus*. Everyone knows the role of ICT in the virtual reconstruction of the Buddhas of Bamyan. Yet what role can cultural heritage ICT play to contain or even prevent future explosions of inter-ethnic violence—and destruction of heritage resources—in other regions of the world?

The emphasis will be on interdisciplinary collaboration and specific tools to implement ICT applications and to measure their success in contemporary social contexts.

Topics: other

Keywords: social context, public heritage, community, collective memory

Schedule

8:30 – 8:50	"Introduction: What is the ICOMOS Ename Charter and How Does it Relate to Digital Technologies?" Neil Silberman
8:50 – 9:10	"Hidden Cities: Authenticity and City Fabric," Felicity Morel-Ednie Brown
9:10 – 9:30	"Public Involvement in Multiple Interpretation of Cultural Heritage Through 3D Blog and Photo-Logging," Rieko Kadobayashi
9:30 – 10:00	Discussion
Coffee break	
10:15 – 10:35	"Creating a Sense of Place Through Archaeology: Transforming Communication and Engaging Community Through the Internet," Giovanna Peebles
10:35 – 10:55	"Re-locating Meaning in Heritage Archives: A Call for Participatory Heritage Databases," Angela Labrador and Elizabeth Chilton
10:55 – 11:45	Discussion

Abstracts

Hidden Cities: Authenticity and City Fabric

Felicity Morel-Ednie Brown
Department of the Premier and Cabinet, Australia

Cultural heritage has recently come to be viewed as a panacea for sterility in city development, but a preoccupation with creating or discovering a "sense of place" without investigating the authentic cultural fabric is one of the pitfalls that urban professionals encounter. Lack of authenticity in reading and understanding the development of cities leads to a "Disneyesque" invention of that which a city should be—a place which "entertains" rather than engages. Community-based histories have frequently been the poor cousin of heritage research despite their potential as a rich source of material for establishing cultural heritage significance. Stories of the past, interwoven with artifacts such as photographs, documents, and expressed heritage (stories, dance, tracing of lives) can inform interpretation with a level of authenticity difficult to otherwise replicate. This paper will explore the richness that has been discovered in central Perth through the Northbridge History Project—an initiative whose role is to revitalize the city authentically by drawing on its

diverse histories. Containing sites of recognized cultural heritage significance, Northbridge has undergone significant infrastructural and generational change in the last twenty years, bringing with it dislocation of its identity. Fragments of the cultural fabric are being collated into an online electronic archive of primary sources (http://www.northbridgehistory.wa.gov.au) that is being used to proactively create understanding of the cultural heritage of the area. Discovering and making available histories of this diverse area has created a new sense of identity and community engagement, bringing awareness that the life of the city is played out against the backdrop of the built environment and that the soul of the city comes from its context within the cultural fabric. This is underpinning changes in perception of the area by government and policy makers, in which the heritage of the area is more than that which is represented in the streetscape. No longer is there discussion of physically melding the area seamlessly with the city, but instead there is increasing awareness that the area's living cultural heritage is valuable and has much to offer the city as it seeks to position itself as Australia's Indian Ocean gateway. The final stages of a fully interactive GIS is being planned, whereby cross-linking the archive and an interactive presentation will allow a virtual rendition of the history of the area for interpretation, policy making, and research.

Keywords: cultural heritage, urban, cities, history, community

Public Involvement in Multiple Interpretation of Cultural Heritage Through 3D Blog and Photo-Logging

Rieko Kadobayashi
National Institute of Information and Communications Technology, Japan

Flexibility is one of the most important features of cultural heritage digital resources and offers opportunities to form and test multiple hypotheses. For example, using 3D computer graphics one can simulate an ancient village's spatio-temporal evolution by setting different values to parameters based on excavation records. Iteration of possible interpretations of the site and the resulting 3D visualization could be exhibited in a museum as a means to provide visitors with easier and more intuitive understanding, as compared to pictures and scale models. Obviously, it would be more helpful for visitors if they can test their hypotheses by themselves and if it can be done online. This paper discusses how ICT can facilitate public participation in interpretation of cultural heritage, focusing on the 3D Blog system and Photo-logging system which I developed. These two systems share the concept of a "3D viewpoint" composed of the position and direction of an observer's view in the 3D world, i.e. real and/or virtual world. As cultural heritage sites have a spatial feature, it is very reasonable and straightforward to exploit the 3D viewpoint for storing, organizing and searching information such as images and text of cultural heritage. The 3D Blog system allows users to exchange ideas and feelings about cultural heritage by annotating 3D models of cultural heritage and publishing them as blogs. With this tool, the general public can actively join the discussion on the particular cultural heritage of their local community. For example, when discussing preservation of a historical area or an archaeological site, the 3D

Blog system could be used to facilitate consensus-building efforts among the general public as well as among cultural heritage experts. It may also encourage people who live far from the area to join the discussion. In short, the 3D Blog system can appeal to a wider audience than ever and involve them in preserving valuable cultural heritage.

While the 3D Blog system is a web-based application, the Photo-logging system is a mobile-phone-based application which uses a mobile phone as an input and output device. Recent technologies allow a mobile phone to install a motion sensor that is a combination of an accelerometer and a magnetic sensor as well as a GPS sensor. Using such mobile phones, the azimuth and elevation angle and the position of the mobile phone which are thought to be the position and direction of the user's view can be obtained whenever the user takes pictures. This 3D viewpoint information can be added to the picture as metadata and stored with it for later use. In addition to the report of the experiment of these two systems, other applications using the 3D viewpoint are also introduced and discussed.

Keywords: interpretation, 3D models, 3D viewpoint, mobile phones, public participation

Creating a Sense of Place Through Archaeology: Transforming Communication and Engaging Community Through the Internet

Giovanna Peebles

Vermont Division for Historic Preservation, United States of America

The Vermont Division for Historic Preservation (VTDHP) seeks to transform how archeologists communicate their discoveries and invite community engagement through creation of an Internet-based archaeology museum. The VTDHP was awarded a National Endowment for the Humanities Digital Start-up Grant in the fall of 2008 to create a prototype of a sustainable Vermont archaeology virtual museum that leads the way for other states and organizations to use a similar web design and protocols. Fueled by federal and state laws, American archeologists conduct dozens of archeological studies daily, discovering many important sites each year. The collected data disappear into boxes and information and interpretations languish in unpublished technical reports. Important stories about our ancient and more recent past (that may be relevant to climate change, sustainability, food production, and major and minor global issues) are not shared with communities where the sites are located, nor with landowners, indigenous groups, educators, students, and other individuals and organizations who make decisions about the future of archeological sites. Important data are not shared with other scholars. The little information that is disseminated comes from one direction, and currently there is little place and no easy vehicle for non-archeological voices and points of view. While some rare organizations have created terrific web sites that display a variety of linked archeological information, they are often closed to the public and not comprehensive. They are unique proprietary applications that are designed for a single site or geographic area. In contrast, VTDHP is creating a proof of concept and prototype for an web-based

museum with many rooms populated with all the many digital data sets collected by archeologists but now residing in their hard drives and technical publications: GIS spatial data; photos and interpretations of the site, artifacts, cultural features, and other data; artifact databases; field and laboratory records; site summaries; historic maps; video footage; and archival documents, technical reports, and other information. VTDHP is going a step further with this museum concept by asking archeologists to tell first-person stories about their discoveries, seeking contributions by scholars in other disciplines, inviting indigenous people and other community members to write their own stories about the archeological sites, and providing opportunities for community members and others to comment and "participate." Museum "visitors" can choose a particular time period of interest, a particular town, or a particular theme and look at whatever level of information suits them. With this prototype, VTDHP hopes to facilitate a shift in paradigm for displaying, accessing, sharing, and inviting archeological, historic, and cultural information between archeologists and communities.

Keywords: archaeology, web-based, data, digital, communication

Re-locating Meaning in Heritage Archives: A Call for Participatory Heritage Databases

Angela Labrador and Elizabeth Chilton
University of Massachusetts, Amherst, United States of America

While the use of online digital archives is increasing in the various heritage fields, there are significant problems with traditional digital heritage databases. First, these databases often revolve around collecting and presenting information provided by domain experts and do little to engage end users in the interpretative process. In doing so they centralize the meaning-making process and limit authority—and thus access—to non-expert users. Second, they presume a single, knowable community or heritage audience. Third, they presume a single interpretation of an information object, or at least a consensual interpretation from a larger, static group of stakeholders. However, there is a crisis of heritage access. Public engagement with heritage can be characterized as consumption of highly commodified cultural products that appeal to a pervasive nostalgia (one might say "amnesia"), impeding meaningful connections between people and the past. One response to this crisis and the related need for stated and shared principles is the ICOMOS Charter for the Interpretation and Presentation of Cultural Heritage Sites (Ename Charter). Most relevant to this paper, the Ename Charter includes principles intended to (1) encourage inclusiveness among stakeholders and associated communities, and (2) encourage "the development of technical and professional standards for heritage interpretation and presentation, including technologies, research, and training." We suggest that a heritage database that decentralizes the meaning-making process, supports multiple and disparate interpretations of information objects per user, and facilitates user-mediated interaction regarding information objects offers an alternative to traditional heritage databases and comes closer to meeting the Ename Charter's principles. In this paper we explore the social effects of this crisis of heritage access, draw upon post-modern turns in the field of archival management, and examine several case studies of other participatory archive models. We distinguish our

project by repositioning the meaning-making process as distributed, defying categorization, and ultimately ephemeral. Finally, we analyze how participatory archive models may address the crisis of heritage access while at the same time allow for the safeguarding of authenticity in the Ename Charter sense.

Keywords: online databases, digital archives, cultural heritage, Ename Charter

Session Summary

Monday, 8:30am-3:00pm, Tidewater C

Monday

Archaeological Prospection Using High-Resolution Digital Satellite Imagery: Recent Advances and Future Prospects

Chair: Karsten Lambers, University of Konstanz, Germany
Véronique de Laet, KU Leuven, Belgium

This session will focus on the analysis of high-resolution digital satellite imagery for archaeological prospecting. In the last few years, a new generation of satellite sensors, such as the well-known Ikonos 2 and QuickBird 2, the new WorldView 1 and GeoEye 1, and a variety of others have provided an unprecedented variety of remotely sensed imagery with a spatial resolution of 1m and better, and the launch of several similar sensors with a resolution of up to 25cm has been announced for the near future. The resulting space-borne imagery allows for the first time even small archaeological sites and features to be detected. Although this type of space-borne imagery is still quite expensive and does not yet achieve the very high spatial resolution of aerial imagery, it offers a variety of advantages over aerial imagery: it is available nearly worldwide without major legal or practical limitations, it is rather easy to georeference and to use in GIS, and some sensors feature a near-infrared channel in addition to the usual RGB and panchromatic channels, which potentially allows crop marks to be identified more easily. Furthermore, stereo coverage enables a photogrammetric analysis of the images.

Archaeologists have been quick to realize the potential of this new data source for the detection and documentation of archaeological sites and features, and a growing number of case studies with interesting results have evolved from ongoing archaeological field projects in recent years. While some of these projects have been limited to a visual inspection of the imagery to aid fieldwork, others now go beyond this level by applying advanced methods of digital image analysis in order to extract archaeological information. These methods include, among others, image classification, multispectral analysis, pattern recognition, photogrammetry, and related approaches. However, a systematic evaluation of the potential of these methods, which were usually developed for different kinds of applications, and the potential of the new data source itself remains a desideratum.

In this session, papers will be presented that explore the chances and limitations of high-resolution digital satellite imagery, and of current methods of digital image analysis with regard to the requirements of archaeological prospection. Papers with a methodological focus, addressing specific problems of identifying uncooperative archaeological features through digital image analysis and showing recent advances and promising research strategies are especially welcome. Overview papers and new case studies will complement this session that is hoped to bring together specialists from the fields of archaeology, remote sensing, geomatics, photogrammetry, digital image analysis, pattern recognition, and related disciplines.

Monday

TOPICS: photogrammetry and imaging, prospection and remote sensing

KEYWORDS: satellite imagery, high resolution, digital image analysis, remote sensing, archaeological prospection

Schedule

8:30 – 9:00	"Extracting Archaeological Features from High-Resolution Satellite Imagery: A Review of Current Projects, Problems, and Promising Approaches," Karsten Lambers and Véronique De Laet
9:00 – 9:20	"Characterizing Angkorean Landscapes: RS-based Feature Detection in Tropical Areas," Arianna Traviglia
9:20 – 9:40	"Very High Resolution Satellite Remote Sensing as Part of an Integrated Approach for Archaeological Prospection at Tepe Düzen (Southwest Turkey)," Véronique De Laet, Branko Music, Sabri Aydal, Kim Vyncke, Hannelore Vanhaverbeke, Etienne Paulissen, Gert Verstraeten, and Marc Waelken
9:40 – 10:00	Discussion
COFFEE BREAK	
10:15 – 10:35	"Geo-spatial & Archaeological Investigations for the Interpretation of the Growth of the Holy City of Varanasi," India Bharat Lohani, Bharath Gandhi, Vidula Jayaswl, and Manoj Kumar
10:35 – 11:05	"The Fragile Crescent Project: The Rise and Decline of Bronze Age Urban Settlements in the Ancient Near East," Daniel Donoghue, Nikolaos Galiatsatos, Tony Wilkinson, and Graham Philip
11:05 – 11:25	"Potential of Simple Feature Signatures for Mapping Landscapes of Mobile Pastoralists," David John Tucker
11:25 – 11:45	Discussion
LUNCH	
1:30 – 1:50	"CORONA Imagery Archaeological Atlas of the Middle East," Jesse Casana
1:50 – 2:10	"Effects of Ground Control Point Accuracy on Triangulation and Ortho-rectification of Large Blocks of CORONA Images," Jackson Cothren, Adam Barnes, Jesse Casana, and Tuna Kalayci
2:10 – 2:30	"Accuracy of DEM Generation from CORONA Stereo Pair Images," Tuna Kalayci, Jackson Cothren, Jesse Casana, and Adam Barnes
2:30 – 3:00	Discussion

Abstracts

Extracting Archaeological Features from High-Resolution Satellite Imagery: A Review of Current Projects, Problems, and Promising Approaches

Karsten Lambers[1] and Véronique De Laet[2]

1. University of Konstanz, Germany
2. KU Leuven, Belgium

This paper reviews recent research in the field of archaeological prospection based on high-resolution satellite imagery and digital image analysis. The goal is to give an overview of the state of the art in this field, describe recent methodological progress as well as current research problems, and determine promising starting points for future research. Although satellite imagery has been used for archaeological purposes since the 1970s, imagery with a very high spatial resolution of ≤1m has been available only since about the year 2000, and only since then has the detection of even small archaeological structures become possible. This increase in spatial resolution has thus considerably increased the utility of this data source for archaeological prospection. The methods commonly used to extract archaeological information from satellite images for the most part still rely on the methodology of aerial archaeology, which is considered by many to be the benchmark for satellite-based archaeological prospection. This reduced perspective tends to obscure certain advantages that satellite images offer to archaeology, among them a higher spectral resolution, stereo coverage, nearly world-wide availability, and a fully digital workflow. These advantages make high-resolution satellite imagery a very promising data source for archaeology, even though the image quality is often lower than aerial imagery. The difference in spatial resolution, however, is being reduced with every new sensor launched into space.

A basic research issue in satellite-based archaeological prospection is to what extent methods and algorithms from the field of digital image analysis can assist with the detection and documentation of archaeological features. While digital image analysis has become a powerful tool in such diverse fields as cartography and geomatics, earth and life sciences, and biology and medicine, the application to archaeology is still in its infancy. The fact that archaeological remains may take on a sheer infinite variety of formal and spectral properties complicates their extraction using rule-based algorithms. In spite of these difficulties, case studies from recent years show that, if used properly, image preprocessing and enhancement, multispectral and hyperspectral analysis, photogrammetry, pattern recognition, and related methods can assist the identification of archaeological features to a considerable extent. This is especially true when digital image analysis of high-resolution satellite imagery is combined with other data sources and prospection methods, such as aerial and satellite imagery with different spatial and spectral resolution, digital elevation models, ground-based geophysical prospection, archaeological fieldwork, etc. However, since most research projects focus on particular case studies, it is not clear to what extent these promising results allow a general judgment of the

Monday

applicability of digital image analysis to high-resolution satellite imagery under varying environmental and archaeological conditions. A systematic evaluation of data and methods is still a desideratum. This review is intended to give some general clues and identify the most promising approaches on which future research in the field of satellite-based archaeological prospection can rely.

Keywords: digital image analysis, high-resolution satellite imagery, archaeological prospection

Characterizing Angkorean Landscapes: RS-based Feature Detection in Tropical Areas

Arianna Traviglia
University of Sydney, Australia

This paper will focus on the current results of a project ("Mapping the past using RS: new satellite applications for uncovering archaeological remains at Angkor") that develops and applies satellite remote sensing methodologies for finding and mapping unknown archaeological sites in the surroundings of Angkor, Cambodia. World-famous for its temples, this UNESCO Heritage site is now increasingly recognized as a vast, low-density urban landscape. By applying technologies such as multispectral imaging, the current research aims to scan vegetated and bare soil areas in order to clarify features that are ambiguous on existing maps and to reveal features which would otherwise remain undetected. The innovative approach of the project consists of using the spectral content of remotely sensed images to reveal the presence of buried sites and structures of the ancient Khmer landscape on the basis of the different spectral characteristics of the terrain and vegetation.

Multispectral and radar data have already been adopted, as simple on-screen visual investigation, in previous research by the University of Sydney team to detect and draw maps of archaeological monuments or possible archaeological features. The outcomes of using remotely sensed data so far have been satisfactory, but the process is still incomplete as regards specific areas, due to particular environmental conditions (for example, a large part of the investigated area is strongly forested). Significant new results are now available, exploiting the spectral characteristics and contents of the satellite images through carefully-designed processing of the images. Various satellites images (Ikonos, QuickBird , ASTER, LandsatTM) are submitted to several image-processing techniques, according to what type of natural environment of the target area they represent. Due to the large amount of forest coverage, a particular emphasis is attributed to different and appropriate Vegetation Indices: the vegetation covering archaeological features and hiding them to a pedestrian, aerial, or radar survey have specific spectral signatures that can be detected through image processing and lead to the identification of subsurface archaeological structures. Vegetation suppression also has been tested with significant results. In bare soil or sparse vegetation areas, PCA (Principal Component Analysis) has been extensively employed, since it enhancement soil characteristics that facilitate identification of paleo-rivers and historical channels, a crucial factor in understanding the water flow system and its redirection. The availability of remotely sensed data for the needs of the project allows a multi-scalar and multi-temporal approach to the detection of archeological features and permits the identification of a larger set of typologies of features. The results of the investigation of the treated images augment the current map of greater Angkor and are crucial for a correct understanding of the extension of the Khmer settlement and of the processes which led to its decline and abandonment.

Keywords: Angkor (Cambodia), HR satellite images, spectral analysis, QuickBird, Ikonos

Very High Resolution Satellite Remote Sensing as Part of an Integrated Approach for Archaeological Prospection at Tepe Düzen (Southwest Turkey)

Véronique De Laet[1], Branko Music[2], Sabri Aydal[3], Kim Vyncke[1], Hannelore Vanhaverbeke[1], Etienne Paulissen[1], Gert Verstraeten[1], and Marc Waelkens[1]

1. Katholieke Universiteit Leuven, Belgium
2. University of Ljubljana, Slovenia
3. Antalya Museum, Turkey

Very high spatial resolution satellite (VHSRS) systems have considerably enhanced the possibilities of detailed archaeological prospection. An excellent illustration of the potential of VHSRS imagery is the discovery and the continuing evaluation of the archaeological site of Tepe Düzen (Turkish for “flat hill”) in southwest Turkey in 2004. During extensive archaeological excavations on Tepe Düzen in 1994 and 1997, the extent and importance of the site were not acknowledged, because only some structures made of fieldstones and rocks were identified and undiagnostic pottery was collected. Specific enhancement techniques on QuickBird imagery showed many rectilinear features forming building-like configurations. The analysis revealed that Tepe Düzen was most likely covered with a large site, extending over an area of at least 1.2 km^2. Its presence and extent was later confirmed by a targeted archaeological survey. Despite its positive contributions, the possibilities of satellite imagery for mapping and interpretation of structures on archaeological sites depend on the type and characteristics of the VHSRS data and on on-site parameters, such as the dimensions of the remnants and the spectral contrast of the marks (shadow, soil, and crop marks). Additional information about the internal site structures, which is absolutely necessary for further interpretation of the VHSRS data, is mainly retrieved from geophysics (electrical resistivity, magnetic survey, GPR) combined with ground control (intensive archaeological survey and excavations). Satellite remote sensing is not an exclusive prospective technique, but should be used in combination. This paper presents a stepwise interdisciplinary integration and back-coupling of very high-resolution satellite remote sensing, archaeological survey, topographic mapping, geophysics, and excavations for archaeological prospection.

Keywords: remote sensing, QuickBird, geophysics, archaeological survey, excavations, Turkey

Geo-spatial & Archaeological Investigations for the Interpretation of the Growth of the Holy City of Varanasi, India

Monday

Bharat Lohani[1], Bharath Gandhi[1], Vidula Jayaswal[2], and Mano Kumar[2]

1. IIT Kanpur, India
2. Banaras Hindu University, India

The major research question posed in this paper is to understand the pattern of shifting settlements in the City of Varanasi during last three thousand years. This is being attempted by combining archaeological and remote sensing data within a GIS environment. The archaeological remains of the Varanasi region, particularly along the Varuna and the Ganga river systems, reveal at least three major shifts of the nucleus of the settlement. Stage I, when the region was colonized for the first time (around twelve- to thirteen-hundred years B.C.E.), was on the bank of Varuna. The left bank of the Ganga was inhabited about four to five hundred years later, when in Stage II, the confluence of Varuna and Ganga became the nucleus. This shift of the main city westwards was a historical event of the fourth and fifth centuries C.E. The city of Varanasi in the late historical periods kept expanding westwards, as to reach the site of the river Assi. It was perhaps this tendency that kept this city alive for more than three thousand years. The paleo-geomorphology and water bodies appear to be major factors responsible for the shifting tendency of this settlement.

This paper aims to study the paleo-environment of the area in and around Varanasi, so as to connect this information with archaeological finds. The authors have collected a large quantity of archaeological data through several excavations in this area. The methodology adopted in this paper first identifies all existing paleo-channels with the help of historical and current remotely sensed data. Investigations have been carried out to interpret and extract the paleo-channels using image processing techniques. It is noticed that the data sets with different spatial and temporal resolution fare better with paleo-channel identification than individual data. Extracted paleo-channels are imported into the GIS. A GIS-based database has been developed that arranges archaeological finds with their spatio-temporal context. The aim of putting all information in GIS is to carry out spatio-temporal queries for supporting the archaeological hypothesis. At present we do not have the dating records for the paleo-channels identified, which would help in conclusively testing the hypothesis. However, considering the overall geological setup of the study area, this paper can conclude that shifting of perennial water sources might have played a crucial role in the movement of the settlements. Combining more archaeological data and dating records for paleo-channels would help in corroborating this result. The paper is novel as it is first such attempt to understand the shifting of Varanasi. Further, the paper presents a method to combine remotely sensed information and archaeological findings with their true spatio-temporal context under a specially developed GIS module.

Keywords: GIS, remote sensing, shifting settlement, paleo-channels, spatio-temporal analysis

The Fragile Crescent Project: The Rise and Decline of Bronze Age Urban Settlements in the Ancient Near East

Daniel Donoghue[1], Nikolaos Galiatsatos[1], Tony Wilkinson[2], and Graham Philip[2]

1. Department of Geography, Durham University, United Kingdom
2. Department of Archaeology, Durham University, United Kingdom

The Fragile Crescent Project (FCP) is a study of the rise and decline of Bronze Age urban settlements and associated political and economic structures in the ancient Near East between ca. 3500 and 1200 B.C.E. The Near East is a key area for urban development; but for too long the settlement record from Southern Mesopotamia has been taken as the paradigm for the entire region, and has provided the key data set for the reconstruction of the processes of urbanism and state development. Large urban settlements are also documented in other parts of north Mesopotamia and Syria and their different developmental trajectories need to be taken into account. Evidence from surveys in the Northern regions suggests not only that developments there were very different from those of southern Mesopotamia, but that there was marked diversity between different sub-regions. Recent overviews highlight the need for a comprehensive review of the settlement record, and the FCP is an attempt to rectify this lacuna. Wilkinson suggests that current models oversimplify a more complex reality, and that a better understanding of the spatial patterns and chronology of the settlement record will allow research to move beyond simplistic notions of "secondary state formation," and allow the data from Upper Mesopotamia and the northern Levant to act as a corrective to the south Mesopotamia "orthodoxy."

In order to tackle the question of how the process and pattern of Early Bronze Age urbanization varied from region to region, it is essential to harness data on trends in settlement from as large an area as possible, and, in turn, to relate these to the regional environment. This requires the creation of a large-scale and coherent set of high-quality settlement data to tackle specific questions fundamental to the economic and social dimension of the rise of early states and civilizations. The FCP can enhance the value of a series of regional surveys by analyzing the data within a single geographical and environmental framework, specifically by taking advantage of recent advances in the use of satellite imagery and digital terrain models. Consequently this is a project that has only recently become possible through the convergence of a range of digital technologies. The core methodology of the project is to re-analyze a series of "sample" surveys, the data from which is readily available, and to re-calibrate these within a GIS framework. Remote sensing is used to identify, confirm and provide a landscape context for sites previously recorded in the field (i.e., within existing survey areas) and also provides data on areas that were not surveyed. The FCP therefore is able to extend existing surveys to encompass larger geographical areas that appear more meaningful for the analysis of questions of urban development. The paper will demonstrate the value to land-scale analysis of high spatial resolution optical imagery and digital terrain models derived from modern and declassified satellite imagery. Research is funded for four years by the UK Arts and Humanities Research Council (AHRC).

Keywords: remote sensing, fertile crescent, CORONA

Monday

Potential of Simple Feature Signatures for Mapping Landscapes of Mobile Pastoralists

David John Tucker
Martin-Luther University, Halle-Wittenberg, Germany

This paper will present a brief overview of an archaeological prospection in the steppe of eastern Syria based on high-resolution satellite images. While earlier research often stressed the extremely limited visibility of nomadic pastoralists in the archaeological record this study illustrates the high density of nomadic traits in arid areas which can be traced in satellite imagery. Using Ikonos (1m) imagery, a 200 km^2 study area 125 km southeast of Palmyra, Syria, was visually searched for evidence for nomadic use of the steppe. Features such as abandoned tent sites, animal feeding sites, stone corrals, cross-wall fields and animal trail networks centered on wells (piospheres) could be readily identified due to their simple characteristic signatures:

- Abandoned tent sites appear as small, regular white (high-reflectance) or sub-white colored rectangles. In just the small study area over 2300 tent sites were visually plotted.
- Sheep are herded together by pastoralists for feeding and drinking where thick layers of dung accumulate. The resulting features are typically dark brown and have a diameter of about 20m.
- Given sufficient rainfall the pastoralists engage in rainwater-harvesting—parallel alignments of low retaining walls in the flat beds of wadis disclose this mode of farming.
- Vast radial networks of narrow animal trails centering on wells, form dramatic patterns over several kilometers. However, as a single piosphere with a radius of six kilometers is composed of around five thousand linear elements it is not efficient to manually map these features in detail.

The tent site rectangles, the circular brown dung patches, the parallel lines of wadi walls and the radial linear piospheres are highly suitable for semi-automated detection due to their simple form, the repetition and configuration of the form and their sheer abundance against the background of a largely uniform barren steppe landscape. This range of features will be of particular interest to scholars looking for a body of data with which to test algorithms in semi-automated archaeological prospection with good chances of achieving high levels of detection. Semi-automated pattern recognition would thus be an efficient method to map the extensive patterns of nomadic activity known to exist and assist in documenting range degradation in arid landscapes across the Near East.

Keywords: satellite imagery, prospection, pastoral nomads, pattern recognition, arid landscapes

CORONA Imagery Archaeological Atlas of the Middle East

Jesse Casana
University of Arkansas, United States of America

In the past decade, Cold War-era CORONA satellite imagery has proven to be an invaluable resource in the archaeology of the Middle East. Since the 1960s, when the imagery was acquired, dam construction, urban expansion, and agricultural intensification have radically transformed the region's landscape, destroying or obscuring countless archaeological sites and other ancient cultural features. CORONA imagery thus preserves a high-resolution (<2m) picture of a pre-industrial landscape that by and large no longer exists. Despite its undisputed value, the integration of CORONA imagery into archaeological projects has remained very limited, owing to the enormous difficulties involved in rectifying and processing these highly irregular images. This paper presents initial results of a two-year NEH-funded project that utilizes newly developed methods which will efficiently and accurately orthorectify CORONA imagery of the Middle East and surrounding regions. In addition to providing spatially corrected CORONA overlaid on Google Earth imagery, the accuracy of the methods we employ also enable CORONA to be viewed in stereo and for high-resolution digital topographic data to be extracted. Orthorectified imagery, DEMs, and stereo pairs can be viewed and downloaded through a user-friendly online database that includes tools for locating and mapping archaeological sites, as well as for importing field observations and GPS points. Data have already enabled the discovery of many previously unrecorded archaeological sites, ancient roads, canals and field systems in many areas of the Middle East.

Keywords: CORONA, satellite imagery, Middle East, orthorectification, photogrammetry

Effects of Ground Control Point Accuracy on Triangulation and Ortho-rectification of Large Blocks of CORONA Images

Jackson Cothren[1,2], Adam Barnes[1], Jesse Casana[1,3], and Tuna Kalayci[3]

1.Center for Advanced Spatial Technologies (CAST), University of Arkansas, United States of America
2. Department of Geosciences, University of Arkansas, United States of America
3. Department of Anthropology, University of Arkansas, United States of America

We discuss automating several photogrammetric processes associated with a project funded by the NEH to develop and distribute a digital CORONA satellite imagery-based archaeological atlas of the Near East. Archaeologists have long appreciated the extraordinary power of aerial photography and satellite imagery to aid in the discovery and interpretation of archaeological sites, the recognition of larger cultural landscape features such as roads, canals, and field systems, as well as the mapping and management of cultural resources. However, in the Near East little available imagery of adequate spatial resolution was available to archaeologists until 1995, when a large archive of US intelligence satellite images from the 1960s and 1970s, were declassified and made publicly available. These CORONA images provide high-resolution views of the landscape and have been employed recently in a handful of innovative archaeological projects in the Near East. Because CORONA images are over thirty years old, they preserve a picture of archaeological sites prior to their destruction by recent industrialization and urban expansion, making this imagery an absolutely unique resource that can never be replaced by new technologies. However, due to the size of the digital image

files provided by USGS, the spatial distortions produced by the fast-moving panoramic camera and the sparse metadata associated with each mission, the imagery is difficult to georeference, let alone accurately orthorectify. Many researchers have presented rigorous models and methods for exploiting CORONA images suitable for small areas or a few images. We discuss several innovative strategies to apply these rigorous methods to more than one thousand overlapping CORONA images from the KH-4A and KH-4B missions by automating: 1) the stitching of partial USGS scans into a full image, 2) the matching of image tie points along and across revolutions, 3) collection of ground control points from Google Maps reference data, 4) triangulation of the images in a rigorous bundle block adjustment and 5) orthorectification of the images using available elevation data. We pay particular attention to the difficulties associated with economically collecting ground control across a large land area and quantify the effects of ground control point errors on the resulting CORONA orthoimages which will populate the Near East Atlas.

Keywords: photogrammetry, satellite photography, panoramic

Accuracy of DEM Generation from CORONA Stereo Pair Images

Tuna Kalayci[1], Jackson Cothren[2,3], Jesse Casana[1,3], and Adam Barnes[2]

1. Department of Anthropology, University of Arkansas, United States of America
2. Center for Advanced Spatial Technologies (CAST), University of Arkansas, United States of America
3. Department of Geosciences, University of Arkansas, United States of America

This study investigates the DEM-production capabilities of a project funded by the National Endowment for the Humanities. The project's aim is to develop and distribute a digital CORONA satellite imagery-based archaeological atlas of the Near East. CORONA satellite imagery can be used for discovering and interpreting sites, understanding more of cultural landscapes and reconstructing sites and physical landscape they reside in. However, correction of spatial distortions of the CORONA satellite images is crucial to producing accurate elevation models to re-construct the physical landscapes as well as individual sites. The best publicly available digital elevation model is the 90-meter Shuttle Radar Topography Mission (SRTM) with vertical accuracy in the range of 10-16 meters. The CORONA Archaeological Atlas of the Near East aims to produce a publicly accessible digital elevation data at 10-meter spatial resolution. This study uses ASTER imagery, and 1:25000 topographic maps to evaluate the planimetric and vertical accuracies of DEMs produced out of spatially corrected stereo-pairs. Geometric accuracy tests are conducted by using check points generated from the ASTER imagery as well as topographical maps. Elevation transects are also employed to inspect the height accuracies of CORONA elevation models. RMSE values of the residual errors are also investigated in order to provide formal statistical measures. By doing this, the reasons for discrepancies in elevation models are understood and some suggestions are made to the process of digital elevation model building. Once its accuracy is proved, an elevation model can be used to produce topographic maps of individual mounded archaeological sites. Moreover, these DEMs can be used to assess the amount of damage

and reconstruct the original extents of the sites and determine precisely how they had been damaged. In this respect, the CORONA Archaeological Atlas of the Near East will be an invaluable tool for archaeologists and government officials of the area and even for the researchers who investigate environmental and land use studies, human impact on environment, and historical and cultural geography of the area.

Keywords: photogrammetry, CORONA, DEM, accuracy assessment

Monday

Session Summary

Monday, 8:30am-5:30pm, Tidewater D

Excavation to Publication: Developing and Applying Integrated Digital Technologies

Chair: STEPHEN STEAD, Paveprime LTD, United Kingdom

The UK JISC-funded VERA (Virtual Environments for Research in Archaeology) project is a collaboration between the University of Reading (Department of Archaeology and School of Systems Engineering), University College London, and York Archaeological Trust. Over the last two years, the project has looked at various aspects of the acquisition, management and dissemination of the digital record of the large research excavation at Silchester Roman Town, Hampshire, England. The project is centered on the IADB (Integrated Archaeological Database), which has been used as the excavation recording system at Silchester since the start of the archaeological project twelve years ago. A key aim of the VERA project has been to improve the accessibility of the digital records to co-workers, particularly those who are not generally physically present on the excavation, such as artifact specialists. In practical terms this has involved a number of themes:

- Trials of digital recording devices including hand-held internet tablets, digital pens, and digital clipboards to speed up the availability of the digital records.
- Extensive user needs analysis, linked to these trials, to ensure that the solutions created fit problems exposed.
- New visualization techniques, both 2D, through enhancements to the traditional stratigraphic matrix diagram, and 3D mechanisms.
- Improvements to IADB functionality and the user interface.
- Standardization of the IADB within a portal framework to improve security, accessibility and sustainability.
- Direct web report and database publication within the IADB framework.

During the course of the VERA project a number of important issues have arisen, including:

- The fragility of on-site infrastructure.
- The robustness and usability of digital recording devices.
- The central role of the Context Recording Sheet in excavation recording.
- Managing the introduction of new technologies and techniques into long-running fieldwork projects with well-established management and recording systems.
- The importance of training.

- The need for well established management and data validation procedures.
- The importance of extensive and detailed user needs analysis.
- The role of appropriate and useful visualization techniques, and whether legacy data can have a role in 3D visualizations.
- The appropriate Open Source model for applications, such as the IADB and the data they contain.

These issues will be covered in two ninety-minute sessions in a number of papers to be submitted by members of the VERA team. Proposed topics include:

- Managing Change: introducing innovation into well established systems.
- User Needs Analysis: what do users really need and want?
- Innovation in Visualization: using data in innovative ways, which fulfils researcher needs.
- Evaluating Innovation: does it work? Is it worth it?

Papers have also been invited from other CAA members who would like to address any of these issues, particularly from their own practical experience. The VERA project session will be chaired by Stephen Stead. It is proposed that the formal paper session should be followed by a round table discussion which would focus on the implications of the VERA project for the wider archaeological community. The round table will be chaired and moderated by Steve Stead and the panel will include both VERA and non-VERA participants.

Topics: databases, 3D data capture and modeling, data management systems and other field applications, Open Source software in archaeology

Keywords: VERA, IADB, User Needs, 3D

Schedule

8:30 – 9:00 "Managing Change: Introducing Innovation into Well-Established Systems, " Emma Jane O'Riordan, Amanda Sarah Clarke, and Michael Fulford

9:00 – 9:30 "Integrating New Technologies into Established Systems: A Case Study from Roman Silchester," Claire Rebecca Fisher, Claire Warwick, and Melissa Terras

9:30 – 10:00 "Preserving the Record—Context Recording in the Digital Age," Michael John Rains and Claire Rebecca Fisher

Coffee break

10:15 – 10:45 "Ask Not What GIS Can Do for You: Current Limitations and How to Overcome Them," Benjamin Ducke

10:45 – 11:15 "iDAI.field and More—Documenting Field Projects at the German Archaeological Institute (DAI)," Felix Falko Schäfer and Rainer Komp

11:15 – 11:35 "Large-Scale Preventive Archaeological Fieldwork: Data Collection and Recording in France," Pablo Ciezar

Lunch

1:30 – 1:50 "The VERA Information Environment," Hugo Ranger Mills and Mark Baker

1:50 – 2:10 "Accessing Grey Literature: Present and Past," Catherine Suzanne Hardman

2:10 – 2:30 "Precision Recording of Pompeian Standing Remains Via Stitched Rectified Photography," Michael Anderson

2:30 – 3:00 "Solving Old Problems with New Methods: Considerations about a Neolithic Cemetery," Raluca Kogalniceanu and Alexandru Morintz

Coffee Break

3:15 - 5:30 Round Table, Chaired by Stephen Stead
Participants: Michael John Rains, Amanda Clarke, Claire Fisher, Carla Schroer, Eric Kansa, Sarah Whitcher Kansa, Julian Richards, and Benjamin Ducke

Abstracts

Managing Change: Introducing Innovation into Well-Established Systems

Emma Jane O'Riordan, Amanda Sarah Clarke, and Michael Fulford
Department of Archaeology, University of Reading, United Kingdom

In 1997 a major new British excavation project was launched. Run by the Department of Archaeology at the University of Reading, the excavation was located within one block of the Late Iron Age and Roman town of Silchester in Hampshire. The project was important in two senses; firstly, at 3025 square meters, the excavation area was large in any urban context, and secondly, the expectation was that this was a project which could last for as many as ten seasons in the field. It was clear from the outset that managing the volume and variety of archaeological data generated by such a large site would require engagement with digital technologies, and, twelve years on and still going strong, the project acknowledges that one of the keys to its success has been the core use of an Integrated Archaeological Database (IADB). During excavation this IADB is a data gathering, storing, and recording tool, and during post-excavation it allows integrated desktop access to all aspects of the growing excavation record. The IADB can be accessed from anywhere with an Internet connection, allowing the geographically dispersed research team to interact with the core project team throughout the year. Traditionaly, Silchester's excavation data—be it plans, written records, or photographs—has been entered in the IADB through manual digitization, usually once the excavation season is over. A new project, begun in 2007, aims to find ways to enhance the collection of site data, with the intention of speeding up the transfer of information from trowel to database. During field trials, varieties of digital recording methods were used, including digital pens and notebooks, and handheld internet browsers. The objective was to have fewer paper

records to digitize during post excavation. In 2008 this aim was achieved, with 43% of the site record being digitized before the season was finished. Key to the use of these new technologies was the requirement that they should not cause an unacceptable level of interruption to the traditional site recording processes. It was also important that there should be no lapse in the quality of the recorded data, a task already daunting on a university training excavation.

This paper will discuss the steps that were taken to trial new recording methods on a project with a proven track record for recording and publishing its archaeological information. What are the main obstacles to challenging traditional and embedded systems? The effect of introducing new working methods into a long-running archaeological research and training project will be discussed. Is the inevitable extra investment of time and money ultimately worth it? What implication does innovation on-site have for post-excavation work? This paper, jointly written by the Director of the Silchester Field School and the Research Assistant coordinating the use of the new technologies on site, will look at the challenge of managing such a project through times of change, whilst maintaining the integrity of the research and training outputs.

Keywords: excavation, digital data, site recording

Integrating New Technologies into Established Systems: A Case Study from Roman Silchester

Claire Rebecca Fisher, Claire Warwick, and Melissa Terras
University College London, United Kingdom

This paper presents the results of user needs analysis undertaken as part of the VERA project (Virtual Research Environment for Archaeology) and addresses the wider issue of change management in ICT-enabled projects. Introducing new ways of working into well-established systems can be problematic, especially if the change involves the introduction of unfamiliar technology. This paper focuses on the adoption of digital field recording systems at the Roman site of Silchester and explores how the implementation of new technology has impacted on the workflow of the site. The University of Reading's excavation of approximately one-third of Insula IX began in 1997 and last summer saw the completion of its twelfth field season. The challenge of successfully integrating new technologies into an existing well developed and long established excavation recording systems provides an ideal case study for change management in archaeology.

Digital field recordings and born digital data have often been vaunted as the future of archaeological practice and identified as a prerequisite in a brave new world where "information flows seamlessly from excavation, through post-excavation to publication and archive" (Lock 2003, p265). There has perhaps been an underlying assumption that "digital" necessarily means "better" or "faster" but the adoption of new technologies should not be undertaken lightly or without careful research and preparation. "Publication after publication reaches the same conclusion: that technology is important but insufficient on its own for the success of ICT-enabled

Monday

projects. Again and again technology projects fall down not because the hardware is unstable, but because different systems' architectures have been poorly scoped and designed. Without good change management and careful thought given to the people using the systems as well as the technology itself, ICT-enabled projects are unlikely to be successful" (Jones & Williams 2005). Fieldwork observations, user needs discussions and formal written questionnaires at the Silchester excavation have shown that whilst the technology itself was robust and easy to use, issues arose around its implementation. Issues encountered included: staff involvement and commitment, staff and student training, workflow difficulties, the central role of the traditional context card, and problems associated with hybrid systems. The issues encountered at Silchester are by no means unique to the project and after presenting the results of our particular case study we will endeavor to draw out some of the themes that we feel can be more widely applied to change management in ICT-enabled projects.

Jones, A. and L. Williams, 2005. *How ICT? Managing at the Frontline.* London: Work Foundation
Lock, G. 2003. *Using Computers in Archaeology.* Routledge

Keywords: VERA, user needs, digital recording

Preserving the Record—Context Recording in the Digital Age

Michael John Rains[1] and Claire Rebecca Fisher[2]

1. York Archaeological Trust, United Kingdom
2. University College London, United Kingdom

Recent trials of "direct to digital" or "born digital" context recording at the Silchester Town Life Project have revealed some of the problems and potential pitfalls of introducing new technologies into existing well developed and long established excavation recording systems. The field trials of handheld internet tablets, digital pens, and digital clipboards have also challenged the assumption that we should always be striving towards the direct production of a digital record during excavation. Attempts at replacing the "traditional" context recording card have in fact highlighted its central role in such systems, the "ancestry" of which in many cases can be traced back to the context recording system developed at the Museum of London Archaeology Service (MoLAS) in the early 1980s. Some doubts have also arisen as to whether the direct-to-digital methods tested have actually saved any time or effort. These issues have prompted a re-evaluation of the role and form of the digital context record within the Integrated Archaeological Database (IADB) used at Silchester. The IADB context record was designed as a full digital transcription of the context recording cards into a structured data table, the creation of which is a time-consuming process, particularly when it is considered that much of the transcribed information will rarely if ever be used or referred to again. This paper proposes a new approach to digital context recording in which a scanned image, or facsimile, of the original context recording sheet is stored along with key metadata such as keywords and stratigraphic relationships, sufficient to support post-excavation searching and indexing of the data. Use of automatic scanners with sheet feeders and batch upload techniques, combined with careful selection of the manually transcribed metadata, can greatly reduce the time required to create the complete digital context record while producing a very usable resource and archive with many advantages for the excavator and researcher. A report will be given on recent trials of this approach to context recording at Canterbury Archaeological Trust and at York Archaeological Trust. The Canterbury trial has involved the rapid digitization of well over 10,000 context records from a single large project, while the York trial has examined the use and appropriateness of this approach through all stages of a small project from excavation, through post-excavation analysis and research, to publication.

Keywords: IADB, databases, excavation recording, facsimile

Ask Not What GIS Can Do for You: Current Limitations and How to Overcome Them

Benjamin Ducke
Oxford Archaeology Digital Ltd, United Kingdom

Archaeologists routinely use GIS to map, manage, and explore excavation site data. At Oxford Archaeology (OA), Europe's largest independent provider of archaeological services and Information Technology (IT) research (OA Digital, http://oadigital.net), we employ GIS in most of our projects. Compared to other technologies, particularly Computer-Aided Design (CAD), GIS remains the best choice for excavation data management and analysis, being the only platform equipped with both the theory and implementations necessary for handling spatial information. GIS also offers native database integration and unique support for open, standardized file formats, and data exchange protocols, supporting key collaborative technologies such as Spatial Data Infrastructures (SDI, http://en.wikipedia.org/wiki/Spatial_Data_Infrastructure) and long-term digital archiving systems. Despite all this, however, GIS represent a geographic world view that does not reflect the spatial structure and scale of an archaeological excavation very well. This limits the applicability of common GIS for essential tasks such as 3D and subsurface data modeling, integration of photogrammetry data or stratigraphic analysis. Current software can be "bent" for these purposes to a certain degree, using creative work-arounds or costly, proprietary add-on technology—neither of which is particularly elegant or sustainable in the long term. Although archaeologists are aware of these issues, no comprehensive study has been undertaken to identify the problems with current GIS and offer strategies for resolving them. Indeed, to overcome current technological limitations, optimize workflows, data quality and efficiency and make more of available spatial data, archaeological IT needs to change its paradigm from consumerism to sustainable, collaborative research and development of applications that suit our discipline's needs. Free and Open Source (FOSS, http://en.wikipedia.org/wiki/Free_and_open_source_software) GIS technology, representing the most dynamic field of development in the GIS world, offers the chance to do just that. OA has committed itself to making the most of the FOSS potential, working together with major projects such as GRASS GIS (http://www.grass.itc.it), Quantum GIS (http://www.qgis.org), and gvSIG (http://www.gvsig.gva.es).

A recent accomplishment has been the release of the OA Digital Edition of the gvSIG desktop application, freely available on our website (http://oadigital.net/software/gvsigoade).

For the first time ever, archaeologists have the chance to influence and shape the development of a ubiquitous software technology. To make the most of this unique chance, it is crucial that we can clearly define our needs at a data model and technological implementation level. This paper will present an analysis of current technological limitations of GIS in archaeology, relating to its data models and spatial theory. It will look at ways to resolve them, outline sustainable, cost-efficient ways to get involved in software development and offer a glimpse of the shape of things to come in FOSS GIS for archaeology.

Keywords: GIS, Open Source, data models, excavation data, software research

iDAI.field and More—Documenting Field Projects at the German Archaeological Institute (DAI)

Felix Falko Schäfer and Rainer Komp

1. Deutsche Archäologische Institut, Germany
2. Institute for Classical Archaeology, University of Cologne, Germany

The German Archaeological Institute (DAI), with its headquarters in Berlin and several departments in the Mediterranean region and the Near East, is the biggest archaeological institution in Germany. About 150 archaeologists, anthropologists, historians, architects, geophysicists, surveyors, zoologists, etc. carry out field projects such as excavations, surveys, building documentation, geoprospections, and restorations around the world, often in cooperation with local and international research partners. In the past all these projects have developed and used individual information systems to store and retrieve data. This can results in the loss of digital data after a project has been completed or isolation of data possibly useful for others. Current efforts at the DAI to overcome this unfortunate situation are focussing on two solutions: first, establishing internal standards for the workflow of field projects, by setting up regulations and infrastructures for the long-term preservation of files and by improving the interoperability of DAI repositories; and second, developing an open, modular, web-based documentation system, named iDAI.field, with Open Source technology. These measures are not restricted to one method (such as only excavations or only surveys) but instead integrate several approaches adopted in the course of one or several field project. Therefore archaeological data collected by different persons are brought together at an early stage of documentary work. iDAI.field is designed to interact with various digital resources provided by the DAI itself or other cultural institutions. For instance, the bibliography module will be connected with the literature database ZENON of the DAI. Another objective is the integration of interfaces to GIS and 3D applications, which run either via web-services or on local desktop machines, in order to ease the analysis and visualization of the archaeological material. The modular architecture of the whole system will ensure that it will be easily adaptable for different field projects despite their dealing with different questions and materials. A further benefit of iDAI.field will be that the data, once technically structured in PostgreSQL and XML, can easily be transformed into an online publication, into a draft of a printed version, or—after the necessary mapping process—into CIDOC CRM-conforming expressions. The first part of the paper will describe the existing and planned infrastructures of the DAI when handling digital data. The implementation and control of best practice guidelines based on authoritative standards will ensure the proper production and storage of field data. The second part will present aspects of the ongoing developments of iDAI.field, e.g., the semantic structure, the functional requirements, and the technical implementation. Both parts will be based on practical experience from coordinating the users, offline-/online processing, distributed data input, multilingualism, or the differences between project-based and institutional-based funding.

Keywords: best practice guidelines, field work, documentation, Open Source, long-term preservation, practical experience

Large-Scale Preventive Archaeological Fieldwork: Data Collection and Recording in France

Pablo Ciezar
Institut national de recherches archéologiques préventives (INRAP), France

The last thirty years of work in the area of recording archaeological data tend to apply thorough methodological concepts and have served to define several efficient data and software models. Elaborating on this asset, this article proposes to report and evaluate the implications of introducing such concepts in large-scale preventive archaeology in France through a collaborative process already underway. The study briefly presents the rules regarding scientific documentation in preventive archaeology defined by the French Ministry of Culture. INRAP (the French National Institute for Preventive Archaeological Research), as the main national organ in the field, is supposed to foster different data recording approaches aiming at the improvement in data collection measures. The paper discusses different solutions and the main tools for data capture applied by the excavation team managers of the Institute, and it assesses the particularities of these tools such as origin, method, type of field, and scientific questioning. It also presents the adjustments to which these tools are being subjected in order to fit different kinds of realities. Attention is also drawn to an on-going project planned to smoothly establish connections between a myriad of possible approaches. Development of a conceptual platform shared with the Ministry of Culture for the labeling of various archeological database software has begun and may serve as a data source for research missions. Implementation of a common core is the first measure being taken and the CIDOC-CRM may serve as the leading reference guiding the elaboration of a conceptual platform for INRAP. The adoption of a larger nationally recognized thesaurus open to customization will be promoted and will count on INRAP 's documentation service and its network. Finally, the implementation of field work practices aiming at more efficient, lasting and shared work processes is previewed for 2009 with new devices such as rugged tablet PCs available at the archaeological sites under

investigation. Other cooperatively generated technology applications will link data description and drawings more easily. As a conclusion, the study argues that an interchange between the three approaches cited above, and still open to other on-going projects such as the Intrasite GIS, will most probably generate an efficient model not difficult to implement due to its collaborative origin.

KEYWORDS: data recording software, archaeological thesaurus, large-scale preventive archaeology

The VERA Information Environment

HUGO RANGER MILLS and MARK BAKER
University of Reading, United Kingdom

The VERA (Virtual Environment for Research in Archaeology) project is based on a research excavation of part of the large Roman town at Silchester in north Hampshire that aims to trace the site's development from its origins before the Roman conquest to its abandonment in the fifth century C.E. The VERA project aims to investigate how archaeologists use information technology (IT) in the context of a field excavation, and also for post-excavation analysis. Effectively the project is investigating the impact of e-Infrastructure and the take-up of digital devices on an archaeological community. The technical developments within VERA revolve around three main areas relating to portal technologies, producing a prototype system that can undertake cross-archival searches across the Internet, and creating 3D visualization capabilities.

- The portlet-bridging technology, called the Recycle Bridge, was designed specifically to host complex web-based applications, with the main technical challenge being to elegantly combine the application's security with that of the portal so that it provides single sign on. The aim being rather than developing new portlet-based applications that were typically readily available on the Web, the Recycle Bridge consumes web-based applications within a portlet using bridging technologies. This approach has a number of advantages, which includes not forking the original application code, and not having to support any code migrated into a portlet.
- The distributed archival search system, called XDB-Arch, aims to create a generic and easy to use a web-based system that can be utilized by various communities to search through existing distributed databases and potentially find matches between the artifacts or finds being studied. For example, it may be the case that an archaeologist has a piece of pottery with a particular stamp or graffiti mark on it; from their perspective it would be useful to gather more information about the stamp or graffiti, to help date the pottery, identify who made the it or verify where it was produced.
- The data visualization service, called Arch3D, allows the integration and investigation of the multi-dimensional data sets obtained from an excavation. Integrating these disparate data sets into a coherent whole can be valuable to an overall understanding of the site. Previous attempts at visualizing archaeological sites in three dimensions have generally concentrated on either artistic reconstructive representations of

the site above ground, or on representing the physical location of finds within the ground. As a departure from either of these approaches, Arch3D displays the data from the site in a logical manner, linked to the stratigraphic structure. The system displays the plans of a set of contexts in their stratigraphic relationships to one another within a 3D environment. It then allows the selection of one or more additional data sets within the given contexts—for example, displaying small finds by type and material. Finally, the system allows the manipulation of the stratigraphy shown in the display, to allow the viewer to investigate directly the effects of alternative stratigraphic decisions in a complex excavation.

Keywords: visualization, data integration, portals

Accessing Grey Literature: Present and Past

Catherine Suzanne Hardman
Archaeology Data Service, United Kingdom

The advent of developer-funded fieldwork in many countries has inevitably led to an increase in the production of fieldwork reports. Despite being a major resource for archaeological research, the majority of these reports have remained unpublished and are often only accessible via the local authority curators or state historic preservation offices (in the UK known as Historic Environment Records). In the UK, the OASIS project (Online AccesS to the Index of archaeological investigationS) is a collaborative venture between the Archaeology Data Service (ADS), English Heritage (EH), Historic Scotland (HS), the Royal Commission for Ancient and Historical Monuments of Scotland (RCAHMS) and the Archaeological Investigations Project (AIP). The project has aimed to provide data to create an easily maintainable and publicly accessible unified index to archaeological investigations. In addition, it has created a system by which fieldwork reports can be deposited in a digital format with the ADS. In February 2005, the ADS was able to make public its growing archive of such fieldwork reports. There are now over 2,500 reports in this grey literature library, and this is being added to at the rate of 50-100 a month. From August to October 2008 there were 33,000 web requests from the library.

However, indexing of this grey literature resource by hand would be a very time-consuming process and it is estimated that there is a backlog of over 10,000 reports. In September 2007 the ADS and the Natural Language Processing Research Group at the University of Sheffield began work on the Archaeotools project. One of the aims of this cyber infrastructure project, funded under the UK AHRC-EPSRC-JISC e-Science program, is to investigate the use of natural language processing (NLP) to allow automated tools to search within documents for terms which are part of known classification schemes, adding them to a facetted index, and providing much deeper and richer access to unpublished archaeological literature, such as that available though the OASIS project. Tools will also be explored which will allow users to impose their own classifications and index the documents according to their own criteria, adding further user-defined dimensions to the classification.

Keywords: grey literature, management, access, archive

Precision Recording of Pompeian Standing Remains Via Stitched Rectified Photography

Michael Anderson
San Francisco State University, United States of America

Accurate recording of standing archaeological remains, such as the walls and masonry constructions of ancient Pompeii, can be an extraordinarily time-consuming process, especially when implementing traditional hand-measured techniques. Such methods additionally suffer from increased inaccuracy when dealing with walls or features greater than one or two meters in height. At the other end of the spectrum, powerful 3D scanners for recording of archaeological remains pose a different set of difficulties. Obvious among these problems are the significant cost for rental or purchase of the necessary equipment, considerable knowledge and expertise required on the part of the field operators, and the occasionally quite lengthy setups before data acquisition. However, the sheer volume of data produced by this method can be so dense that preparation for basic analysis, 3D manipulation, or GIS applications may require extensive post-processing with expensive proprietary software. This paper presents the results of recent work directed towards providing a method for recording and publishing standing archaeological remains that falls between these two approaches and makes use of low-cost and open-source software in combination with simple field techniques to produce accurate, scaled, rectified results in a digital format. This work employed a freely-available, Open Source lens correction and photo-stitching software package called PanoTools written by Professor Helmut Dersch, together with its front-end helper application Hugin. Both of these tools were originally designed for stitching panoramic images, but have here been put to an alternative use for scaled photo rectification, perspective correction, and automated image stitching, producing an image resolution and pixel-to-feature ratio that is limited only by the number of input images. The methods presented in this paper have been tested extensively as a component of recent archaeological research by the Via Consolare Project in the ancient city of Pompeii and subsequently have been adopted as the standard process for recording ancient architecture. They now provide the primary documentation of stratigraphic sequencing of wall phases identified through field study. It has been found that with appropriate controls, outputs can be significantly more accurate (+/- 2cm) than more traditional methods and may be produced in a fraction of the time spent in the field. In addition, the uses of these freeware packages within the methodology proposed here may be extended to other types of archaeological recording such as traditional planning of archaeological deposits, particularly in complicated contexts such as skeletal remains or potsherd scatters, when hand-measured methods might be extremely time consuming. Such future applications and potentials of this approach will also be discussed as well as plans for future development and implementation. It is hoped that these tools and methodology may be of use to other projects of archaeological research that face similar challenges in their recording procedures.

Keywords: photo rectification, Pompeii, PanoTools, stitching

Solving Old Problems with New Methods: Considerations about a Neolithic Cemetery

Raluca Kogalniceanu[1] and Alexandru Morintz[2]

1. Giurgiu County Museum, Romania
2. Vasile Parvan Institute of Archaeology, Romania

Our presentation is focused on the processing of unpublished documentation of a Neolithic cemetery from Cernavoda, belonging to the Hamangia civilization. The information at our disposal was: drawings/plans of the excavated sections (preserved below 50%) and field notes (preserved slightly above 50%). Human bone material and artifacts found in the cemetery area were also considered. Given the lacunose character of the data, our enterprise constituted a real challenge. Our enterprise consisted in connecting the spatial data with the attribute data. The spatial data consists in the location of the graves inside the cemetery area and in the location of the artifacts. The attribute information consist of the anthropological analysis of the human remains and the description of the artifacts. A first step was the transformation of the spatial data collected and registered with traditional means (manually, on paper support) in a spatial database. The plans were initially transformed into a raster image (using a scanner device) and at a later stage in a vector-image (using CAD equipment). This last version was divided into layers, each layer containing only one type of data: human bones, animal bones, pottery, stone axes, idols, etc. The existence of these layers facilitates the analysis of spatial distribution of a certain type of discovery, activating only the layer that interests us at a certain moment. The attribute data were stored in various Access databases that helped us correlate the attribute data with the spatial data. The next step of our research was the combination of the spatial data with the attribute data and the making of the 3D model of the site. Given the incomplete set of data, our spatial analysis was confronted with four types of situations, in which we have: a) spatial data and attribute data, b) only spatial data, c) only attribute data, and d) nothing. We will discuss examples of these types of situations.

Keywords: databases, 3D models, Neolithic, cemetery, Romania

Session Summary

Monday

Monday, 8:30am-5:30pm, Patriot

Symposium on Digital Archaeology in North America

Chairs: Brian Rose, University of Pennsylvania, United States of America
Dean Snow, The Pennsylvania State University, United States of America
Lu Ann De Cunzo, University of Delaware, United States of America

Sponsored by the Archaeological Institute of America (AIA); the Society for American Archaeology (SAA); and the Society for Historical Archaeology (SHA)

Led by the presidents of three of the largest professional archaeological associations based in North America—the Archaeological Institute of America (AIA), the Society of American Archaeology (SAA), and the Society for Historical Archaeology (SHA)—this session has several goals: (1) to give North American archaeologists the opportunity to present their work utilizing digital technology to colleagues from elsewhere around the world in order to get feedback and constructive criticism; (2) to identify possible areas of new collaboration between North American digital archaeologists and their colleagues in CAA; and (3) to address problems, prospects, and challenges facing all archaeologists as they apply digital solutions to their research. It is hoped that through this session, the North American membership in CAA, which has grown steadily over the past decade, will expand at an even faster pace as North American archaeologists have a chance to meet and interact with colleagues from elsewhere in the world who are making innovative contributions to the new field of digital archaeology. The session will be broken down by professional organization, with each president serving as session chair of a group of scholars presenting papers representative of how digital technology is being employed in a given society. The session will conclude with a roundtable discussion in which the presidents and several other invitees will reflect on the strengths, weaknesses, and grand challenges that are reflected in the papers and discussions earlier in the day.

The Archaeological Institute of America (http://www.archaeological.org) promotes a vivid and informed public interest in the cultures and civilizations of the past, supports archaeological research, fosters the sound professional practice of archaeology, advocates the preservation of the world's archaeological heritage, and represents the discipline in the wider world. The Archaeological Institute of America (AIA) is North America's oldest and largest organization devoted to the world of archaeology. The Institute is a nonprofit group founded in 1879 and chartered by the United States Congress in 1906. Today, the AIA has with nearly 250,000 members and subscribers belonging to 104 societies in the United States, Canada, and overseas. The organization is unique because it counts among its members professional archaeologists, students, and many others from all walks of life. This diverse group is united by a shared passion for archaeology and its role in furthering human knowledge.

The Society for American Archaeology (http://www.saa.org) is an international organization dedicated to the research, interpretation, and protection of the archaeological heritage of the Americas. With more than 7,000 members, the society represents professional, student, and avocational archaeologists working in a variety of settings including government agencies, colleges and universities, museums, and the private sector. Since its inception in 1934, SAA has endeavored to stimulate interest and research in American archaeology; advocated and aid in the conservation of archaeological resources; encourage public access to and appreciation of archaeology; oppose all looting of sites and the purchase and sale of looted archaeological materials; and serve as a bond among those interested in the archaeology of the Americas.

Formed in 1967, the Society for Historical Archaeology (http://www.sha.org) is the largest scholarly group concerned with the archaeology of the modern world (1400 C.E.-present). The main focus of the society is the era since the beginning of European exploration. SHA promotes scholarly research and the dissemination of knowledge concerning historical archaeology. The society is specifically concerned with the identification, excavation, interpretation, and conservation of sites and materials on land and underwater. Geographically the society emphasizes the New World, but also includes European exploration and settlement in Africa, Asia, and Oceania.

Schedule

Archaeological Institute of America

Chair, Brian Rose

8:30 - 8:40 Introduction, Brian Rose

8:40 – 9:00 "Rome Reborn in Google Earth," Bernard Frischer, Sarah Wells, Doug Ross, and Chad Keller

9:00 – 9:20 "Rome Reborn 2.0: A Framework for Virtual City Reconstruction Using Procedural Modeling Techniques," Kimberly Anne Dylla, Pascal Mueller, Andreas Ulmer, Simon Haegler, and Bernard Frischer

9:20 – 9:40 "'Rome Reborn' and 'SAVE': Archiving and Sharing a 3D Model of an Ancient City," David Koller

Society for American Archaeology

Chair, Dean Snow

9:40 – 10:00 "Making Legacy Literature and Data Accessible in Archaeology," Dean Richard Snow

Coffee break

Monday

10:15 – 10:35 "The Role of Technical, Operational and Conceptual Specifications in the Development of Digital Archaeological Archives: the Digital Antiquity Initiative," Frederick Limp

10:35 - 10:55 "How Do We Pay for this Stuff? The Challenges of Financing an Archaeological Digital Archive," Jeffrey Altschul

10:55 - 11:15 "Digital Antiquity–A View From Across the Pond," Julian Richards

11:15 - 11:35 "Envisioning the Digital Archaeological Record," Keith Kintigh

Lunch

Society for Historical Archaeology

Chair,Lu Ann De Cunzo

1:30 - 1:40 "Computer Applications in Historical Archaeology: Introduction," Lu Ann Decunzo

1:40 - 2:00 "Jamestown Rediscovery Abstract," David Givens

2:00 - 2:20 "Engaging a Twenty-First-Century Audience with the Eighteenth Century: Using Digital Technologies at Colonial Williamsburg," Lisa Fischer

2:20 - 2:40 "Digital Data Sharing in Historical Archaeology: a DAACS Perspective," Fraser D. Neiman and Jillian E. Galle

Coffee Break

3:15 - 3:35 "Virtual Vessel—Universal Digital Ship Construction Database," Dan Warren

3:35 - 3:55 "The Museum of Underwater Archaeology: A Collaborative Approach to Getting Underwater Archaeologists on the Internet," T. Kurt Knoerl

3:55 - 5:30 Round Table Discussion with the Presidents of the AIA, SAA, and SHA
Participants: Brian Rose, Dean Snow, Lu Ann De Cunzo, and speakers

Abstracts

Rome Reborn in Google Earth

Bernard D. Frischer, Sarah Wells, Doug Ross, and Chad Keller
IATH, University of Virginia, United States of America

Rome Reborn (http://www.romereborn.virginia.edu) is an international project managed by the Institute for Advanced Technology at the University of Virginia (http://www.iath.virginia.edu) . Several universities are partners in the venture. The goal of the project is to illustrate the development of the ancient city from the first settlement in the late Bronze Age (ca. 1,000 B.C.E.) to the depopulation of the city in the early Middle Ages (ca. 552 C.E.). Rome Reborn 1.0 is the first fruit of the project. It was completed in 2007 and shows the city at the height of its development in 320 C.E. and consists of ca. 7,000 buildings within the Aurelian Walls. Rome Reborn 1.0 had at least two major weaknesses which the project team attempted to solve in 2008: it could not be run in real time using the Internet; and many of the buildings lacked architectural detailing. In this paper, we will describe how we solved the first problem of making the model available for use over the Internet. Key to this solution was a partnership with Google Earth, which made the model available under the name "Ancient Rome 3D" in November, 2008 (http://earth.google.com/rome). The project involved converting the original version of the Rome model, authored in Multigen Creator (OpenFlight format), to the Sketch-Up (SU) file format. To make managing the model easier, it was divided in to five distinct areas. The Creator file could not be imported directly to SU, so PolyTrans was used to convert the model. SU has the ability to import 3ds and .dwg files. After experiments with both formats, 3ds was found to retain the most usable data. In addition to making the model available, the user experience was enriched by adding over 250 information balloons that automatically open when the user flies over a known site or feature. Inside the information balloon is a link that can be clicked to take the user to a landing page with additional academic resources (Wikipedia, the OPAC of the German Archaeological Institute in Rome, etc.) for a deeper study of the site. For this project, KML was the output. We had a great deal of information that had been organized from various sources into tabular data. Each row of this tabular data was related to a unique geospatial coordinate. KML allowed us to create a system for browsing and searching through that data via an intuitive interface, Google Earth. KML elements supported by Google Earth provide great flexibility for aesthetic design, on top of a well structured data-centric substrate, through the implementation of abstracted "styles." With the publication of Rome Reborn 1.0 in Google Earth in November, 2008, our goal of making this model freely and widely available was achieved.

Keywords: 3D modeling, Google Earth

Rome Reborn 2.0: A Framework for Virtual City Reconstruction Using Procedural Modeling Techniques

Kimberly Anne Dylla[1], Pascal Mueller[2], Andreas Ulmer[2], Simon Haegler[2], and Bernard D. Frischer[1]

1. IATH, University of Virginia, United States of America
2. Procedural, Inc., Switzerland

Rome Reborn is a virtual reconstruction of the entire city of ancient Rome at the height of its civic development, in 320 AD. Within the Aurelian walls, there are more than 7000 buildings about which only general data from regional catalogs is known. In order to create visually compelling and detailed models of this architecture, procedural modeling techniques have been employed. The detailed 3D models of Rome's monuments—such as the famous Colosseum and the Circus Maximus—have been created manually in several man-years of work by experts in archaeology and computer graphics over the whole world. To reconstruct in similar detail the surrounding urban environment consisting of over 7000 domestic Roman buildings, novel procedural modeling methods have been applied. As a starting point, the mass volumes of the domestic

Monday

buildings have been used. Therefore a 3D scan of the famous Plastico di Roma Antica of Italo Gismondi, a huge plaster model exhibited and preserved in the Museum of Roman Civilization in Rome, has been classified by topology into several mass model types. In the next step, these mass models have been imported into the procedural modeling solution CityEngine. Since the mass models are represented as polygon data of arbitrary topology, novel split algorithms have been developed to subdivide the mass into its components such as facades, roof or interior. Then, under the guidance of archaeological consultants, grammar rules have been designed. These rules have then be applied to refine the mass models, resulting in detailed 3D building models, which then can be exported into any 3D package or visualization software. Since the Rome Reborn project supports different kinds of visualization and publishing platforms, different levels of detail have been integrated into the rule set. These levels of detail can either be controlled individually or via global image maps. Besides the domestic buildings, the CityEngine has been applied to reconstruct many of the numerous temples in Rome. These ancient temples have been modeled by following the well-described rules of Classical Architecture. Thus, one grammar rule set has been written which generates Ionic and Corinthian temples. The rule set contains almost hundred attributes which can be modified to control the final appearance. Most of the temples have been destroyed or significantly damaged which limits the possibility of gathering additional geometric data. Therefore, the proportions as described by Vitruvius have been easily implemented in the rule set. As a consequence, the archaeologist has just to enter only the few parameters he knows, the remaining parameters are then calculated proportional to the known parameters. Procedural modeling methods made the modeling process very efficient without sacrificing detail or quality. Furthermore, the flexibility of the approach helps to quickly change and regenerate the model as new scholarship or discoveries warrant.

Keywords: procedural modeling, city modeling, virtual reconstruction

"Rome Reborn" and "SAVE": Archiving and Sharing a 3D Model of an Ancient City

David Koller
IATH, University of Virginia, United States of America

The "Rome Reborn" initiative involves the creation of a large, detailed 3D digital model of ancient Rome. With a scientific advisory committee and a peer-review process to guide additions and modifications to the model, Rome Reborn will evolve as a centralized online repository for scientifically authenticated 3D models of the ancient city. Developing the tools and techniques to support such a 3D digital archive is the mission of the "SAVE" research project: Serving and Archiving Virtual Environments of cultural heritage. In this paper, we describe the application of the SAVE principles to the Rome Reborn project. One of the primary needs addressed by SAVE is the digital rights management of 3D cultural heritage models. Large, complex, valuable models such as those included in Rome Reborn may require technological solutions for intellectual property protection, while still allowing the 3D models to be shared widely and visualized interactively. For Rome Reborn, we are developing a remote rendering system that allows users to directly interact with low-

resolution versions of the urban models, while corresponding 2D images and video streams are generated from the high-resolution versions of the models stored on a secure server. This approach allows content owners to freely share their models via the Internet, while still protecting the valuable 3D data from unauthorized re-use. Additionally, the server-based approach eliminates the need for users to download, store, and update large datasets, and it does not require users to possess high-performance computing hardware. Other SAVE research challenges that arise in the Rome Reborn project include the organization and presentation of metadata for a large, heterogeneous 3D urban model, and the representation and visualization of the uncertainties inherent in a virtual 3D reconstruction of the ancient city. Additionally, we describe our ideas for managing multiple versions of 3D models, and providing for interoperability within and beyond the Rome Reborn archive. We are developing analytical tools for users to study the 3D models, and also methods for indexing and efficiently searching the 3D model archive as it grows ever larger. Finally, we address the long-term preservation and sustainability of the Rome Reborn data, and the organizational and logistical structure for maintaining an online, peer-reviewed 3D model repository.

Keywords: 3D cultural heritage models, digital libraries, ancient Rome, digital rights management, remote rendering

Making Legacy Literature and Data Accessible in Archaeology

Dean Richard Snow

The Pennsylvania State University, United States of America

Archaeological publications, including old ones, are increasingly available in electronic form. JSTOR, Google Books, and other services are digitizing an increasing array of journal back issues and out-of-print books, and providing them as PDF files with optical character recognition enabled. Virtually all publications going forward will be available in searchable electronic formats. The data that underlie publications are also increasingly available, and the Digital Antiquity initiative discussed by other papers in this session is a major step forward in the archiving of databases. However, that still leaves many thousands of unpublished gray literature reports inaccessible or very difficult to access. CRM reports are an important source of legacy information for many researchers, but making them accessible will require us to overcome many obstacles. Government agencies sequester many reports in order to protect resources, older reports are often unreadable by optical character recognition systems, there is and probably never will be a single repository for all such resources. Proposals to overcome these obstacles are discussed. These include the development of additional new tools for searching a distributed network of repositories, further development of ArchSeer and other specialized search tools, and development of a secure software package that will be attractive to the guardians of gray literature repositories.

Keywords: ArchSeer, CRM, gray literature, search

The Role of Technical, Operational and Conceptual Specifications in the Development of Digital Archaeological Archives: The Digital Antiquity Initiative

Frederick Limp
University of Arkansas, United States of America

The next three years will see the creation of a comprehensive archive of digital archaeological data for the US. The project, called Digital Antiquity, has been made possible by the Andrew Mellon Foundation's Scholarly Publications Program. A central element in the process will be the adoption and/or instantiation of a range of data, metadata and interoperability specifications at technical, operational and conceptual levels. The US archaeological community is substantially lagging British and European initiatives in the development of these specifications. The Digital Antiquity metadata specification will describe the metadata that are critical for the long-term preservation of newly created and legacy digital data and for the practical and productive reuse, normalization, and integration of these data by scholars. It will include basic elements that document collections of digital resources in ways that are sufficient for basic resource discovery and for data longevity. It will also provide both semantic and syntactic documentation of individual table- and column-level metadata that are essential for the long-term preservation and utility of such resources. The multilevel metadata specification used by the current NSF-funded Prototype tDAR, is an expansion of the UK's Archaeology Data Service (ADS) metadata specification and was developed in consultation with ADS. The development of these specifications will require consultation and coordination with all sectors of the US archaeological community (CRM, government archaeology, academic archaeology, and museums) and with other stakeholders, including agency officials and tribes. The key U.S. professional societies (SAA, SHA, AAPA, and AIA) have all nominated representatives who will participate in this process.

Keywords: digital antiquity, tDAR, DRM, databases

How Do We Pay For This Stuff? The Challenges of Financing an Archaeological Digital Archive

Jeffrey Altschul
SRI Foundation, United States of America

While there is great enthusiasm among archaeologists for the creation of a cyber-infrastructure that can serve as the basis for an archaeological digital archive, the financial wherewithal to undertake this initiative remains elusive. Archaeological curation in general is under financed, and this is particularly true of the curation of digital materials. As part of the Digital Antiquity initiative supported by the Andrew W. Mellon Foundation, the beginnings of a business model have been developed that will lead to a financially self-sustaining digital archive. This paper explores the various funding sources that were identified as part of this process, examining the pros and cons of each. The exact mix proposed for the Mellon-sponsored Digital Antiquity archive

is presented, along with the rationale for predicating a U.S. archaeological cyber-infrastructure on policy changes mandating the deposit of CRM digital materials in a trusted repository.

Keywords: digital antiquity, tDAR, CRM, cyber infrastructure

Digital Antiquity—A View From Across the Pond

Julian Richards
University of York, United Kingdom

Comparison of the evolution of digital archiving and the dissemination of archaeological data in the USA and the UK reveals many similarities, but also some interesting differences. Some of these reflect the different organizational structure of archaeology in each country, but others relate to different archaeological traditions and contemporary cultural differences. My involvement in North American initiatives, most recently Digital Antiquity, has given me the opportunity to reflect upon these differences and this paper will attempt to draw out some of their implications for archaeology on both sides of the Atlantic. It will also survey current European projects looking at cross-border interoperability and standards, and examine their implications for international coordination and cooperation within archaeological informatics and related fields.

Keywords: cyber infrastructure, CRM, digital antiquity, databases, grey literature

Envisioning the Digital Archaeological Record

Keith Kintigh
Arizona State University, United States of America

The Digital Antiquity initiative is devoted to enhancing preservation and access to digital records of archaeological investigations in order: to permit scholars to more effectively create and communicate knowledge of the long-term human past; to enhance the management of archaeological resources; and to provide for the long-term preservation of irreplaceable records of archaeological investigations. Digital Antiquity is funded by the Andrew W. Mellon Foundation to establish a financially and socially sustainable, US national/international, online digital repository that is able to provide preservation, discovery, and access for data and documents produced by archaeological projects. The repository, known as tDAR (for “the Digital Archaeological Record”) will encompass documents and data derived from ongoing CRM and academic research as well as legacy data collected through more than a century of archaeological research in the Americas. This initiative builds on the successful model developed by the Archaeology Data Service (ADS) in the UK but diverges in important ways. ADS captures information from a relatively small number of projects each year, but provides an archive of very high quality. In contrast, tDAR aspires to capture the digital data and documentation from a substantial fraction of the 50,000 federally mandated cultural resource field

projects conducted each year in the US. In order to succeed, tDAR must have a much lower marginal cost for ingesting the information from a project. Where ADS has a substantial reliance on data curators that it employs, tDAR relies much more heavily on the data contributors to provide the necessary metadata. As a consequence, tDAR's success hinges on the usability of a sophisticated Web-based software interface for data ingest and the interface's ability to elicit metadata of archival quality. tDAR's design requires more detailed database metadata (e.g., at the table, column, and value level) than the current ADS model. Where ADS provides a refined presentation layer for the projects it serves, the initial design for tDAR invests much less in the project by project presentation. This paper will outline the conceptual design for tDAR, explore the implications of the philosophical and practical tradeoffs involved in its design, and demonstrate the operation of a prototype interface developed under a grant from the US National Science Foundation.

Keywords: cyber infrastructure, digital antiquity, tDAR, ADS

Computer Applications in Historical Archaeology: Introduction

Lu Ann De Cunzo
University of Delaware, United States of America

Formed in 1967, the Society for Historical Archaeology (SHA) is the largest scholarly group concerned with the archaeology of the modern world (1400 C.E.-present). SHA promotes scholarly research and the dissemination of knowledge concerning historical archaeology. The society is specifically concerned with the identification, excavation, interpretation, and conservation of sites and materials on land and underwater. Computer applications have become as central to the practice of historical archaeology and to the goals of the SHA as they have to all archaeologists and archaeological organizations. In this session, we propose to address three principal issues: 1) Data access and comparability, 2) Visual interpretation and virtual reality, and 3) Ethical practice. The applications we have chosen to highlight, two in underwater archaeology and two centered on terrestrial sites, all use the Internet as a means of delivery. The Digital Archaeological Archives of Chesapeake Sites is a community resource of comparative site and artifact data from archaeological excavations of sites associated with enslaved Africans in the Chesapeake. The Colonial Williamsburg Digital History (CWDH) program uses innovative technologies such as GIS, Virtual Reality, and XML to create digital resources for studying and analyzing eighteenth-century Williamsburg. The power, potential, and challenges of Graphics and 3D virtual reality platforms present archaeologists with powerful interpretive and analytical tools. The CWDH and Virtual Jamestown projects and the Virtual Vessel project will present the new model scholarship they are pioneering. The Internet presents historical archaeologists with ethical challenges as well as great opportunities. The Museum of Underwater Archaeology assists underwater and maritime archaeologists in preparing and hosting online presentations of their research for the public in an effort to promote understanding of, and support for, an ethical archaeology. This paper will introduce historical archaeology and the SHA and briefly review the history of computer applications in the field. Issues relating to data access, virtual reality, and ethics will be outlined in the context of the session's objectives, and recommendations for future directions suggested.

Keywords: historical archaeology

Jamestown Rediscovery

David Givens
Jamestown Rediscovery, United States of America

Since its inception in 1994, the Jamestown Rediscovery project has integrated computers into the archaeological project. The effect has been a change at all levels of the excavation, ranging from data acquisition, management, interpretation, analysis, and dissemination, to the eventual archiving of information. This presentation aims to explore this digital transition and implementation over the past fourteen years. Following a brief introduction to the project, the following topics will be addressed: the use of a single context GIS plan for data processing, analysis, and archive; leveraging web design and platforms for dissemination of archaeological findings; virtual interpretations of differing phases and styles of architecture at Jamestown based on the archaeology; and the use of virtual reconstructions of James Fort in site interpretations for enhancing visitor experience.

Keywords: seventeenth century, Chesapeake, Virginia

Engaging a Twenty-First-Century Audience with the Eighteenth Century: Using Digital Technologies at Colonial Williamsburg

Lisa Fischer
The Colonial Williamsburg Foundation, United States of America

Visitors to Colonial Williamsburg, the largest outdoor living history museum in the United States, are drawn back into the eighteenth century to experience what life was like in Virginia's colonial capital. Digital technologies, however, open up new research and educational opportunities for enhancing our understanding and interpretation of the past. The Digital History Center (DHC), founded in 2002, employs innovative technologies to develop applications for scholars and the public. The DHC works closely with the foundation's research staff—archaeologists, architectural historians, curators, and historians—to incorporate our most current findings into the range of digital tools being developed. Although these applications are built individually, the projects have been designed to complement one another as part of an overall strategy in which materials developed for one may be easily adapted or incorporated into others to further enhance our capabilities and online offerings. The eWilliamsburg project, for example, uses GIS technology to develop map tools for studying and analyzing the town. A new map component that will allow users to visualize the physical layout of the town for any year in the eighteenth century will be released later this year. Another

Monday

initiative, the Virtual Williamsburg project, will result in a new, interactive 3D view of the town as it appeared on the eve of the Revolution and will rely heavily on the information learned through the eWilliamsburg project. The DHC is also currently developing a comprehensive website on the American Revolution to highlight the role of Virginia and Williamsburg in this important era in American history. The virtual models of relevant sites and map tools will be incorporated into the website to make it interactive and engaging. This paper will explore these ongoing projects in order to address how museums must reinvent themselves in the digital age.

Keywords: eighteenth century, Virginia, Chesapeake, museum

Digital Data Sharing in Historical Archaeology: a DAACS Perspective

Fraser Neiman[1] and Jillian E. Galle[2]

1. Department of Archaeology, Monticello, United States of America
2. DAACS, Monticello, United States of America

Since 2004, The Digital Archaeological Archive of Comparative Slavery (DAACS) has offered scholars easy Web access to fine-grained data on artifacts and the contexts from which they were excavated from multiple domestic sites inhabited by enslaved people Chesapeake, Carolina Lowland, and the Caribbean. This paper offers a brief outline of the project's history and future prospects. Our discussion emphasizes the extent to which the project has achieved its primary goal: to advance synthetic comparative research on the archaeology of early-modern slave societies in the British Atlantic. While the availability of comparable data has allowed some progress, major theoretical and methodological obstacles remain. We discuss them and highlight strategies to circumvent them.

Keywords: database

Virtual Vessel—Universal Digital Ship Construction Database

Dan Warren

United States of America

Many shipwrecks, especially those now found at depth reveal remarkable insights into historic and prehistoric technology and related cultural stratagems. Finding comparative data in the published and gray literature is challenging and time consuming. However, with new web-based programs it is possible to logically organize and share technological details revealed through archaeology, globally. The power of web tools is remarkable. They let us produce a modern database with an open framework that can assimilate new, expanding ideas for the site without a complete renovation. This presentation showcases the goal, design, and plan for VirtualVessel.org scheduled to launch this year. Virtual Vessel will provide a global platform for sharing ship construction information and allow researchers to search for information and compare construction details derived from

published archaeological investigations and historic documents. We are presenting the new website, prior to launch, to increase its visibility in the professional archeological and historical communities and to solicit individuals participation in the web site by contributing their expertise.

Keywords: underwater

The Museum of Underwater Archaeology: A Collaborative Approach to Getting Underwater Archaeologists on the Internet

T. Kurt Knoerl
Museum of Underwater Archaeology, United States of America

There is no shortage of media attention when the latest treasure wreck is discovered. Images of silver and gold coins, jewels, and cannon capture the public's attention. How do ethical underwater archaeologists compete with such media images? The Internet offers the best opportunities for reaching the widest possible audience for the lowest costs yet underwater archaeologists have been slow to adopt this method of public outreach because of the time, technical expertise, and money required to produce well designed websites. The nonprofit online Museum of Underwater Archaeology (MUA) was founded to help combat this problem.

The MUA was created in 2004 as a way to encourage professional, student, and avocational underwater archaeologists to share the results of their research via the Internet with each other and, more importantly, the general public. The MUA does this by working with ethically committed researchers to create web posts about their projects that are hosted on the museum's website. By utilizing donated services and bandwidth the MUA has helped over 100 underwater archaeologists from around the world post over 200 pages of information about their projects. The MUA uses numerous formats to present an underwater archaeologist's research to its varied audience located in over ninety countries. This presentation will discuss the museum's current and future work and its impact on the field of underwater archaeology.

Keywords: underwater

Session Summary

Monday

Monday, 8:30am-10:00am, Liberty

ECAI: Frontiers of Digital Culture

Chair: LEWIS LANCASTER, ECAI International and Area Studies, University of California, Berkeley, United States of America

The opening panel of ECAI deals with the current state of technology, in terms of how representations of data are constructed and managed. Stephen Griffin of the National Science Foundation sets the theme while two leaders in software and data development discuss Web 2.0 and the new uses of virtual reality in cultural studies.

Schedule

8:30-9:00	"Developments in Digital Representation of Material Culture," Stephen Griffin
9:00-9:20	"Reinventing the ECAI Clearinghouse—A Web 2.0 Approach to Research Data," Ian Johnson
9:20-9:40	"The Virtual Museum of the Western Han Dynasty," Maurizio Forte
9:40-10:00	Discussion

Abstracts

Developments in Digital Representation of Material Culture

STEPHEN GRIFFIN
National Science Foundation, United States of America

Abstract text not available as of press time.

Reinventing the ECAI Clearinghouse—A Web 2.0 Approach to Research Data

IAN JOHNSON
University of Sydney, Australia

The ECAI Clearinghouse—a spatial metadata repository indexing "cultural data sets"—was developed by my team at the University of Sydney from 1998, along with tools for uploading metadata and generating interactive maps on the fly using TimeMap. The system is still operational on the ECAI server, although no significant development work has been done on it for the last few years. In many ways, the ECAI clearinghouse was a precocious Web 2.0 application, intended as a forum for sharing information, building maps from data shared by others, and publishing those maps back into the system. The technology of the time was not conducive, however, to the sort of instant, zero-barrier publishing we associate with social network sites today. The clearinghouse also suffered from the restricted size of the interested community, the heterogeneity of what was understood as a 'cultural dataset', and the lack of tangible rewards for participation.

Over the past three years, we have been developing a new web service called Heurist (HeuristScholar.org) which can be described as an academic social bookmarking database of just about anything (bibliographic records, web bookmarks, notes, annotations, historical events, people, sites, multimedia—currently more than seventy record types). As part of the development of Heurist, we are duplicating the metadata storage capability of the ECAI clearinghouse through spatial dataset record types. Not only will this allow us to duplicate much of the functionality of the clearinghouse in a modern social web application—with all the advantages of tagging, annotation and linking of records that this implies—but the increased flexibility of Heurist allows direct digitising of locations within the system and allows spatial data (notably KML files) to be attached directly to Heurist records and included in the maps generated from them. The use of alternate web mapping technologies—TimeMap, Google Maps, Google Earth, and Openlayers—as well as timeline and network relationship functions, also gives users greater flexibility in generating lightweight spatio-termporal visualisations for use on the web. This paper will include an overview of the ways in which spatial data can be stored and manipulated in Heurist, as well as specific examples of mapping applications developed with the Heurist API, Cocoon and XML feeds.

Keywords: Heurist, metadata

The Virtual Museum of the Western Han Dynasty

Maurizio Forte
University of California, Merced, United States of America

Abstract text not available as of press time.

Session Summary

Monday, 10:00am-11:45am, Colony

Poster Session 1

Abstracts

The Archaeology of Deforestation in Ancient Rough Cilicia (Turkey)

Nicholas K. Rauh[1], Christopher Dore[2], Martin Doyle[3], Hülya Caner[4], and Ünal Akkemik[4]

1. Purdue University, United States of America
2. Statistical Research, Inc., United States of America
3. University of North Carolina, Chapel Hill, United States of America
4. Istanbul University, Turkey

Since 2000, the Rough Cilicia Archaeological Survey Project has incorporated research on landscape transformation as a component to its regional survey of ancient Rough Cilicia (south coastal Turkey opposite Cyprus). The region of western Rough Cilicia was celebrated during antiquity for pristine cedar forests that stood between 1500-1800m in altitude along the slopes of the Tauros Mountains. Today along the front range of the Tauros this forest is completely denuded or otherwise replanted with recent growth (over the past eighty years). The current forest represents third-generation vegetation. To investigate questions of landscape alteration over the period of human occupation in this region, the survey team has employed an array of field methodologies, including dendrochronology, river basin modeling, geomorphological trenching of ancient river terraces and lagoons combined with pollen, lignin, and macrobotanical analysis, and remote sensing of existing floral patterns in chromatic satellite data. In combination with these research methods, the survey conducts systematic pedestrian survey in the highlands to demonstrate evidence of ancient settlements, such as archaeological remains of Roman era "logging camps." Preliminary results indicate that the oldest stands of cedar forests in the Tauros are less than 400 years old; the pollen data indicates a transition from forest growth to grasses and orchard tree production, particularly black walnut. Carbon dates obtained from geomorphological trenches along regional river terraces indicate that some 3m of alluvium has been deposited in Gazipasha river basins since 600 C.E. Preliminarily, it would appear that at least two eras of deforestation occurred—one in Roman antiquity followed by land abandonment, forest rebound, and a massive transfer of stored alluvium from the highlands to the river basins after 600 C.E., and a second one since 1860 C.E. when the regenerated forest became similarly depleted at an extremely rapid pace. At the very least, the results we have obtained thus far demonstrate the degree to which a combination of geoarchaeological and paleo-environmental procedures help to articulate the form, scale, and duration of Cilician resource utilization

during antiquity, and the extent to which these resources were exploited potentially by offshore maritime empires over time.

Keywords: remote sensing, GIS, geoarchaeology, paleoenvironment

Automatic Pen-and-Ink Drawings of 3D Archaeological Objects

Beatriz Ramos and Fco. Javier Melero
Universidad de Granada, Spain

Artistic drawing is a classical manner of presenting archaeological objects. Experts illustrate their papers with hand-made illustrations, where shadows are drawn with a higher density of points than the illuminated areas of the object, and feature lines outline some details on the surface that must be recognized by anyone that observes the illustration. We present in this poster the results of applying non-photorealistic rendering algorithms to 3D models so these artistic handmade drawings can be generated automatically in real time by a computer. We have developed a simple software prototype that makes it possible to obtain several styles of 2D artistic drawings from one 3D model: only silhouettes and feature lines, dotted shadows, grayscale drawings, etc. It is possible to generate large digitalized models from laser scanner devices, and after processing the triangle mesh, detect the silhouette depending on the viewpoint. Also, the feature lines are easily found out in real time, so the artistic view of the model is rendered in fact in 3D, but the appearance is a 2D drawing. The model is textured depending on the normal value of each triangle and the light position, also in real time. The user can choose the type of texture to apply, and the range of intensities where to apply it. Furthermore, the tool allows the user to take measurements from the virtual 3D model and reflect these measurements on the final 2D drawing. With this feature, the tool is not only suitable for dissemination of cultural heritage objects, but also for illustrating research papers. Using non-photorealistic rendering for archaeological objects makes the task of research documenting easier and allows the expert to obtain different views of an object displayed as it has been done for decades with no effort at all.

Keywords: non-photorealistic rendering, illustration of artworks

From Virtuality to Reality: Contributions of 3D Printing

Bruno Dutailly, Hélène Coqueugniot, Pascal Desbarats, Stefka Gueorguieva, and Rémi Synave
CNRS / University Bordeaux 1, France

Virtual paleoanthropology is based on the techniques of image processing and particularly on CT scanner images (tomodensitometry: calculated axial tomography) or 3D laser scanner surface acquisition. Rapid prototyping devices have become widely available and, among them, 3D printing fits our objectives because of

its precision both for measurements and for heritage preservation. We integrate those features on a more global level for research on precision measurements, virtual objects, and 3D reprints. We also further investigate how those copies could be used in preservation and promotion of cultural heritage, with applications to museums and teaching. The reasons for reproducing objects are numerous. The first, and the more important, is the possibility of making high-resolution copies of fragile and not easily movable objects like fossils. Indeed, non-invasive acquisition techniques prove to be efficient and widely accepted by both the scientific community and museum curators. A second reason is the ability to make as many copies as necessary. A third one is the ability to scale, cut, or restore virtually objects, print them, and even cut the printed object to observe internal structures, in the case of CT scanned objects. A fourth one is the ability to make measurements with a computed range error. This last point is the subject of our future researches on 3D printing. The measurement precision will be dependent of the size of the original object, and the precision of its acquisition. The LaBRI (Bordeaux Department of Research in Computer Science) acquired a 3D printer with a near 50 microns resolution. The object is composed of a UV-polymerized resin. To avoid the problem of bridge objects, the printer uses another kind of resin that does not polymerize to make a support between the pillars of the bridge. This resin is removed manually at the end of the process with a high pressure water jet.

Keywords: anthropology, 3D printing, cultural heritage, museum, CT scan, laser scan

How to Create a Virtual Mountain with a Map, Compass, and Camera

Ralf Gehrke
University of Applied Sciences Berlin, Germany

Since 2004, archaeological excavations of the well-preserved city wall in the ancient Messene on the Peloponnese/Greece have been underway. The results of this project, which is done under the leadership of members at the Institut für Klassische Archäologie at the Freie Universität Berlin, will be published within the next few years. For the purpose of a 3D presentation of the existing wall fragments, a DEM is necessary. The generation of this DEM was the task given to the two surveying students, Ulf Boettcher and Ralf Gehrke, for their bachelor thesis as a final work in 2008 after the three-year study, and the work is performed under the supervision of the Laboratory for Photogrammetry at the University of Applied Sciences in Berlin. The base data are scans of a 1:5000 scale map with 4m equidistant contour lines. The major part of the model is being created by digitizing and processing of these contour lines with a suitable software to a grid data format. In this step, the model is adapted to the existing survey results of the archaeologists to ensure the fitting of the known wall parts to the model. There is a striking mountain called Ithome in the area of the wall. The rocky, steep slope is not presented properly by contour lines. This special area is surveyed using terrestrial stereophotogrammetry, which has the big advantage of getting a huge amount of data within a short time period in the field. The students are using simple equipment like a digital camera, compass, and clinometer for the camera orientation and self-made control point signals of black and white bed sheets. Compared

with the results, the costs are very low. Analysis of the photos is done with the Leica Photogrammetry Suite. As this software is made for aerial imagery, the students have to rotate the coordinate system of the ground control points to simulate the aerial image case for their terrestrial photos. The rotation and translation is done by using the data from the compass and clinometer. As a result of the image data processing, a cloud of 56,000 usable points is generated. The combination of the image-derived point cloud and the map data is made by using laser scanning software. In the end the point cloud, which is connected as a triangulated irregular network (TIN), is inserted in the grid data of the map derived model without an elevation step. By the combination of these two data formats the minimum requirement to computing capability is lowered. The digital stream of data is ensured from the beginning to the end by using simple data formats. The amount of equipment is limited to a minimum, so the work in a pathless terrain is possible without any big difficulties. The presented topic shows a cost- and time-efficient solution for a highly specialized, uncommon task.

Keywords: digital elevation model, terrestrial stereophotogrammetry

RICH Results

Guus Lange[1], Laurens van der Maaten[2], Paul Boon[2], and Hans Paijmans[2]

1. National Service for Archaeology, Cultural Landscape, and Built Heritage, The Netherlands
2. Tilburg Centre for Creative Computing, University of Tilburg, The Netherlands

At the National Service for Archaeology, Cultural Landscape, and Built Heritage, in the Netherlands a four-year project is nearly at its end. The project was part of a larger program financed by the National Science Foundation and incorporated larger cultural heritage institutes, such as museums, archives, and other institutes with collections, teamed up with the computer science departments from the universities. Our project, RICH, Reading Images in Cultural Heritage, focuses on computer vision techniques. Important breakthroughs will be shown on aspects of image analysis and automatic classification.

Keywords: image analysis, automatic classification, computer vision, language technology

A Sanskrit Buddhist Canon for the Twenty-First Century

Miroj Shakya

University of the West, United States of America

The DSBC project (Digital Sanskrit Buddhist Canon) focuses on extant Sanskrit Buddhist texts printed in the last centuries. To make this dream project a reality, Prof. Lewis R. Lancaster, former President of University of the West and coordinator of the project, initiated cooperation with the Nagarjuna Institute in Nepal in digitizing the Sanskrit Buddhist Canon since the year 2003. The Sanskrit Canon could be made easily accessible to all. We are accelerating our work by broadening our support and applying the latest computer technology. Currently we have placed 62 Sutras (Buddha vacana, the Word of the Buddha), 108 Stotras (Hymns), and 95

Monday

Shastras (commentaries) texts online. Now, for the first time in history, the basic texts of Indian Buddhism are accessible freely downloadable via the Internet (http://www.uwest.edu/sanskritcanon/). The availability of all the Sanskrit Buddhist texts online will be an important milestone in Buddhist scholarship, and will make this immensely useful to educators and non-specialists. However much effort and support will be needed to meet this distant goal. Future milestones include the categorization of a digital Sanskrit canon; collaboration with ECAI Sanskrit web group; creation of a comprehensive bibliography of Sanskrit Buddhist texts; a formation of a team of experts who will work for the publication of DSBC in CD-ROM; publication of a diplomatic edition of unpublished Sanskrit texts from Manuscripts (DEST); and publication of the Sanskrit Buddhist Tripitaka Series (SBTS) in the near future.

Keywords: digitization

SHARE I.T. (Spatial Heritage & Archaeological Research Environment I.T.)

Anthony Corns[1], Robert Shaw[1], John McAuley[2], Robert Sands[3], and Kieron Goucher[4]

1. The Discovery Programme, Republic of Ireland
2. Digital Media Centre (DMC), Dublin Institute of Technology, Republic of Ireland
3. UCD School of Archaeology, Republic of Ireland
4. Margaret Gowen & Co. Ltd, Republic of Ireland

Over the past fifteen years, much financial and professional effort has been invested in the collection and analysis of spatial archaeological data by government, research, and commercial sectors. Within this digital domain asset, landscape data form a substantial component. This includes aerial photography; topographic surveys created by LIDAR and digital photogrammetry; and geophysical surveys. Once these data are recorded and interpreted, the printed report is often seen as the final deliverable, while the digital archaeological assets created often remain hidden and unused within the source organizations, eliminating any possible knowledge transfer to the wider archaeological community. Recently, several reports reviewing the current archaeological research framework in Ireland have highlighted concerns within archaeological community that require further action. The solution to many of these problems is the creation of an effective complimentary ICT strategy that provides easy access to primary research information whilst providing a sustainable and robust digital archive that adheres to recognized international standards. Developments in GIS have provided researchers with new mechanisms for accessing improved archaeological data sets. GIS tools enable the visualization, cataloguing, and analysis of a varying scale of spatial data, improving the researcher's investigative capacity. Creating a coherent infrastructure where high-quality landscape data is easily accessible will maximize the knowledge return from this resource and enhance future archaeological research. The aim of the Spatial Heritage& Archaeological Research Environment I.T. (SHARE IT) project is to investigate spatial archaeological landscape data in Ireland and to develop a web-mapping application pilot exploring its use in further research. The key research challenges were assessing current levels of spatial

data content and standards within the Irish archaeology sector, identifying suitable digital archiving strategies for spatial landscape data, developing and testing a suitable web mapping application for the exploration of spatial archaeological landscape data, and promoting this data to the archaeological research community. Initially the web-mapping application will host geophysical, aerial, and LIDAR data, together with their associated interpretations. Specific objectives include:

1. Review current spatial landscape data policies within the commercial, institutional, and academic sectors of Irish archaeology
2. Review current best practices for the long term archiving and access to archaeological landscape data
3. Create a strategy for the creation of a web mapping application which provides access to digital landscape data
4. Develop and implement a web-mapping application pilot for the delivery of selected landscape data to the research community
5. Promote and disseminate the results of the project through workshops, reports and website
6. Produce an exploitation plan for the long term development of the SHARE I.T. resource

Project partners include the Discovery Programme, Dublin; the Digital Media Centre, Dublin Institute of technology, Dublin; the UCD School of Archaeology, Dublin; and Margaret Gowen & Co.Ltd.

Keywords: archives, standards, metadata, SDI, online access

Monday

The 3D Documentation Labor of the Madrid's Community Archaeological Heritage

JORGE LÓPEZ QUIROGA[1], FRANCISCO JOSÉ LÓPEZ FRAILE[2], JORGE MORÍN DE PABLOS[2], ARTEMIO M. MARTÍNEZ TEJERA[1], and LAURA GARCÍA PÉREZ[1]

1. Universidad Autónoma de Madrid (UAM), Spain
2. Departamento de Arqueología, AUDEMA, Spain

For archaeological excavations involving partial or total destruction of the land where the deposits are located, it is necessary to remove the land where the archaeological remains lie. Complete documentation is very important due to this principle. A documented site (via drawing, photography, video, fact sheets, etc..) can generate more data for the interpretation of our past. New technologies have been assimilated by archaeology, making a qualitative leap in the improvement of registration systems. Documentation in 3D allows us to see an archaeological site or object as it was before being excavated and in the successive stages of excavation. We will show in this presentation some examples from the region of Madrid from 3D scanning and photogrammetry: the photogrammetry of the archaeological excavation of the Epipaleolithic site of Darwin Park (Madrid); the photogrammetry from the chimney of the nineteenth-century Royal Cloth Factory of San Fernando de Henares (Madrid); 3D scanning of the Middle Paleolithic site of Cañaveral (Coslada, Madrid); a 3D scanning of bifaz in quartzite (quarry agregates from Arjanjuez, Madrid); 3D scanning of sheet flint and a human mandible (Torrejón de Velasco, Madrid); and the 3D scanning laser process in a dentate quartzite from Aranjuez and a Chalcolithic object of Torrejón de Velasco (Madrid).

KEYWORDS: archaeological heritage, documentation, scanner, photogrammetry, Madrid

3D Reconstructions of Archaeological Sites from Madrid's Community

Jorge López Quiroga[1], Francisco José López Fraile[2], Jorge Morín De Pablos[2], Artemio M. Martínez Tejera[1], and Laura García Pérez[1]

1. Universidad Autónoma de Madrid (UAM), Spain
2. Departamento de Arqueología, AUDEMA, Spain

Reconstructions or analyses in 3D are nowadays one of the best instruments for the diffusion and scientific publication in archaeology. Images, videos, and interactive material are the perfect information vehicles to achieve all the scopes of a society influenced by images. Therefore, the main purpose of this poster is to show several examples of building reconstructions, landscapes, and other objects of diverse historical periods from the Madrid community: a 3D terrain model of the route of High Speed Train (A. V. E.) and archaeological sites of "Las Zanjillas" (Torrejón de Velasco, Madrid); the reconstruction of a longhouse of Iron Age I of "Las Camas" (Villaverde Bajo, Madrid); a model of land reconstruction of the village of "La Gavia" (Vallecas, Madrid); a reconstruction of a Roman furnace (Torrejón de Velasco, Madrid); a reconstruction of the foundations of the Fountain of Tritons of Francesco Sabatini (Boadilla del Monte, Madrid); 3D reconstructions of plates and bowls used in public orphanages under Franco's regime (Boadilla del Monte, Madrid); and a reconstruction of a raid shelter from the Spanish Civil War, 1936-1939 (Black Hill, Madrid).

Keywords: 3D reconstructions, diffusion, scientific publications, Madrid

A Toolbox for Manuscript Analysis

Melanie Gau[1], Maria Vill[2], Florian Kleber[2], Markus Diem[2], Heinz Miklas[1], and Robert Sablatnig[2]

1. Universität Wien, Austria
2. Technische Universität Wien, Austria

Manuscript analysis has long been the domain of philologists who had to perform a complex task without the aid of specialized tools and result management facilities. Even with computers, an investigation into the paleographical and codicological details of a manuscript requires a great deal of rote manual work to gain reliable results and a representative amount of samples. Also, the various stages of analysis often involve more than one instrument of examination which is time and money consuming as well as prone to error. With our conjoint philological and computational approach we created a toolbox for semi-automated manuscript analysis. On the basis of high resolution digital images it combines four tools of manuscript analysis according to the palaeographer's needs. Based on *a priori* data, a line structure analysis is run and the ruling (lines) is shown directly on the image. If necessary, as is often the case with damaged manuscripts, manual corrections can be made at this stage. A simple but efficient application cuts out letters or other cases of interest from the manuscript. The object on the page can either be detected via its distinct greyscale value or, if the object is not easily distinguishable from the background, simply by drawing a rectangle around it. Critical features

Monday

like threshold and border buffering can flexibly be adjusted. By thresholding, the extricated letter is converted into a binary image. Then the structure of the character is characterized by its skeleton and dissected into analyzable segments (strokes and nodes) for an automatic formal classification of static, i.e., as they look like, graphetic attributes. These attributes can be automatically transferred to a database for graphetic script description. The database also allows a manual classification of these attributes and thus enables a comparison between computer generated and human classification. Also, it permits statistical queries and produces six different types of quantifiable and graphical results. The toolbox was developed on the basis of ancient Slavic manuscripts (tenth/eleventh centuries), in the first Slavic script Glagolitica, and has proven essential for our research. The automatic character feature classification represents the starting point from which—in the end—we will single out those features for computer processing that are able to mark a character distinctly in order to facilitate script reconstruction, automatic amendments of (incompletely preserved) letters, and OCR.

Keywords: palaeography, detail and character analysis, database

Session Summary

Monday, 10:15am-11:45am, Liberty

ECAI: Technology and Cultural History

Chair: Michael Buckland, University of California, Berkeley, United States of America

The emerging research and methodologies of technology and the study of cultures and their histories will be the theme of this panel. Lewis Lancaster, Director of ECAI, opens the discussion with questions regarding approaches to markup of archival data as "event" rather than "object." The two presenters bring examples of how these applications can be used with historical examples in China and Vietnam.

Schedule

10:15-10:35	"Archive as Event," Lewis Lancaster
10:35-10:55	"The Digital Gazetteer of Song Dynasty China," Ruth Mostern
10:55-11:45	Discussion

Abstracts

Archive as Event

Lewis Lancaster

ECAI International and Area Studies, University of California, Berkeley, United States of America

The history of information technology has shown that new generations of software and hardware are short-lived and dramatically different from one another. Applications of digital formats that were at the very limits of our capacities a few years ago, tend to become amusing as we compare them with current equipment and programs. At the same time, any tendency to sit back and wait for the future before entering into and contributing to technology advances cannot be characterized as the exercise of prudence. The reluctance of many scholars in the humanities to step forward and take risks in an age where printing has been encapsulated by the digital, has placed our fields at a disadvantage. Caution, with regard to the new, often only implies fear of failure. These are not offenses that apply to those in this conference. In the field of Buddhist studies, the hard work of creating data and strategies of research have come from this small community who are meeting here. I believe that you all deserve an enthusiastic expression of approval. You have been the pioneers who had the ability and the capacity for endurance and resolution. From your energy that has been directed toward the actual work of digitization, we have seen the rise of the productive power of scholars. The appearance of Buddhist canons in electronic medium has transformed what was once merely theoretical and speculative into

a practical and fundamental part of scholarly research. The digital texts, dictionaries, and tools for users are the support from which future insights and research additions will be derived. The codex will not be soon replaced but it is less important as an element in study than was the case a decade ago.

We cannot yet be complacent about these developments. The rapidly evolving process of the digital world has not been completed. There are a whole range of events that mark the changes which still transform and provide the shifting identity of electronic complexity and progress. The challenges we face today are no less daunting than those of the past. Our goal must be to identify the next stage of the digital era and to consider all of the possibilities of applications and variations. One of the themes of this conference will be to discuss ways in which we can join forces for the sake of mutual support as well as action for interoperability of data sets. The information that has been produced by such hard labors must not be dropped into the forgotten corners of the internet or cached in such a fashion that it is either concealed or suppressed by our policies and practices. We must present our material in a manner that allows it to be studied or viewed in relationship to other sets of data as an intelligible part of a distinctive whole.

Keywords: looking ahead, data sets

The Digital Gazetteer of Song Dynasty China

Ruth Mostern
University of California, Merced, United States of America

During China's Song dynasty (960-1276 CE), a scholar-official bureaucracy superceded an earlier aristocracy. Population doubled (and in some regions tripled) as wetland drainage and new crops allowed agriculture to flourish in new locations. The Song empire had the most urbanized and commercialized economy that would exist anywhere in the world prior to the eighteenth century. Song settlers and armies colonized small-scale societies that still persisted in the far south. At the same time, the regime struggled to resist incursions by the newly powerful and centralized regimes of the northern steppes. The northern half of Song territory fell to the Jurchen Jin in the early twelfth century, and the whole empire was conquered by the Mongols a century and a half later. During this extraordinary period of history, the imperial court maintained a precise inventory of counties, prefectures, and provinces: a territorial landscape which organized tax collection, census taking, military campaigns, and which determined the density of the state presence in different regions of the realm. During the three centuries of the Song, there were over a thousand occasions when these jurisdictions were founded, abolished, merged, split, and organized into new hierarchies. My recently completed *Digital Gazetteer of Song Dynasty China* is a spatially and temporally referenced reconstruction of the Song spatial landscape and its frequent changes. This presentation introduces the Gazetteer, explains its development and structure, and demonstrates how this work can be used for an innovative approach to spatial history.

Keywords: China, Song dynasty, spatial landscape

Session Summary

Monday, 1:30pm-3:00pm, Tidewater B

CyArk Digital Preservation (Part 1)

Chair: Elizabeth A. Lee, CyArk, United States of America

3D data capture is widely used for documentation and proves invaluable to cultural heritage. As 3D documentation becomes the standard for heritage sites, new problems arise around the complete process of capturing, producing, presenting, and archiving this digital media. Using CyArk's Digital Preservation Process as the session theme, several presentations will be given on the widespread implementation of this process. Presentations will be given by CyArk partners who have leveraged newly developed web-based applications to manage digital media and make it accessible to the general public. Presentations will also demonstrate how to add value to data by producing rich digital media and placing it within a spatial and cultural context. Presentations will also examine the CyArk web-based archive (http://archive.cyark.org) and its emphasis on user interactivity. Papers presented will be selected from a wide range of disciplines, including professional survey firms, universities, the media and foundations. The goal of the session is to foster awareness of the CyArk methodology and to encourage discussion about its adaptation for more widespread implementation.

Topics: 3D data capture and modeling, data management systems and other field applications, high precision surveying

Keywords: 3D, web-based, digital, interactivity

Schedule

1:30 – 2:00 "Large-Scale Implementation of Digital Preservation Methods," Elizabeth A. Lee and Ben Kacyra

2:00 – 2:20 "The Role of 3D Laser Scanning in Rescue Archaeology and Heritage Preservation, Case Studies from Ireland," Conor Graham

2:20 -2:40 "Designing the Next Generation Virtual Museum: Making 3D Artifacts Available for Viewing and Download," Angelia Michelle Payne, Keenan Cole, Katie Simon, Christopher Goodmaster, and Frederick Limp

2:40 – 3:00 "High-Definition Scanning of the Basilica of the National Shrine of the Immaculate Conception," Alfred Amago

Abstracts

Monday

Large-Scale Implementation of Digital Preservation Methods

ELIZABETH A. LEE and BEN KACYRA
CyArk, United States of America

Through its pilot project, CyArk developed a process to digitally preserve cultural heritage sites through collecting, archiving and providing open access to data created by laser scanning, digital modeling, and other state-of-the-art technologies. In a new initiative, CyArk seeks to implement this process of Digital Preservation on a much larger scale. This paper will examine the challenges facing a global initiative and highlight some of the opportunities such a challenge presents. The processes of capturing, producing, presenting, and archiving 3D digital media will each be discussed. In addition to the process, the paper will examine many of the implementation and management challenges.

KEYWORDS: digital preservation, public dissemination, web-based, 3D, archiving

The Role of 3D Laser Scanning in Rescue Archaeology and Heritage Preservation, Case Studies from Ireland

CONOR GRAHAM
Gridpoint Solutions Limited, United Kingdom

Government-planning law in both the Republic of Ireland (ROI) and Northern Ireland (NI) allows for archaeological remains and features to be excavated subject to agreed planning conditions. Many archaeological excavations occur as a direct result of pre-development ground works during commercial and state funded building and infrastructure developments, or as a result of repairs or conservation to historic buildings. Commercial archaeologists use a range of traditional site-recording techniques, including stratigraphic recording, scale plan, section and elevation drawings, and photographic records. Such recording practices are tried and trusted but due to the manual nature of the site recording, time consuming. In the case of commercial lead excavations, professional site directors and crews may be under considerable pressure to complete the excavation on time and within budget (rescue archaeology). Sites also may be subject to intense public interest with both the archaeological contractor and commercial client keen to publicize the use of best practice and technological advancements in recording and archive as a mitigation compromise. Gridpoint Solutions Ltd. has been providing 3D laser scanning technologies to complement the traditional archaeological site record on commercial and state infrastructure projects since 2003. Site features are laser scanned in situ using tripod-mounted survey-grade laser scanners (e.g. Leica HDS) in a fraction of the time needed to record the features by traditional methods. High-fidelity point cloud data is archived together with scanner RGB imaging and external DSLR photography to allow archaeological features to be analyzed off-site as a post-excavation method. Supplementary Network RTKGPS survey measurements are observed on site to allow full registration and geo-location of point cloud data to local map grid and datum (Irish Grid). The 3D point cloud data is used to construct traditional (and mandatory) full plan, section and elevation 2D outputs and in many cases have completely removed the need to "plan" these features on site. The 3D point cloud data, 2D drawing outputs, 3D visualizations of the site and any modeling outputs are submitted to the statutory authorities in digital form as a component of the final site report required for planning approval. Grid Point Solutions has found that 3D laser scanning can be used as planning leverage on sensitive sites and sites that are under time constraints, and has proved that the technology significantly increases the information recorded on site and the quality of the record and archive generated. It is hoped as the technology is applied to more site projects laser scanning will be seen as a standard method of preservation record and archive on applicable commercial and state funded infrastructure excavations in Ireland.

Keywords: 3D laser scanning, commercial archaeology, preservation through record, 2D output, rescue archaeology

Designing the Next Generation Virtual Museum: Making 3D Artifacts Available for Viewing and Download

Angelia Michelle Payne[1], Keenan Cole[1], Katie Simon[1], Christopher Goodmaster[2], and Frederick Limp[1]

1. Center for Advanced Spatial Technologies and University of Arkansas, United States of America
2. GeoMarine, Inc., United States of America

A search for "virtual museum" on the web returns a variety of fundamentally different websites. From sites that host photo collections to those with "interactive" QuickTime tours, the common thread with current online virtual museums is that they use a form of innovative digital media to present content. The Virtual Hampson Museum Project is a next generation virtual museum that provides high-resolution, 3-dimensional data of scanned artifacts from the Native American collections at the Hampson Archeological Museum State Park in Wilson, Arkansas. The Virtual Hampson Museum Project uses close range 3D laser scanning to document and digitally archive over 800 artifacts from the collections in Wilson. While the collections at Hampson are known by most in the archeological community, they are not widely known to the public. Visitors to the online museum can view the artifacts in full 3D within their browser window using tools available in Adobe Reader. Additional high and low resolution versions of the artifacts are available for download in a number of common 3D formats (VRML/X3d, obj, pdf). Interested researchers, and others, can use a free software package that permits very detailed analysis to be conducted on one's own computer. They can perform a range of measurements, create cross-sections and do comparative analyses of the artifacts. Under Creative Commons license, the 3D objects can be reused in other visualizations and 3D contexts. This

paper will present the challenges in compiling, distributing, and presenting a large number of 3D datasets in an online environment. By combining 3D laser scanning for digital artifact curation and the internet as a distribution platform, the Virtual Hampson Museum Project goes beyond typical online virtual museums and provides accurate 3D data of museum artifacts for public viewing and use and provides users the necessary tools to explore, view, and even analyze the Virtual Hampson collection.

Keywords: virtual museum, 3D scanning, web dissemination, digital curation

High-Definition Scanning of the Basilica of the National Shrine of the Immaculate Conception

Alfred Amago

Precision Measurements, Inc., United States of America

Precision Measurements, Inc. (PMI) was the surveying sub-consultant for the 3D High Definition Surveying (HDS) services of the Redemption Dome and Incarnation Dome in the Basilica of the National Shrine of the Immaculate Conception in Washington D.C. The Basilica is the largest Catholic Church in the Americas and is among the largest churches in the world, and as a result welcomes hundreds of thousands of visitors a year, attracted by its magnificent size, art, and architecture. The PMI team performed a 3D scan of the two domes in order to capture the exact volume and area of each dome so the proper amount of materials could be ordered for the renovation of the domes. The client wanted a quick turnaround without putting up scaffolding in the church. The PMI team blockaded an approximately 5' x 5' section for the 3D HDS equipment. This allowed people to come and go without any distractions and only required a small amount of space. The scan had to be very accurate to ensure that the exact amount of materials were ordered because the client didn't want to have too much material or not enough material therefore delaying the project. Because of the advantages of 3D scanning, PMI was able to collect a significant amount of data, without distracting the visitors in the church, in a relatively short period of time.

Keywords: National Shrine of the Immaculate Conception (Washington, DC), 3D high-definition surveying

Session Summary

Monday, 1:30pm-3:00pm, Constitution

Digital Approaches for Coins (General Session)

Chair: Jeffrey Clark, North Dakota State University, United States of America

Schedule

1:30 – 1:50	"Simulacra Database Management System—An Object-Oriented Approach Towards Knowledge Retrieval," Brienne R. Cignarella
1:50 – 2:20	"Encoded Archival Description for Numismatic Collections," Ethan Gruber
2:20 – 2:40	"Image-Based Measurement of Ancient Coins," Michael Herrmann, Sebastian Zambanini and Martin Kampela
2:40 – 3:00	Discussion

Abstracts

Simulacra Database Management System—An Object-Oriented Approach Towards Knowledge Retrieval

Brienne R. Cignarella
Rutgers University, United States of America

The retrieval of knowledge from Special Collections databases can often be a trying experience. Search results are limited to keyword queries, neither considering more abstract nor specific concepts related to it. At the root of the problem is the method chosen for storage, one which does not account for the semantics of data. Relational databases do not allow for the representation of semantics, instead they store data as tuples, flattening any hierarchy of meaning that may be achieved. Data found in Special Collections is better suited to be seen as hierarchical, making an ontology-based approach more appropriate. Therefore, this paper intends to implement a database whose storage structure accounts for the semantic nature of its data, making for accessibility in knowledge retrieval. Simulacra, derived from the Latin meaning "similarity," is an object-oriented database management system (OODMB) that represents an object's attributes through hierarchies. Using data provided by Princeton University's Numismatic Collection, the Department of Classics and Computer Science has worked to formulate an ontology for the description of a coin. This ontology is stored in a system of classes and properties, typical of object-oriented databases. Each class, the abstract characteristic of an object, has a set of properties which specify requirements for membership. There

are two types of properties, literals which express constants, and relationships which describe a relation to another class. This system of classes and properties utilizes inheritance, a subclass inherits the properties of its superclass. The actual object is then an Instance of a Class which meets property specifications. For example, coins belong to class Coin with literal properties weight, date, and relational property geography, a relation to class State. As a subclass of Class Object, Coin inherits Object's property Name. Constructing an object-oriented database makes for easy implementation of our coin ontology. SQuery, an extension of XQuery, then makes it possible to navigate through the hierarchy of classes. It utilizes Simulacra's representational structure when constructing queries, not only allowing one to search for an particular instance of a class, but guiding searches based upon the class structure. This is particularly helpful when the user does not know how an object is represented in the database. The guided search starts by choosing an instance of Class Object, and thereafter choosing relevant subclasses which come to define the object. It is because of Simulacra's class structure that makes it possible for SQuery to guide users querying. As one of the first fully-implemented object-oriented databases, data in Special Collections can now be represented with its full semantic meaning. The hierarchical storage structure allows for the abstraction of descriptions, a feature relational databases could never achieve. With this new level of accessibility, Simulacra opens entirely new methods of compiling data that never before has been possible.

Keywords: object-oriented database management system, ontology, querying

Encoded Archival Description for Numismatic Collections

Ethan Gruber
University of Virginia Library, United States of America

Developed in the 1990s and revised in 2002, Encoded Archival Description (EAD) is a non-proprietary XML-encoding standard commonly used in libraries and archives in the United States and Europe to describe collections of paper materials, such as manuscripts and photographs. Numerous physical, organizational, and categorical facets of the collections can be effectively described in EAD, including physical materials, genres, index terms, provenance, and essays of biographical or historical nature (complete with footnotes, bibliographies, figures, tables, etc.). These facets are not unique in their usefulness to the library and archival fields, and the descriptive standard's flexibility allows it to effectively describe collections of objects that are more commonly found within museums. Recently, the University of Virginia Library worked in conjunction with the University of Virginia Art Museum to digitize the museum's collection of nearly 600 coins of classical—predominantly Roman—origin. It was decided before the commencement of the project that the standard structured database model utilized by other numismatic collections online was too rigid to both appropriately describe the facets of a numismatic collection and to allow for graduate students to contribute their own research to records of individual coins and the series to which those coins belong. Instead, Encoded Archival Description would be used and adapted specifically to address the physical and categorical attributes of Roman and Greek coins, and the project website (http://coins.lib.virginia.edu) developed around the XML data utilizes Apache SOLR for faceted searching and browsing, greatly improving the searchability of the data within the Art Museum's collection. Over the course of the project, best practices guidelines were developed to standardize the project team's usage of EAD across the numismatic collection. These guidelines may prove useful to other institutions wishing to provide access to their own collections but are wary of the limitations of structured databases. The purpose of this paper is to introduce the concept of using Encoded Archival Description to describe numismatic data, which is a concept that can also be applied more generally to museum collections as a whole.

Keywords: numismatics, XML, EAD, museums

Image-Based Measurement of Ancient Coins

Michael Herrmann, Sebastian Zambanini, and Martin Kampel
Vienna University of Technology, Austria

Many museums around the world catalogue their ancient coins using top-view photographs. These pictures usually contain a ruler which makes it possible to determine the scale of the image and thus the real-world size of the coin. However, due to a lack of specialized tool support, gathering this information is difficult and time consuming and has not been done for large parts of most numismatic databases. Determining the image scale has a twofold benefit for numismatists' needs. Firstly, it allows for a 1:1 scaling of coins for publication. And secondly, it allows to obtain real-world measures of the coin like area and maximum diameter. We present two plug-ins for the image processing application ImageJ that facilitate these tasks for a wide range of rulers and coins. The first automatically calibrates the image so that measurements can be made in terms of the units on the ruler. The second then isolates the coin from the background so that ImageJ's built-in tools can be used for measuring and editing as in other image processing applications. A novel algorithm is proposed for determining the image's scale from a ruler. It finds the peaks in the two-dimensional Fourier transform of the image that correspond to the recurring pattern of the dashes on the ruler and then uses the frequency that corresponds to these peaks to calculate the scale. The algorithm is designed to be invariant against the ruler's location, rotation and size. Isolating the coin from the background is done using an existing algorithm which uses the fact that the local information content is higher for the coin than for the rest of the image. The algorithm is very robust and literature exists on how to acquire the images for the best results. We give its implementation as an ImageJ plug-in. Our paper closes with an evaluation of the algorithms' performance on 190 images from the Fitzwilliam Museum, Cambridge; the Museum of Fine Arts, Vienna; and the National Museum of Romanian History, Bucharest.

Keywords: computer vision, scale detection, segmentation

Monday

Session Summary

Monday, 1:30pm-3:00pm, Liberty

ECAI: Creating Digital Human Records

Chair: Timothy Tangherlini, University of California, Los Angeles, United States of America

The panel takes three areas of the world as examples for exploring the ways in which records of human activity are recorded and presented. David Blundell will initiate the exploration by reviewing the need of dealing with the local communities who are the object of research. Examples of both contemporary and ancient information provide the basis for dealing with the differing needs and problems of each period.

Schedule

1:30-1:50	"Initiating a Sustainable Ethnographic Cultural Atlas from the Grassroots," David Blundell
1:50-2:10	"Progress in the Buddhist GIS Project," Jiang Wu
2:10-2:30	"Participatory Knowledge, Historical GIS, Tourism, and Ethnography: The Integrated Study of Tibet in Place," David Germano
2:30-3:00	Discussion

Abstracts

Initiating a Sustainable Ethnographic Cultural Atlas from the Grassroots

David Blundell
National Chengchi University, Taiwan

Abstract text not available as of press time.

Progress in the Buddhist GIS Project

Jiang Wu
University of Arizona, United States of America

After several years' hard work, the team of the Atlas of Chinese Religion Project has accumulated a large amount of data about religious sites in China, especially Buddhist sites. While team members work on these data, a new paradigm for studying Chinese Buddhism emerges. Unlike the traditional sectarian model which tends to label Buddhist figures and sites according to their ambiguous sectarian identity, the new paradigm calls for a shift from a sectarian notion to an emphasis on monasteries as local institutions. These monasteries

operate on the local level and assimilate all heritages in the Buddhist tradition. We believe that this new paradigm can accommodate new findings in our project and explains well the various issues in the study of Chinese Buddhism.

Keywords: GIS, Chinese Buddhism

Participatory Knowledge, Historical GIS, Tourism, and Ethnography: The Integrated Study of Tibet in Place

David Germano
University of Virginia, United States of America

Abstract text not available as of press time.

Session Summary

Monday

Monday, 3:15pm-5:30pm, Tidewater B

Workshop: Capturing and Publishing Information with the Heurist e-Research Framework

Chairs: Ian Johnson, University of Sydney, Australia
Cathy Campbell, University of Sydney, Australia

In this two-hour workshop we will move from the creation of a database and related bibliographic information in a flexible Web 2.0 environment to its interactive publication on the web using interactive maps, timelines and linked records of related information (presented as pop-ups on the map or as formatted lists coordinated with the map). We will illustrate this process with a small sample of heritage site locations and the publications and web sites related to them, but you are welcome to bring some additional site and bibliographic data for inclusion (or indeed other types of archaeological or historic information which you would like to be able to record, relate, share and publish).

The software used—Heurist (HeuristScholar.org)—is freely available and was developed as generic eResearch infrastructure for use in archaeology, history and related fields where geography, time and rich descriptive and classificatory information are common. Heurist is designed to be a single, integrated solution to most of the data management, bibliographic, and web publication needs of an individual or workgroup (whether co-located or virtual). Heurist has a very wide range of functions—of which we will barely scratch the surface—from simple day-to-day activities such as Internet book-marking, social discovery and sharing of information within workgroups (including bibliographic data, rich textual description, notes and annotations with embedded multimedia) through web publication of research databases (such as project inventories, people, events, date determinations or samples), to a programming API that can be used to develop advanced applications (including complex networks of related records, granular annotation within documents and synchronization with repositories).

We will start by book-marking some relevant web sites (including importing some browser bookmarks), import some bibliographic data from Zotero and EndNote, some photographs from disk and some geographic data from Google KML files, and also enter a few records by hand. Then we will build relationships between records, linking sites to photographs and the bibliographic references which describe them, and tag and save subsets of these sites (by period, by tagging) for eventual publication. Finally we will publish an interactive map and timeline of sites and a formatted list of sites, embedded in a web page.

You will not learn everything there is to know about Heurist in this short introduction, but we will introduce you to many of the essential elements and give you a taste of the ways it is being used in a wide variety of applications. You will leave with the skills to start book-marking web sites and using Heurist day-to-day as well as creating databases, bibliographies and data feeds into web pages (including web sites in an institutional CMS).

The workshop is suitable across a wide range of skill levels—beginners will gain confidence in being able to collect data, including geographic data, and publish live data to the web; advanced users will grasp the potential for an integrated approach to web-based data management, sharing and repurposing.

Maximum audience: 40

Topics: databases, data management systems and other field applications, other

Keywords: social applications, online databases, web mapping, eResearch infrastructure, web publishing

Monday

Session Summary

Monday, 3:15pm-5:30pm, Computer Lab BHS 209

Tuesday, 3:15pm-5:30pm, Computer Lab BHS 209

Workshop: Archaeological Site Prospection Using Google Earth

Chair: Scott L. Madry, University of North Carolina at Chapel Hill, United States of America

This workshop will be a hands-on introduction to using Google Earth for archaeological site prospection and recording. The presenter has several years experience in using Google Earth for site prospection in France, the Isle of Man, and Peru. Methods and techniques for systematic site prospection will be covered, along with physical processes leading to site visibility. Techniques of recording, documenting, and sharing located features will also be covered. After this workshop participants should be able to conduct independent site surveys using Google Earth.

The session will run 135 minutes and has no required prerequisites other than minimal computer ability or minimal experience using Google Earth. The maximum number of participants will be the number of computers available. One computer per participant, loaded with Google Earth and with internet access is required, along with a projection system for the instructor's computer.

This session will be similar to the one presented at the Berlin CAA.

Size Limit: Each session of this workshop will be limited to 16 participants (2 per computer). An additional 2-4 participants, who wish to use their own wireless-enabled laptop with Google Earth installed may also join.

Topics: GIS, Google Earth, and archaeology

Keywords: Google Earth, site prospection, aerial image analysis

Session Summary

Tuesday, 8:30am-3:00pm, Tidewater A

Envisioning the Past: Virtual Reconstructions of Archaeological Sites

Chairs: Alyson Gill, Arkansas State University, United States of America
Arne Flaten, Coastal Carolina University, United States of America

Over the past decade various digital technologies ranging from three-dimensional reconstructions or models, laser scanning, GIS databases and digital mapping have been used to contribute to our understanding of various aspects of ancient sites. In some cases these tools have led to the creation of three-dimensional virtual models of buildings or of entire sites, while in others they have been used in a variety of contexts to address specific archaeological problems. While acknowledging that there are some problems native to the creation and use of digital models, digital technologies can be an exceptionally powerful tool when used in reconstructions and there is information that can be gained from them that is not available through traditional archaeological means. Virtual reconstructions allow scholars to consider a vast array of theoretical issues for the built environment, including sight lines, the ways in which space would have functioned in antiquity, and how buildings would have interacted with each other. Three-dimensional digital models also allow us to engage a diverse set of experimental architectural problems, including lighting and engineering issues.

The organizers of this session are interested in the diverse perspectives offered by data providers, producers, and end users of three-dimensional models with respect to problems and possibilities presented by digital technologies as research tools in archaeology. This session is intended to foster discussion between these groups. Papers should focus on the ways in which digital technologies might be used as research tools, or the presentation of a specific project that models a specific digital research tool or set of tools in the study of a specific archaeological problem or site.

Topics: data management systems and other field applications, GIS, Google Earth and archaeology, North American archaeology and digital technology, virtual museums, virtual reality

Keywords: archaeology, 3D models, reconstructions, archaeometric, digital

Schedule

8:30 – 8:50 "'The Storeroom of the Pithoi' at Akrotiri (Thera)—3D Reconstruction," Demetra Kriga

8:50 – 9:10 "Architectural Analysis and 3D Reconstruction: A Case Study of Leopoli-Cencelle in Italy," Giovanna Liberotti, Corrado Alvaro, and Daniele Nepi

9:10 – 9:30 "Interactive Visit of the City of Rome in the Fourth Century C.E.," Philippe Fleury and Sophie Madeleine

9:30 – 9:50 "Multimedia, Mythos, and Mimesis: on the Use of IST for the Research, Conservation, and Public Outreach of CH—The Paphos Roman Mosaics as a Case Study," Sorin Hermon and Demetrios Michaelides

Coffee break

10:15 – 10:35 "Virtual Sambor Prei Kuk: Weaving the Tangible and Intangible Cultural Heritage," Daniel Michon, Yehuda Kalay, and Selina Lam

10:35 – 10:55 "The Study of the Armenian Historical Architectural Heritage: The Numerical Model and the Reconstruction of the Geometric Structural Model of Ereruk Church," Hilde Romanazzi

10:55 – 11:15 "3D Technological Platform at the Ausonius Institute (CNRS-University of Bordeaux)," Robert Vergnieux

11:15 – 11:35 "Participatory Research in Cyber-Archaeology," Maurizio Forte and Eva Pietroni

Lunch

1:30 – 1:50 "Cyber-Archaeology: Embodiment Experiments of Training and Research," Maurizio Forte and Nicolò Dell'Unto

1:50 – 2:10 "The Digital Shakers Project: First Steps towards an Online Database on Shaker Architecture," Jose Kozan and Iara Beduschi Kozan

2:10 – 2:30 "Embedding Metadata into Virtual Reconstruction Models," Christopher Paul Redmann

2:30 – 2:50 "Using Primary Resources, GIS, and 3D to Visualize Green Spring, Virginia, in the Eighteenth Century," David Clinton Frederick

Abstracts

"The Storeroom of the Pithoi" at Akrotiri (Thera)—3D Reconstruction

Demetra Kriga
College Year in Athens, Greece

The archaeological site of Akrotiri is located near the modern village of Akrotiri, by a small bay looking to Crete, in the southernmost edge of the island of Thera. The extremely well-preserved multistory buildings, the squares, and the town planning of the Late Bronze Age coastal settlement are unique and worth studying. Life stopped at the international port of Akrotiri when the island's volcano erupted around 1630 B.C.E. The eruption was so strong and large, that part of the island sunk into the water and the island became crescent-shaped. The city of Akrotiri was buried under the tons of pumice and sealed with tons of volcanic ash. The building Sector A (or the "storeroom of the Pithoi"), located on the northern edge of the excavated part of the settlement is the first that was excavated by S. Marinatos, when the site was revealed in 1967. Today the old roof of the archaeological site has been replaced by a new bioclimatic one, which, when finished, will provide elevated ramps all along the excavated area of the site. Most of the buildings will be more accessible to visitors from a closer distance. The architectural form of the three ground-floor rooms of Sector A is extremely interesting and different from any other excavated building in the settlement. Equally interesting and impressive are the contents of these rooms and the built installations preserved there. The entrance to the building was made through a small open-air antechamber, paved with large schist slabs. A clay bathtub was built along the northern wall of the antechamber, perhaps for collecting rainwater. The digital reconstruction of the building is a team effort between computer experts (Athens Polytechnic team) and an archaeologist. The project's outcome is a 3D model, for which several computer software tools were used. The model of the building was shaped by creating "copies" of architectural materials used in the Bronze Age and using texture maps. The light in the building was made by radiosity. The final photorealistic rendering makes possible the virtual touring within the building by using animation in real time.

Keywords: architecture, prehistory, Akrotiri, 3D, digital

Architectural Analysis and 3D Reconstruction: A Case Study of Leopoli-Cencelle in Italy

Giovanna Liberotti, Corrado Alvaro, and Daniele Nepi
University of Rome "La Sapienza," Italy

This paper focuses on the integration of data between laser scanning, GPS, and orthophotography, which were collected during the investigation of the medieval church of Leopoli-Cencelle, Italy. Cencelle is located within the territory of Tarquinia in the province of Viterbo, 70 km north from Rome. The remains of a 740m-long wall with three gates, and seven towers are still evident on the top of the hill at 160m ASL. As reported in the *Liber Pontificalis* of the Holy Ecumenical Roman Catholic Church, Leopoli-Cencelle was directly founded by Pope Leo IV (847-855) during his eighth year of his pontificate, that is to say on 15 August, 854 C.E. Following this evidence, since 1994 archaeological excavations have been carried out under the direction of Professor Letizia Ermini Pani and Professor Francesca Romana Stasolla (Medieval Archaeology and Topography, Rome University "La Sapienza"). During the research, various relevant discoveries such as housing structures, fortified residential areas, and workshops have also been unearthed. Together with this evidence the road network of the town has been also partially discovered. One of the most interesting monuments of Leopoli-Cencelle is the church with three naves, built in the twelfth century with the remains of a bell tower and an underground crypt. This complex has been surveyed both with laser-scanning LEICA HDS 3000 and with orthophotography. Laser scanning data have been collected in several scans with a resolution of about 5mm; orthophotos have been performed with a commercial software and digitalized using CAD software; all data have been positioned on UTM world standard coordinate system using LEICA GPS and a digital elevation model (DEM) has been produced. According to this documentation and to the new data coming from the excavations, a 3D reconstruction of the building will be presented together with

a discussion on the importance of these methodological approaches and on the archaeological implications arising from their adoption.

Keywords: laser scanning, GPS, orthophotography

Interactive Visit of the City of Rome in the Fourth Century C.E.

Philippe Fleury and Sophie Madeleine
Université de Caen Basse-Normandie, France

Work on developing a virtual model of the city of Rome in the fourth century C.E. began in Caen in 1994. The project is based on a 70m^2 model of ancient Rome built made by the architect P. Bigot at the beginning of the twentieth century, known in French as the "Plan de Rome." The Plan de Rome is an exceptional piece of our cultural heritage whose only equivalents are its twin in Brussels and the model made by I. Gismondi which is in the Museum of Roman Civilization in Rome. Our relief plan is the origin of a multidisciplinary project for a virtual 3D model reconstructed in computer-generated images. A new research structure—the Interdisciplinary Virtual Reality Center (Centre Interdisciplinaire de Réalité Virtuelle or CIREVE)—has since been added to support the work of building the virtual model of the ancient city of Rome. CIREVE is a shared resource at the University of Caen that makes it possible to pool the staff and equipment for the application of virtual reality techniques for research purposes. The work involves the development of a fully interactive model of ancient Rome that includes both its architecture and the machinery in use. In reconstituting the past, scholars will be able to test their assumptions from architectural and topographic viewpoints and test machine functionality. A visitor to the virtual site will be able to wander through a full-scale city and enter most of its large public monuments and a few residences. Work preliminary to the reconstruction itself involves the analysis of ancient source materials, which is currently being carried out by project team members who have recourse to outside experts for help with specific points. The body of source material is directly accessible via the interactive model. We propose to explain our methodology and to visit some interactive model of ancient Rome with the documentation accessible.

Keywords: ancient Rome, virtual reality, architecture, town planning, topography

Multimedia, Mythos, and Mimesis: On the Use of IST for the Research, Conservation, and Public Outreach of CH—The Paphos Roman Mosaics as a Case Study

Sorin Hermon[1] and Demetrios Michaelides[2]
1. STARC - The Cyprus Institute, Cyprus
2. Archaeological Research Unit, University of Cyprus

The paper will discuss an integrated methodology for the research, conservation and public outreach of Cultural Heritage in general and the ancient Roman mosaics from Paphos, Cyprus, in particular, using

Information Society Technologies as a framework of activities. Parting from a proposed definition of CH, based on Durkheim's description of collective consciousness (paralleled here with CH), and its social role and its nature (multi-layered and based on individual's experience), we are proposing to create a pubic outreach framework based on digitally acquired images of the mosaics (and their image analysis), to be used for conservation, iconographic analysis, techniques analysis, materials provenance, and finally restoration of the mosaics. Further on, a virtual reality platform for public outreach will be developed, taking into consideration various layers of meanings, fulfilling some social role in the ancient Roman society, as decoration of domestic spaces, relations between the scenes depicted and their spatial location, etc.

Keywords: 3D modeling, cultural heritage, image analysis, public outreach

Virtual Sambor Prei Kuk: Weaving the Tangible and Intangible Cultural Heritage

Daniel Michon[1], Yehuda Kalay[2], and Selina Lam[2]

1. Claremont McKenna College, United States of America
2. University of California, Berkeley, United States of America

Computational modeling of tangible and intangible heritage provides a new media for researching the genesis and evolution of sites of cultural significance. This project uses a MUVE (Multi-User Virtual Environment) based on digital modeling of the site, people, and activities that were part of the heritage. This paper illustrates a cultural heritage project that captures and communicates the interplay of context (geography), content (architecture and artifacts), and temporal activity (rituals and everyday life) leading to a unique digital, material, and intangible archive of Sambor Prei Kuk. The MUVE is used to provide a platform that enables an experience of weaved tangible and intangible cultural heritage. This offers visitors a *genus loci* of the site and its culture as well as the *raison d'être* and a direction for combining the three research areas. The Virtual Reconstruction Project of the central temple at Sambor Prei Kuk (SPK), in Cambodia, is an attempt to apply twenty-first-century technology to seventh-century cultural heritage. Sambor Prei Kuk provides the earliest record of Khmer temples, predating the better-known (and better-preserved) Angkor Wat by several centuries. Hence, study of SPK is crucial for understanding the Khmer, pre-Angkorian tradition and the subsequent development of temple cities such as Angkor Wat in Cambodia. As benefits an important cultural heritage site, SPK has been studied by archeologists and other scholars for many years. Their work has provided much knowledge of the culture and the period, especially regarding the eastern expansion of Hinduism along the trade routes from its Indic origins into Southeast Asia—one of the great cultural assimilations in human history. From the fifth century through the sixteenth century, this diastolic interaction created a unique blend of canonical, local, and borrowed cultural and artistic traditions, which can be seen today in the remains of the many temple complexes along the Pacific Rim.

Keywords: MUVE, new media, intangible heritage, place-making, Hinduism

The Study of the Armenian Historical Architectural Heritage: The Numerical Model and the Reconstruction of the Geometric Structural Model of Ereruk Church

Hilde Romanazzi
Polytechnical University of Bari, School of Architecture, Italy

The cultural heritage of Armenian architects is expressed chiefly in a large number of Armenian religious buildings (isolated churches or monasteries). They are representative of the great design opportunities that masonry architecture provides. The frequency of serious seismic events over the centuries is the main reason for the urgency of conservation/restoration of such monuments. The results presented here are among the last ones of a very complex and long-lasting history of analysis and archaeological studies on one of the most mysterious buildings in the architectural heritage of Armenia. This work was born from the passion and the cultural interests of scholars of the Italian non-profit organization "Centro Studi e Documentazione della Cultura Armena," with whom I had the honor of collaborating. New technologies (like the total station theodolite) for architectural surveying allow a global and three-dimensional knowledge of Ereruk church, as well as all the changes and the alterations that the construction practices through the centuries provide. The monument's incompleteness prevents a full understanding of the original architectural form: there is no documentation of the covering system of the building, probably because its collapse occurred in ancient times. Armenian scholars have advanced different hypotheses. For these reasons, digital 3D modeling is a very powerful tool for the study of this kind of monument, offering the possibility of previsualization, extreme precision, and the chance of obtaining the formal geometry of the whole monument by means of virtual processes of "assembly" and "disassembly." It is a powerful resource during the design phase, when it is possible to prefigure the final result and advance a reconstructive hypothesis about the lost integral shape of the monument itself, and during the restoration phase, when it is possible to get the geometry of every single stone element set by masons or to produce pieces artificially with the help of CAM systems.

Keywords: reconstruction, 3D virtual model, restoration, conservation

3D Technological Platform at the Ausonius Institute (CNRS-University of Bordeaux)

Robert Vergnieux
Centre National de la Recherche Scientifique, France

Creation of a 3D digital model for visually restoring an archaeological site is a way of enhancing research but it has also become a new discipline in its own right. Questioning the relevance and validation of a restoration leads to new thoughts about ancient societies. The heart of the matter, restoration of ancient spaces, is a full-fledged research topic. But the great originality of this methodological approach is probably its collective and multidisciplinary aspect. The Bordeaux team focuses on the development of specific procedures for building and validating the 3D-restoration proposal. All the projects that we are involved with are managed by teams

of researchers. Using data still in place, a 3D model is developed to be a first synthesis of previous proposals of restoration modulated by associated scientific literature. The 3D model becomes a scientific object with which researchers can do their studies. This phase is difficult and much longer and more complex than what is usually encountered. The confrontation between the assumptions of restoration and documentation (archaeological, epigraphic, iconographic, archeometry) often requires the intervention of outside experts (mechanical engineer, acoustician, cabinetmaker, town-planner, maker of bronzes, stone-cutter, etc.). Teams consisting exclusively of 3D modelers are insufficient because negotations between the 3D digital model and the scientific data must be continuous during the different phases of research. After the first work, the digital pattern can serve as a virtual model from which it is possible to perform simulations (sound propagation, time for movement, solar lighting in the temples, mechanical or quantitative test: flow, volume of a well, etc.). So for these two reasons it is necessary to keep (archive/perpetuate) numerical models, because their scientific life is extended well beyond their preparation. The PFT3D has become therefore the resource center for digital 3D under the Very Large Equipment TGE-ADONIS for the humanities. This means that we preserve not only our own models, but also those entrusted to us as voluntary deposits. Our models, once in V3 version, are set up on Google Earth to make them known all over the world.

Keywords: 3D, archaeology, virtual reality, virtual retrospect, restitution

Participatory Research in Cyber-Archaeology

Maurizio Forte[1] and Eva Pietroni[2]

1. University of California, Merced, United States of America
2. CNR ITABC, Institute of Technologies Applied to Cultural Heritage, Italy

This paper aims at introducing and discussing an innovative approach to cyber-archaeology in relation to the need to investigate what happens in an immersive environment where every user is embodied in cyberspace through participatory activities. It is argued that virtual reality (both off- and online) represents a possible ecosystem, which is able to host top-down and bottom-up processes of knowledge and communication. In these terms, the past is generated and coded by a simulation process. Thus, from the first phases of data acquisition in the field, the technical methodologies and technologies that we use influence in a decisive way all the subsequent phases of interpretation and communication. In the light of these considerations, what is the relationship between information and representation? How much information does a digital model contain? What sorts of and how many ontologies ought to be chosen to permit an acceptable transmittability?

In this context, it is possible to find virtual communities developed entirely within three-dimensional environments, where users (represented by avatars) can directly contribute to modify and update cyberspace. Despite this development and these new metaphors of "virtual aggregation," the state-of-the-art in the field of virtual cyber-archaeology is still quite pioneering, because there are a few Multi-user domains (MuD) specifically for sharing and exchanging cultural and scientific contents. In this field we are developing new research projects oriented to virtual archaeology and to the study and communication of cultural heritage through multiuser virtual reality applications (off- and online). The presentation will discuss different methodological case studies: the experience of teaching Cyber-Archaeology in Second Life at the University of California, Merced; the creation of a virtual museum based on collaborative environments in Rome (http://www.vhlab.itabc.cnr.it/flaminia/index02.html); finally an experiment of a MuD cyberspace for virtual archaeology (Integrated Technologies of robotics and virtual environment in archaeology) made in collaboration with CNR-ITABC (National Research Council, Italy). Different virtual platforms of participatory learning and collaborative environments are able to create diverse outcome for research and training: a more advanced level of knowledge, validating the entire interpretation and reconstruction process in the field of cyber-archaeology.

Keywords: virtual reality, embodied communities, learning, cybernetics, editable scenario, transparency, data sharing

Cyber-Archaeology: Embodiment Experiments of Training and Research

Maurizio Forte and Nicolò Dell'Unto
University of California, Merced, United States of America

Virtual heritage can define all of the digital processes connected with a multidisciplinary approach to the interpretation, knowledgen and communication of cultural heritage. The interpretation and communication process is created by spatial-temporal coordinates, but it depends on a sense of place transmitted through cross-cultural domains. This gap of distance in time, space, and place between present and past can be partially filled by a virtual reality environment, where a simulation can reproduce a holistic context of cybernetic information. This simulation represents a possible past and the interaction determines the level of communication and exchange, first with the space (uncoded) and second with the place (coded). The result of the mutual eco-interaction and feedback between users and environment constitutes the virtual heritage process. VR, for now mainly off-line but destined to migrate and settle permanent on the web, constitutes the concluding segment of a process of knowledge-communication, precisely because it is able to produce first difference, then knowledge and communication. Most part of the world seems to be interested mainly in technological and digital aspects of the virtual, but this direction is over-technological without a correct evaluation of the relations between mind and environment. We'd like imagine the virtual like a 3D cyberspace, in which artificial organisms and humans interact, move, and grow based on rules of the artificial societies and of the relations of the ecosystems; the realm of the virtual in a technical sense includes all the 3D worlds where the action/reaction/retroaction is free and in real time. In network and collaborative environments, cyberspaces and information are shared and the experience, subjective and objective, is embodied by avatars, actions, interactions, behaviors, navigations, dialogues, feelings, storytelling.... This embodiment constitute a new way of learning, communication and cultural transmission; in cybernetic terms it is a mirror effect—we can display our action and mind in someone's embodiment. At UC Merced we are experimenting with digital media learning and research in Second Life, collaborative spaces within the UCM Virtual Heritage Island, and through immersive systems such as the Powerwall. In these experiments of virtual reconstruction, we test feedback, reactions, participation, and informational transmission between users and environments.

Keywords: cyber communities, social network, embodiment

The Digital Shakers Project: First Steps Towards an Online Database on Shaker Architecture

Jose Kozan and Iara Beduschi Kozan
University of Cincinnati, United States of America

The project to digitally rebuild the White Water Shaker Village began in 2005 with the reconstruction of a minor portion of the buildings. This historical site, occupied by the United Society of the Believers in Christ's Second Appearing, known as Shakers, was originally established in Ohio during the nineteenth century. We will present the continuation of the work that now encompasses the full extent of the buildings and shifts from a high-polygon modeling approach to low-polygon models intended for real-time online visualization. The White Water site accommodates structures portraying mixed levels of maintenance, and the overall condition of the location urges action to support the restoration and preservation of the remaining buildings and lands. In this phase we explore the connection of 2D data with web-based 3D interfaces, using Google Earth as the primary application for visualizing the digital models of all the buildings in the Shaker village, including extant and demolished structures. The existing buildings showcase in the facades textures originated from a recent photo-survey, portraying their current conditions. An archaeological survey and historical photographs provided the data to rebuild the vanished structures, represented with schematic detail levels compatible with the amount of information available. The initiative expects to: 1) increase public awareness to the site, aiming at a positive impact in preservation support and tourism; 2) benefit by utilizing developed web-interfaces to minimize implementation and maintenance costs; 3) facilitate access to online information about Shaker architecture with direct links in the georeferenced 3D models; and 4) define the basic components for an open collaborative network focused on creating and sharing resources on Shaker architecture on the web. We aim at highlighting the association of open web services and interfaces with digital models of historical sites built for real-time visualization, allowing the integration of archaeological research with information originated from multiple online sources.

Keywords: digital reconstruction, virtual reality, architecture, Shaker, Google Earth

Embedding Metadata into Virtual Reconstruction Models

CHRISTOPHER PAUL REDMANN
Drexel University, United States of America

The use of digital recreations as a means of presenting information about historic sites is becoming more commonplace, but further effort needs to be made into investigating how these digital assets can evolve with technology. Creating digital assets that harness only the current level of technology limits their future usefulness and fails to take full advantage of the nature of digital media. Development of digital assets should take full advantage of the information known about an historic site, as well as hold more information that simple color (visual) data. There are also no widespread standards for the creation of digital models of historic sites, which would hold them to the high standards of physical reconstructions. At Drexel University, we are exploring methods of embedding metadata into our 3D recreation of Colonial-era sites in the Philadelphia area and integrating the steps of model creation and cataloging. Accurate representation of the recreations is key to the success of the program, and these high-resolution models can easily be scaled back for output to various systems (i.e., real-time game engines). Models for 3D Colonial Philadelphia are developed in commercial software packages, and then stored using the Open Source Collada format. By avoiding proprietary formats, we hope to extend the longevity of the assets. In the same fashion, RenderMan Shading Language is being used for shading of the models; this is the standard specification for shading in the visual effects industry and is compliant with a number of open-source render engines. Secondary information about the site, such as material type, location, and date of creation can be stored as primitive variables in the model without the need to limit surface topology or geometry type. Using shader profiling and Arbitrary Output Variables, we can output all of this secondary information at render time. Through the use of another visual effects standard image format, OpenEXR, multichannel images can store visual descriptions of secondary data. Also integrated into the shading language and model, renders can output XML documents with additional information or write directly to MySQL databases. By creating models with the highest possible level of detail and focusing on the accuracy of the information presented, we hope to create digital assets that are suitable for archiving and will be open to further development.

KEYWORDS: modeling, open-source, cataloging, virtual history

Using Primary Resources, GIS, and 3D to Visualize Green Spring, Virginia, in the Eighteenth Century

DAVID CLINTON FREDERICK
National Park Service, United States of America

Green Spring, Virginia, is a nationally significant site and was the home to influential and productive governors/owners in the early initial stages of the state of Virginia. The mansion and estate has been protected

Tuesday

by the National Park Service since 1966. Many attempts have been made to portray Green Spring in the past. In a map drawn by surveyor John Soane in 1683, Green Spring plantation was placed on the landscape. John Soane made an attempt to give dimension to the plantation house displayed on his map. Diaries kept by the many visitors to Green Spring during the eighteenth century describe domestic gardens, orchards and grounds. A 1796 watercolor painting of the Green Spring Mansion house by architect Benjamin Latrobe along with his notebook sketches helps illustrate exterior architectural details and interior function. French officer Jean-Nicholas Desandrouins drafted a map in 1781 with Green Spring and surrounding environs. Archeological investigations at the core area of Green Spring during the 1950s and 2001-06, provide excellent information on the locations and use of structures. Archeological information collected of Green Spring has been placed into a GIS ArcGIS database at Colonial National Historical Park. With this, GIS layers of information can be filtered or queried and then displayed. Recently, the 3D software tool SketchUp came out with an ArcGIS-to-SketchUp plug in. Now, GIS data can be exported from ArcGIS and imported into SketchUp, holding on to spatial references. No structures from the industrious Ludwell era at Green Spring stand today. By combining historical documents such as maps, text, paintings, recent archeological reports, GIS and 3D software, the eighteenth century plantation of the Ludwells will emerge on the landscape. There will be a transition from a two-dimension world to a three-dimension world, advancing understanding and visualizing information about the site. All these resources will help in the re-creation of a possible domestic landscape at Green Spring during its summit of stateliness during the eighteenth century.

Keywords: GIS, archaeology, 3D reconstruction, historical documents, cartography

Session Summary

Tuesday, 8:30am-3:00pm, Tidewater B

Close-Range 3D Laser Scanning: Recent Developments and Applications

Chair: CHRISTOPHER GOODMASTER, Geo-Marine Inc., Plano TX, and the Center for Advanced Spatial Technologies, University of Arkansas, United States of America

Recent advances in three-dimensional (3D) laser scanning hardware coupled with the development of improved scanning methodologies on the part of a growing community of practitioners, advances in micro-computing capabilities allowing the ability to process and manage large data files, and the capability of integrating these data across a variety of platforms have made this technology an effective and practical option for the documentation, analysis, archiving, curation, and dissemination of archaeological information. For these reasons, 3D laser scanning has become an accepted and widespread practice in the European archaeological community with increasing popularity in North America as well. This session specifically explores close-range 3D laser scanning, i.e., techniques that rely on an active near-infrared sensor to generate sub-millimeter three-dimensional surface data for artifacts, features, monuments, architectural elements, etc. Session participants should highlight:

- Improved methods for data collection and processing
- New and innovative applications of the technique and resultant data
- Issues in digital archiving, data curation, and data dissemination
- Metadata standards
- The implications of this technology with regard to archaeological practices

Participants are encouraged to draw upon a wide variety of case studies to underscore the utility and potentials of close-range 3D laser scanning, as well as share their tribulations and successes. This session is also intended to foster a sense of community among the practitioners of this technique and serve as the potential basis of an international working group dedicated to the application of this technology to archaeology.

TOPICS: 3D data capture and modeling, North American archaeology and digital technology

KEYWORDS: close-range 3D laser scanning, field methods, 3D data processing, data curation, metadata

Schedule

8:30 – 8:50 "Beyond Cabinets of Curiosity? Analysis Potential in 3D Laser Scanning and Virtual Museums," Katie Marie Simon, Angelia Michelle Payne, Keenan Cole, Christopher Scott Smallwood, Christopher Goodmaster, and Fredrick Limp

8:50 – 9:10	"Lighting Systems in Three-Dimensional Non-Contact Digitizing," C. Scott Smallwood, Angelia Michelle Payne, Katie Simon, Christopher Goodmaster, Frederick Limp, and Jackson Cothren
9:10 – 9:30	"Cutting Edge Research: An Old Solution in Search of a New Methodology," Rob Sands,
9:30 – 9:50	"Automatic Point-Cloud Surveys in Prehistoric Sites Documentation and Modeling," Mercedes Farjas, Francisco J. García-Lázaro, Julio Zancajo, and Teresa Mostaza
Coffee break	
10:15 – 10:45	"Mesoamerican Sculpture: From 3D Documentation to Dissemination," Travis F. Doering and Lori D. Collins
10:45 – 11:05	"Development of a 3D Model for Archiving and Dissemination of the First Hindu Temple at Bhitar village, Kanpur, India Using Laser Scanning and Digital Photography," Bharat Lohani, N. Balaji, Satyaki Roy, and Onkar Dikshit
11:05 - 11:45	Discussion
Lunch	
1:30 – 1:50	"LIDAR Scanning of Elmina (Ghana) (A Slave Fort)," Patricia Seed
1:50 – 2:10	"Virtual Reconstruction of a Ceramic Vessel: A Case Study from The Pas, Manitoba," Morgan John Tamplin, Kevin Brownlee, Leigh Syms, Andrew Fallak, and Myra Sitchon
2:10 – 2:30	"A Future for the Past: Use of Digital Technology in Preserving a Twentieth-Century Legend," Shamim Javed, Robert P Schubert, and Ki-Hong Ku
2:30 – 3:00	Discussion

Abstracts

Beyond Cabinets of Curiosity: Analysis Potential in 3D Laser Scanning and Virtual Museums

Katie Marie Simon, Angelia Michelle Payne, Keenan Cole, Christopher Scott Smallwood, Christopher Goodmaster, and Fredrick Limp

Center for Advanced Spatial Technologies (CAST), University of Arkansas, United States of America

The growing popularity of 3D laser scanning is a testament to many of its useful applications. These include virtual preservation and digital dissemination of objects and architecture in highly accurate, sub-millimeter resolution forms. While the practicality of these uses is self-evident, one important question remains at the core of many discussions and debates concerning 3D laser scanning: what is the practical application of this data within the realm of research? How can collections of 3D data function in a role beyond virtual curiosity cabinets? This paper aims to explore the analysis potential of laser scanning data and the role such analysis could play in formulating new research questions. These questions will be investigated using the specific case of the Virtual Hampson Museum Project, a virtual museum comprised of over 200 digitally scanned artifacts from the Hampson Archaeological Museum State Park in Wilson, Arkansas. This digital archive has been made available online for 3D viewing using Adobe Reader or downloaded for viewing and analysis in a variety of common 3D formats. A review of available software tools and how these tools can potentially be employed in analyses will be made. One of the most obvious benefits of such tools and data sets is the ability for increased precision in point to point measurements as well as volume, perimeter and surface area calculations. The usefulness of such information in ceramic analysis will be discussed along with other types of analytical methods that are unique to 3D point cloud data. These include hill shade analysis, curvature mapping, and texture/color stripping and their abilities to isolate surface features such as fine incising and other elements that are difficult to observe and evaluate effectively with traditional techniques.

Tuesday

KEYWORDS: laser scanning

Lighting Systems in Three-Dimensional Non-Contact Digitizing

C. SCOTT SMALLWOOD[1], ANGELIA MICHELLE PAYNE[1], KATIE SIMON[1], CHRISTOPHER GOODMASTER[2], FREDERICK LIMP[1], and JACKSON COTHREN[1]

1. Center for Advanced Spatial Technologies (CAST), University of Arkansas, United States of America
2. GeoMarine, Inc., United States of America

The Virtual Hampson Museum project, directed by the Center for Advanced Spatial Technology and funded by the Arkansas Natural and Cultural Resources Council, has been an important testing ground for three dimensional non-contact digitizing. The project uses Konica-Minolta Vivid 9i scan system to scan and digitally archive over 800 artifacts from the Hampson Archeological Museum State Park. Being that the VIVID 9i has a 0.3 megapixel on-board camera, the control of the environment around the artifact being scanned is of the utmost importance. Since we lack the ability to adjust the camera accordingly to account for variations in artifact color, a solid lighting system must be used so that the scanner offers the optimal performance. Concerning ourselves both with the quality of surface and color data, we have provided a means through which adequate representation of an artifact can be achieved. In the beginning of the project, data was collected by simply using ambient light. Problems quickly arose from this approach, leaving the artifacts poorly lit, which resulted in darker color data and shadows between scan rotations. Realizing that product photography offered solid methods that could aid us, a large light tent was constructed for use with studio lighting in efforts to diffuse the ambient light, to eliminate shadows and to provide a solid white background. These methods allowed researchers to collect better quality color data that more accurately represented the artifacts from which they were taken. This paper will discuss the route we have taken to gather high quality data and the lighting system necessary to create it. The lighting system has been a cornerstone of gathering the data necessary to make an object ready for public and academic consumption. With an eye to developing a system in which the digitizing of artifacts is efficient across multiple uses and artifact types, a light system must operate as a constant source of reliability. Further improvements will be made to the lighting system

that more control can be taken with the on-board camera. These improvements include the re-engineering of the light tent and the number and intensity of lights used during data collection. The end result, with as much possible control over the lighting and camera, is that the process should be able to be repeated with similar returns each time.

Keywords: 3D imaging, lighting, virtual museums

Cutting Edge Research: An Old Solution in Search of a New Methodology

Rob Sands
UCD School of Archaeology, Republic of Ireland

Tuesday

Between 1991 and 1994, I was undertaking my Ph.D. research into the marks left behind by Bronze Age tools on wooden objects found on a Late Bronze Age lake dwelling site in the Scottish highlands. Axe marks such as these not only leave behind proxy evidence for the general form of the tool used but also leave micro traces of the damage sustained by all edge tools. It is this edge damage that is of most interest in the context of this session. An edge tool with damage will leave striations on the long axis of the facet that it produces, the pattern of striations produced uniquely identifies the tool used and can connect together work conducted by the same tool across different objects. This paper will illustrate the potential of this type of data through the original case study and will briefly describe the original image analysis-based solution to data capture and analysis. Having completed this work in 1994 and published the findings in the same year the research was put to one side. Now some, fifteen years later, the technology has caught up with the original research aims and it is hoped that the new methodologies presented in this session might solve some of the limitations of the original capture and analysis solution.

Keywords: image analysis, 3D scanning, toolmarks

Automatic Point-Cloud Surveys in Prehistoric Sites Documentation and Modeling

Mercedes Farjas[1], Francisco J. García-Lázaro[1], Julio Zancajo[2], and Teresa Mostaza[2]
1. Universidad Politécnica de Madrid, Spain
2. Universidad de Salamanca, Spain

This paper describes research related to multi-scale measurement and documenting of any spatial objects or spatially-linked information, covering, but not limited to cultural artifacts, prehistoric sites, and archaeological landscapes. The aim is providing the practitioners of human sciences with quality-controlled metric and geometric descriptions of any material elements concerning their disciplines. The starting point of this paper is a brief reference to some previous works participated by any of the authors, including a Photogrammetric Survey of pictographs in Altamira Cave and several geodetic, cartographic and GIS works, together with 3D modeling of graves and petroglyphs. A review follows of current 3D point-cloud data capture methods

covering both, laser-scanner and photogrammetric methods. Some study cases out of the authors´ current research are then presented, describing and evaluating methodologies applied in each work. Among these study cases the most relevant are Atapuerca, the eldest human settlement in Europe known up to now. Close-range and long-range laser scanners were used to document the stratigraphies of the caves, as well as fossils and other findings. Low-altitude photographs were taken from a remote-controlled helicopter. Spatial data were georeferenced by means of GPS technologies. Another case study concerns paleographic pieces modeling. A different kind of problem arises in this task, covering features in the small scale. An inscribed late-Roman brick, used to cover a medieval grave, has been surveyed by photogrammetric methods to build up a 3D model of the engraved characters, the resolution being on the order of a few tenths of a millimeter. The methodology developed in this work can also be useful when applied to other kinds of engraved lines, such as those of petroglyphs. In most of these study cases, research and education were combined, the works having been done by students directed by the research authors, using the new teaching methods like project-based learning, in the framework of Intensive Program activities included in the ERASMUS Program.

KEYWORDS: 3D scanning, point cloud, photogrammetry

Mesoamerican Sculpture: From 3D Documentation to Dissemination

TRAVIS F. DOERING and LORI D. COLLINS
University of South Florida, United States of America

The use of close-range 3D laser scanning for documentation of ancient Mesoamerican sculpted artifacts (e.g., stone, ceramic, stucco, wood) provides significant advantages in issues of conservation, research, analysis, and dissemination. A series of case studies will illustrate how scan data have been used as a core element in the development of expandable research databases that offer benefits and advancements to archaeological investigations. Results from this approach have substantially expanded opportunities for international study and collaborative research initiatives. Innovative techniques for the examination, analysis, and interpretation of Mesoamerican sculpture, the development of research and educational resources, metadata documentation, and methods of electronic dissemination are discussed. Results from projects in the United States, Mexico, and Guatemala will show how researchers have access to data sets that allow for comparative and metrological analyses of size, shape, features, and surface detail of Mesoamerican carved artifacts. Examples include the use of close-range scanning technology as a foundational referent that improve, enhance, and increase the extraction of the detail and information carved and encoded on Mesoamerican sculpture. These objects can be analyzed, visualized, measured, and evaluated more effectively and precisely than if the researcher were in the field or had the physical object in their presence. In addition to other advantages produced by laser scanning techniques, it is possible to disseminate these data resources to an international audience of researchers, educators, students, and interested parties via web-based collaborative platforms.

This type of presentation offers exceptional opportunities for the development of specialized methods for epigraphic and iconographic analysis and interpretation. Along with these benefits, however, come a variety of disparate and controversial issues that must be addressed. Foremost are the rights and privileges of the owners or stakeholders of the artifacts that have to be recognized and protected. Potential problems that could arise from the dissemination of the data must be identified and safeguards put in place to prevent improper use of these data.

Keywords: Mesoamerica, stone sculpture, databases, research tools

Development of a 3D Model for Archiving and Dissemination of the First Hindu Temple at Bhitar Village, Kanpur, India Using Laser Scanning and Digital Photography

Bharat Lohani, N. Balaji, Satyaki Roy, and Onkar Dikshit
IIT Kanpur, India

The brick temple at Bhitaar village, Kanpur, India is the first Hindu temple made of non-perishable material. This temple was built in fourth century C.E. and shows ample signs of decay. A project was initiated with the permission of Archaeological Survey of India to document this temple for purposes of archiving and dissemination. This paper shows the methodology that was followed for carrying out laser scanning and photography of the temple site. ILRIS3D was employed for laser scanning while NIKON200 was used for photography. The temple was scanned from eleven stations to have better coverage. Digital photographs were collected from all these locations. In addition, very close range photographs were collected which provide details of small artifacts on the temple wall. Polyworks has been used for data processing and visualization. The exterior and interior scans and photographs were collected separately. Use of specially designed targets was made to combine several scans together including the interior scans. A 3D point cloud model of the temple was generated which is corrected for the shadows and missing details. The digital images were wrapped over the model for photo-realistic visualization. A polygonal model generated from the above is being currently used in 3D Studio MAX for further improvement of the 3D model and to generate a model which is suitable for dissemination through internet. The work is significant as the field survey planning was able to overcome the difficulties posed by the highly clustered growth around the site. In addition, the interiors of the temple are very small and it was challenging to scan and later combine the featureless scans. Further, we aim to combine high-resolution very close-range photographs with the 3D model generated for completeness of details. The paper will also summarize the problems faced in field data capture and processing of data and possible solutions.

Keywords: laser scanning, documentation, 3D modeling, dissemination

LIDAR Scanning of Elmina (Ghana) (A Slave Fort)

Patricia Seed

University of California, Irvine, United States of America

While many archeological sites are preserved as they were originally built, several interesting sites have been repeatedly rebuilt and enlarged. When such a structure continues to be occupied, it usually becomes impossible to examine the site extensively (remove walls for example) and otherwise take apart an edifice looking for the original building. We used a combination of historical pictures, texts, and architectural drawings recent LIDAR scans to build a 3D model of a currently occupied site that was the largest slave fort in Africa during the fifteenth and much of the sixteenth centuries. The place still in use (although now as a museum) is located at Elmina (Ghana). Originally completed circa 1485, the site operated as an entrepot for gold and slaves for 350 years. The Portuguese operated the fort for 152 years, during which time they made several minor changes. The Dutch defeated the Portuguese inhabiting the fort from 1627-1872 and making several significant changes in the building.The English ousted the Dutch and proceeded to enlarge the Dutch building considerably partly for use as a garrison. While the edifice deteriorated in the immediate post-Independence years, the government of Ghana has restored the English fort as a major source of tourism. However, we wanted to see what the original slave fort looked like. In this way we hoped to learn more about the conditions under which slaves were held in the first 150 years of the trade.

We had access to relatively little information from the Portuguese period—only a few paintings and two brief texts. We did find more information from those who restored the fort, traveler's accounts, Dutch and English paintings of the fort, and architectural drawings (from the Dutch and English periods only). The University of Cape Town recently undertook a LIDAR scan of the entire reconstructed English fort. While the LIDAR data can easily be employed to create a 3D model, we wanted to recreate a 3D model of the original fort. Hence we employed the English and Dutch historical texts, paintings, and architectural drawings to eliminate features that did not feature in forts before the early sixteenth century. Combing the LIDAR data to locate and eliminate features unquestionably from a latter era left us with a core area to examine. Using the remaining areas of detailed LIDAR scans we then compared the heights, and shapes with the earliest surviving paintings of the fort (made between 1500 and 1507). We then matched the features on the LIDAR scan to the paintings and were able to identify the early characteristics of the largest slave holding fort at the end of the fifteenth century. Using Rhino we built a 3D model of the earliest slave fort, thus undertaking a virtual archeological reconstruction of a 524-year-old fort. We are in the process of transforming the output drawings into a 3D animation.

Keywords: LIDAR, 3D modeling, historical archaeology, virtual archaeology, history of slavery

Virtual Reconstruction of a Ceramic Vessel: A Case Study from The Pas, Manitoba

Morgan John Tamplin[1], Kevin Brownlee[2], Leigh Syms[2], Andrew Fallak[2], and Myra Sitchon[3]

1; Trent University, Canada
2; Manitoba Museum, Canada
3; University of Manitoba, Canada

From 1967 to 1972, M. Tamplin directed the excavation of a stratified, multicomponent site (FkMh-5), on the Saskatchewan River at The Pas, Manitoba, Canada. Five radiocarbon-dated occupations span 4000 years: nineteenth-century Historic Period; Precontact Sipiwisk, ca. 1400 C.E.; Avonlea, ca. 900 C.E.; Laurel ca. 400 C.E.; and Archaic ca. 1500 B.C.E. The direct ancestors of the present Opaskwayak Cree Nation (OCN), where the site is located, occupied the 1400 C.E. Sipisik layer. Our 10x14m excavation exposed distinct surfaces sealed by seasonal flooding, revealing cooking hearths, storage pits, and lithic workshops. Associated clusters of sherds were stabilized with gauze and white glue before removal. Vessel reconstruction started at the University of Manitoba in 1972 and continued in 1981 at the Manitoba Museum, supervised by the Curator of Archaeology L. Syms. In 2004, with funding from the Manitoba Museum Foundation, archaeological collections from The Pas were consolidated at the Museum for cataloguing and analyzed. Previously unreconstructed vessels were identified and the originally reconstructed vessels restabilized using new techniques developed by museum conservator A. Fallak. This process has been recorded using traditional drawing, digital photography, and laser scanning techniques. One large fragile Sipisik vessel ("Vessel 2") had many reconstructions that repeatedly collapsed. The vessel was never intended to be permanent and could not support the combined weight of the thin-walled fragmented sherds and their adhesives, which had also deteriorated over time. Each attempted repair further damaged the actual and hypothetical sherd connections. Cumulative angular errors of reconstructed 3D globular vessel portions resulted in mismatched edge connections. If any internal strains set in the initially fired vessel, were released on breakage, it may never be possible to restore the original shape with complete accuracy.

In 2005, museum archaeologists L. Syms and K. Brownlee, supervised the latest reconstruction. M. Sitchon digitally photographed interior and exterior surfaces, scanned it using a Polhemus Fastscan handheld scanner and texture mapped the photographs onto the surface of the scan to colorize the monochromatic surface. In 2007, we located a large portion of rim not included in the earlier reconstruction and scanned it using a higher resolution Nextengine desktop scanner with color capability. The two scans were combined to produce a 3D animated color reconstruction. We are now attempting to use scanned images of potentially connectable sherds to produce non-destructive virtual vessel reconstructions. Digital images of sherds can be matched using shape analysis software and angular errors may be corrected to restore more accurately the vessel's original shape. Tamplin presented earlier results of this research as part of a poster at a CCI symposium in September 2007, published in: *Preserving Aboriginal Heritage: Technical and Traditional Approaches* (edited by

Carole Dignard, Kate Helwig, Janet Mason, Kathy Nanowin and Thomas Stone). Ottawa, Ontario, Canada: Canadian Conservation Institute, 2008, pages 401-403.

Keywords: ceramics, reconstruction, scanning

A Future for the Past: Use of Digital Technology in Preserving a Twentieth-Century Legend

Shamim Javed, Robert P. Schubert, and Ki-Hong Ku
Virginia Tech, United States of America

Tuesday

The Rice House by the west coast architect Richard Neutra in the only example of the Modern Movement's International Style residence in the city of Richmond, Virginia. Built less than fifty years ago, its inclusion in the National Registry of Historic Places testifies to its importance. The present research is an ongoing effort to document and analyze the existing condition of the house and suggest to its current owner, the Science Museum of Virginia, strategies for its renovation that would ensure a viable future for this house without destroying its architectural charm. The present paper specifically looks at the tools and techniques used for documenting and analyzing the Rice House. 3D laser scanning is used to document the physical characteristics of the building. The paper compares this technique with solid modeling of the house in other software to show the strengths and weaknesses of the 3D laser scanner as a documentation tool for buildings. The use of thermal imaging to identify points of heat-loss from the building, combined with recordings of its temperature and humidity levels using portable data-loggers, is fed to energy-modeling software to arrive at solutions that can bring the energy performance of the Rice House to current standards. Lastly, an attempt is made to assist collaboration amongst the various parties involved in preserving the house by use of a virtual immersive environment. The paper ends with a summary of lessons learned so far in this on-going research activity to ensure a future for this beautiful past—lessons that may well inform preservation efforts of similar icons of twentieth-century architecture.

Keywords: 3D laser scanning, thermography, digital collaboration

Session Summary

Tuesday, 8:30am-3:00pm, Tidewater C

Why Did It Take So Long? Spatio-Temporal Modeling and GIS

Chairs: Ian Johnson, University of Sydney, Australia
Ruth Mostern, University of California, Merced, United States of America
Cathy Campbell, University of Sydney, Australia

One might expect archaeologists and historians to be early adopters—or indeed demanders—of spatio-temporal GIS, dealing as we do with objects and events situated in space and time. Yet GIS and 3D reconstruction have remained largely atemporal. Where time is addressed at all, it is generally in the form of layers or alternative views at different periods (snapshots), more rarely in the form of objects with time stamps allowing filtering of extant material for different dates. Little serious attempt has been made to address issues such as the representation of temporal uncertainty. The reasons, we believe, are to do with the often imprecise nature of historical and archaeological dating—we deal with periods, with *terminus post* and *ante quem* dates, with indirect observations, with observations made during an extended period rather than dating the beginning or end, with statistical dating errors, with dating by association and so forth. The resolution of our observations often varies within a single corpus depending on the circumstances of discovery or the nature of the phenomenon recorded (site, shard, settlement, battle, etc.).

For these reasons, most research in the area of spatio-temporal systems deals with contemporary phenomena where the data is more easily defined and collected. Archaeologists and historians therefore have particular needs which are less likely to be addressed by mainstream spatio-temporal research. However, over the last couple of years, papers on temporal modeling and temporal GIS have started to appear in the CAA program. It therefore seems timely to bring these papers together into a special session to review the current status of spatio-temporal work and its application in our domain, to share ideas, to define how our needs differ from work on contemporary material, and perhaps to stimulate new collaboration.

We invite papers which review attempts to integrate spatial and temporal information, papers which provide theoretical or methodological insight into the issues of spatio-temporal modeling and analysis in the history and archaeology, and papers which provide practical examples of spatio-temporal GIS or visualization in action. Papers proposing original approaches and new directions are also invited. To provide a concrete outcome for the session, we plan to produce a short annotated bibliography of spatio-temporal applications in archaeology and history, which will be published on the web using Heurist (http://HeuristScholar.org), allowing ongoing addition and discussion around the topic. We will ask participants to provide key bibliographic references and/or web sites prior to the session for inclusion in the bibliography and to kick off discussion—we plan to conclude the session with a roundtable discussion, with the aim of developing a 'manifesto' identifying the current status and particular needs of this domain.

TOPICS: agent-based models, GIS, other

KEYWORDS: spatio-temporal systems, spatio-temporal modeling, simulation, historical events, timelines

Schedule

8:30 – 8:50	"Introduction: Finding the White Mice: There's More to Spatio-Temporal GIS Than What, Where and When…" Ian Johnson, Ruth Mostern, and Cathy Campbell
8:50 – 9:10	"Spatio-Temporal Dimensions of Population History, Settlement Patterns, and Landscape Archaeology in Orkney (1750 to 2000)," Timothy Michael Murtha, James Wood, Patricia Johnson, and Stephen Matthews
9:10 – 9:30	"Niche-Based Subsistence: Foraging in Heterogeneous Landscapes," Jubin J Cheruvelil
9:30 – 9:50	"Time as a Hidden Dimension in Archaeological Information Systems: Spatial Analysis Within and Without the Geographic Framework," Ladislav Smejda
COFFEE BREAK	
10:15 – 10:35	"ToToPI (Topography of Tours in the Pre-Industrial Era), a GIS for Understanding Urban Dynamics Based on the OH_FET Model (Social Use, Space, and Time)," Xavier Rodier, Laure Saligny, and Bastien Lefebvre
10:35 – 10:55	"How to Describe and Show Dynamics of Urban Fabric? Cartography and Chronometry," Lefebvre Bastien
10:55 – 11:15	"Models for Complex Spatio-Temporal Relationships and their Implementation Using Open Source Components," Riyaz Fazal
11:15 – 11:45	Round Table Discussion, "Developing a Manifesto for Event-based Spatio-temporal Modeling and Visualization"
LUNCH	
1:30 – 1:50	"eWilliamsburg2: Spatio-Temporal Modeling the Colonial Past," Joshua Travis Muse, Peter Anthony Inker, and Jessica Curci Krop
1:50 – 2:10	"Reconstruction of *Machiya* Landscape: 4DGIS Comprising Spatial and Temporal Dimensions," Ayako Matsumoto Katsumura, Takafusa Iizuka, Ritsumeikan University, Japan; Keiji Yano, Tomoki Nakaya, Tatsunori Kawasumi, Yuzuru Isoda, Yutaka Takase, Keigo Matsuoka, Toshikazu Seto, Dai Kawahara, Akihiro Tsukamoto, Manabu Inoue, and Takashi Kirimura
2:10 – 2:30	"GIS Database on the State of Deterioration of the Buildings in Volubilis Archaeological Site (Morocco): Example of a Risk Map," Abdelilah Dekayir, Sihame Essalmi, and Hassane Limane

2:30 – 2:50 "A Contribution to the Study of the Defence of the City of Lisbon," Maria Helena Rua
2:50 – 3:00 Discussion

Abstracts

Spatio-Temporal Dimensions of Population History, Settlement Patterns, and Landscape Archaeology in Orkney (1750 to 2000)

Timothy Michael Murtha, James Wood, Patricia Johnson, and Stephen Matthews
Penn State University, United States of America

Between 1750 and 2000 C.E., the northern islands of Orkney (Scotland) underwent a major cycle of population growth and decline. After several hundred years of what was a presumably stable population regime, these island communities experienced significant population growth between 1780 and 1850 (roughly), followed by severe population decline. The population decline observed in Orkney during the past century (the modern demographic transition) was late to begin (nineteenth Century) and was accompanied by massive net out-migration, leaving a complex archaeological landscape covered with the remains of households, field boundaries, and agrarian improvements. Our project is attempting to understand spatio-temporal dynamics of this population history within the context of the transition from near-subsistence farming to modern, commercialized livestock rearing. Unusual for archaeology and historical demography, we are linking archival documents, census data, and historic cadastral maps to archaeological surveys and geospatial information on houses, farmsteads, and the past environment. To better inform our research, we are linking these data to ethnographic observations of the recent changes (the past eighty years or so).

Generally, we offer traditional approaches to historical demography, which rely more or less exclusively on written documents, can be narrow and produce demographic reconstructions that are often decontextualized. Conversely, we believe that information from historical demography can be more effectively integrated into broader anthropological and archaeological research questions. We argue that combining historical demographic research with methods and models from landscape archaeology, settlement archaeology, spatial analysis, and oral history is critical way to understand the spatio-temporal dimensions of past settlement, landscape, and population dynamics. In this paper, we use a sub-sample of data from the islands of Westray and Sanday to compare the spatial distribution of households using multi-scale point pattern analysis in order to ascertain the extent to which surviving archaeological remains can capture the historically documented settlement patterns. We also link archaeologically-surveyed farmsteads to the well documented population history to analyze the extent to which household form, size, and composition (and the temporal variation in those factors) are reflected in the physical remains of now abandoned and farmhouses (a fundamental problem in archaeological estimation of past population size and settlement dynamics). For example, we examine the role of "hidden household extension" within pre-industrial agrarian systems comparing historic population records with buildings archaeology. Finally, we place the spatial distribution of houses and farmsteads in their landscape context using information derived from remote sensing (satellite imaging, aerial photography), land-productivity surveys, and old cadastral and OSGB maps, to better interpret the settlement ecology of Orkney after 1750.

Keywords: historic archaeology, demographic archaeology, settlement patterns, GIS, spatial analysis

Niche-Based Subsistence: Foraging in Heterogeneous Landscapes

Jubin J. Cheruvelil
Michigan State University, United States of America

In the American Midwest, hunter-gatherer societies use diverse subsistence strategies to cope with environmental variability on the landscape. During the Late Archaic, Early and Middle Woodland periods in Saginaw Watershed of Michigan, foragers are observed to focus heavily on wetland resources. However, no model of subsistence has evaluated the behavioral strategies that would result in these observations. Specifically, the implications of landscape context (i.e., spatial organization, structure and scale) and resulting subsistence strategies has not previously been undertaken. Using ecological and spatial concepts of habitat and patch, the heterogeneous landscapes of the study area is reconstructed to evaluate the probability of available and selected resources. Further, ecological concept of communities and niches with ethnographic and ethnohistoric background data are used to determine spatial resource preferences, behavioral strategies and the general subsistence strategies. This task has been accomplished by the use of various tools, including GIS, agent based modeling environments, relational databases and ecological models. The landscape reconstruction has been undertaken with the use of GIS tool set. The ecological data is managed by relational databases and linked with the aforementioned GIS spatial data. An agent based forager model is used to simulate hunter gatherer behavior in order to determine probable forager behaviors. Further, the results of these models are applied to the archaeofaunal, archaeobotanical data sets and site distributions from the study area. The analysis of landscapes, simulations and archaeological data suggests niche-based strategies that vary both spatially and temporally to cope with environmental variability.

Keywords: human behavioral ecology, predictive models, agent-based models, landscape modeling

Time as a Hidden Dimension in Archaeological Information Systems: Spatial Analysis Within and Without the Geographic Framework

Ladislav Smejda
University of West Bohemia, Czech Republic

The timeline certainly represents an indispensable structuring principle in most archaeological studies. Yet it is in no way a straightforward task to incorporate time into GIS models. The reasons for this difficulty are manifold and almost any GIS project can provide its own unique combination of problems. Instead of looking for any kind of all-purpose remedy we have to develop strategies taking into consideration particular contexts. One issue, however, seems to be of principal importance everywhere: the initial assessment of the formation processes and post-depositional transformations that may have affected the archaeological record. The recognition of the ratio of human intentions and natural forces in the taphonomic history of archaeological deposits, as well as the time span during which these factors were effective would ideally set the scene for any sound data analysis. This is not merely the matter of simple site dating; perhaps more importantly this relates to the question of quantitative structural distortions of excavated data in comparison with the situation in living culture (effects of fragmentarization, reduction and accumulation). The processes of this kind have usually influenced the present-day appearance of archaeological sites and deposits more than human activities that originally produced them. On these theoretical grounds we can critique traditional distribution maps that remain so popular in archaeology. Quite obviously, they grasp time as a discrete variable, divided into archaeological stages of considerable duration. Therefore, they frequently include elements that were not *sensu stricto* contemporary. Second, distribution maps usually do not contain some features that existed and belonged to the human world at a period of our interest, for instance because their occupation had already ceased, yet they could continue to figure in myths and rituals. To some extent, this applies to plans of archaeological sites too, as we can only rarely bring evidence that all excavated houses (to give an example) in a given stratigraphic layer were built and abandoned at the same dates. However, our synoptic (asynchronous) plans and maps look too tempting in terms of apparently providing a firmer ground for interpretation. Unfortunately, the problem cannot be resolved with ease, because time cannot be observed on archaeological finds directly and must be derived from the complex process of archaeological inference.

My paper will highlight problems emanating from this matter for a GIS user and will introduce an approach that may potentionally avoid at least some of them, asking research questions rather differently. It will be done through a comparison of the traditional GIS application, based on the concept of geographical space, with new experiments, where the spatial analysis is understood more broadly. The exposition will demonstrate that GIS can successfully model relationships of many archaeological phenomena, be they primarily geographic or not. Maps and plans—quite understandably—cannot explain entire chronological variability in our data. To move beyond their limits, other (non-geographical) spatial models may be built and analyzed in GIS, taking advantage of the mathematical branches known as linear algebra, graph theory, and topology.

Keywords: spatial models, chronology, linear algebra, graph theory, topology

ToToPI (Topography of Tours in the Pre-Industrial Era), A GIS for Understanding Urban Dynamics Based on the OH_FET Model (Social Use, Space, and Time)

Xavier Rodier[1], Laure Saligny[2], and Bastien Lefebvre[1]
Centre National de la Recherche Scientifique, France

Tuesday

ToToPI, for Topography of Tours in the Pre-Industrial era, is a GIS for studying the city of Tours (France) in large time span. The aim of this presentation is to explain how GIS is used for historical data processing to understand time-space dynamics. The proposed principle for understanding the urban dynamic is based on considering the town as a set of complex objects, taking a systemic approach. The town system used to study the urban fabric over large time spans is composed of three sub-systems relating to historical objects from the level of the excavation to that of the former urban space: function (social use), space (location, surface area and morphology) and time (dating, duration and chronology). The historical object is the analytical unit of the space studied. It is the Cartesian product of the three sets, Social use, Space and Time, from which it stems. The OH_FET model is based of this process. The Historical Object (OH) is broken down into three types of simple object, functional (EF), spatial (ES) and temporal (ET).

- The thematic approach to the OH in an urban environment is based on social use, organized according to a hierarchical thesaurus.
- Space, the most formalized of the three sets, is structured on the model of a planar topological graph without isthmi.
- Time, always considered as continuous and linear, will be modeled by analogy with space using temporal topology defined in the field of artificial intelligence.

The relationships between these three sets each characterize an interaction (social use-space, social use-time, time-space, or function-space-time). In addition to reconstructing the OH, they allow urban changes to be observed by analyzing the distributions and mapping of each of the entities singly or two-by-two. The originality of this procedure lies in its approach whereby it is possible to start not from the mapping of a phenomenon at a time *t1* and comparing it to that at a time *t2*, but to look at it in the same way whether its input is social use, space or time. Different analyses lead to an overall view of the social, spatial and temporal structure of the selected OH. For example, the time pattern can be represented as a whole, illustrating the structure of time. The heuristic value of this modeling lies in the shift from description (what, where, when) to understanding the phenomena of change (how, why). The Implementation of OH_FET model in ToToPI, with classical GIS software (ArcGIS from ESRI), makes possible on one hand the analysis of data sets in large time span and on the other the creation of new analyses and of new products which result from it as the time pattern.

Keywords: spatio-temporal modeling, town, urban functions, spatial dynamics, temporality, GIS

How to Describe and Show Dynamics of Urban Fabric Cartography and Chronometry

Lefebvre Bastien
Laboratoire Archéologie et Territoires, Université de Tours, France

To understand the dynamics of an urban fabric, it is necessary to consider an alternative approach to that provided by traditional historical topography. This alternative places less stress on the situations than on the transformations of urban objects. If defining these objects is the first stage of the modeling, the second is to deconstruct their components in order to analyze the dynamics of the whole and to consider them according to their functions, spatial and/or temporal. This deconstruction, which is based on the notion of simple objects and complex objects, was used as a basic principle for the spatial analysis of data but also, more innovatively, for modeling and analysis of time. Indeed, while it is a common practice to perform spatial analysis in archaeology, this practice is limited in that it looks at objects in a fixed state, to compare two predefined statements: there is rarely an analysis of the temporal dimension. Nevertheless, it seems is possible to model both space and time in a similar way. This is what I propose in my doctoral research about the formation of the urban fabric on the site of the Roman amphitheatre at Tours. This modeling of the dynamics of the urban fabric (streets, plots, but also buildings that emerge from the ancient amphitheatre) allows us to identify and to describe the processes resulting in the formation of the urban space in the Medieval and Modern Periods. Implementation of the model in GIS allows a series of analyses, to understand the dynamics of the formation of the urban fabric. If traditional GIS is able to manage and produce requests from spatial analysis, it cannot analyze time. In general, cartography represents phenomena on a geohistorical scale, yet there is no equivalent time. The expression of "chronography" which form part of the time pattern is a formulation that I propose to remedy this lack.

Keywords: spatio-temporal modeling, spatio-temporal analysis, urban fabric, timelines

Models for Complex Spatio-Temporal Relationships and their Implementation Using Open Source Components

Riyaz Fazal
Recording Heritage Network, United States of America

Spatial and temporal aspects of an object, site, area, region, event, age, era or epoch have always been important in historical or archaeological documentation or description. The visualization of spatial dimensionality is well modeled by geospatial systems. Timelines are used for visualizing serial progression along the temporal dimension. Often it is the linkage between the temporal and spatial dimensions that is more illuminating. Functionality for visualization of spatio-temporal relationships is not available in standard GIS. TimeMapTM (Johnson, 2004) is a system that records and delivers time-stamped spatial data. It is made up of a Windows-based data and map preparation application and a Java-based application to deliver the visualization of the

Tuesday

dynamic spatio-temporal relationships. KML, the standards-based format for the data displayed on Google Earth has been extended so that spatial objects may have temporal attributes (http://code.google.com/apis/kml/documentation/time.html). For data containing the time attributes (time span or time stamp) the Google Earth application displays a time slider control. Timeline is an Open Source tool developed by the SIMILE project (http://simile.mit.edu/timeline/) for the dynamic visualization of complex, nested timelines. Visualizations that integrate such complex and nested timelines with spatial objects would provide enhanced tools for describing historical and archaeological subjects. The purpose of this paper is two-fold. The first is to describe the data and relationship models that enable the complex linkages between temporal and spatial objects. Modeling temporal aspects as attributes that are subordinate to spatial objects is restrictive. Temporal objects may not be continuous (e.g., the Mughal emperor Humayun's reign had a break while he was in exile). Gaps exist in spatial objects as well. Temporal objects may be nested (e.g., Humayun's reign was part of the Mughal empire period). Modeling the spatial and temporal objects as separate entities having parity, and defining complex relationships between them provides more flexibility. Data structures implementing the models are shown, as are examples of usage. A second purpose is to describe the use of Open Source and Geoweb components for implementing the data model, the data preparation interface, and the visualization interface. With the level of sophistication of Geoweb tools it is not necessary to start with a GIS to create the spatial objects. Geoweb tools already have the map background tiles (road map, satellite imagery, or terrain) and the spatial objects in the visualization are overlaid on these backgrounds. Rich internet application tools now enable dynamic interfaces and visualizations in web browsers.

I. Johnson, "Putting Time on a Map," *GeoInformatics*, July/August 2004.

KEYWORDS: spatio-temporal models, Open Source, KML, Google Earth

Tuesday

eWilliamsburg2: Spatio-Temporal Modeling the Colonial Past

JOSHUA TRAVIS MUSE, PETER ANTHONY INKER, and JESSICA CURCI KROP
The Colonial Williamsburg Foundation, United States of America

Williamsburg's restoration to its eighteenth-century appearance is based on exhaustive documentary and field work by several generations of scholars. The Colonial Williamsburg Foundation's Digital History Center (DHC) was created to direct digital initiatives for the Division of Research and Historical Interpretation. Founded in 2002, the DHC uses innovative technologies to engage the public in continuing conversation about the American Revolution, citizenship, and democracy. eWilliamsburg is a multi-phase project designed as an access point for Colonial Williamsburg's research departments, interpreters and academic scholars, and the general public to gain information about the past. The first phase of eWilliamsburg set up a database of information retrieval accessed through GIS technology, to perform geographic queries and access reports written about specific structures. eWilliamsburg2 is the second phase of this ongoing project and is designed to produce a spatio-temporal visualization of the development of the city throughout the course of the eighteenth-century. Firstly, a synthesis of the archaeological, architectural and historical evidence was put together, merging existing interpretations with new work. The resulting information formed a database containing both temporal and spatial information on extant structures and inhabitants in eighteenth-century Williamsburg. The building foundations and their occupants were recorded using five different parameters of certainty, ranging from definite to unknown. The specific locations of the identified structures were defined using GPS and then plotted in GIS; additionally, period topography was recreated by digitizing the data from topographic maps drawn before the city's historic reconstruction. Combined, these strategies aim to make the final map as accurate to the original land and cityscape as possible. This project is still ongoing and once finished, will provide a complete visualization of the history of the city, which the user can query chronologically by year or spatially by area. Ultimately, the aim is to provide Colonial Williamsburg employees, academic researchers, and members of the public with a unique spatio-temporal understanding of Williamsburg's changing structural landscape and its occupation throughout the eighteenth century.

Keywords: spatial temporal GIS interactive

Reconstruction of Machiya Landscape: 4DGIS Comprising Spatial and Temporal Dimensions

Ayako Matsumoto Katsumura[1], Takafusa Iizuka[1], Keiji Yano[1], Tomoki Nakaya[1], Tatsunori Kawasumi[1], Yuzuru Isoda[2], Yutaka Takase[1], Keigo Matsuoka[2], Toshikazu Seto[1], Dai Kawahara[3], Akihiro Tsukamoto[1], Manabu Inoue[4], and Takashi Kirimura[1]

1. Ritsumeikan University, Japan
2. Ritsumeikan Asia Pacific University, Japan
3. CAD Center Corporation, Japan
4. St.Agnes University, Japan

The purpose of our project is to reconstruct the *Machiya* landscape of Kyoto since the late nineteenth century. A *Machiya* is a Japanese traditional town house built between the eighteenth century and World War II. Unlike other cities in Japan, Kyoto was spared from wartime air raids and thus retains numerous buildings from the pre-war period, such as Machiyas, temples, and shrines. There are 1,300 temples and 350 shrines, and 375 of them are designated or registered historical buildings. On the other hand, almost no Machiyas have been protected by any policy system in spite of their impact on the landscape. We estimate that there are 50,000 Machiyas in the city, but this number decreases by 2% per year as they are replaced with modern houses and high-rise buildings. Kyoto City is now seeking ways to protect Machiyas and is collaborating with Ritsumeikan University to study Machiyas with information technologies. We've already built 4DGIS "Virtual Kyoto" made up of series of 3DGIS at different points in time, constructed by integrating current digital maps, old topographic maps, cadastral maps, aerial photos, picture maps, street photos, landscape paintings, archaeological sites data, and historical documents (Yano *et al.*, 2007; Yano *et al.*, 2008; see also our

web site at http://www.geo.lt.ritsumei.ac.jp/webgis/ritscoe.html). In this reconstruction of historical Kyoto, we first modeled present-day Kyoto as a virtual city and then substituted older, no longer extant buildings, many of which are Machiyas. Machiyas data will certainly be of great importance to connect each time slice of GIS data and will make it possible to analyze Kyoto's landscapes and architectural history over time.

Through "Virtual Kyoto," we can disseminate Kyoto's subtle and sophisticated forms of culture and the arts to the world over the Internet. The web-based system provides user-friendly interface: fly-through, walk through, landscape simulation, and bi-directional information exchange system corresponding to the web 2.0. Surveys of Machiya and reconstruction of the Machiya landscape will contribute to enhance accuracy on such information platforms.

Yano, K., T. Nakaya, and Y. Isoda, eds. (2007). *Virtual Kyoto*. Nakanishiya.

Yano, K., T. Nakaya, Y. Isoda, Y. Takase, T. Kawasumi, K. Matsuoka, T. Seto, D. Kawahara, A. Tsukamoto, M. Inoue, and T. Kirimura, 2008. "Virtual Kyoto: 4DGIS Comprising Spatial and Temporal Dimensions," *Journal of Geography,* 117(2): 464-478.

Keywords: virtual cities, historical GIS, 4DGIS, visualization, Kyoto

GIS Database on the State of Deterioration of the Buildings in Volubilis Archaeological Site (Morocco): Example of a Risk Map

Abdelilah Dekayir[1], Sihame Essalmi[2], and Hassane Limane[2]

1. Moulay Ismail University, Meknes, Morocco
2. National Institute for Archaeology and Cultural Heritage (INSAP), Rabat, Morocco

The site of Volubilis conforms to several of the criteria for inscription in the World Heritage list. The archaeological remains of several civilizations have been found, representing all the phases of its ten centuries of occupation, from prehistory to the Islamic period. Volubilis has produced a substantial amount of artistic material including mosaics, marble and bronze statuary, and hundreds of undescribed features in situ. This documentation and all that which remains to be discovered, is representative of the creative spirit of the people who lived there over the ages. Many of the existing monuments—columns, capitals, arcades, etc.—have been restored and demonstrate the monumental and architectural importance of the city in a tangible way. The buildings of Volubilis are for the most part constructed using grey-blue limestone quarried at nearby Zerhoun massif. These buildings are notable for the large number of floor mosaics still in situ. In this site, the majority of historic monuments and buildings suffer greatly from cracking as well as chemical and physical weathering. Additionally, degradation of the buildings' walls has occurred due to the soil gravitational creep phenomena, etc. In this study, a great number of buildings (~1000 units) were inventoried. The weathering and degree of deterioration was identified and classified. By using GIS, it was possible to manipulate large amounts of geographical and archaeological spatial information which otherwise would be difficult or impossible to accomplish. GIS offers management of the archaeological environment in a useful and practical fashion to fulfill the needs related to the conservation and restoration. All the GIS-georeferenced archives and maps concerning the monuments and buildings which were studied provided a well-rounded understanding about the state of the archaeological site. This was then used to characterize to the most degraded areas which require the most care and awareness.

Keywords: Volubilis, degradation, Soil creep, risk map, cultural heritage

A Contribution to the Study of the Defense of the City of Lisbon

Maria Helena Rua
Instituto Superior Técnico, Portugal

While the city of Lisbon remained contained between walls, the question of safety was taken care of by a remarkable structure. What ensued, whether at time of the original nucleus (the Moorish enclosure—occupied from 1147 C.E.) or at the time of the expansion brought about by the wall built by King D. Fernando (1375), to update the city so that it could shelter of the growing population, was that the quarters where the "infidels" congregated were strategically ignored. The problem arose when King D. Manuel (of Portugal) decided to concentrate on trade and thus installed himself in a palace close to the river front (Ribeira Palace, 1498), more in keeping with his objectives and image. The enclosure ceased to make any sense, was absorbed by buildings that abutted it, and new political-administrative limits were established, because to live in the city implied a tax on the resident. The construction of a new wall, motivated by growth and by the need to define the new city, nevertheless accommodated technological progress and was substituted by a coastal defensive system, because it was from the sea that new threats from pirates and corsairs came. On land, the occupation was balanced and it remained so, at least until the French invasions. Although the need for land defenses was less pressing, it is very probable that they were not neglected: they were merely outside the public domain. If we accept that this concept of defense strategy was, little by little, established on the ground and kept up to date, in relation to the equipment used and urban pressure, then it might be thought that the natural evolution of raising lines of defense would be in concentric circles, developing outwards, whenever necessary. In the same way, the construction of a new line of defense implied re-numbering, since in military terms, the first corresponds to the first confrontation, where military engagement is concerned. The lines of defense draw together two types of strategy: passive, that of observation and communication, to allow distribution of resources; active, that of combat when in imminent danger. The success of this sequence depends on how quickly it can be put into action. If the aim is the defense of the capital, where the military decision-making centers are found, the hope is that communication with the centre can be established at each and every segment of this line. This has not been satisfactorily substantiated where the Lines of Torres Vedras are concerned. Nonetheless, this research work has made it possible to develop the computer-generated model of the Lines of Torres Vedras, which reconstructs the terrain and the hill forts built there. This allowed the first measurements to be taken—of

technical aspects of the defenses, i.e., the determination of data corresponding to the drawing up of building specifications. In turn, this enabled the military strategy (on the ground) to be evaluated, the results of which are presented here.

Keywords: archaeological-environmental patterns, 3D model, regional BD, virtual reality

Session Summary

Tuesday, 8:30am-3:00pm, Tidewater D

Integration and Sharing of Cultural Information Resources

Chair: Klaus E. Werner, Capitoline Museums, Italy

Tuesday

Cultural heritage organizations—public or private museums; national and federal heritage agencies, cultural institutions, public archives—rely on many different kinds of information resources for their day-to-day work. Most of these are held in autonomous containers like word documents, databases, spreadsheets, image files, etc. which were not originally meant to interact with other resources. This scenario is gradually beginning to change. We think it was actually the introduction of XML as *lingua franca* of most underlying file formats (or, where not as file format, so at least as metadata format) that made people aware of the potentialities of seeing data and documents as differently structured containers of information, which can and should to be accessible via a common API. The in-house use of standardized APIs and the subsequent opening up and linking of information resources inside the cultural organizations themselves inevitably led to the idea of federated networks, which would connect these same information resources to different cultural heritage organizations. Technically simple mechanisms like RDF/RSS feeds would allow ad hoc aggregation of resources from different "knowledge domains" (Englebart). Much of this is still in an early phase but one thing is clear: the possibility of search, retrieval, repurposing, and aggregation of structurally different information resources originating from different knowledge domains will lead to greater contextualization of cultural objects—something that seemed to have been lost long ago, even before every institution began storing its information in closed data silos—and, as a side-effect, lead to more collaboration between cultural heritage organizations.

The session will therefore concentrate on three points: (1) the content of the information resources we think worth exposing, (2) the laborious reconstruction of the context between cultural objects and information resources, (3) the collaboration (technical and organizational) between different cultural heritage institutions.

Topics: databases, data management systems and other field applications, other

Keywords: information resources, cultural heritage, API, mash-up, knowledge domain

Schedule

8:30 – 8:50 "A Unified System for the Management of Information Resources: The Case of the Capitoline Museums, Rome," Klaus Werner

8:50 – 9:10	"Archiving Archaeological Spatial Data: Standards and Metadata," Robert Shaw, Anthony Corns and John McAuley
9:10 – 9:30	"Development of an Archaeological Spatial Data Infrastructure (SDI): Democratising Tools and Sata," Anthony Corns, Robert Shaw, and John McAuley,
9:30 – 10:00	"Site GIS's Technological Development, Status, and Benefit at Taiwan," Jr Jie Jang and I-Chun Fan
Coffee break	
10:15 – 10:35	"AMASDA Online: Creation and Implementation of an Online Site and Project Management System and GIS for the State of Arkansas," John Richard Samuelsen
10:35 – 10:55	"How to Establish National Satabase Systems: Cooperate or Dictate?" Espen Uleberg and Joel Boaz
10:55 – 11:15	"Grass Roots Imaging: A Case Study in Sustainable Heritage Documentation at Chersonesos, Ukraine," Adam Rabinowitz, Carla Schroer, and Mark Mudge
11:15 – 11:45	"Integrating and Querying Diverse Digital Resources in Classical Epigraphy," Mark Hedges, Tobias Blanke, Stuart Dunn, and Gabriel Bodard
Lunch	
1:30 – 1:50	"Sharing Interpretation with Virtual Reality Web Labs," Sofia Pescarin
1:50 – 2:10	"Visualizing the Past: Tools and Techniques for Understanding Historical Processes," James W. Wilson
2:10 – 2:30	"Digitizing the Material World of Williamsburg," Jeffrey Eugene Klee
2:30 – 3:00	"Extending Archival Standards to Support Graphical Documentation," Jose M. Aroza, Celia Moncada, and F. Javier Melero

Abstracts

A Unified System for the Management of Information Resources: The Case of the Capitoline Museums, Rome

Klaus E. Werner
Capitoline Museums, Italy

The Capitoline Museums, Rome, have implemented a strategy for a management of its information resources. These resources reside on different supports and formats (both physical and digital), have different times of origin (in our case, from the middle of the fifteenth century until today) and are physically stored on different domains (museum A, institute B). But to museum researchers and users alike we must present all resources together or, where centralization is not possible, at least reference each other. Our approach aims therefore at a contextualization of each museum object across inventories, documents, data, media, including application

data, across different and even remote domains. Our paper describes the transfer of documents, including archival documents, and so-called flat or tabular data into standardized or ad hoc developed XML dialects (depending on the source material); the use of an URN-based system for referencing purposes; the deployment of an XML repository for all types of information resources; and finally the integration of remote resources located in other museums, archives and institutes which have agreed on data sharing. Special attention will be given to technical solutions:

- The use of XML as exclusive document and data format or, where this isn't not possible (binary files), at least as metadata format (DocBook/T EI for text documents, museum records in XML/RelaxNG dialect, tabular data in ad-hoc developed XML schemata, image metadata in XMP, geographical references in GML etc.).
- The definition of object references as URNs, normally inside an Xlink expression.
- The use of a XML repositories for all information resources (document/data/meta data).
- The use of XQuery for building contextual relationships across all materials/collections/repositories (local and remote).
- The query & retrieval system for remote repositories using RDF/RSS feeds.

Finally, some actual examples will show how this holistic approach to information resources can greatly promote actual research.

Keywords: museum information resources, data interchange, XML repository, XQuery, RSS

Tuesday

Archiving Archaeological Spatial Data: Standards and Metadata

Robert Shaw[1], Anthony Corns[1], and John McAuley[2]

1. The Discovery Programme, Ireland
2. Digital Media Centre, Dublin Institute of Technology, Ireland

The Spatial Heritage& Archaeological Research Environment I.T. (SHARE IT) project was a collaborative venture supported by the Heritage Council (Ireland) under its Irish National Strategic Archaeological Research Programme 2008. Partners were drawn from research (the Discovery Programme), academia (School of Archaeology, UCD; Digital Media Centre, DIT), and archaeological consultancy (Margaret Gowen Ltd) with the aim to develop a strategy for the archiving and dissemination of spatial archaeology landscape data sets, initially LIDAR, aerial orthoimagery and geophysical survey. The project goal was to develop a pilot web mapping application tool for data exploration and use in further research. One of the key research challenges was to identify a suitable digital archiving strategy for spatial landscape data and this was approached by a review the current best practices that have been adopted within the cultural heritage sector and within the wider professional community. Standards organizations specific to cultural data such as the Archaeological

Data Service (ADS) and ARENA (Archaeological Records of Europe “ Networked Access) were consulted on their prescribed policy. Issues addressed included:

- What are the adopted data formats and standards for the sharing and long term archival preservation of digital spatial data?
- Are there any prescribed metadata formats associated with the storage of digital archaeological and spatial data that should be adopted?
- Are there any standards organizations that can assist and integrate Irish digital spatial data into an international framework?

Tuesday

This paper discusses the findings of this process and how it shaped our recommendations for the management of spatial archaeological landscape data and the development of an archiving policy. Amongst the topics it will consider are:

- The importance of the OAIS model as an archival system.
- The need for metadata schema compliant with international standards such as ISO 19115 and INSPIRE.
- The advantages of expanding keyword fields to include controlled vocabularies and thesauri to standardize the description of geographical and cultural components.
- The definition of “preferred” data formats for archiving and dissemination of information.
- The need for a comprehensive copyright and access policy to accompany the archiving process.
- The financial implications and cost models available to calculate the lifecycle costs of implementing an appropriate archival strategy.

In conclusion the paper will consider how the understanding gained from this approach to archiving spatial data may be applied to a wider range of cultural digital resources.

KEYWORDS: OAIS, cultural heritage, spatial data, thesauri, archiving

Development of an Archaeological Spatial Data Infrastructure (SDI): Democratizing Tools and Data

ANTHONY CORNS[1], ROBERT SHAW[1], and JOHN MCAULEY[2]

1. The Discovery Programme, Republic of Ireland
2. Digital Media Centre, Dublin Institute of Technology, Republic of Ireland

The creation and use of digital spatial data within archaeology and its associated disciplines has become increasingly prevalent over the past decade. Data sets ranging from archaeological excavation plans recording stratigraphic relationships to the high resolution LIDAR models detailing the three dimensional nature of an archaeological landscape and its monuments have enabled archaeologists and other interdisciplinary experts to catalogue, analyze and visualize cultural heritage information. This information can then be used to discover trends and explain archaeological theories and concepts. Traditionally, the GIS technology used to view and interrogate spatial data has been expensive desktop based software solutions, but in recent years technological developments have enabled the delivery and exploration of spatial data within an Archaeological Spatial Data Infrastructures (SDI). SDI is the collective name for a group of technologies and supporting measures that enables access to spatial data. Besides, an SDI is more than a single data set or database, since it hosts geographic data and attributes; sufficient documentation (metadata); a means to discover, visualize, and evaluate the data (Catalogues and Web mapping); and provides methods to access to the geographic data. Sharing archaeological information and spatial data sets is, in general terms, the basic goal of any Archaeological SDI, since it considers that maximizing the access to spatial data is minimizing the production cost of spatial information. Each discrete data set is stored only by the cultural heritage organization that created or with an elected archive for smaller independent data creators, and served out to be shared by the community as a whole. The benefits for this are numerous: the financial and technical cost of maintaining the data lies with the creator and provider, not with the user; elimination of the duplication of effort in the generation and maintenance of spatial data; and the currency of the data much greater as the user's data is consistent with that of the data creators, and can become part of the research resource rapidly

Consequently, an Archaeological SDI is consistent with sustainable development policies and the democratization of data access. This is especially pertinent for spatial data that has already seen public finances contributing to its generation, which in areas in economic regression, like rural ones, is particularly significant and useful to all agents involved in its management. This paper discuses the components of an Archaeological SDI, including web catalogue portals, discovery metadata, web mapping applications and web mapping services. This paper also explores the supporting mechanisms needed to create the environment for the establishment of an ASDI. The final component of this paper will highlight the development of a web mapping application component of the Archaeological SDI and the web mapping services that enables the public and interest groups access to archaeological landscape data.

Keywords: GIS, SDI, web mapping, OGC, data democratization

Site GIS's Technological Development, Status, and Benefit at Taiwan

Jr Jie Jang and I-Chun Fan
Academia Sinica, Taiwan

The Council for Cultural Affairs (CCA) Taiwan is the primary central government agency in charge of cultural affairs. In 2006, Academia Sinica started a three-year project whose aim was to develop a management system with GIS and CMS core technology. This system can let CCA manage archaeological sites. Now, we have finished the system's development and continue creating database content. The target sites are not just archaeological site but also historical monuments and historical building. We published papers about this project's fruitful results at 2007 CAA and 2008 CAA in "GIS Technology and CMS Application in Archaeology Field Investigation, Data Analysis and Information Display : Example of investigation" (2007CAA) and "GIS Technology and CMS Application in Archaeology site management and research" (2008CAA). The system contain three parts: Site in time and space (CMS), Archaeology Web GIS, and Archaeology survey system (Mobile GIS). CMS provides search-and-management functions for cultural heritage. It also provides a forum to discuss and share archeological methods, ideas, study, and research. Mobile GIS can help CCA's staff and archaeologists correctly and efficiently enter site information into electric forms. And these data will be saved by SHP files (GIS format). We use the Google Maps API as a web GIS platform, so users can search any spatial information of site, historical monuments, and historical building in Google Maps. Each selected cultural heritage's point or polygon has a hyperlink to CMS, then users can explore detailed information including text and photos. Web GIS provides not only Google Maps and Google satellite image, but also a 1904 map, old aerial photos, and other image maps (more than ten types). Users can view these image maps at any time as a GIS layer. Furthermore, the system has national digital cadaster maps (SHP file), so we get basic land and owner information about cultural heritage through overlapping cultural heritage data and digital cadastre map SHP data. This information helps CCA manage cultural heritage more effectively. The Taiwan Site GIS (which may change its name to "Cultural Heritage Spatial Information Manage System") provides important benefit to CCA and academic research.

Tuesday

1. Save costs of processing data and creating map when archaeologists survey a site.
2. Provide a platform to integrate text, image, map and spatial information.
3. Provide good reference information to government apparatus to manage culture heritage.
4. Popularize culture heritage knowledge.

Guest can visit the system at http://gis174.sinica.edu.tw/Archaeology (account and password is guest).

KEYWORDS: archaeological field survey, mobile GIS, web GIS, CMS, culture heritage management

AMASDA Online: Creation and Implementation of an Online Site and Project Management System and GIS for the State of Arkansas

JOHN RICHARD SAMUELSEN[1,2]

1. Arkansas Archeological Survey, United States of America
2. University of Arkansas, United States of America

The Arkansas Archeological Survey (AAS) developed a grant funded by the Arkansas Highway and Traffic Department to modernize the Automated Management of Archeological Site Data in Arkansas (AMASDA) system. This project has concluded its second year. The first year included the integration of multiple data sets housed by the AAS including the citations database containing the information on all archeological reports and publications at the AAS, the radiocarbon database, the sites database, the projects database, and the study units database which contains information on archeological phases in the state. In addition, these databases were modernized into relational databases for proper data integration. A text based interface was created allowing internet access to these databases as well as the ability to manage the data itself. The second year of this project centered on the creation of an online GIS for querying and displaying the more than 43,000 archeological sites in the state. This system takes advantage of the many fields in the database allowing for possible studies on geographic location, cultural affiliation, or any of the other fields in the database. Users can download information about the sites that have been selected including site forms, locational information, radiocarbon dates, relevant citations, or any database field.

Keywords: web, databases, GIS

How to Establish National Database Systems: Cooperate or Dictate

Espen Uleberg[1] and Joel Boaz[2]

1. Museum of Cultural History, University of Oslo, Norway
2. Norwegian Directorate of Cultural Heritage, Norway

In database development, establishing cooperation within a single institution can be difficult, cooperation between institutions even more difficult, and cooperation on a national level is often impossible. Individuals within an institution have differing and usually conflicting views of what kind of database systems are needed and how they should work. When these conflicting viewpoints are multiplied on a national scale it is often impossible to reconcile these different viewpoints, and projects either result in massive boondoggles of systems that are useless or in endless series of meetings and working groups that only produce an endless series of documents. In this presentation we will discuss national database development projects in Norway that have met with varying degrees of success. Among these are the National Sites and Monuments Database, and the MUSIT cooperation between the university museums. Development of The Norwegian National Sites and Monuments Register ("Askeladden") has been directed by the Directorate for Cultural Heritage. Detailed planning for the database began in 2001 and the database was launched in 2004. The processes involved in the production of the database were largely internal, while regional management authorities were consulted, their ability to influence the process was limited. Despite considerable initial skepticism and criticism of the system, it is now widely accepted and is quite popular with management authorities. In contrast the University museums have attempted cooperation throughout the entire process. MUSIT, the IT organization of the university museums, strives to involve all museums in the process of database development and content quality enhancement. Predecessors to MUSIT have developed different parts of the system in cooperation with different museums. Large amounts of texts and images have been converted to electronic formats and made available for the university museums. An internet access to parts of the information was established in 1995. Gradually, all parts of the system will be interconnected and used at all the museums. This process is supported by a series of committees which ensures the involvement of all museums. In this presentation we will discuss the experience we have had in Norway in developing national database systems. While there are differences in legal and administrative frameworks in all countries, many of the processes and considerations involved in the development of large database systems are common. These include setting overall goals, who gets to have an opinion about how to implement these goals, and how one chooses to deal with changing goals during development. There are no simple universal answers to these considerations, however there are a number of common considerations that allow us to learn from each other's experiences.

Keywords: database development, overall goals, cooperation, Norway

Grass Roots Imaging: A Case Study in Sustainable Heritage Documentation at Chersonesos, Ukraine

Adam Rabinowitz[1], Carla Schroer[2], and Mark Mudge[2]

1. University of Texas at Austin, United States of America
2. Cultural Heritage Imaging, United States of America

This paper documents a joint project of the Institute of Classical Archaeology (ICA) of the University of Texas at Austin, Cultural Heritage Imaging (CHI), and the National Preserve of Tauric Chersonesos in Crimea, Ukraine. The project centered on a workshop in which staff of the National Preserve learned to use Reflectance Transformation Imaging (RTI) to document unique objects from the Chersonesos museum. RTI creates interactive relightable images with 3D content. The Chersonesos project serves as a case study of the potential of this technique for a sustainable, locally-directed program of heritage imaging and documentation at a site without independent access to complex and expensive digital resources. In the West, developments in archaeological documentation are now frequently driven by technological advances: digitally-minded archaeologists are quick to adopt new and ever more powerful tools, even in the absence of specific questions these tools might help to answer or strategies for the dissemination of the results to the public. Approaches to the digital documentation of cultural resources thus often rely on equipment and software available only to a minority of well-funded projects, and disproportionately concentrated in Europe and the United States. When these technologies are applied to sites with limited resources outside Europe and the U.S., they are usually deployed by teams of Western specialists using software and equipment that are neither affordable nor locally available. Local collaborators can rarely continue such documentation programs without ongoing support, and in some cases, they cannot even use the digital information that has already been generated. Even more often, this digital heritage information is unavailable to the citizens of the country in which the site is located. At Chersonesos, the joint project of ICA, CHI, and the National Preserve centered on the use of relatively

inexpensive, easily available equipment and software to create images that capture information interesting for both specialists and the general public, and that can be viewed with conventional web software.

The goal of the project was to equip local participants to carry out independently further Reflectance Transformation Imaging of the rich but little-known collection of inscriptions, coins and gems at Chersonesos so that these interactive images could be shared with the Ukrainian and international public. We discuss the results of the workshop, the reactions of the participants and the National Preserve community, and perspectives on the future role of this imaging technique in the online dissemination of heritage information at the site. The applications of Reflectance Transformation Imaging for the monitoring of the condition of unstable objects and for the exchange of information between conservation professionals are also considered.

Keywords: imaging, photography, documentation, dissemination, sustainability

Integrating and Querying Diverse Digital Resources in Classical Epigraphy

Mark Hedges, Tobias Blanke, Stuart Dunn, and Gabriel Bodard
King's College London, United Kingdom

Databases and corpora of marked-up texts form a significant proportion of the outputs of digital archaeology. Although the development of standards (such as TEI and EpiDoc) for the representation of such information creates new possibilities for interoperability between resources, significant problems remain. Legacy data is often to be found in diverse and often obsolete formats, and where standards are applied, the sheer variety of cultural data and research means that there remains a great deal of "fuzziness." Users have to be trained in the correct application of standards, entailing significant outlay of time and money (which are scarce in many archaeological projects). However, there is inevitably diversity of representation when information is gathered together from different projects and for different purposes, and consequently there will always be a need to integrate this diversity whilst preserving the integrity of the data itself. The LaQuAT (Linking and Querying Ancient Texts) project is investigating technologies to provide integrated SQL-based views of diverse data resources. Specifically, our demonstrator will provide integrated views of a selection of data resources related to classical archaeology, incorporating epigraphic and papyrological resources. These resources comprise of relational databases with different schemas, and some XML-based data, and have been developed by researchers in discrete projects over recent years. The data resources in question are:

1. The Projet Volterra database of late Roman legal texts (http://www.ucl.ac.uk/history/volterra/) at University College London.
2. The Heidelberger Gesamtverzeichnis der griechischen Papyrusurkunden Ägyptens (HGV) (http://www.rzuser.uni-heidelberg.de/~gv0/), a database of metadata on Greek papyri, collated at the University of Heidelberg.

3. The Inscriptions of Aphrodisias data set, which comprises a corpus of inscriptions in TEI XML format.

As these resources overlap geographically, chronologically and prosopographically, it is self-evident that an integrated and cross-searchable view of them will be very fruitful for the researcher. For example, a particularly challenging issue being investigated is that of handling different levels of uncertainty in temporal data: some dates are extremely precise—even to the day—whereas many others are very vague—perhaps to a span of fifty or one hundred years. From a technical point of view the three databases employ diverse standards, they are structurally heterogeneous, their availability is limited, they are hosted by different institutions in different countries, and they are the research outcomes of divergent research communities. These distinctions are typical archaeological databases, and to address them our paper will explore the broader applicability of grid computing for linking distributed archaeological data. Grid computing is a term which covers a family of technologies that support virtualization of digital or computational resources, so that heterogeneous resources can be treated in a common fashion. We are using the OGSA-DAI (http://www.ogsadai.org.uk/) software to integrate these three diverse structured data resources. This supports the sharing of data resources, widens their availability, and increases their usability and effectiveness (e.g. where resources are held locally in a department and not widely published). Our paper will demonstrate an OGSA-DAI-based overview of all three data sets, and explore the grid's wider applicability to archaeological data.

Keywords: data integration, epigraphy, papyrology

Sharing Interpretation with Virtual Reality Web Labs

Sofia Pescarin
CNR, Italy

The future of digital archaeology will bring together Internet, Virtual Reality (intended as 3D real time environments), Inclusivity and Sharing dynamics. This for several reasons, that will be discussed in this paper. Recent technological advances have open up possibilities just dreamed in the past. Internet is today at first places in the entire world, as media and symbol of global connection; Virtual Reality is wide spreading, even thanks to computer-game industry that transformed into a normal experience, 3D interactive digital worlds; Social networks are today also very famous, thanks to Second Life "brand" diffusion. Archaeology has built several projects in the last decade into these realms. Archaeology in fact has to deal with spatial information (both bi- and three-dimensional), with Time, with complex systems and different non homogeneous pieces of information. Its goal is to search, interpret, understand, conserve and to communicate. For this reason interpretation process is fundamental: it is at the bottom of the entire pipeline and the base for any development and knowledge spreading activity. For this reason a particular care should be taken in interpretation, which should be built as an open process, in order to manage uncertainties and data updating, and should enable different disciplines and data sets inter-connection, in the spatial domain. Web-based collaborative environments could represent a perfect solution in order to increase research advances and results reliability in archaeology. Case studies of interactive collaborative environments will be presented.

Keywords: virtual archaeology, collaborative environments, internet, open

Visualizing the Past: Tools and Techniques for Understanding Historical Processes

James W. Wilson

James Madison University, United States of America

The digital revolution has made massive amounts of historical and social science data available to scholars in electronic formats, and this phenomenon is opening new possibilities for exploring the human past. The ability to interact with and to plot historical processes embedded in these data sets using mapping and visualization tools holds remarkable promise for providing scholars new insights into old questions. Yet significant obstacles currently prevent scholars from sharing their spatial-temporal data with one another, and thus from taking full advantage of the potential of visualization techniques. This presentation will provide an overview of the lessons learned from an U.S. National Endowment for the Humanities-funded workshop that will be held February 20-21, 2009, in Richmond, Virginia. The workshop, "Visualizing the Past: Tools and Techniques for Understanding Historical Processes" (http://dsl.richmond.edu/workshop), will focus on visualizing and interacting with spatial-temporal data and will bring together a multidisciplinary team (geography, history, archaeology, geographic information science, computer science, psychology, etc.) of leading scholars and practitioners from around the world to discuss two main issues:

1. How can we harness emerging cyber-infrastructure tools and interoperability standards to visualize, analyze, and better understand historical events and processes as they spread out across both time and space?
2. How can user-friendly tools or web sites be created to allow scholars and researchers to animate spatial and temporal data housed on different systems across the Internet?

Keywords: GIS, distributed systems, open standards, visualization

Digitizing the Material World of Williamsburg

Jeffrey Eugene Klee

The Colonial Williamsburg Foundation, United States of America

At Colonial Williamsburg, we have begun an ambitious project to create a detailed virtual model of our city in 1776. Carefully rendered and accurate to a fraction of an inch, the first building to be completed shows a part of Williamsburg that has not been seen for 200 years. Incorporating decades of accumulated knowledge,

the completed model will be a celebration of our collective expertise and, for our public, a revelation about a place they thought they knew well. Our plan is to build much more than a beautiful digital artifact. From the beginning, the model will be both an illustration of and an interface to our knowledge about the town. Users will select an artifact—a door, a cornice, or a foundation wall, for example—and be able to retrieve the records that describe it. For surviving buildings, relevant material might include who installed it, when it was made, and a research report describing how we know what we do. For speculative reconstructions, documentation will include archaeological records as well as relevant comparative material from surviving sites around the Chesapeake, including photographs, drawings, and written descriptions. All of this material will be drawn from our databases of architectural and archaeological artifacts, each encompassing thousands of records. The inclusion of archaeological as well as architectural data represents a significant challenge. These records have been collected according to very different disciplinary imperatives, to say nothing of standards that have evolved significantly over the past eighty years. One solution, suggested by the model itself, involves locating every catalogued object in space and time. A fragment of creamware, for example, from a context in a builder's trench can be associated spatially with the foundation that it helps to date. A piece of baseboard, installed in 1718 and re-used as a lath nailer in 1770 can be shown in both locations. The benefits of investing our databases with spatial information are several: first, doing so will enliven our model with the rich data used to construct it, making it a useful tool for researchers; second, it will allow us, in time, to present data to our museum's visitors in real time, via location-aware handheld devices; and third, it will allow us to integrate the records of several distinct collections of material culture at Colonial Williamsburg, including architectural and archaeological materials, and decorative arts. This paper describes the early planning process for the model and the challenges of integrating material culture data in a computable way.

Tuesday

KEYWORDS: modeling, cultural heritage, interdisciplinarity

Extending Archival Standards to Support Graphical Documentation

JOSE M. AROZA, CELIA MONCADA, and F. JAVIER MELERO
Universidad de Granada, Spain

EAD is an emerging standard used internationally in an increasing number of archives and manuscripts libraries to encode data describing corporate records and personal papers. It is based in XML and it is straightforward to implement international standards like ISAD(G) and ISAAR(CFP). We have developed software that allows users to handle historic archives by using these international standards. This software has been implemented in Java, and uses the Spanish translation of EAD 2002, ISAD(G) 2000 and ISAAR(CPF). As EAD is based on XML, we use eXist, a pure XML database manager system, to store the data. Our tool includes privileges for several types of users, and it is restricted the archive data that each one of them is allowed to modify. We have extended the standards in such way that it is possible not only to append one image to the documented item, but including links and detailed images in the proper image. This means that

one record can describe a complex cultural heritage monument, and the images that illustrate this record may include links to other more detailed images or even another record related to an specific item. Furthermore, it is possible to include hyperlinks into the description of each record so it is possible to be redirected to and extended text, or even to another ISAD(G0) or ISAAR(CPF) record. This gives the opportunity of navigating through records by clicking on the outlined words or on outlined areas of the record images. We think that providing such graphical interface for the documentation of cultural heritage elements improves greatly the amount of information managed by the historical archive, and we could say that introduces the *documenting 2.0* concept, in the sense that archives are not only a set of textual records (with some attached images) but that images themselves can provide and extend information about the recorded item.

Keywords: EAD, documentation

Session Summary

Tuesday, 8:30am-11:45am, Patriot

Computational Intelligence in Archaeology

Chair: JUAN ANTONIO BARCELO, Universitat Autonoma de Barcelona, Spain

Computational (or "artificial") intelligence is not just about robots. It is about understanding the nature of intelligent thought and action using computers as experimental devices. The purpose of this session is to present investigations about the nature of inferential mechanisms for archaeological explanation, and how computer programs allow us to discover how we produce inferences. The discussion should be between what is considered an artificial way of reasoning (computer programs) and our supposed natural way of reasoning (verbal narrative). Critics of the Constructive and Formalized view of archaeological discipline are ignorant of the true renaissance of the cybernetic paradigm experienced in the late 1980s, and its integration with new paradigms of cognitive science, philosophy, and the "new" artificial intelligent paradigm. One reason for its resurgence is the discovery of more powerful machine-learning algorithms: new generation adaptive algorithms (neural networks, support vector machines, genetic algorithms, Bayesian models) appear to be formally true universal mechanism devices.

If we want to reproduce human intelligence in a machine, we should place emphasis on three central aspects: development, interaction, and integration. Development forms the framework by which machines imitate how humans successfully acquire increasingly more complex skills and competencies. Interaction should allow an "automated archaeologist" to use the world itself as a tool for organizing and manipulating knowledge, and then allow it to exploit humans for assistance, teaching, and knowledge. Integration should permit the automated archaeologist to maximize the efficacy and accuracy of complementary mechanisms for perceiving and acting. These subjects are inspiring a new generation of cyberneticists in the fields of situated robotics or "New Artificial Intelligence," and they offer an interesting domain for debating what it means to "produce" knowledge.

To imitate a human scholar, an automated archaeologist should not be fully programmed at the beginning, but developmentally. The gradual acquisition of interpretive skills and the consequent gradual expansion of the automated archaeologist's capacities to explain archaeological observables (creating more and more self-training data as it does so) will define then the cognitive behavior of an "intelligent" machine. This strategy facilitates learning both by providing a structured decomposition of skills and by gradually increasing the complexity of the task to match the competency of the system. Behaviors and learned skills that have already been mastered enable the acquisition of more advanced explanations by providing sub-skills and knowledge that can be re-used,by placing simplifying constraints on the acquisition, and by minimizing new information that must be acquired.

This special session intends to explore the implications in archaeology, both theoretically and methodologically of machine learning. Suggested contributions can be about the application of standard "artificial intelligence" tools and methods (neural networks, agent-based simulations, genetic algorithms, expert systems, Bayesian networks, automated induction, rule generation, etc.) or specifically on any contribution at the interface between theory and method, that is to say, investigations using computers to discover the way we think.

Topics: other

Keywords: artificial intelligence, machine learning, neural networks

Tuesday

Schedule

8:30 – 9:00 "Towards Indexing and Data Mining all the World's Rock Art," Eamonn Keogh, Sang-Hee Lee, Qiang Zhu, Xiaoyue Wang, and Taryn Rampley

9:00 – 9:20 "Where Do You Want to Go Today? Pathfinding, Algorithms and Agent-Based Modeling," Martin Hinz

9:20 – 9:50 "Automatic Construction of Typologies for Massive Collections of Projectile Points and other Cultural Artifacts," Eamonn Keogh, Lexiang Ye, Taryn Rampley, and Sang-Hee Lee

Coffee break

10:15 – 10:45 "A Proposal of Ceramic Typology Based on the Image Comparison of the Profile," Ana Luisa Martínez-Carrillo, Arturo Ruiz-Rodriguez, Manuel Lucena, and Jose Manuel Fuertes

10:45- 11:15 "Visualization and Automatic Typology Construction of Ceramics Profiles," Laurens van der Maaten, Guus Lange, and Paul Boons

11:15 – 11:35 "3D Pottery Shape Similarity Matching Based on Digital Signatures," Anestis Koutsoudis and Christodoulos Chamzas

Abstracts

Towards Indexing and Data Mining All the World's Rock Art

Eamonn Keogh, Sang-Hee Lee, Qiang Zhu, XiaoyueWang, and Taryn Rampley
University of California, Riverside, United States of America

Petroglyphs and pictographs are one of the earliest expressions of abstract thinking, and a hallmark of humanity. They provide a rich body of information on several different dimensions, beyond their value as an aesthetic expression. Motifs can identified, traced through time and space, which in turn may shed light on the

dynamic histories of human populations, patterns of their migrations and interactions, and even continuities to the present indigenous societies. A decade ago, Walt *et al.* summed up the state of petroglyph research by noting, "Complete-site and cross-site research thus remains impossible, incomplete, or impressionistic" Surprisingly, there has been little change in the intervening decade, yet in the same time frame we have seen significant advances in image processing and artificial intelligence. These advances combined with general improvements in computer hardware have resulted in thousands of applications in domains as diverse as medicine, entertainment, wildlife management, e-commerce, biometrics, zoology etc. Nevertheless, these advances have had essentially zero impact on the analysis of petroglyphs and pictographs. We have identified two major reasons for this. First, the raw digital images of rock art are uniquely difficult to automatically transform into a representation that is amiable to computer analysis. Second, the diverse and complex structure of rock art images defies most existing image matching algorithms. In this work we show how to solve both these issues. We show that the recently introduced framework of "Human Computation" allows us to build a tool capable of processing a million images per month (von Ahn *et al.*). At such a rate, all the worlds' rock art could be processed in just a few years. We further introduce a novel distance measure for rock art, and show that it can correctly capture the subjective (and in some case, objective) similarity between petroglyphs and pictographs. We show how we can use this distance measure as a basis of several higher-level data-miningalgorithms, for example finding repeated motifs, finding outliers from a collection, or simply enabling query-by-content. For the latter operation, a user may sketch a glyph and inquire "are there any petroglyphs like this in this collection." As we shall demonstrate, our system allows such queries to massive data sets to be answered in seconds. We demonstrate our ideas with detailed pilot study on a few tens of thousands of petroglyphs from Southwestern United States, and discuss our plan to build an Open Source and freely available on Google for petroglyphs.

von Ahn, L., B. Maurer, C. McMillen, D. Abraham, and M. Blum, 2008. "reCAPTCHA: Human-Based Character Recognition via Web Security Measures," *Science*, September 12, 2008. 1465-1468.

Walt, H., B. David, J. Brayer, and C. Musello, 2006. The International Rock Art Database Project. http://www.cs.unm.edu/~brayer/rock/waltet.html

Keywords: rock art, image processing, artificial intelligence

Where Do You Want to Go Today? Pathfinding, Algorithms and Agent-Based Modeling

Martin Hinz

Università di Roma "La Sapienza," Italy

A major branch of computational archaeology is the least cost path calculation. Here the main presumption is that humans—given enough time—tend to find eventually the optimal solution for a path between two places and use them as route. But does this correspond with the archaeological reality? Or is this idea rather

Tuesday

based on recent conceptions of road building today? If one compares medieval maps with this model clear differences become visible. On the one hand these old road systems consists of a network of equal-ranking paths which is very different from modern hierarchical road systems. On the other hand these roads are often laid out in relation to landmarks. A prominent example for this are roads on the Jutish peninsular—North Germany and Denmark—which are often located along rows of Bronze Age grave mounds (Hill/Zich 2002). The theoretical background focused on the question if a purposive rationality (*Zweckrationalität*) or a value-orientated rationality (*Wertrationalität*) for the spatial planning of Neolithic cultures is feasible. Are such basic decisions characterized by costs/benefit optimization only" Or could the individual/collective optimum be archived by a solution different from the calculated optimal way" Therefore this is not a search for the best algorithm. Generally it is questionable if a algorithmic computed solution mirrors the archaeological reality at all. For solving this question agent based modeling can be of great value. Therefore a model was made that take the topography of the terrain into account and selects the optimal way between places of interest by using a classical algorithm (toblers hicking function, Tobler 1993). But also communication between the agents as source of information for routes were incorporated as well as the beating of paths which leads to lowered costs and landmarks as points of orientation. The preferences for minimal costs, easiest orientation and the cutting of costs for routes already in use are adjustable parameters for the simulation. Extensive sensitive tests allow a conclusion for the important of the different factors in actual pathfinding of the agents.

This analysis is part of my Ph.D. thesis on settlement structures of the Funnel Beaker societies. The aim of this thesis is approach the settlement topology of the first farmers in northern Central Europe, in which ways linking different places in landscapes play a very important role. The layout of way structures defines the organization within a region. It is fundamental for the relation between different places and determines—in a strict sense—the topology by which these places are connected.

Thomas Hill and Bernd Zich, 2002. *Von Wegen. Auf den Spuren des Ochsenweges (Heerweg) zwischen dänischer Grenze und Eider* (Flensburg 2002).

Tobler, Waldo, 1993. "Nonisopic Modeling." *Three Presentations on Geographical Analysis and Modeling. National Center for Geographic Information and Analysis*. Technical Report 93-1. University of California, Santa Barbara.

Keywords: agent-based models, spatial analyses, theories & methods, least cost paths

Automatic Construction of Typologies for Massive Collections of Projectile Points and Other Cultural Artifacts

Eamonn Keogh, Lexiang Ye, Taryn Rampley, and Sang-Hee Lee
University of California, Riverside, United States of America

Tuesday

In the last few decades there have been several attempts to use computers to automatically construct typologies (keys, classifiers, decision trees etc) for projectile points (Bisson 2000, Buchanan 2005, Thomas 1981). However, all these methods require human effort to extract the features. There are three problems with this. First, it is clearly not scalable to large data collections. For example on the UCR campus alone there is an estimated one million projectile points. Even if a human could extract the features for each in ten seconds it would require a year of eight hour days to build the feature list. Second, human extraction of features is subjective, with all the attendant problems that brings. Finally, and most importantly, we believe that all such attempts essentiality put the cart before the horse. We don't want to use our preconceived ideas to build classifiers; instead we should use the classification algorithm to tell us the defining features for each class. In this scenario, we simply give the classier some examples of Class A and of Class B, and in addition to producing a piece of software that can then automatically decide which class an unknown object X belongs to, the algorithm should be able to explain why it made the decision. In this example the algorithm might say… "Object X was classified as Articulate because Notch was present AND total length was LESS THAN 0.7 AND." In this work we demonstrate, for the first time, a classifier system which can not only classify projectile points with a high degree of accuracy, but produce intuitive explanations as to what makes the classes different. Our algorithm is completely automatic and parameter free, all the user does is provide two or more labeled sets of photographs/drawings. We demonstrate the utility of our work on a large collection of North American points, and a smaller collection of African points, and we show how the work can be easily extended to other cultural artifacts, such as pottery and textiles.

Bisson, M. S., 2000. "Nineteenth Century Tools for Twenty-First Century Archaeology" Why the Middle Paleolithic Typology of François Bordes Must Be Replaced, " *Journal of Archaeological Method and Theory* 7(1):1-48.

Buchanan, B., 2005. "Cultural Transmission and Stone Tools: A Study of Early PaleoindianTechnology in North America." Dissertation, University of New Mexico.

Thomas, D. H., 1981. "How to Classify the Projectile Points from Monitor Valley, Nevada," *Journal of California and Great Basin Anthropology* 3(1):7-43

Keywords: projectile points, typologies , classification

A Proposal of Ceramic Typology Based on the Image Comparison of the Profile

Ana Luisa Martínez-Carrillo[1], Arturo Ruiz-Rodriguez[1], Manuel Lucena[2], and Jose Manuel Fuertes[2]

1. Andalusian Center of Iberian Archaeology, University of Jaén, Spain
2. Computer Sciences Department, University of Jaén, Spain

Ceramics are one of the most documented materials in the archaeological record. The documentation and the analysis of pottery shapes allow knowledge of the chronology and the functionality of the settlement where they have been found. The achievement of a typology of ceramic materials is made attending on different aspects (function, context, morphometry). In this contribution a methodology of analysis of archaeological ceramic is showed. This methodology is based on the technique of non-rigid deformable analysis applied to the drawing of the profile and is aimed at the construction of a ceramic typology. This work is included on the CATA project (Archaeological Wheel Pottery of Andalusia in its acronyms in Spanish). The main objective of the project is the achievement of a reference collection accessible by Internet. The above-mentioned reference collection consists of a sample of 1390 complete shapes corresponding to different chronological periods; from the seventh century B.C.E. until the fifteenth century C.E., documented in the region of Andalusia. Also fragments of ceramic shapes have been compared with complete vessels to be associated to certain shapes. The morphometric analysis allows on one hand the evolution of the ceramic shapes across the different historical periods and the creation of typologic groups based on the similarity of the shape. On the other hand, the computerization of the archaeological ceramic data across Internet allows a uniform and standard ceramic analysis.

Keywords: archaeological pottery, morphometric analysis, tipology

Tuesday

Visualization and Automatic Typology Construction of Ceramics Profiles

Laurens van der Maaten[1], Guus Lange[2], and Paul Boon[1]

1. Tilburg Centre for Creative Computing, University of Tilburg, The Netherlands
2. National Service for Archaeology, Cultural Landscape, and Built Heritage, The Netherlands

Keywords: machine learning, ordination, automatic classification, pottery, computer vision

Recent advances in techniques for machine learning and computer vision open up new ways for the study of ceramics profiles. Automatic classification has seen a long tradition in archaeology, but, due to poor practical solutions, became out of fashion lately. In our approach to the study of ceramics profiles, we use novel machine learning and computer vision techniques for two main tasks: (1) the construction of visualizations that reveal the similarities between ceramic profiles and (2) the automatic construction of typologies of ceramics profiles. The basis of our approach is formed by a technique that measures the similarity between ceramics profiles using shape contexts (Belongie *et al.*, 2002). The resulting similarity measurements can be used as input into

a new technique called t-SNE (van der Maaten and Hinton, 2008) that visualizes the similarities between the ceramics profiles in a two-dimensional map (task 1). Alternatively, the similarities can be used as input into a novel clustering technique called affinity propagation (Frey and Dueck, 2007) in order to automatically construct typologies (task 2). We performed experiments on a data set of over 1,000 ceramics profile drawings, and the results of the experiments were evaluated by ceramics experts. From the results of the evaluation, we conclude our approach to the study of ceramics profiles is very promising (especially when it is combined with automatic approaches for the study of ceramic fabric). Moreover, our approach provides new ways to present information on ceramics to the public.

3D Pottery Shape Similarity Matching Based on Digital Signatures

Anestis Koutsoudis and Christodoulos Chamzas
Department of Electrical and Computer Engineering, Democritus University of Thrace, Xanthi, Greece

Pottery is considered as one of the most representative artifact category in the cultural heritage domain. They enjoy a great interest from both scholars and general public as they are exhibited in both museums and archaeological sites. Nowadays, several 3D digitized pottery replicas are available to the public through the Web. This is due to the continuous evolution of 3D scanning technologies and the mature era of computer graphics we are experiencing. It is a fact that shape characteristics and attributes are of great importance in the archaeological research. Pottery has exerted a large influence on understanding the society that produced them. Furthermore, the information provided by 3D models of vessels is superior to that of any other form of iconography, as it may lead to physical replications by means of 3D printing. Thus, such content richness can be used in the development of tools that will provide the archaeologist with automated shape matching functionality of three dimensional replicas. In this work, we present a digital signature that can be used for shape matching and carries information regarding the morphology of the vessel. Characteristics such as the radius of a vessel's main body and the position of a part of a handle at a given height are encoded within the digital signature which can be used for shape matching. The successful extraction of the signature from the vessel's 3D mesh is affected by a pre-processing procedure which attempts to perform pose and scale normalization of the vessel in the 3D space. This procedure is solely based on one of the most important characteristics of pottery, its axially symmetric shape. Our recursive pose normalization algorithm is performed by contouring the 3D mesh and identifying the orientation of the vessel's main body axis of symmetry and the location of handles or feet. In each recursion, the appropriate rotations of the 3D mesh are performed and the algorithm continues until the vessel's axis of symmetry is set as parallel as possible to the Y axis of a left-handed 3D Cartesian coordinate system. In cases where the vessel carries handles, then an additional rotation around the axis of symmetry is performed so that the most distant, to the vessel's body, handle is placed on the positive side of the X axis of the same coordinate system. The top and bottom of the vessel is identified by using a depth buffer rendering technique. Once the vessel is normalized, a final plane contouring

is performed along the axis of symmetry at different height positions. The objects resulted in each contour, are identified as parts of the main body or the handles. Once the identification is completed, data are extracted regarding the position and the size of vessel's main body, handles, etc at a given height. Further morphological characteristics such as the error variance of fitting a circle around each object are also computed.

Keywords: 3D pottery, shape matching, content-based retrieval

Session Summary

Tuesday, 8:30 am-10:00am, Constitution

Short Paper Session on Research Projects Looking for Collaborators

Chair: Stephen Stead, Paveprime LTD, United Kingdom

Organizers: Stephen Stead, CAA Steering Committee, Paveprime LTD, United Kingdom
Nick Ryan, CAA Steering Committee, University of Kent at Canterbury, United Kingdom

Sponsored by the CAA International Steering Committee

This session allows for projects, units, institutions, individuals and groups to ask for collaborators and data providers to help further their research. It is a bit like a clearinghouse or brokerage session where you can find people that have data for you to test your new software on or have software to process some data that you have. Students or their supervisors may be able to find research opportunities or projects for them to complete as part of a degree or masters program. It is organized as a series of short papers and additional time is available for late additions to the program. So you can submit a paper ahead of the conference or just turn up and ask if anyone can help use up your free time or solve your problem! So if you are looking for data or collaborators, need a project for a research student to work on or just have some free time, this is the place to come and announce it or volunteer!

The session is organized by the CAA International Steering Committee as a part of the conference program. This is the third time such a session has been run.

Schedule

8:30 - 8:50 "Computer-aided Analysis of Michelangelo's Tool Marks," David Koller

8:50 - 10:00 Additional Presentations and Discussion

Abstracts

Computer-aided Analysis of Michelangelo's Tool Marks

David Koller

IATH, University of Virginia, United States of America

New 3D data capture and digital analysis techniques have the potential to facilitate our understanding of the tools and sculpting techniques that Michelangelo employed in carving his statues. In particular, the extant

tool marks on the statue surfaces, such as the grooves resulting from the strokes of a chisel, are a primary source of information for reconstructing Michelangelo's methods. In prior work, we have digitized the surface shape of Michelangelo's statues with high precision laser scanners, and constructed accurate 3D models that can be used as input to automated algorithms that identify, measure, classify, and visualize the tool marks. Other scholars have previously completed a tool mark analysis of Michelangelo's unfinished *St. Matthew*, by tediously gathering manual measurements of the chisel marks visible on several regions of the statue, and then classifying the tool marks by the tool types that produced them. Our current research applies techniques from computer graphics and computer vision to more automatically locate and classify the tool marks, and uses the manual measurements as a ground truth for evaluating the efficacy of these computer-aided methods. Using our 3D model of *St. Matthew* as input, we have experimented with various learning algorithms and differential geometry measures (curvature, accessibility, etc.) for tool-mark recognition and classification. We require new methods to compensate for noisy 3D input data, and to perform robust classification on statue surfaces that may include multiple overlapping tool mark types. Additionally, we plan to expand our sculpture analysis software system to include more interactive analysis and visualization tools that may be useful for art scholars.

Keywords: tool marks, classification, Michelangelo

Session Summary

Tuesday, 8:30am-10:00am, Liberty

ECAI: Digital Mapping as Communication

Chair: Paul Ell, Queens University, Belfast, Ireland

The issues of how digital mapping can be used to communicate information occupy the presentations of this session. Susan Whitfield, Director of the International Dunhuang Project of the British Library provides a narration of how mapping can be used to deal with material related to the "Silk Road." The following presenters give examples of how the mapping can best be done and finally used in pedagogy.

Schedule

8:30-8:50 "Mapping the Silk Road," Susan Whitfield
8:50-9:10 "GIS and Cultural Data," Jianxiong Ge
9:10-10:00 Discussion

Abstracts

Mapping the Silk Road

Susan Whitfield
IDB, British Library, United Kingdom

The International Dunhuang Project (IDP) at the British Library has been an ECAI member for over a decade, digitizing and mapping archaeological sites and artefacts from Chinese Central Asia, the Eastern Silk Road. In this talk, IDP's director, Susan Whitfield, will introduce work being done under a recent grant to look at archaeological sites and artefacts not as static, but with complex biographies which show them at different stages of development over time and space, and how IDP is representing this on its web site.

Keywords: Dunhuang, mapping, Silk Road

GIS and Cultural Data

Jianxiong Ge
Fudan University, Shanghai, People's Republic of China

Abstract text not available as of press time.

Session Summary

Tuesday, 8:30am-10:15am, Colony

Poster Session 2

Abstracts

Aerial and Near-Surface Remote Sensing at the Prehistoric Old Town Ridge Site in Northeastern Arkansas

Jami J. Lockhart, Juliet E. Morrow, and Shaun McGaha
Arkansas Archeological Survey, University of Arkansas, United States of America

This poster presents the results of two weeks of geophysical survey and mapping at the prehistoric site 3CG41, known as Old Town Ridge. The site is located in extreme northeastern Arkansas within the St. Francis River drainage, which is a major tributary of the Mississippi River some forty kilometers to the east. Judging by numerous artifacts discovered to date, Old Town Ridge was occupied at approximately 1300 C.E. during the Middle Mississippian Period. Some artifacts discovered at the site signify ancient power and prestige. An engraved "birdman" gorget displaying elements of Braden and Craig-style iconography and a ceremonial stone mace suggest association with what has been called the "Southeastern Ceremonial Complex," a theoretical construct that links geographically-distant world-class archeological sites, such as Cahokia (Illinois), Spiro (Oklahoma), Etowah (Tennessee), and Moundville (Alabama). In addition to diagnostic artifacts, true color and color infrared aerial photographs of the site, which is located in a modern-day cotton field, present an intriguing spatial pattern interpreted as an eighteen-acre rectangular area of intensive use and dense population bounded on the north by what is now a relict river channel. The recent magnetometry surveys at the site have revealed numerous magnetic anomalies that are consistent with aligned prehistoric structures and other burned and unburned archeological features, such as possible hearths, pits, and burials. The geophysical imagery also indicates completely encompassing perimeter earthworks and evidence of a possible defensive palisade. In addition, Old Town Ridge is located very near the epicenter of the large early nineteenth century New Madrid earthquakes, as well as much earlier quakes of comparable magnitude. In the magnetometer imagery, earthquake liquefaction features known as "sand blows" are evident as irregular trends of greatly decreased magnetism bisecting and displacing elements of the pre-Columbian occupation. Also, of particular importance to archaeology in the region, the southern portion of the prehistoric enclosure has been land-leveled for modern agriculture. Yet, as verified by the magnetometry and subsurface investigation, much of the anthropogenic horizon remains.

As shown in this presentation, approximately fourteen acres of the eighteen-acre enclosure at Old Town Ridge have been surveyed using a gradiometer, providing pinpointed locations for subsurface testing, as well as primary data regarding intrasite organization.

Keywords: geophysical remote sensing, middle Mississippian Period, Southeastern Ceremonial Complex, prehistoric structures, perimeter earthworks

The Application of a Georelational Database and Data Mining Technologies for Predictive Site Modeling for the Paleolithic of the Iranian Plateau

Michael Märker, Saman Heydari, Nicholas Conard, Zara Kanaeva, and Volker Hochschild
Universität Tübingen, Germany

In this poster we present a concept for the storage, exchange, presentation, and analysis of geospatial environmental and archaeological data to study and assess Paleolithic settlement dynamics and subsistence of the Iranian Plateau. GIS, database solutions, and web-based technologies are used to handle and process archaeological and physiographic information. The project deals with a variety of variables and formats such as geology, geomorphology, landforms, and archaeology in vector and raster as well as text formats. The study presents an unique set of archaeological information sampled on the Iranian plateau and its physiographic settings. The system's structure is aimed at exchanging information and providing a platform to add information and discuss results and research on the Paleolithic of the Iranian plateau. The system is designed to be an international central data focus of all kind of archaeological and related physiographic information to investigate and model with holistic approaches the early human settlement dynamics, subsistent and land use on the Iranian Plateau. We present the structure of our database system in detail, as well as first results of topographic analysis to explain the spatial distribution of archaeological sites. Topographic indices were calculated and analyzed on a 90m resolution based on Shuttle Radar Topography Mission (SRTM) elevation data. These indices deliver i) information about erosion, transport and deposition processes of materials and sediments, ii) information about water availability and location, as well as iii) information about site-specific characteristics such as aspect, radiation, elevation, lines of sight, etc. We show that the distribution of the archaeological sites is strongly related to this parameters and proxies of ancient and current geomorphological, pedological, and hydrological processes. This information was utilized to derive predictive models based on machine-learning technologies. In this case we utilized classification and regression trees and a more robust version of the random forest model. The application of the model on a test sample showed the potential of the methodology.

Keywords: georelational database, predictive site modeling, paleolithic, Iran

Commercial Application of Archaeological Predictive Modeling for B.C. Forestry

Kimberly Lynn Jankuta and Kristin Elizabeth Soucey

Altamira Consulting Ltd., Canada

The use of GIS has become prevalent within the study of archaeology. Utilization of GIS has allowed archaeologists to reconstruct sites, create detailed site maps and predict the location of sites, and the academic applications are numerous and invaluable. However, there is another application that is rarely discussed. Archaeologists working for commercial units have readily embraced the computing technology of GIS, be it for cartography or more advanced projects such of predictive modeling. As professional archaeologists working within Cultural Resource Management, we regularly employ GIS during archaeological overview assessments (AOA) for forestry cut blocks within the interior region of British Columbia. Analysis of blocks are done based on several variables that are commonly employed by archaeologists when creating a predictive model, although we assess without a pre-determined model. Each forestry cut block is individually examined and its archaeological potential is ranked based on variables including (but not limited to) topography, hydrology and proximity to known archaeological sites. Blocks are assessed as having high, low, or moderate potential. Blocks believed to have low potential are not surveyed by field crew, while all blocks exhibiting potential, whether high or moderate, are surveyed, with the expectation that blocks with high potential will have sub-surfacing shovel testing.

The purpose of our research is to examine the results of AOAs and the corresponding field work throughout the past three years of forestry work conducted by Altamira Consulting Ltd. On occasion those blocks recommended on the basis of a predictive assessment to have moderate potential are determined to have high potential in the field and ground truthing, and high potential areas have been determined through field survey to have moderate potential and were not shovel-tested. The basis of our model relies on the accuracy of our predictions; our research for this poster is to determine the accuracy of our models through analysis of the percentage of blocks that maintain the original assessment and how often the assessment is altered upon field exploration. We have also analyzed in which blocks archaeological sites are found, those recommended as high or moderate potential. The results of our research demonstrates the accuracy archaeologists have when utilizing GIS to analyze areas for archaeological potential and the problems that are associated with reliance upon GIS to perform survey tasks that were once conducted by archaeologists in the field.

Keywords: GIS, archaeological overview assessment, predictive modeling, British Columbia

Development of New Technology for Virtual Georadar Modeling of Archaeological Memorials

Dmitry Leonidovich Shishkov[1] and Anna Aleksandrovna Klochko[2]

1. geor.ru, Russian Federation
2. Lomonosov Moscow State University, Russian Federation

This poster concerns a development of a new tool introduced by a group of authors at geor.ru for the solution of the following virtual georadar 3D modeling: in a short time (several weeks), compose a precise map of the bedding of archaeological objects in the investigated territory of several hectares. The results should be accessible by Internet via compact PCs. The georadar survey used the following equipment GSSI: geo-radar SIR-3000, antennas 5103 and 5106, topographic carts, Radan software; the complete set of high-precision GPS Javad receivers and the program MZ, developed by the authors. If antenna 5103 is traditionally used for the shallow depth survey, then the choice of antenna 5106 for archaeological examinations is caused by a significant depth of buried memorials detected under the considerable cover of Quaternary sedimentary formations. The equipment and Radan were used to develop a series of accurately positioned 3D georadar projects (each georadar project is a sequence of parallel georadar profiles), which maximally cover the investigated territory. This network of projects does not exclude the lacunas, inaccessible for measurements, or the very territory of survey can be heavily developed. The number of projects is not limited and several can be run at the same time. Thus, the scope of gathered data can be very large. The newly developed program MZ organizes data as a stream of Internet-TV, where each frame is a sequential horizontal layer accessible for a compact PC.

In this case, it is possible to open both—every 3D project separately and the integrated picture of all 3D projects. This technology is used for mapping the Muroma annalistic necropolis (original Early Medieval memorial, the majority of which monuments is lost because of the development) in the vicinity of the Verbovsky settlement, partially dug out at the beginning of the twentieth century. It turned out that less than half of this monument has been studied. The distance between the burials can exceed ten meters, and a continuous excavation was not suitable for this site. The technology was also applied to archaeological studies of Old Ryazan. The investigation revealed the exact location of the ancient Dormition Cathedral and allocated layers for the subsequent excavations. The study of the rural settlements is a separate issue since they cannot be excavated in principle in view of the large volume of works. With the aid of our technology, it is possible to allocate the most interesting fragments of monuments, to classify them and to explore further by 3D modeling.

Keywords: georadar, 3D modeling

Directions of Magnetization

Bruce W. Bevan
Geosight, United States of America

Analysis of a magnetic map allows one to determine more than just the shape and the location of a magnetic feature; the direction of total magnetization within that feature may also be estimated. This direction may reveal additional information about the feature. If the direction is the same as Earth's current field, the object may be magnetized by induction (a refilled pit could cause this direction); if the feature has remanent magnetization, it may have been fired (or otherwise magnetized) recently. If this direction is different, remanent magnetization is likely to be predominant in the feature. If the direction is far from Earth's field, the object has probably moved from the place where it was magnetized. If the direction is within about 45° of the Earth's field, there is a possibility that remanent magnetization could reveal the ancient direction of the Earth's field, and an archaeomagnetic date may be possible. If the direction of magnetization is almost horizontal, the object might be an elongated artifact of iron or steel. This is because long artifacts might be horizontal in the soil; self-demagnetization will then cause the inclination of magnetization to be near zero. If this direction is both toward the horizon and also toward magnetic north, the artifact might be made of iron, rather than steel, for induced magnetization may then be more important. These directions of magnetization may be determined from mathematical models of the anomalies that are found in a magnetic map. In addition to these directions, the models may also allow a good estimate of the depth of magnetic materials, and also their quantity (volume or mass). Many of the objects that are detected during an archaeological survey are rather compact and cause an anomaly that is similar to that of a dipole. Six parameters define each dipole: Magnetic moment, direction of total magnetization (inclination and declination), and location (X, Y, Z). A seventh parameter, the magnitude of the Earth's magnetic field at the location of the anomaly, must also be determined during the analysis.

Keywords: magnetic survey, analysis, directions

eGISpat Timis: Topographic 3D Measurements Using the Total Station and GIS Processing in the Analysis of the Archaeological Sites in Timis County, Romania

Dorel Micle, Măruia Liviu, and Adrian Cintar
West University of Timisoara, Romania

Timis County, the most western Romanian district, is one of the richest in archaeological finds from all periods. Unfortunately, the Timis Historic Monuments List contains only minimal information about these sites. Our project aims to improve this situation by creating analytic records for each archaeological site. The records contains precise placement information and professional topographic measurements, which can lead to the editing and correction of digital maps. None of the archaeological sites in Timis have a correct digital

Tuesday

map (a lot of these sites have never even been excavated), so the West University of Timisoara and the Board of Culture, Cults and National Cultural Heritage of the Timis County have started a long-term project meant to identify and to digitally map all the archaeological sites from the Timis Historic Monuments List. In 2008, 57 sites were finalized, from all periods and environments in our district. Our poster presents the work methodology and the results of these sites research.

Keywords: GIS, total station, landscape archaeology, field archaeology, cultural heritage

From Atlas to Satellite, From Gsell to QuickBird through Archaeological Evidences

Tuesday

Anna Maria Marras
University of Siena, Italy

The University of Trento has worked in northeast Algeria since 2003 to create a new archaeological map. The cartography reference is the famous *Atlas archéologique de l'Algérie* (1902-1911), created by Stéphane Gsell, and a satellite image from the area called Aïn Karma. The image is a QuickBird image ortho standard panSharpen with 4 bands, shot 13-03-2007 at 16.45. It has good spatial resolution, but unfortunately it is the only image. Therefore we followed current practice with this kind of image, such as the application of normalized difference vegetation index (NDVI), since the area is characterized by the presence of dense vegetation. We also applied convolution filters to enhance some crop marks; all data were used in order to assess their capability in the field of archaeological prospection. In this case we used the satellite data after the survey, and it's very important to see the real utility of this kind of data.

Keywords: remote sensing, land coverage, survey, North Africa, landscape, ancient maps

Geomagnetic Survey at Zincirli Höyük, Turkey

Jason Thomas Herrmann and Jesse Casana
University of Arkansas, United States of America

A geomagnetic survey at Zincirli Höyük clearly shows the unique urban plan of the city of Sam'al, the seat of an important Aramean kingdom that prospered in southern Turkey from the ninth through seventh centuries BC. A 2007 survey by a University of Arkansas team covered almost half of the 40+ha site, focusing on the extensive lower town, which is surrounded by pair of massive, perfectly circular fortification walls. The archaeology of the lower town at Zincirli is characterized primarily by reasonably shallow architectural remains of basalt construction set in alluvium that represent a relatively short period of occupation and make this site almost ideal for geomagnetic survey. Geomagnetic data reveal the plans of buried archaeological features, including the northern sections of the outer fortifications, a network of roads and paths, and the architectural plans of large palaces and small private houses. These data, combined with the results of archaeological

investigations from more than a century ago, detail most of the ancient city plan, demonstrate the effects of modern agricultural practices on the site preservation, and serve as powerful tools for interpreting the results of ongoing excavations at the site. Our results have led to extraordinary archaeological discoveries at Zincirli Höyük, provide insight into site development and challenge popular conceptions of the organization of cities in the ancient Near East.

Keywords: archaeological prospection, magnetic gradiometry, ancient Near East, Turkey

New Discoveries from Magnetic Surveys at Classical Sites

Tatiana N. Smekalova

Moesgård Museum, Denmark/Danish National Research Foundation's Centre for Black Sea Studies, University of Aarhus, Denmark

The success of a magnetic survey at classical archaeological sites is determined by two factors. First, these sites often have rather thick cultural layers, and the difference between the magnetic properties of the archaeological structures and the surrounding ground is large. Second, ancient Greek and Roman towns, settlements, and farmsteads are usually characterized by rectangular rooms or buildings, by the right angles at the junctions of walls, and by the "classical" proportions of their temples, which help to reveal and interpret the anomalies. Streets in Greek and Roman towns were often paved with fragments of ceramic tiles, pots, and pieces of slag. All these materials are very magnetic. Furthermore, the building walls, which stood along both sides of the streets, were constructed of nonmagnetic limestone, marble, or sandstone. Therefore, the streets are seen as positive anomalies in magnetic maps (magnetic highs) with differing amplitudes (10-100 nT), depending on the amount of paving material. It was possible to reveal the street system in the ancient towns of Kalydon in Eatolia, in Tegea, at Asea, and at Kyparissia in Arcadia on the Peloponnesus. In 2006-2007, a site called Arachamitai was investigated with the help of a magnetic survey. This site is situated in a long valley between two hilly ridges in the foothills near the ancient Greek town of Asea in Arcadia. The magnetic survey revealed a large complex of monumental and rectangular stone buildings. The whole complex can be interpreted as a previously-unknown sanctuary; further excavations will be needed to prove this interpretation. In the area of the northern Black Sea, several sites from classical and Hellenistic times have been investigated with a magnetometer. Greek settlements are usually characterized by their rectangular and compact plans, while the free-standing buildings of the contemporaneous "barbarian" sites usually have an irregular shape. With help from a magnetic survey, it was possible to reveal the fortification system of the ancient town of Labrys (modern Semibratnee) in the Kuban' area (Southern Russia), which was possibly a capital of the region some time between the fifth century B.C.E. and first century C.E. The industrial quarters of ancient Greek and Roman towns can be revealed by means of a magnetic survey because of the very high magnetic anomalies that are found over pottery or tile kilns, pits filled with ceramic debris, metalworking furnaces, and slag heaps. These types of industrial areas have been investigated in Kalydon and at the Roman towns of Kellis and

Trimithis in the Dakhleh Oasis. At the temple site of Dime in the Fayyum Oasis mudbrick walls covered with sand revealed almost no anomaly; unlike Nile loam, the clay in Fayyum is nonmagnetic. At the Dime site, a single dipolar anomaly (+88/-131nT) was detected. The source of the anomaly was a large iron sword with an iron case; it was lying at a depth of 0.8 meters below the surface. A sword of this type is depicted in a relief from Palmyra, now kept in the Louvre and dated to the second century C.E.

Keywords: magnetic surveys, classical sites, Greece, Turkey, Fayyum Oasis, Dakhleh Oasis, Egypt, Crimea, Southern Russia

Tuesday

Remote Sensing and GIS Applied to the Study of an Iberian Iron Age *Oppidum*'s Hinterland: La Carència Project (Valencia, Spain)

Hector A. Orengo[1], Ana Ejarque[1], and Rosa Albiach[2]

1. Catalan Institute of Classical Archaeology, Spain
2. Servei d'Investigació Prehistòrica de València, Spain

The conjunction of remote sensing and GIS techniques offers an unmatched choice when it comes to analyzing ancient landscapes from an archaeological perspective. Many studies have successfully employed such techniques (Palet *et al*. in press, Nuninger and Ostir 2005, Pizziolo and Sarti 2005, etc.). This case study presents evidence drawn from an ongoing project aiming at analysing the hinterland of La Carència Iberian *oppidum* following a long-term and microregional approach. La Carència project focuses its interest in the genesis and evolution of this Ibero-Roman city of outstanding political importance and its immediate territory. The Iberian (Iron Age) to Roman transition is of special interest, given the thorough transformation it supposed to Iberian cultural practices. The combination of surveying, archaeomorphological analysis, old aerial stereophotographic pairs analysis, satellite imagery analysis, GIS-based topographical analyses, and the study of written evidence has allowed the inferring of theories on how the landscape was transited, conceived, and exploited along time. The study of human-induced landscape change in Roman times presents a special interest. The results provided by these techniques suggested that damp areas were drained with the purpose of creating new spaces to inhabit and exploit during Roman times. The Roman presence also involved changes in site distribution patterns of the area which deprived the Iberian *oppidum* of its previous visual control over its territory. These changes would be also reflected in the way in which people moved through the landscape Data drawn from this case study will aim at showing how a sensitive combination of remote sensing and GIS can offer insights on to the long term shaping of landscapes and the role that humans played on it.

Nunniger, L. and K. Ostir, 2005. "Contribution à la modélisation des paléo-reliefs de la plaine littorale de l'étang de Mauguio (Languedoc, France) : premières approches par télédétection" in J.-F. Berger, F. Bertoncello, F. Braemer, G. Davtian and M. Gazenbeek (Dirs.) T*emps et espaces de l'homme en société, analyses et modèles spatiaux en archéologie.* Éditions APDCA, Antibes, pp. 123-34.

Palet, J.M., H.A. Orengo, and J.I. Fiz, In press. *Análisis planimétrico digital de la red viaria y del parcelario en el ager tarraconensis: formas del paisaje y articulación del territorio*. Archivo Español de Arqueología.

Pizziolo, G. and L. Sarti, 2005. "Landscape archaeology in Sesto Fiorentino: a GIS analysis for investigating settlement strategies in wetland area" in J.-F. Berger, F. Bertoncello, F. Braemer, G. Davtian and M. Gazenbeek (Dirs.) *Temps et espaces de l'homme en société, analyses et modèles spatiaux en archéologie*. Éditions APDCA, Antibes, pp. 441-50.

Keywords: remote sensing, GIS, Roman, Iberian, landscape archaeology

Communication Routes and its Role in the Structuration of the Late Antique Territory of Majorca (Balearics Islands, Spain)

Catalina Mas Florit[1], Patricia Murrieta Flores[2], David Wheatley[2], and Miguel Angel Cau Ontiveros[3]

1. Departament de Prehistòria, Història Antiga i Arqueologia, Universitat de Barcelona, Spain
2. Archaeology Department, University of Southampton, United Kingdom
3. Institució Catalana de Recerca i Estudis Avançats (ICREA)/Equip de Recerca Arqueomètrica de la Universitat de Barcelona (ERAUB), Spain

The use of communication routes has allowed the movement of goods and people within the territory since the early years of humankind. Mobility through these routes made possible the sharing of material culture and ideas that played an important role in the transition from Antiquity towards the Early Middle Ages. In the framework of a larger project on Late Antique pottery and landscape in Majorca, there are many problems in fully exploring the structuring of the territory. This is due, among other reasons, to a lack of information regarding communication routes. Therefore, the only way to explore the role of communication routes as an important element for the structuration of the territory is to model them through methodologies of spatial analysis such as Cost Surfaces and Least Cost Paths. This paper presents the results of a GIS-based spatial analysis simulating possible communication routes in the Eastern part of Majorca (Balearic Islands, Spain) during the final moments of Antiquity. For these analyses we have considered Early Christian rural churches, which had a central role in the organisation of the territory, and other sites such as settlements and ports, the later due to their importance as centres for redistribution of goods and arrival of people. In this research, four of the most popular formulas used in spatial analysis for the calculation of least cost paths were applied. In the end, this paper evaluates the methodology used and compares the results of the different formulas applied and discuss on the obtained results and its importance for the interpretation of the distribution of the sites on the landscape of the Eastern part of this Mediterranean island.

Keywords: Majorca, communication routes, GIS

Session Summary

Tuesday, 10:15am-11:45am, Constitution

Short Paper Session for Presentation of Students' Research Projects

Chair: Stephen Stead, Paveprime LTD, United Kingdom

Organizers: Stephen Stead, CAA Steering Committee, Paveprime LTD, United Kingdom
Nick Ryan, CAA Steering Committee, University of Kent at Canterbury, United Kingdom

Tuesday

Sponsored by the CAA International Steering Committee

This session allows for students and new scholars to describe their current or new research project. It is intended that this will provide a platform for students to give a brief (five minutes maximum) presentation on their research. It is particularly aimed at first-year Ph.D. or Masters candidates who have only recently started their research. But all are welcome, young or old we do not care we are just interested in what you are up to! It is hoped that this will give an opportunity for newcomers to gain some experience in giving papers at an international conference without the pressure of a full paper and the expectation of publication (although contributions can be submitted for publication if you want). Some old CAA hands will be around to make suggestions as who might be a good person to network with (consumption of fluids is of course optional during such "networking").

It is organized as a series of short papers and additional time is available for late additions to the program. So you can submit a paper ahead of the conference or just turn up and give a brief outline of what you are embarking on. Pre-submitted papers may be considered by your department as a reason to help support you attending the conference. So if you fancy getting you feet wet by presenting at CAA but don't fancy a full paper just yet or want a few pointers as to who might a good person to chat with, come along and tell us what you are up to! As a final incentive the best contribution (as voted by the all attending the session) will receive a small prize (contributed by the CAA International Committee).

The session is organized by the CAA International Steering Committee as a part of the conference program. This is the third time such a session has been run.

Schedule

10:15 - 10:25 "Revealing Semantics Behind User Behavior in Large-Scale Object-Oriented Databases," Andreas Geißler

10:25 - 10:35 "3D Visualization Interface for Cultural Landscapes and Heritage Information," Arnoud de Boer, Leen Breure and Hans Voorbij

10:35 - 10:45 "Collaboration of International Students and Spanish Archaeologists—A Survey of Archaeological Excavations," Claudia Bothe
10:45 - 10:55 "Applying a Neutral Agent Based Model of Lithic Material Procurement to the Middle Atlantic Region, United States," Matthew D. Harris
10:55 - 11:05 "Archaeological Modeling in East Anglia and Norfolk," William Wilcox
11:05 - 11:15 "Travelling in a Prehistoric Landscape: Exploring the Influences that Shape Human Movement," Patricia Murrieta Flores
11:15 - 11:45 Additional student papers and discussion

Abstracts

Revealing Semantics Behind User Behavior in Large-Scale Object-Oriented Databases

Andreas Geißler

German Archaeological Institute, Berlin; Research Archive for Ancient Sculpture and Research Institute in Computer Science for the Humanities at the University of Cologne, Germany

So far, little is known about how intense and in which ways the more and more growing databases on cultural-heritage objects are actually used. This work in progress, which started in January 2008, intends to exemplary examine the user behavior in one of such large scale cultural-heritage databases and in a further step wants to develop possible ways to exploit this analyses for the enhancement of this databases. This research project is going to be the basis of a doctoral thesis which is planned to be submitted in 2010 at the University of Cologne's research institute in Computer Science for the Humanities. Arachne (http://www.arachne.uni-koeln.de) is the central object-database of the German Archaeological Institute (http://www.dainst.org). In 2004 the German Archaeological Institute and the Research Archive for Ancient Sculpture at the University of Cologne joined their efforts in providing and further developing Arachne as a tool for free internet-based research. With currently 3000 registered users and more than 200,000 archaeological objects, the conditions for a large-scale database are more than complied with. The key aspect which makes Arachne so exceptionally interesting for this research is the fact that a huge amount of this objects is contextualized. This can be best experienced by the user via the navigation through a so called context-browser. Especially the analysis of the user's navigation between contextualized objects is expected to be the key for answering one of the main questions of this thesis: Can the way users navigate from one object to another possibly be used for any conclusion on relations between the initial search term an the afterwards visited objects? Up to now a first test drive has been made which had the goal to verify that the usage of Arachne is not just superficial but has indeed an extend which can be a profound basis for a deeper research with the questioning depicted above. The proposed paper would give me the opportunity to present the promising results of this test drive and put the upcoming steps, like the technical aspects within the implementation of a full-scale user tracking

and even the question whether the CIDOC-CRM could/should be possibly used for describing "research-events," forward for discussion.

Keywords: user tracking

3D Visualization Interface for Cultural Landscapes and Heritage Information

Arnoud de Boer, Leen Breure, and Hans Voorbij
Utrecht University, The Netherlands

Tuesday

3D visualization of cultural landscapes has numerous applications in fields ranging from landscape planning and edutainment to landscape archaeology and history. While technology of Computer Graphics and Virtual Reality matured and photorealistic representations were achieved, we encountered three problems that strongly impede the creation of 3D virtual environments during some preliminary experiments in modeling historical buildings and landscapes (in our case the Palace Honselaarsdijck and its surroundings, near Naaldwijk, The Netherlands).

1. Limited sources, and therefore uncertainty in the historical situation, make it difficult to efficiently process and combine temporal geo-information (e.g. historical maps and drawings) using 2D and 3D GIS technology;
2. (Photo)realistic 3D modeling of objects that have completely disappeared, is a laborious and skilful work and therefore obstructs the feasibility of detailed 3D historic reconstructions;
3. Required user interaction and perceived 'realism' of the 3D virtual environment are strongly related to project defined objectives and information requirements.

Our research differs from that of landscape archaeologists and architects in that our focus is not on providing tools and methods to visualize historic scenes as realistic as possible. It aims at searching a methodical way to realize 3D virtual environments that holds the essential characteristics of the landscape in the past, and searches for decisive variables that influence user experience. Such a model could, for example, serve as an interactive (user) interface for a federated search through cultural heritage repositories. Therefore in our opinion, a realistic experience does not necessarily goes together with a (photo)realistic representation, so we are exploring the use of among others a 3D object library (including historic artifacts and decoration relating to a specific space and time) and other 3D visualization tools (e.g. 3D symbols, markers) to effectively communicate and visually narrate cultural landscapes and heritage information by means of an interactive 3D visualization interface. We expect our research will contribute to the realization of 3D visualizations of cultural landscapes, in particular the presentation of cultural heritage information to a broader public to enable them to "read" the landscape in space and time on different topical levels.

Keywords: 3D visualization, cultural heritage information, interaction, realism, user interface

Collaboration of International Students and Spanish Archaeologists—A Survey of Archaeological Excavations

Claudia Bothe
Universität Hamburg, Germany

In September 2008, nine German and eleven Spanish students met up in Madrid to spend two weeks in the north of Spain, gaining practical experience in surveying archaeological excavations. The collaboration of the Geomatik department of the HafenCity Universität Hamburg, as well as the Universidad Politécnica de Madrid and the Universidad del Pais Vasco in Vitoria, exists for five years already and for summer camp 2008 it was supported by lectures and students as it offers a wide range of praxis-based projects. The first project took place in Atapuerca/Burgos. Atapuerca, which belongs to a world cultural heritage, consists of a widespread system of caves and sinkholes. This is where Europe's oldest hominids were discovered. Those caves were surveyed and scanned by the students and the captured data analyzed independently. The second station was the archaeological excavation Segeda, which is located in Mara/Saragossa. Each day, all students were separated into four groups so everybody got the chance to learn something about different survey challenges. The work consisted of defining the Geodetic Reference Systems, topographic surveys and the laser scanners Mensi 100 and Imager 5006. One of the projects in Segeda was to capture data from an ancient Roman city wall. Most parts of the wall were excavated by erosion over the years and destroyed by the contemporary winegrowing. This is why it was just possible to scan a small section of the wall which is located in the middle of a winegrowing district. To survey this section, which has 200 meters in the length and a height of 4 meters, it took two days. One day gave us the possibility of visiting an Ibero-Roman excavation called Contrebia. There as well we accomplished some relevant laser scans which were presented to local archaeologists later so they could get an impression of how students of geomatik work and how it could be useful to them.

Keywords: archaeological excavations, Spain, surveying, aerial survey

Tuesday

Applying a Neutral Agent-based Model of Lithic Material Procurement to the Middle Atlantic Region, United States

Matthew D. Harris
John Milner Associates Inc., United States of America

Agent based modeling (ABM) is a useful tool in the assessment and creation of archaeological theory. Specifically, the use of neutral models allows researchers to develop baseline theories by relying on few assumptions. In the place of attempting to model complex and often poorly understood real world mechanism, stochastic processes are used as attributes of the model. By reducing the number of potentially conflicting processes being modeled, interpretation and validation can focus on a single process. The outcome of a neutral model can act as a null theory from which to compare and contrast established archaeological hypothesis. This

research follows and expands a neutral approach of lithic material procurement and assemblage development originally developed P. Jeffery Brantingham. The neutral model method is used to remove assumptions about the desirability and location of different lithic materials, lithic material consumption rates, and the settlement patterns in which lithic procurement is mapped. Lithic resource "outcrops," each with the same perceived desirability, are scattered randomly across the model landscape. As the agent traverses the model landscape in a random walk, lithic material is utilized at a constant rate and collected when encountered. The standardization of these factors leads to a model with limited assumptions serving as a baseline for how random lithic procurement may look in an archaeological context. Measurements of the model record a time series of the "richness" of the agent's lithic assemblage, the number of time steps spent at various richness states, and distance each material is carried from its source. The neutral model results are used to evaluate the null theory of stochastic lithic selection against the variability of lithic materials recorded on prehistoric sites in the Middle Atlantic region of the United States. Implications for the similarity of modeled and actual assemblages call into question the basis for long held ideas about lithic selection. However, the differences in models allow the opportunity for explanatory hypothesis regarding social and trade/exchange dynamics.

Keywords: agent-based model, lithics, neutral model, Middle Atlantic region, prehistory

Archaeological Modeling in East Anglia and Norfolk

William Wilcox
United Kingdom

I will briefly detail my research into archaeological modeling in East Anglia (UK) and in particular Norfolk. I will expand upon the difficulties I have encountered with modeling across political boundaries and across topographical regions plus I will explain how I have derived an independent dataset with which to test my models against. I will give my basic thoughts and ideas about using archaeological predictive modeling for cultural heritage management.

Keywords: archaeological modeling

Travelling in a Prehistoric Landscape: Exploring the Influences that Shape Human Movement

Patricia Murrieta Flores
Archaeology Department, University of Southampton

"We move, are moved or we die." Fernandez (1979) begins one of the classical researches in social science with this statement. His assertion was true in the context of his research, but has been also relevant for other sciences that attempt to understand the complexity of movement. It can be said that as human beings, the desire to

explore the world has been with us from the beginning of our existence. From the basic act of looking for food and water, to travelling many kilometers to trade goods and engage in commerce, humans have had to travel at various geographic scales. Due to movement's importance not only for implied economic consequences, but also as a key to understand the development of diverse social aspects such as technology, political complexity and even social inequality, human movement had become a central concern for archaeology and anthropology. Several studies have already shown the complexity of the phenomena and the difficulties inherent to this area of research. Between the complications identified it can be mentioned the limitation in the available archaeological data, a lack of understanding of the variables and factors that influence and constrain human movement, the difficulty of finding and choosing adequate analytical tools to analyze movement which present extremely complex relationships; and finally, the inherent difficulty to model human movement and mobility even with the use of the most current and sophisticated spatial technologies such as GIS. This paper explores the complexity of human movement on a landscape scale, delving into the main variables and factors that might have influenced mobility during prehistory and the implementation of spatial technologies for its study.

Keywords: human mobility

Session Summary

Tuesday, 10:15am-11:45am, Liberty

ECAI: e-Resources—Space, Time, and Text

Chair: Susan Whitfield, British Library, United Kingdom

Each of the panelists provides an existing and expanding project of how resources can be used from the full scope of the humanities and social science. Paul Ell gives the first report on the large project to capture Irish history data. The other speakers give examples in North America and Australia.

Schedule

10:15 - 10:35	"Structure or Serendipity: e-Resource Development in Ireland, A Case Study," Paul Ell
10:35 - 10:55	"Issues in Visualizing History—Early California Culture," Jeanette Zerneke
10:55 - 11:15	"Locating Missions in Space and Time: Lessons from the North American Missions Project," Tracy Neal Leavelle
11:15 - 11:35	"EarthTextSpaceTime: Making Historical Sources in Cities Available through the Agency of GIS," Felicity Morel-Ednie Brown
11:35 - 11:45	Discussion

Abstracts

Structure or Serendipity: e-Resource Development in Ireland, A Case Study

Paul Ell
Queens University, Belfast, Ireland

Until recently, the United Kingdom has invested much in digital humanities, focusing both on the creation of research resources and the provision of e-infrastructure. The development of Irish Studies e-resources have benefited from these initiatives through government Research Council investment from ESRC, AHRC and JISC (organizations mirroring with work of NSF, NEH and IMLS). However funding to maintain and build on this work is increasingly fragile. By contrast, in the Republic of Ireland digital humanities funding was largely absent until a €28,000,000 investment through the Humanities Serving Irish Society (HSIS) and the related Digital Humanities Observatory (DHO) collaboration from 2007. Significant grants, involving almost all universities on the island of Ireland, offered a structured approach to the development of digital humanities. This paper reviews the UK's and Ireland's approaches to the creation of e-resources, the

opportunities for new scholarship through inter-linking scholarly corpora in a spatio-temporal context, and the long-promised step-change in humanities research outputs in a post grid-computing environment.

Keywords: e-resources, funding, UK, Ireland

Issues in Visualizing History—Early California Culture

Jeanette Zerneke
University of California, Berkeley, United States of America

Abstract text not available as of press time.

Locating Missions in Space and Time: Lessons from the North American Missions Project

Tracy Neal Leavelle
Creighton University, United States of America

Abstract text not available as of press time.

EarthTextSpaceTime: Making Historical Sources in Cities Available through the Agency of GIS

Felicity Morel-Ednie Brown
Department of Premier and Cabinet, Australia

We are all constrained by our location on the planet, as has also been the past. The capacity to place historical information accurately within a geographical framework can open sources of information which may previously have been obscured. This is particularly so in the most intensive land-use areas: cities. Whilst geography may not consciously influence analysis, the use of GIS to collate, analyze, and investigate historical material creates new possibilities for understanding the agency of the environment with our cities. As tool and technique combined, GIS provides tools to read the landscape differently and to map against the landscape information from other sources, not traditionally thought of as spatial. A finely grained investigation of cities can subsequently become the driver for a better understanding of human agency in the creation of our urban environment and reveal the connection between place, source, space, and history. Such understandings, in turn, become the catalyst for a reassessment and refreshment of the urban environment through the rediscovery of its unique characteristics.

Keywords: GIS, cities, urban environment

Session Summary

Tuesday, 1:30pm-3:00pm, Patriot

CyArk Digital Preservation (Part 2)

Chair: Elizabeth A. Lee, CyArk, United States of America

Tuesday

3D data capture is widely used for documentation and proves invaluable to cultural heritage. As 3D documentation becomes the standard for heritage sites, new problems arise around the complete process of capturing, producing, presenting, and archiving this digital media. Using CyArk's Digital Preservation Process as the session theme, several presentations will be given on the widespread implementation of this process. Presentations will be given by CyArk partners who have leveraged newly developed web-based applications to manage digital media and make it accessible to the general public. Presentations will also demonstrate how to add value to data by producing rich digital media and placing it within a spatial and cultural context. Presentations will also examine the CyArk web-based archive (http://archive.cyark.org) and its emphasis on user interactivity. Papers presented will be selected from a wide range of disciplines, including professional survey firms, universities, the media and foundations. The goal of the session is to foster awareness of the CyArk methodology and to encourage discussion about its adaptation for more widespread implementation.

Topics: 3D data capture and modeling, data management systems and other field applications, high-precision surveying

Keywords: 3D, web-based, digital, interactivity

Schedule

1:30 – 2:00	"Introduction: Large-Scale Implementation of Digital Preservation Methods," Elizabeth A. Lee and Ben Kacyra
2:00 – 2:20	"LD3 Technology and Historical Preservation," John R. Brown and Chris Royak
2:20 -2:40	"Using 3D Laserscanning for the Additional 3D Documentation of New Excavations from Different Time Periods," Erwin Christofori
2:40 – 3:00	"RADAAR Department Experience in Documentation and Digital Preservation of Ancient Performing Spaces: from the Rome Coliseum to Athena Project," Carlo Bianchini

Abstracts

Large-Scale Implementation of Digital Preservation Methods

Elizabeth A. Lee and Ben Kacyra
CyArk, United States of America

See p. 92

Tuesday

LD3 Technology and Historical Preservation

John R. Brown and Chris Royak
CH2MHILL, United States of America

CH2M HILL, a world leader in technology, and its partner software and hardware development partner, InteliSum, are utilizing its LD3 technology to take point cloud data to the next step. By fusing the visual aspects of a scene together with the spatially accurate location of each point, LD3 will change the way the industry views point cloud data. John Brown, Senior HDS Practice Leader with CH2M HILL, will show how this firm is utilizing this fascinating LD3 technology in many of its current projects and will highlight the value of high resolution data capture on preservation and archeological sites worldwide.

Keywords: point cloud data, high resolution data capture

Using 3D Laserscanning for the Additional 3D Documentation of New Excavations from Different Time Periods

Erwin Christofori
Christofori Und Partner, Germany

This presentation will highlight work done on four different sites of four different time periods. The first site was a bronze-age grave in Biburg, discovered during the planning of a residential area. After completion of the excavations, documentation was carried out with the HDS 6000. It took the form of a paper plan and a 3D print. The second site was a former Roman border in Rätien. The former Roman border lies in the area of the former Roman castle at Dambach. The water-level of the lake was reduced. The limes became exposed. A castle wall and a gate were found and the results were documented by a 3D laser scanner. The third site was a former monastery, Heilsbronn. A new sewer was planned in the cloister area of the former monastery, through the city of Heilsbronn. The cloister area was mostly destroyed 200 years ago. Preliminary examinations hadn't led us to expect any archeological results. Remains of different periods were found and many walls and some vaults were exposed. The excavation was documented with a 3D laser scanner. The fourth site was the

Monastery of Plankstetten. The Monastery is a successfully managed business, run by the monks. A big new building was provided by the monks: the old cloister was pulled down some centuries ago. The foundations and a cemetery still lie under the old cloister. An archaeological dig was carried out before the new building could start. The excavations were documented by 3D laser scanning. A virtual reconstruction of the old situation is planed in 2009.

Keywords: 3D laser scanning

Tuesday

RADAAR Department Experience in Documentation and Digital Preservation of Ancient Performing Spaces: From the Rome Colosseum to Athena Project

Carlo Bianchini
"La Sapienza" Università di Roma, Italy

Ancient theatres are among the most extraordinary monuments of Mediterranean civilizations. From a cultural point of view, these structures played an important role in the social life of cities. From an environmental point of view, they are notable for their design criteria and territorial and urban impact. From a technological and functional point of view, the quality of distribution schemes and acoustical solutions is striking. Furthermore, the capillary diffusion of this architectural type along the whole Mediterranean basin is extraordinary, as well as the number of ancient theatres currently still in use. Nevertheless, the life of ancient theatres actually swings between two extremes: on the one hand they experience a contemporary reuse that revives the functions and the cultural, social, and economic role of the structure but in the long run would lead to a progressive general decay; and, on the other hand, there is an urge for strict protection of the theatres and total exclusion of human pressure, which would preserve the site but also lead to its inexorable cultural, social, and economic death. For all these reasons, the set-up and deployment of a general documentation strategy is urgent, in order to achieve an overall preservation of sites. New technologies can play a relevant and innovative role in this process.

The Department of Survey, Analysis, Drawing of Environment and Architecture (RADAAR) of "La Sapienza" University of Rome has been working on this specific problem for the last ten years. In this paper we shall focus on the different problems encountered in this period of the laser-scanning revolution. Starting with the Anfiteatro Flavio Project, we will pass through more recent experiences in the Merida (Augusta Emerita–Spain) and Taormina (Italy) complexes, finishing with descriptions of the conception and development of the Ancient Theatres Enhancement for New Actualities (Athena) Project, in which the digital preservation strategy appears to be significantly mature. The Athena Project, one of the new EU-funded projects in the Euromed Heritage Programme, is going to spend the next three years dealing with this class of problems and trying to establish procedures and standards for documentations and digital preservation of ancient performing spaces. In this area CyArk, especially in the frame of the 500 Challenge, aims to develop a

sound synergy with positive mutual feed-backs: the Athena Project would in fact usefully draw on CyArk potential in terms of technical assistance and web dissemination potentials, while CyArk would profit from the scientific and methodological achievements as well as from the results of a focused (Ancient Theatres) but complete Pilot Project in the field of cultural heritage documentation and management.

Keywords: ancient theatres, digital documentation, survey, 3D modeling

Session Summary

Tuesday, 1:30pm-5:30pm, Constitution

Workshop: The CIDOC Conceptual Reference Model—New Standard for Knowledge Sharing

Chair: Stephen Stead, Paveprime LTD, United Kingdom

Tuesday

This tutorial will introduce the audience to the CIDOC Conceptual Reference Model, a core ontology and ISO standard (ISO 21127) for the semantic integration of cultural information with library, archive and other information. The CIDOC CRM concentrates on the definition of relationships, rather than classes, in order to capture the underlying semantics of multiple data and metadata structures. This leads to a compact model of 82 classes and 132 relationships that is easy to comprehend and suitable to serve as a basis for mediation of cultural and other information. It thereby provides the semantic "glue" needed to transform today's disparate, localized information sources into a coherent and valuable global resource. It comprises the concepts characteristic of most museum, archive and library documentation.

The tutorial aims at rendering the necessary knowledge to understand the potential of applying the CRM where it can be useful and what the major technical issues of its application are. It will present information integration by employing a core ontology of relationships, in contrast to the prescription of a common data format, as an approach applicable to other domains. Participants with some background in information modeling should be able to use the CIDOC CRM in their applications after this course and some further reading.

Topics: CIDOC and other digital standards

Keywords: CIDOC CRM, ISO21127, Data standards, Ontology

Tuesday

Session Summary

Tuesday, 1:30pm-3:00pm, Liberty

ECAI: Inventing Paths in Digital Data

Chair: David Blundell, National Chengchi University, Taiwan

The Co-Director of ECAI, Michael Buckland, opens this part of the conference with a report on explorations of how to assist users of digital libraries. The presenters will provide differing approaches to this task of assisting users. Imaging of data and special metadata for searching provide new approaches for users and creators of databases.

Schedule

1:30-1:50 "Empowering Readers to Find Explanations: A 4W Approach," Michael Buckland
1:50-2:10 "Spatiotemporal Tools and Metadata for Area Studies," Shoichiro Hara and Ikuo Oketani
2:10-2:30 "Blue Dots—Visualization of Text Corpus," Howie Lan
2:30-3:00 Discussion

Abstracts

Empowering Readers to Find Explanations: A 4W Approach

Michael Buckland
iSchool, University of California, Berkeley, United States of America

Understanding anything depends on knowing the context and how it is related to other elements in its context. Some recent work has focused on ways to enable any reader of any text to find explanations conveniently, as if sitting in a reference library, of any unfamiliar name, place, institution, topic, or event. Explanations can be provided through a specialized interface using search and retrieval protocols with a range of recommended resources. To provide an effective structure, we have been distinguishing What, Where, When and Who because these facets have different resource genres and specialized display requirements. Experimental prototype interfaces will be presented. The technical problems of creating and deploying a 4W structure will be discussed based in part on an attempt to enhance short biographical texts with an event-based 4W structure.

Keywords: context, reading

Spatiotemporal Tools and Metadata for Area Studies

Shoichiro Hara[1] and Ikuo Oketani[2]

1. Center for Integrated Area Studies, Kyoto University, Japan
2. Osaka International University, Japan

Tuesday

The H-GIS (Humanities GIS) research group has been engaged in establishing Area-Informatics, a new paradigm for integrating individual disciplines, and creating new knowledge for projects using information engineering technologies, such as metadata standardization, databases engineering, ontology engineering, GIS, GPS, and remote sensing. H-GIS has also constructed some spatiotemporal applications. This presentation will introduce and discuss some applications. The group has created several kinds of databases, which are expected to be the basis of Area Studies, but since each database is different, users must learn the specifications (e.g., data structures, operations, locations, etc.) in order to retrieve data. The Resource Sharing Information System (RSIS) is a framework for seamlessly integrating multiple databases on the Web, and it allows users to retrieve data from multiple databases with a single operation. One of the key features of RSIS is standardized metadata. The latest version of RSIS introduces a Metadata Suite which can include metadata for specific and general purposes, including EAD, MODS, METS and DCM. H-GIS has also developed two spatiotemporal tools to analyze data. The first, HuMap (Humanities Map), is derived from the TimeMap Open Source mapping system. The latest version has many GIS analytical functions, and source codes are completely original. It is composed of a server application and a client GIS tool. Like TimeMap, the client tool has an ability to process time attributes. It also has a database function, which is used to retrieve and import data from the H-GIS Data Clearinghouse, and a Java-plug-in function, which links users' Java programs and the HuMap layer data framework. The second tool is HuTime, a revolutionary time-oriented software. Where HuMap treats maps as layers, HuTime treats historical tables as layers. HuTime can overlay many layers according their timelines, retrieve events from each layer, and execute logical operations among layers. Due to the different development phases, the two tools use different sets of metadata and at present HuMap and HuTime cannot use the same spatiotemporal data simultaneously. Mutual metadata for HuMap, HuTime, and the H-GIS Data Clearing House is under construction and will be used to operate HuMap and HuTime seamlessly and connect both applications with the H-GIS Data Clearing House. Two ontology databases have been created to support spatiotemporal data organization. The one is the Gazetteer Database on Japanese Classical Places, a database of past and present place names (rivers, lakes, mountains, shrines, temples, houses, etc.) and their attributes and locations by longitude and latitude. The other database is a calendar table: all dates described by different calendars are grouped and ordered according to Julian dates. This simple table can be used to convert a date of a calendar to the date of another calendar. We will open metadata definitions of these databases to expand their contents via cooperation with other institutes.

Keywords: GIS, mapping, databases

Blue Dots—Visualization of Text Corpus

Howie Lan
University of California, Berkeley, United States of America

Developed by the "Text Analysis and Pattern Detection" project team, the "Blue Dots" web-based tool provides a new way of visualizing textual analysis of a large amount of traditional Chinese Buddhist texts, such as the Korana Tripitaka canon, as well as multi-dimension linking to scanned images of original text and contextual information. We will see some sample applications, demonstrating the concept, ideas, and models behind the project.

Keywords: text analysis

Session Summary

Tuesday, 3:15pm-5:30pm, Tidewater B

Workshop: New Dimensions in Profile Modeling: Rapid Digitization of Archaeological Objects

Chair: DOUGLAS W. GANN, Center for Desert Archaeology, United States of America

Profile modeling allows for the rapid, accurate, and low-cost digitization of three-dimensional objects or artifacts without the use of expensive and cumbersome LIDAR scanning. Within the profile modeling process, digital representations of three-dimensional artifacts are created through the use of calibrated digital photography. Photo-realistic texture maps are then automatically generated, along with associated UV mapping data. The resulting three-dimensional models generated by this process have tremendous utility in research and interpretive contexts, with the most obvious applications being in virtual museum and virtual reality display systems. A NEH-funded prototype of this technology, currently being used for the digitization of a large collection of southwestern ceramics, is available online at http://www.cdarc.org/vv/vv-example-1.html. A pdf version of this prototype is available at http://www.cdarc.org/vv/gp-4730.pdf.

This workshop will critically examine the benefits and drawbacks of profile modeling by demonstrating the profile modeling process on a variety of real or replica artifact types. Different profile modeling systems will be compared for the discussion of suitable applications in archaeological research. Workshop participants will be given a DVD-ROM with raw data sets and trial versions of all of the software necessary to create a detailed three-dimensional artifact model of their own choice. Workshop participants will need to either bring a suitable MS Windows based laptop, or be provided with a similar workstation for participating in the creation of three-dimensional artifact models. Should time and the setting allow an extended demonstration, workshop participants should be able to generate their own data set for an artifact model of their choice. The demonstration will utilize end-user instruction with the programs 3d Solid Object Modeler Professional Version 2, Strata Photo 3d and Strata Live 3d. Additional demonstrations will employ the use of Virtual Reality Markup Language (VRML) display software, 3d Studio Max and Adobe Acrobat to highlight additional refinements and applications of the end result of profile modeling projects.

Upon completion of this two-hour workshop, participants should be able to begin using profile modeling for the rapid digitization of the morphology and texture of three dimensional artifacts. Workshop participants will also be provided with a basic working knowledge of the techniques used to share these models over the internet through HTML using Javascript, Flash, or Shockwave as well as PDF and VRML display systems.

TOPICS: 3D data capture and modeling, photogrammetry and imaging, virtual museums, virtual reality

KEYWORDS: 3D, digitizing, modeling, virtual, museum

Session Summary

Tuesday, 3:15pm-5:30pm, Tidewater D

Workshop: ArchCamp 7

Chair: Gareth C. Beale, University of Southampton, United Kingdom
Leif Isaksen, University of Southampton, United Kingdom

Tuesday

ArchCamp is a regular meeting of minds and idea-swapping session held by the Antiquist Cultural Heritage and IT online community. ArchCamp is intended as an open forum within which participants can demonstrate and discuss ongoing interesting and innovative projects and ideas. The session will take a round table format with all attendees welcome to comment and interact on an equal footing. In order to keep things interesting, we ask that participants bring a topic or topics with them that they would be interested in presenting. These will be listed during a round of introductions, after which we will agree upon a loose thematic agenda according to the interests of those present. Generally speaking, presentations will last 5-10 minutes followed by a further 10-20 minutes of interactive demonstration of the relevant tools and technologies. Time will be set aside at the end to pass on and discuss any web discoveries or matters of common interest that participants may have stumbled upon prior to our session.

ArchCamp has been successfully held in conjunction with four previous CAA conferences (Southampton and Berlin 2007, York and Budapest 2008) and will also be held at CAA UK 2009 in Liverpool. The session generally lasts for around three hours and is traditionally followed by drinks, food, and sparkling conversation at a local watering hole.

For details of past ArchCamps, see: http://www.antiquist.org/wiki/index.php?title=Archcamp

Topics: other

Keywords: open discussion

Session Summary

Wednesday, 8:30am-3:00pm, Tidewater A

Visual Archaeologies for the Digital Age: Rethinking Representation in Archaeology

Chairs: GRAEME PETER EARL, University of Southampton, United Kingdom
GARETH C. BEALE, University of Southampton, United Kingdom

Visualization has been central to the archaeological process from the inception of archaeology as a discipline. Visual representations have been created to aid every stage of the archaeological process from the capturing of field data to the representation of complex theories, interpretations and concepts. In turn, representations have shaped and directed many aspects of archaeological thought. Computer graphics introduce a new range of visual media to archaeology. Many of these new representative forms are grounded in established archaeological practice. However, others provide new challenges to a critical archaeology.

In this session we wish to discuss the interface between computer graphics and the archaeological process. In particular we are interested in the extent to which computer graphics produced in an archaeological context are themselves a form of archaeological practice. We encourage papers demonstrating computer graphics not only as alternatives to traditional illustrations but also as new tools for engagement and knowledge formulation. Some of the ideas we wish to explore include:

1. *Graphical recording techniques*. How have computer graphics altered the way that we record archaeological data and how have these changes altered the way that we think about archaeological practice?
2. *Graphics as collaborative environments*. Computer graphics allow us to construct a vast range of interactive and non-interactive archaeological spaces, places and environments. What impact have these played on archaeological interpretation?
3. *Performative Graphics*. CGI encourages new modes of representation that can communicate to a diverse audience in ways impossible through traditional archaeological modes of expression. How do these changes alter our perception of archaeological subjects and how can this be of use to us?

TOPICS: 3D data capture and modeling, virtual museums, virtual reality

KEYWORDS: computer graphics, representation, performance

Schedule

8:30 – 8:50 "Documenting Authenticity: The Publication and Citation of Sources used in the Reconstruction of Papyrus-bundle Columns from the Pyramid of Senwosret III," David Sherratt Johnson

8:50 – 9:10 "Harmonizing Archaeologies: Digital Reconstructions of Pisidian Antioch and the Sanctuary of the Great Gods, Samothrace," J. Matthew Harrington

9:10 – 9:30 "A System of Pottery Shape Recovery and Repairing," Mingquan Zhou, Guo-hua Geng, Zhongke Wu, and Wuyang Shui

9:30 - 9:50 "A Scientific Approach Using Computer Graphics to Reconstruct the Potential Original Architectural Unity of Archaeological Ruins," Valentina Castagnolo

Coffee break

10:15 – 10:35 "Towards a Strategy for Evaluating Heritage Visualizations," William Limp

10:35 – 10:55 "Talks, Articles and Exhibitions: Does Interactive History Need New Metaphors?" Catja Alexandra Pafort

10:55 – 11:15 "Representing the Present Past: Interacting with Archaeological Information in Museums and on the World Wide Web," Christopher Aaron Sevara, Per Stenborg, Johan Ling, Mats Sodorstrom, Jonas Tornberg, and Liane Thuvander

11:15 – 11:35 "Intra-Site Spatial Analysis of a Neolithic Cemetery (Cernica, Bucharest)," Alexandru Morints and Raluca Kogalniceanu

Lunch

1:30 – 1:50 "'A Picture is Worth a Thousand Words'—Visualising Archaeological Textiles," Hembo Pagi

1:50 – 2:10 "Hole Filling for Cultural Relics Restoration Based on the Geometry Image," Mingquan Zhou, Wuyang Shui, Guo-hua Geng, and Zhongke Wu

2:10 – 2:30 "Excavation and Three-Dimensional Data Visualization at the La Brea Tar Pits," Andrea Karoline Thomer, Michael Dale Wilson, and Tara S. Thara

2:30 – 3:00 Discussion

Abstracts

Documenting Authenticity: The Publication and Citation of Sources Used in the Reconstruction of Papyrus-bundle Columns from the Pyramid of Senwosret III

David Sherratt Johnson

The Museum of Reconstructions, United States of America

Computer reconstructions of ruined buildings are typically made up of an amalgam of actual state data and modeled solutions to problems of uncertainty. Because reconstructions often aggregate dimensional data from multiple sources, it can be difficult or impossible to test or review their accuracy in the absence of comprehensive descriptions and citations. For this reason, the advent of undocumented computer reconstructions marks an important shift in how drafting techniques have been applied in archaeological practice. Conventional perspective reconstructions have typically appeared as a component of publications that also included orthographic drawings, descriptions, and citations. One could argue that it is a lack of documentation which has given rise to concerns about the authenticity of computer-modeled archaeological reconstructions. This presentation will evaluate the content, structure, and limitations of a publication documenting computer models developed in a collaboration between the Metropolitan Museum of Art Egyptian Expedition and the Museum of Reconstructions (Johnson 2009). To the extent allowed by the duration of this presentation, complete descriptions will be given of every source and solution used in the reconstruction of papyrus-bundle column fragments excavated at the Dahshur pyramid complex of Senwosret III. In cases where elements of this column were modeled after actual state data recorded by the Egyptian Expedition, specific drawings and dimensions will be cited and reviewed. Where proposed solutions to problems of uncertainty have been used in the modeling of this column, supporting analogies or conjectures will be described in detail along with possible alternate interpretations. Conferees will have the opportunity to choose which elements of this reconstruction will be described during the presentation. The efficacy of conventional forms of publication relative to approaches using structured data and high-resolution orthographic composites will also be discussed.

Johnson, D. S., 2009. "Archaeological Computer Reconstructions and The Metropolitan Museum of Art Egyptian Expedition: The Pyramid Complex of Senwosret III." In *Representing the Past*, edited by S. Bonde and S. Houston, Brown University, Providence, Rhode Island, in press.

KEYWORDS: computer modeling, reconstructions, documentation, dimensional accuracy, Egyptian architecture

Harmonizing Archaeologies: Digital Reconstructions of Pisidian Antioch and the Sanctuary of the Great Gods, Samothrace

J. MATTHEW HARRINGTON
University of Michigan, United States of America

As a method employed to arrange incomplete data sets into meaningful patterns, computerized 3D modeling is a process more efficient in time and expense and entirely less restrictive as a mode of thinking than many other options, whether these methods are termed description, reconstruction, or conservation. It may be that this technique is given less scholarly respect than its utility deserves, due to the ease with which flawed

evidence and ideas can be brought into a photorealistic impression of certainty. Scholarly provisionality is often the quality that is sacrificed in favor of verisimilitude and, if desired, literal tangibility; that a technique may be misused is no intrinsic flaw, however. More than a question of whether one particular method of argumentation is more illusory than any other, the use of text, image, or even stone to represent a hypothesis becomes a question of how our discipline chooses to communicate its understanding of evidence and its significance to other scholars and to the non-specialist. The Augustan colony of Pisidian Antioch was first investigated by the University of Michigan in the 1920s. The range of technologies available at that time were employed to record the site and its monuments. Of particular note are the plans and reconstruction drawings of the expedition architect Fredrick Woodbridge. Taking the hypotheses represented by these images in combination with the expedition reports, additional site study, and current understandings of Roman architecture and urban design, digital reconstruction of the city and its monuments formed the core of an interdisciplinary exhibition effort led by Elaine Gazda for the Kelsey Museum. The process of 3D visualization proved particularly effective in making the materials of the original expedition broadly accessible to the visitors and in advancing new arguments. Similarly, the Sanctuary of the Great Gods on Samothrace, at its maximum development in the early imperial period, provides an effective test case for the consideration of the role of computerized reconstruction in the investigation, unification, and publication of a complex array of disparate data. This site has been excavated and investigated by a series of teams for more than a century, resulting in sets of archaeological data conforming to no one methodology or even language. I will argue that 3D modeling is a uniquely effective tool for integrating and researching such archaeological data and for subsequently reaching the non-specialist audience in the setting of the museum.

Keywords: Antioch, Samothrace, 3D, museum

A System of Pottery Shape Recovery and Repairing

Mingquan Zhou[1], Guo-hua Geng[2], Zhongke Wu[1], and Wuyang Shui[1]

1. School of Information Science and Technology, Beijing Normal University, People's Republic of China
2. School of Information Science and Technology, Northwest University, People's Republic of China

With a profound culture and long history, China is a country where a large number of cultural relics is found every year. Most of the excavation finds are pot-shaped or bowl-shaped and are often incomplete and broken. The missing parts can never be found at all. In the traditional ways for these kinds of restorations, classification and stitching by hand of broken pottery is time-consuming and repetitive work. Therefore, the study of restoring the original appearance of these cultural relics, to protect cultural heritage through modern technology, has become important in recent years. This paper aims to realize the virtual restoration of the original appearance of pottery shapes based on two key features: symmetry axis and profile information. Here, an effective method for calculating the axis of symmetry is proposed at first; and then a new approach for calculating profile information is presented. This method can solve questions involving pottery shapes that

contain a number of fragments and which have gaps in them. Using this method, a much larger fragment of a relic can be obtained by automatically matching a number of small fragments. Meanwhile, in order to ensure the accuracy of matching, human-computer interactions are applied to remove erroneous matches. Then, the profile information of the relic is calculated through the new model. Finally, the virtual restoration of the axial symmetric shape of the relic is realized through texture mapping technology. A system is implemented based on the above method, which is applied to the recovery of Yao Zhou's porcelains (famous in ancient China). Some examples of them in China are shown in the paper.

KEYWORDS: surface of revolution, restoration of pottery shape relics, calculate profile

A Scientific Approach Using Computer Graphics to Reconstruction Potential Original Architectural Unity of Archaeological Ruins

VALENTINA CASTAGNOLO
Politecnico of Bari, Italy

A precise survey, the consequent drawing and the comparison with textual and iconographical sources are the main stages for a methodological approach to knowledge and interpretation of ancient buildings. When few traces of these buildings remain, a survey could be the only way to give form to the original architectural unity, integrating survey drawings with lost parts. These procedures are known as graphic or ideal reconstructions and they are necessary in investigating ancient monuments. The methodology begins with direct building analysis, then it continues with philological and comparative studies, and it ends with the representation of the architecture in its original form. In this way, surveys and drawings not only offer a possible key for reading architecture but they become experimentation and verification tools of the assumptions made at the beginning of study. Research goes beyond the limits set by the ruin itself and looks for the most correct explanations to define the original morphology and typology. The ideal reconstruction, as a formal synthesis model, could help guide further research. Graphic reconstruction is thus useful to demonstrate a proposition; it synthesizes and communicates all the information gathered, and the results of the investigation are visible at a glance. Through graphic reconstruction, lost elements of a structure may be quickly "pre-figured." First, the survey, then the ideal reconstruction encompass all phases of the site's history, from the distant past to the present. The trend to create more photorealistic digital reconsturctions aims at canceling the destructive effects of time separating us from the past. But this desire to remember the past in all its detail can never fully succeed. The reconstruction is always provisional, always in need of updating and correction as research proceeds.

In recent years, computer graphics applied to archaeological reconstruction have helped non-experts to better appreciate and understand archaeological sites. But computer graphics should not be limited to popularization: if used with methodological rigor and consistency, they can have scientific value as well. This paper will review

previous work and report on some experiments conducted using ancient Roman and medieval buildings in the region of Apulia in southern Italy.

Keywords: computer graphics, representation, ideal reconstruction

Towards a Strategy for Evaluating Heritage Visualizations

William Limp
Center for Advanced Spatial Technologies, United States of America

"Who you gonna believe, me or your own eyes?" Marx (Chico), 1933

As heritage visualization grows in scope and power it is becoming increasingly important to develop criteria to judge these products. The process is made particularly difficult because such visualizations fall among and between disciplines and theoretical areas - bridging, among others, history and phenomenology, science and esthetics, to pick only two possible parings. Our ability to assess visualizations is further complicated by our immersion in the visual language provided through television and the movies. With all these constraints it is still possible to see the outlines of a new set of multidimensional criteria that builds on the foundation provided by the ICOMOS (1990), NARA (1994) and London (2006) Charters, and the work of Favro (2006), Frischer (2008) and others. Elements of the criteria include accuracy, engagement, verisimilitude, impact and defensibility across scientific, esthetic, intellectual, ethical, historic and architectural dimensions. This is effectively a problem in multivariate maximization and the tradeoffs between these criteria are complex, as strengthening one dimension may weaken another. The implementation of this approach is illustrated using visualization projects from two quite different settings, Ostia Antica near Rome (circa 100-200 C.E.) and a Native American village (circa 1400 C.E.) from the central Mississippi Valley of the US. Because of substantial differences in the history of the areas' archaeological investigation and theoretical differences, differential availability of historic and first person accounts, the nature of the remains and the cultural and social differences of both the past and present communities, these two setting provide an excellent comparative context to explore the issue of evaluation.

Wednesday

ICOMOS 1990. *Charter for the protection and management of the archaeological heritage*. Accessed (Dec 10, 2008) at http://www.international.icomos.org/charters/arch_e.htm..

ICOMOS 1994. *The NARA document on authenticity*. Accessed (Dec 10, 2008) at http://www.international.icomos.org/charters/nara_e.htm

Beacham, Niccolucci, and Denard (*et al.*) 2006. *The London Charter*. Accessed (Dec 10, 2008) at http://www.londoncharter.org/TLC_Draft_1_1.pdf

Favro, D., 2006 "In the eyes of the beholder: virtual reality re-creations and academia." *Journal of Roman Archaeology*, supplementary series 61(2006):321-334

Frischer, B., and A. Dakouri-Hild, 2008. *Beyond Illustration: 2D and 3D Digital Technologies as Tools for Discovery in Archaeology*. B.A.R. International Series 1805.

Keywords: virtual reality

Talks, Articles and Exhibitions: Does Interactive History Need New Metaphors?

Catja Alexandra Pafort

Independent Researcher, United Kingdom

This paper examines the dazzling array of techniques and technologies grouped under the "interactive history" label, and seeks to place them within established contexts for the presentation and discussion of archaeological research. It focuses on five aspects of information-sharing projects—users and usage, content collection vs. content creation, extent and scale, tools and technologies, compatibility and longevity—in order to create a classification that encompasses the full range of available tools. Although digital technologies like hypertext, GIS, and Virtual Reality have reached maturity in that they can be viewed and created on ordinary desktop computers, many interactive installations continue to have a pioneering character and implement novel solutions without referring to other projects in the same field. It is difficult to dispute the benefits for the users of interactive history, such as allowing an exploration of the past tailored to individual needs and the placement of archaeological artifacts and sites within a broader historical and geographical context, but how do they fit into the wider context of archaeological research? Many of the questions asked in the context of digital reconstructions have direct forerunners, e.g., in the discussions about the conservation and presentation of historic monuments, and the paper will seek to show their relevance for the ongoing discourse. By placing well-established traditional methods of information sharing, such as books or museum exhibitions, in the same framework as the often experimental digital presentations of history, a direct comparison can be achieved which allows the testing of the hypothesis whether long-established traditional methods have found adequate equivalents in the digital realm, and whether, in order to exploit these computing techniques fully, new paradigms need to be found.

Keywords: multimedia

Representing the Present Past: Interacting with Archaeological Information in Museums and on the World Wide Web

Christopher Aaron Sevara[1], Per Stenborg[1], Johan Ling[1], Mats Sodorstrom[3], Jonas Tornberg[2], and Liane Thuvander[2]

1. University of Gothenburg, Sweden
2. Chalmers University of Technology, Sweden
3. Swedish University of Agricultural Sciences, Sweden

The Digital Time Travels Project is an interdisciplinary, collaborative effort which seeks to develop and evaluate new methods for the effective distribution and representation of digital archaeological information to the public. Toward that end, the project has developed two tools for museum and online use. The first is a computer application which uses GIS data, imagery, 3D scans of archaeological objects, 3D reconstructions of past sites and landscapes, animations and text to present information about the past in an interactive, multilingual format available in museums via touchscreen interfaces as well as on the World Wide Web (web). The application is designed to serve as a framework for the display and use of archaeological data in public contexts through the use of existing, browser-based technologies including AJAX, SVG, VRML, and other open-source and proprietary applications designed for the representation of information online. Secondly, the project has created a physical, tactile model of the Göta Älv river valley in western Sweden, which has been combined with overhead projectors that project a GIS-based animation of the valleys natural and cultural landscape change from roughly 1200 BP to the present onto the surface of the model. The model itself is designed to be touched, with various components such as archaeological sites, shoreline locations, and land elevation changes represented by different textures, which are also intended to make the model more accessible to the visually impaired. A computer application displayed on an interactive touchscreen controls the animation projected over the model, allowing museum visitors to select different viewing scenarios.

The touchscreen version of the computer application and the physical model are installed at Lödöse Museum, in the center of the Göta River valley, and a web version of the computer application is available through the project website. Both the museum exhibit and the web application are under evaluation in order to determine how they are used and how to improve them. In this presentation we outline the technical development of these tools, evaluate their use, and discuss future plans for their improvement.

Keywords: animation, 3D reconstruction, GIS, world wide web, virtual museums, 3D scanning, public outreach

Intra-Site Spatial Analysis of a Neolithic Cemetery (Cernica, Bucharest)

Alexandru Morintz[1] and Raluca Kogalniceanu[2]

1. Vasile Parvan Institute of Archaeology, Romania
2. Giurgiu County Museum, Romania

The Neolithic (Boian civilization) cemetery from Cernica was excavated in the 1960s and published as a monograph in 2001. The excavation was executed using traditional methods and the analysis and publication of the data reflected it. The present day techniques, which imply the use of the computer and other modern technologies, allow for better and handier means of analysis. We digitized the existent spatial data (the topographic plan) and we did new field surveys to better place the cemetery in the landscape. We also vectorized the old plans and created a data base for the graves, which includes information regarding the grave as architectural structure, the body of the deceased and the funerary goods. On the basis of the combination of the old and the new data, we produced a 3D model of the area where the cemetery and its pair settlement were located. This allows for a different and better visualization of the landscape. We also produced a series of thematic maps of the cemetery, highlighting the spatial distribution of certain features and their combinations. The making of these maps using a CAD program allowed a quicker manipulation of all the data regarding the cemetery and the final outcome was a series of maps that provided a better visualization of certain spatial aspects, such as the distribution and groping of graves by sex, age, types of grave goods, depth, and orientation. The new methods of recording techniques and the use of computer graphics can be used not only in new excavations, but also for a new look at old excavations. Of course, when using old data, shortcomings can be encountered. Some of them can be solved now using modern technologies, some of them cannot. But in spite of these shortcomings, the results can be good and the visualization can be much improved with the aid of computer graphics. Once this step is taken, the spatial analysis of a funerary area can be improved and new results can be obtained from the analysis of old excavations.

KEYWORDS: databases, 3D models, Neolithic, cemetery, Romania

"A Picture is Worth a Thousand Words"—Visualizing Archaeological Textiles

HEMBO PAGI
University of Southampton, United Kingdom

Wednesday

New technologies have made data collection and recording much less complicated than traditional methods; in a short time we can produce an enormous amount of archaeological data. Digital data can often become an inaccessible mountain to researchers and for non-academic audiences. Furthermore, if one manages to dig out something from that data mountain he might not understand what is is all about. Data must become information to be intellectually accessible. The data used for this project consist of 7000 textile finds. Handling big datasets with computers is not new in archaeology. In 1967, R.G. Chenhall shared his experiences of preparing artifacts for computer analysis. We have more than forty years of experience working with computer-based archaeological data, but sometimes we still get it wrong by recording data as if we were writing a diary. Visual interpretation creates the possibility of reviewing data at the time of recording and even more importantly, it provides new ways for analysis—visualization gives a better understanding of volumes and allows for visual comparison. For that Hammarlund's (2005) visual grouping method was used. She applies the textile industry-standard cover factor to describe the fabric density. From cover factor, fabric thickness and density can be calculated. She proposes 28 different categories to describe a fabric's visual appearance. Three-dimensional representations can be used as a basis for further analysis and, furthermore, for detailed reconstruction of fabrics. Visual interpretation of the textiles also gives the opportunity for non-professionals and students to learn about the textiles directly from the excavation data. The secondary focus of this project is data sharing. Using the popular and widely used World Wide Web publishing platform, WordPress provides an easy to use framework for data recording and sharing. The output of the project;

Textile Recorder & Visualiser (the data management and visualizing tool for archaeological textiles) is written as a plug-in for WordPress. This means that everyone using WordPress can set up the textile data management and visualization module in a single mouse click. The main aims of the project are to evaluate Web visualization techniques that can be used for visualization of archaeological data, with the main focus on archaeological textiles; and to create archaeological textile data management and visualization tools based on an Open Source publishing platform.

Hammarlund, L., 2005. "Handicraft Knowledge Applied to Archaeological Textiles," in *The Nordic Textile Journal*, 87-119.

Keywords: presentation, visualization, archaeological textiles

Hole Filling for Cultural Relics Restoration Based on the Geometry Image

Mingquan Zhou[1], Wuyang Shui[1], Guo-hua Geng[2], and Zhongke Wu[1]

1. Beijing Normal University, People's Republic of China
2. Northwest University, People's Republic of China

Wednesday

The incomplete acquisition of 3D digital relic models information is mainly caused by two factors: (1) the state of the relic itself—the excavated finds might have lost some geometrical information and often have gaps because of erosion and other kinds of damage; and (2) in the process of acquisition the 3D laser scanner cannot precisely scan high-reflective objects or overlapping curved surfaces; therefore, some gaps or other missing information might emerge on the picture. These above-mentioned factors have greatly affected the display of relics and the related research on relic protection. In this paper, a new approach for restoration is investigated. At first, the areas that need to be repaired are indicated interactively. Then the algorithm of inserting some new scattered points is proposed, which is the kernel technique. It includes four steps: (1) generation of the geometry image: vertexes of relic models are transformed to geometry images through the spherical coordinate system, aiming to avoid inserting discrete points on the three-dimensional surface directly; (2) extracting the count of holes in the geometry image on the basis of the image segment; (3) restoration of them based on image in-painting: analyzing the impact of image gradient and curvature of the isophotes, then realizing the restoration of the geometry image on the basis of BSCB model; and (4) creation of new points on the relic models: the newly generated image is re-transformed to the Cartesian coordinate system. Further, a method of triangulation, which achieves hole-filling, is presented on the basis of Delaunay triangulation. Finally, the new surfaces with high accuracy and smoothness and other advantages are generated on the basis of mesh fitting, based on Moving Least-Square. A system is implemented based on the above method. Some experimental results are also provided in the paper.

Keywords: geometry image, hole filling, inpainting, triangulation.

Excavation and Three-Dimensional Data Visualization at the La Brea Tar Pits

Andrea Karoline Thomer[2], Michael Dale Wilson[1], and Tara S. Thara[2]

1. Natural History Museum of Los Angeles County, United States of America
2. George C. Page Museum of La Brea Discoveries, Los Angeles, United States of America

For almost forty years at the La Brea Tar Pits, detailed positional data have been amassed from the thousands of fossils collected from the current excavation site, Pit 91. However, we have lacked the in-house means to analyze or visualize this data en masse. In June of 2008, a new excavation project began on 23 large fossil blocks salvaged from a neighboring construction site. This new project has presented our team with an opportunity to reassess excavation methods, with an eye to taking advantage of 3D data visualization techniques. We will continue to use techniques similar to those of Pit 91. Each deposit is divided into 1m x 1m x 25cm grids and assigned an alphanumeric coordinate. X-y-z coordinates are taken of three anatomical points for each complete fossil within the context of the grid. These three points are used to create a "fossil" triangle utilizing Adobe Director's Shockwave 3-D engine. This application will give excavators a way to visualize fossil assemblages in 3D space, and in real time. This paper explores the benefits of using Adobe Director to create a real-time interactive rendered 3-D space, and of having such technology available to excavators, educators, and researchers alike. Primarily, this application allows field workers to quickly perform taphonomic analyses previously only done over long periods of time by post-graduate researchers. This facilitates better decision making during the excavation planning process. Additionally, Director can "publish" the resulting interactive visualizations to be copied to CD-ROM and shared with educators, or embedded in a blog or website. At a high profile site such as the La Brea Tar Pits, this greatly improves the visitor experience. The general public understands 3D models more intuitively than 2-dimensional diagrams. The visualization is updated as frequently as fossils are excavated. This application could eventually be utilized by researchers to aid in an overall taphonomic, environmental, or geologic study. A "beta" example of the resulting visualization can be found at http://www.morrak.com/3d_map/project23/3D%20mapTri%20web.htm. Adobe Shockwave Player must be installed for it to work (http://get.adobe.com/shockwave/). Each triangle represents a bone from a Giant Ground Sloth (*Paramylodon harlani*). As you mouse over each fossil, the field identification appears in the text box in the lower left-hand corner. Similarly, mousing over each point displays the anatomical abbreviation in the lower right-hand corner. Left-click and hold with your mouse to turn the visualization.

Keywords: 3D data visualization, taphonomy, excavation planning, 3D modeling, 3D data analysis

Session Summary

Wednesday, 8:30am-3:00pm, Tidewater B

Three-Dimensional Surface Recording, Analysis, and Interpretation in Archaeology and Anthropology

Chair: Maria Jacobsen, Clemson Conservation Center, Clemson University, United States of America

Organizers: Michael P. Scafuri, Clemson Conservation Center, Clemson University, United States of America

Maria Jacobsen, Clemson Conservation Center, Clemson University, United States of America

Benjamin Rennison, Clemson Conservation Center, Clemson University, United States of America

This session will focus on presenting and discussing the most recent technologies and methodologies for three-dimensional surface recording, analysis, and interpretation currently utilized in the fields of archaeology and anthropology; the specific emphasis will be on the use of structured light (optical tomography) and laser-based scanning techniques.

Wednesday

The latest generation of structured light and laser scanners offers unique capabilities in terms of their flexibility of range, speed of operation, and accuracy. In addition, they allow for the ability to perform non-destructive/ non-contact data collection, and, in some cases, the capacity to capture high-resolution photographic surface information that is automatically linked to and integrated with surface topography captured during the scanning process. Going beyond highly accurate and fast three-dimensional surface mapping, these new techniques and features greatly enhance our ability to analyze and interpret data captured in both field and laboratory environments. They also lay the foundation for novel ways to manipulate, publish, and display the results of archaeological and anthropological investigations. However, there are unique challenges and inherent problems with applying these technologies to archaeological and anthropological data recording and interpretation that should be addressed as well.

Session papers will focus on discussing experiences with data acquisition, interpretation, analysis, and visualization/ dissemination utilizing structured light (optical tomography) and laser-based three-dimensional scanning techniques and methodologies. Looking to the future, this session is also designed to provide a forum for a discussion on how to improve our current methodologies, as well as explore new avenues for implementing structured light and laser scan techniques for archaeological data processing, manipulation, and dissemination. Therefore, we welcome contributions from researchers that are dealing with data collection under adverse or extreme conditions, or teams that otherwise are testing the range and pushing the capabilities of the currently available scan systems.

Topics: 3D data capture and modeling, photogrammetry and imaging

Keywords: 3D recording; data acquisition; laser scanning; structured-light metrology

Schedule

8:30 – 8:50 "Inside Greek Vases—On Examining the Skill of Ancient Greek Craftsmen Producing Complex 3D Shapes Using Current Technologies," Martin Arthur Boss, Martin Meister, and Dominik Rietzel

8:50 – 9:10 "Combining 3D Laser-Scanning and Close-Range Photogrammetry—An Approach to Exploit the Strength of Both Methods," Marko Koch

9:10 – 9:30 "Symbols and Stories in Stone: Extracting Details from Mesoamerican Monumental Sculpture," Lori D. Collins and Travis F. Doering

9:30 – 10:00 "Reflectance Transformation Imaging: The Next Generation," Mark Mudge, Carla Schroer, Marlin Lum, and Michael Ashley

Coffee break

Wednesday

10:15 – 10:35 "Reverse Engineering a Sculpture from an Incomplete Nineteenth-century Mold," Melvin Joseph Wachowiak, Basiliki Vicky Karas, and Robert E Baltrusch

10:35 – 10:55 "Three-Dimensional Digital Fingerprint of Paintings and Frescos Using Multi-Spectral 3D-Acquisition," Bernd Breuckmann, Hubert Mara, and Zsofia Vegvari

10:55 – 11:15 "The Alabama Yardstick—Three-Dimensional Data Capture Techniques and Best Practice," Benjamin Rennison, Melvin Joseph Wachowiak, Laurence G. Hassebrook, Stuart Robson, Arvid Engström, Maria Jacobsen, and Anja Schmidt

11:15 – 11:35 "Using Structured-Light Scanning Technology for Artifact Assessment, Analysis, and Modeling on the *H.L. Hunley* Project," Maria Jacobsen, Michael P. Scafuri, Benjamin Rennison, and Paul Mardikian

Lunch

1:30 – 1:50 "Scanning in the Rain: A Study of Some of the Unique Challenges of Employing a Structured-Light Scanning System in the Archaeological Recording of Maritime Artifacts," Michael P. Scafuri, Maria Jacobsen, and Benjamin Rennison

1:50 – 2:10 "Scanning the Laocoon: Combining 3D Data Capture of an Original Sculpture and a Plaster Cast," David Koller, Bernard Frischer, Chad Keller, Bernd Breuckmann, and Laurent Wurmser

2:10 – 2:40 "Non-Contact Fiducial-Based Three-Dimensional Patch Merging Methodology and Performance," Laurence G. Hassebrook, Charles J. Casey, and Walter F. Lundby

2:40 – 3:00 "Surface Scanning—New Perspectives for Archaeological Data Management and Methodology?" Bernd Breuckmann, Pablo Arias Cabal, Nicolas Melard, Roberto Ontanon Peredo, Andreas Pastoors, Luiz Cesar Teira Mayolini, Pedro Angel Fernandez Vega, and Christian Weniger

Abstracts

Inside Greek Vases—On Examining the Skill of Ancient Greek Craftsmen Producing Complex 3D Shapes Using Current Technologies

Martin Arthur Boss, Martin Meister, and Dominik Rietzel
Friedrich-Alexander Universität, Erlangen-Nürnberg, Germany

The Antikensammlung of the Friedrich-Alexander Universität, Erlangen-Nürnberg keeps in its collection a small number of ancient figural vases. Amongst them is the famous Attic red-figured masterpiece from the workshop of the potter Sotades in the shape of a pigmy dragging a crane. Nine figural vases in Erlangen provide a representative overview of techniques in manufacturing these vases, which cover a time span of eight centuries, from the late Archaic period to the age of the Roman Emperors, and come from various regions, from Etruria in the west, the Greek mainland, to Alexandria and the Roman province of Syria in the east. Creating a figural vase was a complex procedure, which included free modeling, the potter's wheel, and clay molds. Sometimes all three were used, but a combination of two of these methods was common. Tracing this manufacturing process without destroying the precious ancient artifacts requires a method of generating an accurate 3D model of the particular vase. It should provide information about hidden joints of parts separately manufactured and fitted together before firing, as well as information about variations of density in the clay shard itself. By using X-ray imaging at the Entwicklungszentrum Röntgentechnik (ERZT), of the Fraunhofer Institut, Projektgruppe Ultrafeinfokus-Röntgentechnologie at Fürth, data files containing all this information were created. These were processed at the Department of Computer Science 9 (computer graphics) of Erlangen University, transforming them into 3D models. In computer graphics, methods exist for examining scalar volume data as generated by a CT scanner. Volume rendering provides for an exact method of producing see-through images of the data. There, cracks of joints and borders of shards can be easily analyzed. Repairs of the past become visible by comparing the varying density of plaster or other materials to the original clay. Furthermore, density variations of the clay shard itself reveal wheel made parts as well as the joints of mold-made parts. Compared to a visualization of these results on a computer screen a real 3D object yields the profit of retracing the manufacturing steps of an ancient craftsmen, as it can be disassembled, cut away, and finally reassembled. This was done by the Chair of Polymer Technology (LKT) of the University Erlangen-Nuremberg using selective laser sintering, which is well known as a rapid prototyping technology. This technology was selected, because parts can be directly created out of thermoplastic polymer powder in a

freeform fabrication process. Surfaces for the laser-sintering process can be extracted with standard computer graphics isosurface extraction. Here, a suitable isovalue can be chosen by incorporating an estimate of the mean density of the clay as well as the weight of the object as a reference surface most similar to the real object. All archaic or classical vases appear to be composites of free-modeled figural parts and the wheel-made top. Later pieces show the combining of two joint-mold-made halves of the figural part with wheel-made feet or spouts while late Hellenistic or Roman samples tend to be completely mold-made.

KEYWORDS: non-destructive analysis, CT-scanning, laser-sintering, rapid prototyping

Combining 3D Laser-Scanning and Close-Range Photogrammetry—An Approach to Exploit the Strength of Both Methods

MARKO KOCH
TFH Berlin, University of Applied Sciences, Germany

The use of 3D laser-scanners in the documentation of archaeological and cultural heritage sites is well-established by now. They have become more and more popular for a wide range of archeological purposes because of their high performance. The huge data sets produced by a laser-scanner provide considerable possibilities for the modeling and visualization of objects. Although they deliver a point cloud with high density, the accuracy of individual points barely reaches 1 centimeter. To attain much higher accuracy, photogrammetric methods or optical scanning techniques using structured light can be used. Considering all advantages, each of these methods has its specific limitations. While photogrammetry carries the potential to measure edges very accurately, the measurement of free-formed and sparse-structured surfaces causes problems. On exactly those surfaces a laser-scanner works properly. However, precise determination of edges is not really possible here. The paper describes an approach to exploit the strengths of both sensor-types by combining the acquisition and evaluation of data sets. The object of investigation is the Apadana Palace in Persepolis (Iran). Surveying of the reliefs was carried out in a joint project. Participants are the University of Applied Sciences Berlin (TFH), the Iranian Cultural Heritage, Handicraft and Tourism Organization (ICHHTO) and the Gilan Eng. Surveying Company. The ICHHTO demands detailed mapping of reliefs with all damage, repairs, and joins to use as a base for restoration. Laser-scans were made with a LMS-Z420i from Riegl, Austria. They have a resolution of 3mm. For photogrammetry, a set of 188 images was captured with a calibrated Nikon D200 digital SLR. This image block meets the specific requirements of close-range photogrammetry. Both data sets were oriented to the same reference system. The software package PHIDIAS from PHOCAD, Germany, was applied for simultaneous data processing. During the evaluation process, the edges were determined from the photos and the depth information was taken from the scanner's point cloud. To reach the required accuracy, it was necessary to reduce the noise within the point cloud. This was done by applying filter techniques that originate from digital image processing. At subsequentcampaigns

in Persepolis, Pasargadae and Alamut further possibilities of combining photogrammetric methods and scanning techniques are analyzed.

Keywords: 3D laser scanning, close-range photogrammetry, combining methods

Symbols and Stories in Stone: Extracting Details from Mesoamerican Monumental Sculpture

Lori D. Collins and Travis F. Doering
University of South Florida, United States of America

This presentation is an examination of a system for digitization and metrological analysis of size, shape, features, and surface detail of Mesoamerican carved stone monuments based on three-dimensional laser scan data. Embedded on sculpted monuments are messages that articulated political ideologies and cosmological themes which formed a shared language of rulership and power within Mesoamerican communication spheres. The enhanced ability of scholars to "see" what was actually carved on the monuments allows a more accurate and complete interpretation of the ancient narratives. Therefore, the purpose of this system development is to provide the most objective and exact visualization of sculpted elements possible for comprehensive epigraphic and iconographic analyses. Through the use of 3D scanning as a beginning or foundational referent upon which to base these analyses, specific methods of data capture and progressive processing techniques have been developed. These procedures have demonstrated the ability to increase detail and enhance visibility while lessening the subjectivity inherent in conventional methods of analytical documentation. Examples include the combination of close-range laser scanning data with software analysis and visualization techniques that are then translated into line drawings and computer generated Surface Elevation Models (SEM). Recently, researchers have focused on "finessing more details from old stones," and called for more accurate ways of getting at those faint carvings. Previous recording and analysis of carved stone monuments in Mesoamerica has largely consisted of rubbings, sketches, tracings, and photo documentation from which line-drawings of surface details and carving are rendered. Photographic techniques used to record information include raking light, intended to enhance faint details and reveal contours carved in the stone. This technique, although helpful in many cases, is laborious and introduces substantial problems of spatial control and distortion. Beyond the problems of parallax distortion and limited perspectives, traditional techniques of recording introduce various levels of subjectivity that, intentionally or unintentionally, lead to incomplete or erroneous interpretation.

This presentation documents the use of three-dimensional laser scanning and processing techniques that increase the accuracy of the referent data to allow the viewing of objects and, in some cases, their context in new ways and from different perspectives, reducing subjectivity in their interpretation. These methods allow an examination of symbols and icons in meaningful ways, such as comparative analysis of styles and their social connotation. The resulting data can also permit the "life history" of the stone to be visualized and

deduced. The use, reuse, and recycling of the artifact can be examined and interpreted within the cultural process from its extraction to deposition.

KEYWORDS: Mesoamerica, iconography, laser scanning

Reflectance Transformation Imaging: The Next Generation

MARK MUDGE, CARLA SCHROER, MARLIN LUM, and MICHAEL ASHLEY
Cultural Heritage Imaging, United States of America

This paper explores a set of new reflectance transformation (RTI) tools developed by an international group of collaborators brought together by Cultural Heritage Imaging (CHI). These new tools provide novel approaches to the acquisition, processing, and viewing of "real world" reflectance information and the 3D shape and material properties it discloses. The accuracy of shape and material representation, as compared with ground truth, is significantly better than existing RTI tools based on Polynomial Texture Mapping (PTM). These new tools are designed to capture and carry empirical provenance, the image generation process history, and to enable born-archival RTI representations that are friendly to the museums, libraries, and repositories where our digital heritage is preserved. RTI in the form of PTMs was invented by Tom Malzbender at Hewlett Packard Labs in 2000-2001. PTMs have proven their usefulness in cultural heritage and natural science empirical documentation over a wide variety of material and study areas and are in active use by many cultural heritage and natural science professionals today. The next generation of RTI tools we will discuss in this paper was developed by the combined efforts of the University of California Santa Cruz, the Italian National Research Council, the University of Minho, Stephen Stead and Martin Doerr of the International Council of Museum's CIDOC/CRM Special Interest Group, CHI, and Tom Malzbender, working together in the public interest. The paper will examine mathematical methods for creating RTIs from digital photographs, including hemispherical harmonics (HSH), which offers superior representation of highly specular materials like gold; improved methods for calculating light positions used to determine 3D surface features; a new high-resolution RTI viewer which can display legacy PTMs; and a new RTI file format that incorporates today's RTI building algorithms. The code for these new tools will be available as Open Source. We will demonstrate these new methods applied to challenging materials including hand painted fourteenth-century manuscripts, ancient papyrus under glass, graphite traces on parchment, oil paintings with tooled gold leaf, and gold coins. Side-by-side comparisons will demonstrate the relative merits of traditional PTM-based and next generation digital representations.

KEYWORDS: reflectance transformation imaging, re-lighting, born-archival, 3D acquisition, digitization

Reverse Engineering a Sculpture from an Incomplete Nineteenth-Century Mold

Melvin Joseph Wachowiak[1], Basiliki Vicky Karas[1], and Robert E. Baltrusch[2]

1. Smithsonian Institution, United States of America
2. Survice Metrology, United States of America

This paper describes the 3D documentation of an incomplete 19th century plaster piece mold, the techniques used for the virtual replacement of missing mold pieces and the virtual recreation of the lost cast. 3D imaging by structured light scanning was used to record all spatial data for the mold pieces. The mold is a work by noted nineteenth-century American sculptor Hiram Powers, and is a rare surviving direct link to the artist's creative process. Virtual reconstruction of a cast from the artist's mold results in a unique opportunity to view Powers' work as it was originally intended, fabricate the lost pieces, and provide a physical copy of the mold for proper storage of the original. The virtual reconstruction will also be used for public display and museum programs. The Museum Conservation Institute (MCI) has a portable structured light scanner that can safely produce precise, high-resolution spatial data, as well as color information, from collection objects. Collaboration with Survice Metrology brought engineering and data processing expertise to the project for the cast recreation. The familiar term "reverse engineering" can be applied to this processing step of the Powers' data. That is, reverse engineering uses existing material to reproduce a new part. This is a common task in commercial industry, where research into a competitor's product can involve disassembly, analysis, testing, and virtual reconstruction. In the case of Powers, however, fewer constraints were found. The task for MCI and Survice Metrology was to virtually refit the piece mold surfaces together and then fill the voids: the voids in this case are the missing mold pieces and the cast. For this purpose, the mold surface is assumed to be the same as the surface of any casting. Smithsonian American Art Museum conservators and curators will also compare the cast to known works by Powers. The mold is fragile and has lost two of its eight parts, making it difficult to store or move safely. Methods traditionally used to cast from an existing mold or otherwise copy a surface, like flexible rubber mold making, were deemed too intrusive and thus likely to compromise the surviving mold pieces. Chemical staining is common when mold-making directly from porous substrates. In addition to digitizing existing parts, the conservators wanted to explore the feasibility of recreating the lost mold pieces to stabilize the assembly. Without the missing pieces, the mold surfaces can wear against one another unnecessarily.

Keywords: 3D scanning, reverse engineering, structured light, replication

Wednesday

Three-Dimensional Digital Fingerprint of Paintings and Frescos Using Multi-Spectral 3D Acquisition

Bernd Breuckmann[1], Hubert Mara[2], and Zsofia Vegvari[3]

1. Breuckmann GmbH, Germany
2. University of Heidelberg, Germany
3. Tondo Bt, Hungary

Motivated by cultural heritage, industry and medical applications, advanced 3D scanners and post-processing systems have been developed within the recent years for rapid and precise documentation of surfaces with curvature. By constantly increasing the resolution and accuracy of our systems, we enable the documentation of even the smallest deviation of seemingly flat surfaces like frescos and paintings. This allows documentation of important features for restoration, such as small fractures or the topology of paint-strokes for scientific research. The acquisition with our topometrical 3D scanners can be done *in situ*, radiation-free, contactless and non-destructive, using a structured (coded) light-source and a digital camera. Our 3D scanners are based on fringe projection including color acquisition. 3D features are acquired with a resolution and accuracy in the µm-range in depth and up to 2.400 dpi (~10 µm) for spatial resolution. Our new generation of 3D scanners also allows multi-spectral 3D acquisition of paint from infrared (IR) to deep blue. Detailed specifications and novel opportunities for analysis of paintings and frescos are shown for two different test-cases. First we show preliminary results of the paintings (Mihály Munkácsy Claude Monet), which were partly digitized with our new multi-spectral 3D scanner, by recording both the three-dimensional surface structure and the color. Optionally the use of IR techniques enables the acquisition of hidden structures with maximum precision (µm). The result is a unique digital fingerprint of paintings, including the signatures of the painter and his characteristic colors. This allows us to analyze the characteristic brush strokes of a painter and offers completely new opportunities to recognize and detect fakes. As a second test case we show digitized frescos of the Villa Oplontis in Pompeii, Italy. We acquired the important facing frescos with mirrored content in the *triclinium* (formal dining room). This was a two-fold task as these frescos cover several square meters. First we demonstrated a fast and easy workflow. The second task concerned the fact that one of the frescos appears to be from a later period and/or another workshop. This required a very precise inspection on points of interest. For our test case we chose the bird in the lower central area as this most artistic painting required a highly skilled craftsperson, a fact which correlates to a high probability of determing the characteristic features of a particular workshop.

Keywords: 3D data capturing, multi-spectral 3D scanning, digital fingerprint of paintings, fake detection

Wednesday

The Alabama Yardstick—Three-Dimensional Data Capture Techniques and Best Practices

Benjamin Rennison[1], Melvin Joseph Wachowiak[2], Laurence G. Hassebrook[3], Stuart Robson[4], Arvid Engström[5], Maria Jacobsen[1], and Anja Schmidt[6]

1. Clemson University, United States of America
2. Smithsonian Institute, United States of America
3. University of Kentucky, United States of America
4. University College London, United Kingdom
5. Vasa Museum, Sweden
6. Dresden University of Technology, Germany

Increasingly, methods of archaeological data collection are focusing upon digital documentation. Today, the use of topometric scanning methods is a feasible technological option both in terms of cost and ease of use. The uses and applications of scanning technologies grow at a startling rate; non-contact survey techniques provide detailed records in three dimensions to a degree never before achieved through photography and illustrative techniques alone. However, with the range of technologies available it is surprising that there is no common approach to scanning. No logically consistent approach or precise framework to work with exists within the world of three-dimensional archaeological documentation. This implies that an institution's approach to documentation is measured only by its own achievements, meaning that no comparable "yardstick" for this sort of process exists. How do groups approach the practical aspects of scanning, such as how to elevate an artifact, how to choose light settings, flash intensity, whether to fill a hole, and so on? In order to gauge the abilities of those involved in three-dimensional scanning around the world, a collaborative scanning project was formed involving Clemson Conservation Center, University College London, University of Kentucky, Vasa Museum Sweden, and the Smithsonian Institute. The project was to document a piece of concretion from a cannon found at the CSS Alabama wreck site. By scanning the same object, we will be able to view approaches, understand the variables and consider what the larger implications are to the field as a whole. From the results it is hoped that we can reach a fuller understanding of each institution's approaches to scanning, and thereby recommend best practice techniques, create an open platform for collaborative research, and highlight the technical difficulties existent in non-contact surface measurement and archaeological documentation. The procedures and technologies provide differing results, and each technology can provide highly detailed end products. Therefore, this paper hopes to demonstrate, compare and assess the ability of each group's chosen scanning system (Arius, Metris K, Breuckmann Opto-Top HE, Breuckmann Tritos, and ATOS 1 Optic Scanner) in recording exactly the same object.

Keywords: Alabama, concretion, scanning, techniques, archaeological documentation

Using Structured-Light Scanning Technology for Artifact Assessment, Analysis, and Modeling on the *H.L. Hunley* Project

Maria Jacobsen, Michael P. Scafuri, Benjamin Rennison, and Paul Mardikian
Clemson Conservation Center, Clemson University, United States of America

The excavation of the American Civil War submarine *H.L. Hunley* (1863) conducted in Charleston, South Carolina, has presented the archaeological team with a number of unique challenges in terms of three-dimensional artifact documentation, analysis, and modeling. On the one hand are the sheer size, range, and complexity of objects that require recording. They comprise the 12-meter-long corroded iron hull, the fixed mechanical equipment and boat gear, and the co-mingled skeletonized remains of its crew and their personal possessions. On the other hand are the logistics. The submarine is housed in a water-filled holding tank with fluctuating environmental parameters that make systematic and consistent digital data-capture difficult.

A number of laser-based scanning techniques have been tested, including box scanners and scanners on articulated arms. The newest generations of these scanners have in common the ability to achieve high-precision 3D surface data capture. However, when deciding on a primary 3D recording tool for the Hunley Project, the choice fell on the Breuckmann OptoTOP-HE structured-light scanner, because of its versatility in two areas in particular. First, it is a light, portable, and modular system that can be set up in the field (in this case the tank) or inside the laboratory, and adapted to scan a range of artifacts from large structures to small items of less than 1 cm in diameter. Secondly, the system has the added advantage that it can capture high-quality photographic surface data (in color or black and white) that is integrated with its high-precision 3D surface mapping. Under ideal circumstances, the surface topography can be captured with sub-millimeter precision. This paper discusses the successes and failures of 3D data capture utilizing the OptoTOP-HE scanner for the purpose of artifact analysis, interpretation, and modeling. It also presents the most recent use of the technology for documentation and assessments of artifacts pre- and post-conservation treatment. The high-precision and color capture functions of the structured-light scanner allow archaeologists to depict forensic trace evidence; for example, surface stains that may change or disappear during a treatment of the artifact. With regard to conservation, the ultimate objective is to develop a standardized and quantifiable method of artifact documentation that provides archaeologists and conservators with the ability to monitor and objectively evaluate conservation processes and techniques.

Keywords: 3D artifact assessment, analysis and modeling, structured-light or white-light scanning

Scanning in the Rain: A Study of Some of the Unique Challenges of Employing a Structured-Light Scanning System in the Archaeological Recording of Maritime Artifacts

Michael P. Scafuri, Maria Jacobsen, and Benjamin Rennison
Clemson Conservation Center, Clemson University, United States of America

The application and use of 3D scanning technology for archaeological documentation has progressed much over the last ten years. With the advances in the development of various forms of topometric metrology, archaeologists now have many more powerful tools to implement in the collection of three-dimensional data and the analysis and interpretation of this data. However, it has also become apparent that the applicability of certain scanning technologies varies depending on the type and nature of the archaeological material and the kinds of information that one intends to capture. In 2008, the Clemson Conservation Center acquired a Breuckmann OptoTOP-HE structured-light scanning system to begin the 3D documentation of the American Civil War submarine *H.L. Hunley*. The choice of this particular system was determined by the interests of the archaeological team and the particular research goals of the project. In this case, high resolution 3D surface topography and quality photographic data were considered equally necessary, suggesting an optical-based scanning system. However, maritime artifacts, or artifacts from a marine environment, are necessarily stored in water or other aqueous solutions prior to completing the conservation process. Using structured-light technology on the *H.L. Hunley* submarine itself, as well as other artifacts kept in a wet condition, presented the team with some rather interesting difficulties in terms of three-dimensional documentation. This paper will discuss the use of the Breuckmann OptoTOP-HE structured-light scanning system on the *H.L. Hunley*, and highlight some of the specific problems and challenges encountered when employing this technology on maritime archaeological material. In particular, we would like to present a detailed study of the effectiveness of optical tomography to record surface details in the presence of water, polyethylene glycol (PEG), and other interfering or reflective and refracting substances. The discussion will also include issues of reflectivity, data accuracy, and surface darkness. Moreover, we intend to address our problems with changes in color, wetness, and reflectivity that occurred during the data collection process. It is hoped that this study will both illustrate the problems associated with recording maritime artifacts and present further avenues for research and the development technology aimed at overcoming them.

Keywords: 3D, data acquisition, American Civil War, Hunley submarine, structured light, optical tomography

Scanning the Laocoon: Combining 3D Data Capture of an Original Sculpture and a Plaster Cast

David Koller[1], Bernard D. Frischer[1], Chad Keller[1], Bernd Breuckmann[2], and Laurent Wurmser[2]

1. IATH, University of Virginia, United States of America
2. Breuckmann GmbH, Germany

Wednesday

The statue group "Laocoon and His Sons" is a monumental ancient marble sculpture depicting the Trojan priest Laocoon and his sons Antiphantes and Thymbraeus being strangled by sea serpents. Of Hellenistic origin (ca. 160-20 BC), the statue group was discovered in Rome in 1506 and strongly influenced Michelangelo and other artists of the Italian Renaissance. The work consists of several separable pieces, and further fragments believed to belong to the statue were discovered in the twentieth century. The provenance and reconstruction of the Laocoon has been a source of controversy, with numerous different configurations of the statue group proposed by Renaissance and modern restorers. Digital three-dimensional modeling tools can allow the Laocoon group to be studied in new ways. If we accurately digitize the 3D shape of the Laocoon's constituent parts, we can efficiently visualize various hypothetical reconstructions, and share the resulting 3D models widely via the Internet. However, measuring the 3D shape of the Laocoon group presents several difficulties. The statue is highly complex geometrically, with many occlusions and deep crevices that restrict clear access to many portions of the surface. Additionally, the polished marble surface may not be optically cooperative when using typical active light 3D data capture technologies. In an effort to overcome these difficulties and to create an accurate 3D model of the Laocoon, we have digitized both the original marble sculpture in the Vatican Museums, as well as a first-generation plaster cast of the statue group, using coded structured light

3D scanners. The plaster cast could be physically separated into several independent sections for scanning, allowing much greater surface access compared to the original statue on display in the museum, and the plaster surface was also more optically cooperative than the original marble.

By combining scan data obtained from both the original marble statue and the plaster cast, we are able to create a more complete and accurate 3D model than would be possible from either data set alone. Among other applications, our resulting 3D model of the Laocoon group allows virtual reconstructions to study the different configurations of the statue that have been proposed in prior scholarship. Additionally, by comparing the two different versions of scan data, we are able to precisely evaluate the fidelity of the plaster cast and characterize its variations from the original sculpture.

Keywords: 3D data capture, culture heritage modeling, virtual reconstruction

Non-Contact Fiducial-based Three-Dimensional Patch Merging Methodology and Performance

Laurence G. Hassebrook, Charles J. Casey, and Walter F. Lundby
University of Kentucky, United States of America

Most three-dimensional patch merging is performed by first obtaining a skeleton using photogrammetry, followed by three-dimensional surface patch scanning followed by patch merging onto the skeleton geometry. This approach is effective but generally involves the use of physical fiducials to be mounted onto the object surface and requires costly scanning hardware and software. We present a more unified non-contact approach, where the fiducials are projected light patterns and the patch scanner is software based, in that the cameras and digital projectors used are off the shelf general purpose technologies. We combine the patch depth acquisition with digital color photography, each having different pixel resolutions. In the special effects industry, merging can be performed by blending or averaging the overlapping regions between patches, but in archaeology and forensics, this approach may be unacceptable because the resulting averaged surface is less accurate than the original patches. We present a discussion of this issue with some possible alternatives that will preserve the original patch data. Our perspective on this methodology is based in forensics science. We demonstrate the method's implementation and capability with an artifact from the *CSS Alabama*.

Keywords: structured light illumination, 3D

Surface Scanning—New Perspectives for Archaeological Data Management and Methodology

Bernd Breuckmann[1], Pablo Arias Cabal[2], Nicolas Melard[3], Roberto Ontanon Peredo[2], Andreas Pastoors[4], Luiz Cesar Teira Mayolini[2], Pedro Angel Fernandez Vega[5], and Christian Weniger[4]

1. Breuckmann GmbH, Germany
2. Universidad de Cantabria, Spain
3. Institut National du Patrimoine and C2RMF, France
4. Neanderthal Museum, Germany
5. Museo de Prehistoria y Arqueología de Cantabria, Spain

Documentation and publication of Paleolithic objects such as stone tools, bone tools or mobile art has been mainly done by drawings. These drawings are an indispensable part of scientific research and methodology. Teaching of drawing techniques is even integrated into the educational program at university level. Although the making of a drawing is very time-consuming and needs training, it has not been replaced by photography until recently. Taking a picture of a Paleolithic object is obviously even more difficult than making a drawing. To visualize all relevant scientific features of an object in just one shot is not possible. The cost/performance ratio for drawings is therefore better than for photography. Photos are used mainly to present objects to a broad public. Within the scientific community, drawings are the most frequent medium of information transfer. Drawings do have the advantage that they follow defined conventions and perform the technical status of an object. This facilitates their sensing, allows quick visual comparison of various items and placing the information into a larger scientific context. The sensing of drawings of lithic artifacts works even at higher speed than exploring the originals themselves. Items of mobile art are different. They present more complex visual information than lithic artifacts and are therefore still the field of specialized illustrators. An obvious problem of scientific drawings is a loss of objectivity. Each drawing is an individual interpretation. By skillfully dispensing or adding of minor features the unambiguousness of an item can be manipulated. This is often the case when, e.g., a decision between geofact and artifacts has to be made. Considering this methodological background we did a test run and scanned a set of prehistoric items, mainly from Paleolithic context at the Museo de Prehistoria y Arqueología de Cantabria, Santander. We tested a great variety of objects concerning material, dimension, and surface structure. The basic idea was to cover all potential modes of application. Our preliminary results are convincing. Scanning of big objects like schematic engravings on stone steles from late Copper Age/early Bronze Age context as well as small-sized examples from upper Paleolithic mobile art could be documented in a short time and in high-resolution. All features of the objects were clearly visible using polygon meshes of the scans and digital measuring of the features were possible with, e.g., ArteCore, a software package of NESPOS. The same was true concerning stone tools. Highly elaborated Solutrean points covered by very fine retouches were recorded completely as well as cores for blades or flakes. Surface scanning of Paleolithic objects has the potential to substitute drawings as medium for scientific information transfer.

Polygon meshes are of high scientific value because they allow an objective record of the object and they allow digital measuring. Once recorded the digital data file can be transferred via internet and allows direct access to objects. Prehistoric archaeology will have to adapt to this new recording and needs in the future data bases like NESPOS that allow world wide access.

Keywords: 3D surface scanning, documentation of Paleolithic objects, archaeological data management, NESPOS

Session Summary

Wednesday, 8:30am-3:00pm, Tidewater C

Cell-Based Analysis and Landscape Archaeology: New Approaches and New Applications

Chairs: Gary Lock, Oxford University, United Kingdom
John Pouncett, Oxford University, United Kingdom

Since the early adoption of GIS in archaeology in the late 1980s, the place of cell-based, or raster, analysis has been of central interest. It has become almost routine to apply techniques such as line-of-sight, viewshed, least-cost path and cost-surface analysis in attempts to understand human interaction with past landscapes. Indeed, it could be argued that these techniques are so commonplace and easy to perform that their methodological and theoretical underpinnings are often ignored or, at best, mentioned in passing. Derivatives of elevation such as slope and aspect, the essential building blocks of many analytical techniques and models, are scale dependent. Yet, despite widespread recognition of the significance of scale within landscape archaeology, analysis based on these derivatives is uncritical and typically fails to take this scale dependency into account.

This session is intended to explore beyond the push-button application of cell-based analysis through focusing on new approaches and new applications. We welcome papers that address issues of methodology, new approaches to visibility and movement, topographic modeling and visualization. While visibility and movement will probably remain popular, other areas such as erosion modeling, landscape change and time series analysis would be very welcome. Contributions relating to remote sensing techniques which employ raster data structures and allied image processing techniques are also welcome. It is hoped that this session will provide a platform from which to promote the development of new theoretical and methodological approaches to cell-based analysis within landscape archaeology.

Topics: GIS

Keywords: cell-based analysis, GIS

Schedule

8:30 – 9:00 "Modeling Subsurface Content through Multidimensional Remote Sensing, Multivariate Analysis, and Raster GIS," Kenneth L. Kvamme

9:00 – 9:30 "Using Geographically-Weighted Regression to Predict Site Representativity," Daniel Lowenborg

9:30 – 10:00 "Walking the Ridgeway Revisited: The Methodological and Theoretical Implications of Scale Dependency for the Derivation of Slope and the Calculation of Least Cost Pathways," Gary Lock and John Pouncett

COFFEE BREAK

10:15 – 10:35 "Digital Terrain Model Analysis and the Use of Fuzzy Functions for the Identification of Possible Areas with Rural Post—Roman Archaeological Sites in the S-W Dacia," Marcel Torok-Oance and Dorel Micle

10:35 – 10:55 "An Application of Rule-Based Eco-Cultural Niche Modeling to Archaeological Modeling: Emerging Complexities in Predictive Site Location Modeling for Holocene Land and Resource Use around Lake Turkana," Loretta Jane Dibble

10:55 – 11:15 "Fieldwalk@Kisoji: Second Preliminary Report of the GPS/GIS-aided Walking Experiments for Remodeling Pre-modern Travels in Nakasendo-Kisoji (Central Highland Japan)," Yasuhisa Kondo and Yoichi Seino

11:15 – 11:45 Discussion

LUNCH

1:30 – 2:00 "Beyond the Marsh: Settlement Choice, Perception, and Spatial Decision-Making on the Georgia Coastal Plain," Thomas G. Whitley, Inna Burns Moore, and Gitisha Goel

2:00 – 2:30 "An Improved Method for Extraction of Historical Cartographic Features into GIS: A French Case Study," Scott L. Madry and Elizabeth A. Jones

2:30 – 3:00 Discussion

Abstracts

Modeling Subsurface Content through Multidimensional Remote Sensing, Multivariate Analysis, and Raster GIS

KENNETH L. KVAMME
University of Arkansas, United States of America

Predictive models are frequently constructed at the regional level for the locations of archaeological sites based on correlations with specific features of environment. This paper examines methods for modeling the locations of buried archaeological deposits and features *within* a site to enhance prospecting capabilities through prediction of subsurface content. Currently, predictions about the subsurface are made on the basis of patterns witnessed in aerial imagery or in geophysical survey results. These data form the basis of the approach undertaken here. An axiom in geophysics is that multiple surveys are usually better than one, because various instruments respond to different physical characteristics and each can provide complementary information. This principle is followed in the extreme in the present study with a wide sensor mix from ground-, air-

and space-based platforms. Supervised and unsupervised classification methods integrate commonalities in the highly multidimensional remote sensing data to achieve very specific assignments, or predictions, of subsurface content. The approaches taken are thus data driven, explicitly quantitative, contain theoretical components in interpretation phases, and therefore exceed the mere image-based pattern-seeking common to many remote sensing applications. Moreover, the results yield numerous insights about subsurface content through statistical indicators and contextual clues visible in mappings. Subsurface predictions are robust because features are reconstructed by multivariate combination more fully than is possible using any single data set alone.

This research was carried out at an historic town in Kansas, USA, known as Army City. Founded in 1917 to service troops at nearby Camp Funston (now Fort Riley), it prospered only briefly until economic decline followed the close of World War I in 1918; a major flood occurred in 1919, and a fire consumed its commercial core in 1920. The town was subsequently abandoned and now lies under a hayfield. An intensive data-collection program includes magnetic gradiometry, magnetic susceptibility, electrical resistivity, electromagnetic conductivity, and ground-penetrating radar results from geophysical surveys, thermal infrared imagery from a low-flying powered parachute, and panchromatic and multispectral bands from the QuickBird satellite. Information from over one hundred excavation units selected by a random sampling scheme plus historic photos and maps provide training sites for supervised classifications and ground truthing capabilities that permit validations and accuracy assessments of the wide range of methods investigated. Raster GIS is invaluable in this research for data management, registration, rectification, and resampling of the data, for linkage with statistical analyses, for mapping, querying, and visualization.

Keywords: subsurface modeling, geophysics, QuickBird, GIS

Using Geographically-Weighted Regression to Predict Site Representativity

Daniel Lowenborg
Uppsala University, Sweden

Geographically Weighted Regression (GWR) is a method for exploratory spatial data analysis developed by Fotheringham *et al.* (2002). GWR is included as a tool in the Spatial Statistics library in ArcGIS 9.3 and has a large number of potential applications to archaeology given the claims of the method to handle spatial relations between variables. Traditional models strive to establish the relationship between a dependent variable and a set of independent variables. This model is then used to predict values at other locations. With GWR it is possible to include geographical location in this equation and allow the relation between the variables to differ in space. This would make the model local rather than global, and thus better able to handle spatial relations within data from the social sciences. This paper presents an attempt to use GWR in the ArcGIS environment to explore representativity of sites (burial grounds) in the Mälardalen area in central Sweden.

This area has a large number of burial grounds that survive in the landscape and form the base for a settlement analysis of the Iron Age landscape. Large scale rescue excavations from the 1980s onwards have shown that although there is a large number of sites that are visible in the landscape, there are also a significant number of sites that for different reasons have not been recorded. These could either be sites that have been damaged by later agricultural activities, or that simply have been missed in the surveys. Building on the results of some of the major archaeological projects initiated recently as part of infrastructure developments in the region, the representativity of the known archaeological record is examined. This information is crucial for further analysis of the region using the archaeological record of surveyed sites. The preliminary results of this analysis are presented in this paper, along with a discussion on the benefits of the GWR technique for raster-based landscape analysis in archaeology.

Fotheringham, A.S., C. Brunsdon, and M.E. Charlton, 2002. *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*, Chichester: Wiley.

Keywords: GWR, spatial data analysis

Walking the Ridgeway Revisited: The Methodological and Theoretical Implications of Scale Dependency for the Derivation of Slope and the Calculation of Least Cost Pathways

Wednesday

Gary Lock and John Pouncett
Institute of Archaeology, Oxford University, United Kingdom

The rapid expansion of use of GIS within landscape archaeology during the 1990s went hand in hand with changes in archaeological theory which fetishized the "experience" of the past. In keeping with the core theme of this session, the widespread availability and ease of use of "push button" functionality for cost surface and view shed analysis has resulted in the proliferation of movement and visibility studies seeking to immerse the contemporary observer within the archaeological landscape. Despite their interpretative merits, these studies are largely uncritical. The algorithms employed in cost surface analysis and the calculation of least cost pathways have become increasingly sophisticated. With a few notable exceptions, however, there has been little wider consideration of the methodological implications of the raster data sets (DEMs and their slope derivatives) which underpin this analysis. Papers presented at sessions at CAA 2006 (Fargo) and CAA 2008 (Budapest) have highlighted the potential implications of the cell size or resolution of these data sets. Recent work at the ancient city of Kerkenes Dağ, for instance, has highlighted that least cost pathways respect the urban street network best at finer resolutions (Branting 2006). Conversely, is has been noted anecdotally that least cost pathways for Iron Age *Fürstensitze* ("Princely Sites") provide a better approximation to likely routes at coarser resolutions (Posluschny and Herzog 2008).

The issue of scale lies at the heart of this apparent contradiction, underlining the need to respect local topographic detail on the one hand and the importance of the underlying topography on the other. Long before the advent of GIS, topographic features such as ridges and rivers were highlighted as important axes of movement. Calculations of slope, cost surfaces and least cost pathways are based on cell neighborhoods or "n by n" windows and have traditionally been reliant upon the comparison of the eight cells immediately adjacent to the location for which an attribute is calculated, i.e. a "3 by 3" window. Whilst algorithms such as the "Knight's move" increase the size of the cell neighborhood, expanding the number of cells used in a calculation to 24 cells (equivalent to a "5 by 5" window), emphasis continues to be placed on small scale or localized topographic features. This paper seeks to consider the methodological and theoretical implications of using larger neighborhoods or window sizes with reference to a classic case study based on the hill forts of the Ridgeway (Bell and Lock 2000). In contrast to spreading functions (e.g. Tomlin 1990) which are applied retrospectively to cost surfaces, the approach taken here applies a smoothing function to the slope calculations from which the cost surface is ultimately derived.

Keywords: raster data sets, DEMs, slope, cell neighborhoods, multi-scalar analysis

Digital Terrain Model Analysis and the Use of Fuzzy Functions for the Identification of Possible Areas with Rural Post—Roman Archaeological Sites in the S-W Dacia

Marcel Torok-Oance and Dorel Micle
West University of Timisoara, Romania

Wednesday

The study areas are located in the western part of Romania, in the historic region Banat, with a relatively varied relief formed of low fields, high fields, piedmonts and hills. The identification of areas with a high probability of new archaeological sites was done through the cartographic GIS modeling using complex data sources. The first step was to establish the essential physical and geographic factors in the location and the spatial distribution of known sites. The factors considered are: altitude, slope, aspect and distance from water courses; the values of these parameters are slightly different from one type of relief to the other. Based on statistic analysis of the values of considered factors for each archeological site, values intervals were identified with the greatest favorability. The second step had to standardize these factors. Because all analyzed factors vary in space, the most appropriate method to standardize is by using Fuzzy functions, different for each factor. With their help, these factors were standardized on a scale from 0 (least favorable) to 255 (extremely favorable). Finally, the combination (aggregation) of these factors allows the identification of high probability areas for archaeological sites. Because the factors considered don't have the same importance for the favorability of finding a possible site, before the combination of the previous standard factors, each factor was assigned a relative weight to use in the Analytical Hierachy Process (AHP) implemented by the IDRISI Andes software. The combination of factors considering each weight resulted in the creation of the final model, which presents the probability of identifing new archaeological sites. The probability degree varies continuously in space, from a very high probability (255) to a very low probability (0) depending on the combination mode in a certain area of the considered factors and their weight. Thus generated models, for each relief type, were applied to the archaeological sites from the third and fourth century C.E. and were verified in the field, noting its utility in the identification of new archeological sites.

KEYWORDS: GIS, landscape archaeology, survey archaeology, fuzzy functions

An Application of Rule-Based Eco-Cultural Niche Modeling to Archaeological Modeling: Emerging Complexities in Predictive Site Location Modeling for Holocene Land and Resource Use around Lake Turkana

LORETTA JANE DIBBLE

Rutgers University, United States of America

The development and application of predictive models of complex biological and ecological phenomena using Genetic Algorithm for Rule Set Production (GARP) based models which combine data of widely differing scales (such as climate data used in combination with fossil data) is being explored in archaeological modeling. However, the use of this type of modeling has mostly been limited to large-scale investigations. In this paper, I present an application of the GARP type eco-cultural modeling techniques to a landscape scale project. Investigations of Holocene hunter-gatherers, fishers and pastoralists at Lake Turkana, Northern Kenya have been conducted by the Koobi Fora Research and Training Project, a collaboration of National Museums of Kenya and Rutgers University. A series of land use and resource availability models has been prepared using modern analogs for fishing, hunter-gatherers and for people utilizing pastoralist practices. Key resource variables have been identified for each substance strategy and the distributions of these key resources have been modeled based on climate and geomorphology changes. The strengths and weakness of this attempt are detailed in this paper.

Wednesday

KEYWORDS: predictive model, niche modeling, Holocene, Africa, subsistence

Fieldwalk@Kisoji: Second Preliminary Report of the GPS/GIS-aided Walking Experiments for Re-modeling Pre-modern Travels in Nakasendo-Kisoji (Central Highland Japan)

YASUHISA KONDO[1] and YOICHI SEINO[2]

1. Department of Archaeology, University of Tokyo, Japan
2. Department of Cultural Coexistence, Kyoto University, Japan

In 2007, the authors carried out walking experiments in Kozushima (a small island in southern Tokyo) for evaluating travel-cost algorithms such as Tobler's Hiking Function (Gorenflo and Gale 1990) and the metabolic energy expenditure model (Van Leusen 2002). The results of the experiments largely fit the models: the walking speed decreases on steeper slopes. However, it has also been observed that ground conditions ,such as paved or unpaved, significantly affect walking speed (Kondo *et al.* 2008). In addition, visibility could be another factor affecting speed. In order to examine these effects on walking in more detail, a second

round of experiments was conducted in the pre-modern road of Nakasendo-Kisoji in autumn 2008, and the preliminary results are presented in this paper. Kisoji is a historical road of approximately 80 km in length along the Kiso Valley, connecting the highland region to the southern lowland region in central Japan (Gifu and Nagano prefectures). It was first mentioned in the historical text, *Shoku Nihongi*, in the early eighth century C.E. Then, at the beginning of the seventeenth century, the Tokugawa shogunate reorganized Kisoji as a part of Nakasendo, one of the two major tracks that bridged Edo (the Tokugawa capital in eastern Japan; present Tokyo) and Kyoto (the old capital in western Japan). Kisoji was selected as the location of the experiment because of its authentic historical context.

In the experiment, examinees walked through the preserved trail of Kisoji for four days. The walking tracks were positioned by hand-held GPS receivers (Garmin GPSMAP 60CSx) and differential ones (Magellan ProMark 3). A wristwatch-type GPS receiver (Garmin ForeAthlete 305) was also used for recording heartbeats as an indicator of energy expenditure. The travel was timed, and the road attributes, including roadbed type (asphalt, flags, gravel, etc.) and subjective visibility, were recorded. Then, by means of GIS, the walker's tracks were split into 50m segments with the homogeneous attributes. The GIS-based correlation analysis reveals the following: (1) there is a wide variability in walking speed even on slopes of similar angles, and thus, it is rather inappropriate to generalize walking behavior into a regression expression; (2) visibility does not significantly affect walking speed; (3) walking on flags is remarkably slower than that on gravel paths; and (4) heart rhythms are responsive to the change in ground slope rather than to walking speed. These results allow us to design a "fuzzier" model that loosely estimates travel cost in a format of energy expenditure.

Wednesday

Gorenflo, L. J. and N. Gale, 1990. "Mapping regional settlement in information space." *Journal of Anthropological Archaeology* 9, 240-273.

Kondo, Y. and T. Ako, I. Heshiki, G. Matsumoto, Y. Seino, Y. Takeda, and H. Yamaguchi, 2008. "FIELDWALK@KOZU: A preliminary report of the GPS/GIS-aided walking experiments for re-modeling prehistoric pathways at Kozushima Island (East Japan)." Paper presented at CAA 2008 Budapest.

Van Leusen, P.M., 2002. "Pattern to Process: Methodological Investigations into the Formation and Interpretation of Spatial Patterns in Archaeological Landscapes." PhD dissertation, University of Groningen.

Keywords: travel cost simulation, energetic expenditure, historical context, GPS, field experiments

Beyond the Marsh: Settlement Choice, Perception, and Spatial Decision-Making on the Georgia Coastal Plain

Thomas G. Whitley, Inna Burns Moore, and Gitisha Goel
Brockington and Associates, Inc., United States of America

When we consider the intrinsic value of land units (or cells) in an archaeological analysis of landscape, settlement choice, or site selection, we tend to develop models which use static, unchanging costs or benefits, or which rely on least common denominators for a wide range of human actions or time frames. This is naturally driven by the tendency to find correlative evaluations as the most comforting means of both hypothesis building and hypothesis testing. Correlative approaches used in such applications as "inductive" predictive models are inherently reductionist and typically global-inferential. Likewise, the acceptance of large data set correlation testing, or training sets, as the primary means for assessing model success (even in agent-based models or neural network applications) precludes approaches which deal in sequential actions, local behaviors, or unique site types. In actual application though, cell-based attractors are dynamic and distinctly contextual. They tend to influence individual or group decisions "on the ground" from both an agent-based and cognitive perspective. Thus, we need to develop models which can provide an egocentric, rather than a global frame of reference, and which are explanatory rather than merely correlative. The first steps in this direction are provided by agent-based modeling approaches. However even agent-based models utilize fixed frames of reference, or tools that rely on universal knowledge and global decision-making. In other words, attractors do not typically change their values based on which angle they are being observed from. Here we develop a model which uses cell-based analysis in several ways: First, attractor values are derivative of perception; the interface of knowledge and confidence in that knowledge. Second, spatial decision-making is temporally sequential; thus proximity tempers attractor values. And third, the scale of decision-making distinctly relies on both immediate and long range planning and returns. These concepts will be illustrated with data from the Coastal Plain of Georgia (USA) and placed in the context of adaptations to a seemingly homogenous cultural and ecological landscape.

Keywords: GIS, cognitive, modeling, attractors, perception

An Improved Method for Extraction of Historical Cartographic Features into GIS: A French Case Study

Scott L. Madry and Elizabeth A. Jones
University of North Carolina at Chapel Hill, United States of America

Transferring data from historic maps into GIS databases has always been difficult, due to differing methods of creation, manners of representation, inconsistencies of scale, and the outright errors inherent in historic maps. Standard techniques of georeferencing key points on the landscape and rubber sheeting alone are not

sufficient for tracking landscape change at the local level and scale of the individual parcel. This paper presents a new method for more accurately transferring landscape features from historic maps onto the modern GIS landscape, using the transparency and layering features of Adobe Photoshop. Once historic features have been accurately placed on a modern map of the area using this method, the placement is verified by archaeological field survey, and documented with GPS and Google Earth imagery before the data is finally incorporated into the GIS database. Our research is tracking land-use change over the past three centuries in the rural Commune of Uxeau in Southern Burgundy, France. The land in Uxeau has been continuously farmed by smallholders for millennia, maintaining a high productivity in all periods. By reconstructing historic land-use practices through both their social and physical aspects, we hope to uncover essential information on how people maintained the viability of this resilient landscape during periods of significant environmental, political, economic, social and cultural change. Many studies shaped by resiliency theory tend to focus on the collapse of socioecological systems. This research, based as it is on a positive example of long-term successful adaptation, will be especially useful in refining theory and informing models of sustainability for the future. Historical cadastral records for this period provide a history of landscape change tied to individual parcels and buildings from the year 1790 to the present. Periodic agricultural reports from throughout the period add detail to the land-use information available from the cadastral records. Civil records of births, marriages & deaths are being used to reconstruct farm households, making it possible to connect households to the individual parcels through the tax records, thereby reconstructing the land holdings of farms. The research adds to and is being analyzed as part of the extensive GIS data base of the area begun by Dr. Madry in the 1980s. The combined analysis of the demographic data with the land-use data in the GIS database will reveal each farm's land-use practices through time. The information from the cadastral records is supplemented by a series of detailed maps of the area dating to the years 1759, 1835, 1848, 1895, 1964, 1985 and 2002. The maps from 1835 and 1964 show the parcel outlines and numbers. In addition to the maps we have a series of scanned military aerial photos taken in 1945, and satellite imagery from various dates back to 1972. We will present an example of water-related features extracted from these historical maps using our new method, and present the story of changes in water use and management that that they tell.

Keywords: GIS, France, historical maps, feature extraction, time series

Session Summary

Wednesday, 8:30am-3:00pm, Tidewater D

The Semantic Web: Second Generation Applications

Chairs: Leif Isaksen, University of Southampton, United Kingdom

Tom Elliott, Institute for the Study of the Ancient World, New York University, United States of America

Semantic Web technologies are increasingly touted as a potential solution to the data integration and silo problems which are ever more prevalent in digital archaeology, but there is still much work to be done establishing best practices and useful tools. Now that a number of projects have been undertaken by interdisciplinary partnerships with Computer Science departments, it is time to start drawing together the lessons learned from them in order to begin creating second generation applications. These are likely to move away from (or at least complement) the monolithic and large-scale "semanticization" projects more appropriate to the museum community. In their place we will need light-weight and adaptable methodologies more suited to the time and cash-poor realities of contemporary archaeology.

This session will be a forum in which to present current work, appraise previous projects, identify best practices and look for collaborative opportunities. Papers are invited which explore the use of any Semantic technologies in archaeology—especially those recommended by the W3C: RDF(S), OWL, and SKOS. Subject matter may be either abstract or with reference to a particular project but in either case should seek to engage with the unique technical challenges in this area. The target audience will have at least some previous experience in this field so a reasonably high level of technical discussion is expected. Specific areas of interest include (but are not restricted to):

- The role of the CIDOC-CRM as a domain ontology in archaeology
- Integrating live legacy databases
- Ontology mapping and alignment
- Spatial and temporal semantics
- Barriers to uptake amongst non-IT professionals
- Top-down (e.g. ontology-based) vs. bottom up (e.g. RDF/a-based) approaches
- CoolURIs and stable web dissemination
- Coreferencing
- Triple- and quad-stores
- Trust, authentication and reification

- Semi-antics: integration with RSS/Atom and Web 2.0 technologies
- Visualization and interfaces

Technical demonstrations are also welcomed. The session will conclude with time for general discussion and debate.

Topics: CIDOC and other digital standards, databases, data management systems and other field applications, other

Keywords: Semantic Web, RDF, OWL, CIDOC CRM, data

Schedule

8:30 – 8:50	"An Archaeologist's Reflections on Semantics and the Web," Sorin Hermon, Achille Felicetti, Franco Niccolucci, and Denis Pitzalis
8:50 – 9:10	"Extending and Enriching the CIDOC-CRM Ontology for Task-Ontological Domain Models," Achille Felicetti and Andrea D'Andrea
9:10 – 9:30	"Implementing Semantic Web Software in the Field of Cultural Heritage Using the CIDOC CRM—Prospects and Challenges," Robert Kummer
9:30 – 9:50	"Following a STAR? Shedding More Light on Semantic Technologies for Archaeological Resources," Keith May, Ceri Binding, and Doug Tudhope
Coffee break	
10:15 – 10:35	"A Prototype for Managing Archeological Excavation Data in a Digital Library for the American School for Classical Studies at Athens," Thornton Staples
10:35 – 10:55	"Implementing RDFa in the Publication of Ceramic Data from Troy (Turkey)," Sebastian Heath and Billur Tekkök
10:55 – 11:15	"ArcheoInf—Allocation of Archaeological Primary Data," Matthias Lang
11:15 – 11:35	"ArchaeoKM: Toward a Better Archaeological Spatial Data Sets Management," Ashish Karmacharya, Christophe Cruz, France Frank Boochs, and Franck Marzani
Lunch	
1:30 – 1:50	"Linking Archaeological Data," Leif Isaksen, Kirk Martinez, Graeme Earl, Nick Gibbins, and Simon Keay
1:50 – 2:10	"Automatic Extraction of Archaeological Events from Text," Kate Frances Byrne and Ewan Klein
2:10 – 2:30	"Natural Language Processing within the Archaeotools Project," Michael D. Charno, Stuart Jeffery, Julian D. Richards, Fabio Ciravegna, Stewart J. Waller, Sam Chapman, and Ziqi Zhang
2:30 – 3:00	Discussion

Abstracts

An Archaeologist's Reflections on Semantics and the Web

SORIN HERMON[1], ACHILLE FELICETTI[2], FRANCO NICCOLUCCI[1], and DENIS PITZALIS[3]

1. STARC - The Cyprus Institute, Cyprus
2. PIN scrl - Universita degli studi di Firenze
3. Centre de Recherche et de Restauration des Musées de France, France

The paper will focus on the potential use of semantics and second generation applications for the web in archaeological scientific research, arguing that, starting from the definitions of archaeology and cultural heritage themselves, semantics as they are applied today are of little use for archaeologists, restricting and narrowing down the reachable information to be harvested on the "semantic web." If semantics deal with "significances" and "meaning of signs," then a simplistic integration of metadata formats and mapping of ontologies will somehow miss archaeologists, who are more interested in the "meaning of content," versus "meaning of metadata," as most semantic applications focus on today. Consequently, the paper will present some implementation tools for semantic integration of heterogeneous archaeological data, having CIDOC-CRM as a reference point, and some ideas for future developments, considering Foucault's "heterotopic" space as the "next generation" semantic web, meaningful for archaeological research.

Wednesday

KEYWORDS: semantics, meaning, signs, archaeological scientific research

Extending and Enriching the CIDOC-CRM Ontology for Task-Ontological Domain Models

ACHILLE FELICETTI[1] and ANDREA D'ANDREA[2]

1. PIN, University of Florence, Italy
2. CISA, Università degli Studi di Napoli "L'Orientale," Italy

Ontologies and their use, as of today, are not just a topic in theoretical studies. Ontologies are becoming ubiquitous in many information systems and environments; they constitute one of the cornerstone of the Semantic Web development; and they are used in e-commerce and in various and diverse fields such as medicine and Cultural Heritage. But there is a need for specialization of ontologies, by enriching and extending them, in order to adapt them to specific application domains. This paper describes the conceptual process underlying the creation of a task ontological model growing from the CIDOC-CRM ontology. While the intended scope of the CRM is a subset of the "real" world and is therefore potentially infinite, the existence of task models is fundamental for the improvement of usability of CRM in real scenarios. We illustrate in details how an ontology-based task model for Cultural Heritage can be created by extending a general ontology (core ontology) for adapting it to specific domains of application (archaeological excavation; coins cataloguing).

The paper deals with how the general scope of the core ontology can be focused to capture particular domain concepts. Nevertheless, compatibility of extensions with the CRM means that data structured according to an extension must also remain valid as a CRM instance. Extensibility for integration, also, should be guaranteed through the linkage of other external type hierarchies.

Keywords: CIDOC-CRM, ontologies, enrichment, task models, semantic web

Implementing Semantic Web Software in the Field of Cultural Heritage Using the CIDOC CRM—Prospects and Challenges

Robert Kummer
Universität zu Köln, Germany

Historians do not want to find a database record, they want to understand a historical context. Consequently, historians need to draw sources on a specific subject from the repositories of different cultural heritage institutions to get their work done. For that, interoperability between different and heterogeneous databases needs to be established. This paper deals with experiences and challenges that have been encountered in the course of still ongoing data integration efforts. The collaborating parties are the Perseus Project at Tufts University and Arachne, the central object database of the German Archaeological Institute. Together they gauge Semantic Web concepts by integrating data from multiple databases with the aim to establish interoperable research environments for archaeological research. The main challenges experienced during the first project phase were manifold and will be addressed and discussed. A set of general obstacles stems from the concept of the Semantic Web and its different implementations. The CIDOC CRM has been established as a Conceptual Reference Model and therefore does not provide any statement on how to implement it. Additionally, the concept of the Semantic Web demands high standards of digital data curation from contributing data providers regarding granularity of the data objects and the usage of controlled vocabularies. This addresses a set of problems directly related to the concept of co-reference because the CRM does not get down to database content and terminology. One way to deal with terminology that differs by both being multi-lingual and domain specific at the same time would be to establish shared controlled knowledge organization systems. This also forms the precondition to enable a repository of semantically linked data objects. Unfortunately, in the domain of cultural heritage, this is mostly not the case. Bearing that in mind, the author feels confident in stating that the problem of co-reference subsumes the sensitive point of current Semantic Web efforts. To clarify this, the paper includes a demonstration of a prototype that aims at providing centralized discovery of resources that remain curated in a distributed environment. This prototype provides mechanisms to support full-text search and facetted browsing in large data sets. To tackle the aforementioned problem of co-reference, a naive environment that strives to equip users with the means to make statements on the similarity of objects will be described. As a result of these challenges, the success of cultural heritage projects that want to integrate and link highly heterogeneous data objects from many sources depends on

clearly defining the scope of their projects. The outcome of this definition of scope determines the subset of CRM classes that will be needed and also the level of intellectual precision that goes into the mapping efforts. From an institutional point of view, the response to this situation should be to form smaller communities with shared interests to work out a shared set of best practices.

Keywords: CIDOC CRM, semantic web, interoperability, linked data, co-reference

Following a STAR? Shedding More Light on Semantic Technologies for Archaeological Resources

Keith May[1], Ceri Binding[2], and Doug Tudhope[2]

1. English Heritage, United Kingdom
2. Glamorgan University, Faculty of Advanced Technology, Wales, United Kingdom

Wednesday

The Semantic Technologies for Archaeological Resources (STAR) project has been investigating the use of a number of emerging semantic web technologies for developing interoperability between existing data from archaeological projects in legacy systems, new project data entered in new systems, and other data sets from previously unrelated archaeological recording systems. Initial work began at English Heritage with the use of the CIDOC CRM ontology for cultural heritage and the creation of archaeological domain specific extensions to the CIDOC CRM ontology for the modeling of more specific archaeological information recorded during the evaluation, excavation and post-excavation processes. The initial modeling work has now been mapped to a number of different data sets from various derivations beginning with some from English Heritage projects, but in addition including data from other organizations in a number of different data structures and distinct formats. Work has also been carried out to incorporate domain thesauri into the project's ontological framework and the development of tools. The initial conceptual modeling and mappings have then been used to generate RDF triple statements using a semi-automated process, and a purpose-built data extraction tool with the resulting RDF statements held in a triple store. The archaeological extensions (referred to as CRM-EH) have been made available in RDF format from the STAR web site (http://hypermedia.research.glam.ac.uk/kos/CRM/). A number of web based prototype interfaces have been developed—and following feedback from user requirements workshops are still being developed and refined—to access and query this triple store.

The STAR project has developed an initial set of semantic web services, incorporating the emerging W3C SKOS standard for thesauri representation online. Several thesauri in general use within EH have been converted to the SKOS format for use in query expansion searching of controlled vocabulary fields and further work is being carried out to create SKOS versions of glossary fields and other terminologies. This paper will set out some of the most recent findings from the STAR project, including presentation of the latest web services. It will also look at some of the main Pros and Cons encountered in the project work to

date and try to assess the degree of interoperability provided between the different data sets and some of the cost-benefits associated with mapping the various data sets using the Conceptual Reference Models.

Keywords: semantic interoperability, ontology, conceptual reference modeling, CIDOC CRM, SKOS

A Prototype for Managing Archaeological Excavation Data in a Digital Library for the American School for Classical Studies in Athens

Thornton Staples

Fedora Commons, Inc., United States of America

In 2006, with funding from the Andrew W. Mellon Foundation, the School began a long-term project to create a digital library to manage and deliver digital surrogates of their traditional collections, as well as the rapidly growing collection of born-digital content from their excavations. The first prototype concentrates on the excavation data, including data from the 2006 season at Corinth and 2002-2005 seasons at the Athenian Agora. There are also data from the 1915-1916 notebooks from Korakou, a pre-historic site a few miles from the Corinth excavations. Though the prototype does not use a formal repository system, the approach taken is designed to be easily moved into one such as Fedora to ensure long-term durability of the digital information while maintaining flexibility of access. The system is designed to be a network of information objects among which a variety of formal semantic relationships may be asserted. The backbone of the network is a set of XML files that are digital surrogates for the contexts that are excavated, the finds which are revealed, and the features which are postulated from the evidence. Each of these XML files contains the rich descriptive information that the archeologists capture and/or create, as well as information that describes the relationships among the entities. In general, these are "contained" relationships, indicating that finds were discovered in a context, and a context is part of the evidence for higher order features. There are also relationships sometimes asserted among contexts to indicate when they were dug above or below each other in the trench, or when one context was judged to have originally been deposited before or after another. Relationships to image objects that are digital photographs, plans, drawings and digitized notebook pages are also described in the entity XML files. Both the descriptive and the relationship information is extracted and expressed as Resource Description Framework (RDF) triples in two Mulgara (an open-source RDF engine) indexes. The first index is a "Lucene" model which allows rich descriptive metadata to be searched by a user. The second index is a regular RDF index that allows for the complete tree of relationships to be accessed in a variety of ways. The interface that will be demonstrated allows a user to search the descriptions of the entities, then to browse the network of relationships from each one found. Each hit in the search is a link to an XML file rendered in HTML that presents all of the descriptive information and provides access to related objects in multiple ways. This approach demonstrates that all of this archaeological data can be managed as flat files that can be sustained in the long term without any dependence upon specific software, while allowing for rich semantic

Wednesday

networks to be accessed through purpose-built indexes. It can also be shown that multiple versions of any representation, to provide different states of interpretation for example, can be handled with ease.

Keywords: semantic network, repository, durability, digital library

Implementing RDFa in the Publication of Ceramic Data from Troy (Turkey)

Sebastian Heath[1], Billur Tekkök[2]

1. American Numismatic Society, United States of America
2. Baskent University, Turkey

This paper discusses the use of the newly adopted W3-standard RDFa in the representation, query and publication of archaeological data. The test case is the authors' ongoing digital publication of Greek, Roman and Byzantine pottery from Troy in northwest Turkey. This work is currently available at http://classics.uc.edu/troy/grbpottery/, and has at its core a series of ceramic catalog entries that are analogous to records in a database. These are serialized using XML, with XHTML as the default Document Type Definition (DTD). We have found that XML supports data structures and relationships that are unwieldy when implemented in a relational database. For example, many-to-many relationships, which frequently require a "linking table," can be easily implemented without requiring the additional data-entry implied by the relational approach. It is a design goal of our work that the underlying representation utilize RDFa to facilitate the interoperability of our data. RDFa defines a set of XML attributes that allows the embedding of Resource Description Format triples writing XHTML documents. A RDF triple is a simple statement consisting of a subject, predicate and object. For example, with a hypothetical "Object N" as a subject, "is of ware" is the predicate, and "African Red Slip" is the object. When rephrased as "Object N is a shard of African Red-Slip," triples of this sort are a fundamental part of the publication process for archaeological ceramics.

The advantage of RDFa is that it defines a standard against which we can judge the ability of third party tools to parse and make use of the archaeological data inherent in our publication. In particular, preliminary testing with the W3 RDFa parser at http://w3.org/2007/08/pyRdfa/ and the SPARQL-endpoint at sparql.org/sparql.html indicate that we can make our data visible within such environments. On a practical basis, we have found that XML markup that efficiently captures information as produced in the field and during subsequent analysis does not automatically lead to the production of RDF triples that facilitate successful exploration of all facets of our data. For example, we currently use XSLT-based transformations to generate queries similar to "Object N has a geographic origin of the Roman province of Byzacena." It is also important to note that while XHTML and RDFa specify a syntax for representing information, neither mandates a particular vocabulary that would enable interoperability. There is not currently agreement among archaeologists as to which vocabulary should be used. For the time being, the authors are experimenting with different vocabularies, including the CIDOC-CRM and the inter-related Freebase, OpenCyc and DBPedia

ontologies. We are similarly working to associate our data with collections of named entities such as that being developed by the Pleiades Project, which is working in the domain of ancient Mediterranean historical geography. Our ongoing efforts suggests that existing W3 standards can be the basis for facilitating the discovery, acquisition and analysis of well-structured archaeological data.

Keywords: RDFa, XHTML, semantic web, Troy, ceramics

ArcheoInf—Allocation of Archaeological Primary Data

Matthias Lang
Institut für Archäologische Wissenschaften, Ruhr-Universität Bochum, Germany

Wednesday

ArcheoInf is an interdisciplinary project conducted by the Institute for Archaeological Science at the Ruhr-Universität Bochum, the Department for Computer Science at the Technische Universität Dortmund, the Department for Geo Computer Science at the University of Applied Science Bochum, and the University Libraries of Bochum and Dortmund. The project is funded by the German Research Society. ArcheoInf aims at merging primary data acquired in different archaeological excavations and field surveys. It will provide a single point of access to primary data from heterogeneous information systems. The autonomy of these different databases will not be affected. Archaeological primary data are linked to geoinformation data and miscellaneous library services, i.e. an institutional repository. Thus, ArcheoInf will constitute a comprehensive data pool for archaeological research. ArcheoInf offers a mediator which can simultaneously search many heterogeneous databases without changing the interface. The mediator is based on a comprehensive thesaurus with a maximum number of archaeology subjects and a semantic web-enabled OWL-based ontology providing a efficient search of archaeological data. The ontology is consistent with the CIDOC-CRM. The polyhierachic and multilingual Thesaurus is based on SKOS. Users also have access to archaeological pictures and factual information, electronic full text, and bibliographic data on an archive server. A Geo-Server saves geoinformation in a standardized form for cartographic representation via the internet. WebGIS is used as the client for background maps where various services as Google Maps and World Wind are involved. In this way users will have efficiently presented sites on the maps with variable scales. Spatial analyses are possible for single or multiple projects. ArcheoInf exclusively uses the WGS84 reference system (or ETRS89) to guarantee the coherent storage and presentation of all geodata and to be compatible with GPS. Transformation algorithms offer automated services for projects using the local geographic system or the current country system. ArcheoInf sees itself as an open structure for archaeological projects.

The project cooperates with several partners from different universities and research institutes. Databases in progress are updated by the current project as usual. Completed data collections will be available on the archive server for a long term. Rights management enables ongoing and unpublished projects to limit access

to the involved scientists and to give access to initial results selectively, e.g., in research reports. This will include field collection standards, site selection, and public engagement and interactivity.

KEYWORDS: linked databases, searching, pooling data

ArchaeoKM: Toward a Better Archaeological Spatial Data Sets Management

ASHISH KARMACHARYA[1], CHRISTOPHE CRUZ[2], FRANK BOOCHS[1], and FRANCK MARZANI[2]

1. 1 Institut i3mainz, am Fachbereich 1-Geoinformatik und Vermessung, Germany
2. Laboratoire Le2i, UFR Sciences et Techniques, Université de Bourgogne, France

Most knowledge management research done on excavated objects is based on non-spatial data. Semantics is used both to focus on data integration among heterogeneous data sets and to build up a common language in order to develop a common framework. Consequently, data are self-describing and allow generic and automatic processes. The lack of semantic data that describes objects spatially is an issue that we address. Our proposition is based on a web platform which uses semantic Web technologies and knowledge management processes. It focuses on the identification process which consists in managing data generated during the excavation process. The spatial data are linked to knowledge bases acquired during the identification process. By annotating data with semantic definitions, our Web platform provides a semantic view on spatial data sets. One of the highlights of the system is the involvement of the archaeologists in order to define the management rules. These rules are used to set up the components in the domain ontology which define the knowledge. The knowledge generated and managed through management rules and semantic indexations is used to provide the user with semantic Wikipedia pages. The paper also demonstrates how spatial analysis ofthe spatial data set could provide an extra dimension to the knowledge generation and its management.

KEYWORDS: industrial archaeology, knowledge management, semantic web, semantic annotation, spatial analysis

Linking Archaeological Data

LEIF ISAKSEN, KIRK MARTINEZ, GRAEME EARL, NICK GIBBINS, and SIMON KEAY

University of Southampton, United Kingdom

The concept of Linked Data (http://linkeddata.org/)—information structured using a variety of public schemas and data sources—is beginning to take the Semantic Web out of the laboratory and into real-world applications. However, successful integration of legacy data sets requires the separation of the instances, terminologies and (frequently implicit) ontologies that constitute them so that each can be dealt with appropriately. This paper will discuss recent doctoral research seeking to provide practical solutions to this process and give some early examples of its potential benefit to archaeology. A number of different databases pertaining to amphora and marble origin and distribution have been collated as part of the University of

Southampton/British School at Rome "Roman Ports in the Western Mediterranean" Project (http://www.bsr.ac.uk/BSR/sub_arch/BSR_Arch_05Roman.htm). Initial results have created a guided process by which spatial toponyms are extracted, integrated and enriched with additional data (coordinates, feature types, etc.) within a single RDF database using the Geonames (http://www.geonames.org) and Pleiades (http://pleiades.stoa.org) web services and the GATE Natural Language Processing library (http://gate.ac.uk). The data can then be plotted easily as KML or used for more sophisticated spatial analysis in order to better understand the flow of ancient trade networks. Temporal information will be introduced in the next phase of development. The final part of the paper will look at one of the future challenges to be addressed: the alignment of parallel ontologies and terminologies (taxonomies, thesauri, etc.). The etic nature of archaeological classification dictates that comparisons between entities described using different typologies must be both transparent and easily repeatable using different typological alignments. The Linked Data approach creates both flexibility and dangers in this regard when contrasted with those that utilize a single ontology. Some of these will be outlined with the intention of opening wider discussion on this topic. The use of SKOS (http://www.w3.org/2004/02/skos) as a means for dealing with multiple terminologies will be given specific attention.

Keywords: semantic web, RDF, KML, linked data, maritime trade

Automatic Extraction of Archaeological Events from Text

Kate Frances Byrne and Ewan Klein
University of Edinburgh, United Kingdom

Wednesday

The Semantic Web envisions a web of linked data that can be "understood" by machines, alleviating the drudgery of web searching and making it dramatically easier to interconnect separate data silos. Take-up has been slow so far, but the new Web of Data is gradually gathering momentum as more data are generated in RDF format. If this new web supersedes the existing "Document Web" then it is vital that the cultural heritage material curated in archives around the world becomes part of it. See Schreiber 2006 and Hyvonen 2007 for example initiatives. This paper describes one aspect of a larger research project on transforming cultural heritage material for the Semantic Web. The source data comes from RCAHMS (The Royal Commission on the Ancient and Historical Monuments of Scotland) and is a mixture of structured data in a relational database and unstructured data in free text documents. We use methods intended to be generic for the domain to translate this hybrid data into an RDF graph and integrate it with graphs generated from standard thesauri (Lee 2007) for Monument and Object Types, using the SKOS framework. It has been shown (Binding 2008) that these thesauri can in turn be integrated with the CIDOC-CRM (Crofts 2008). The paper reports new results for transforming text into an RDF graph via the automatic identification of binary relations. We use Natural Language Processing (NLP) techniques such as Named Entity Recognition (NER) to find the content-carrying phrases in the text, followed by Relation Extraction (RE) to discover and categorize relationships between pairs of Named Entity (NE) strings. The ontology into which the RDF

graph is integrated is partly pre-determined and partly generated dynamically from textual content. We will focus on techniques for identifying textual mentions of events such as site visits, excavations and surveys, and then determining their attributes, such as where and when each event took place and what agents were involved.

We shall show that treating events as a kind of reified entity leads to high performing extraction, even though events are not Named Entities as usually construed. As well as producing an integrated RDF graph structure, our event extraction method has another potential application in automatically populating relational database tables. This meets a pressing need of archive organizations like RCAHMS who wish to extend their database structures with temporal information but are faced with the enormous task of generating the content by manually extracting event data from documents. Approaches using NLP have been shown to be successful (Sporleder 2006) and we hope to explore this in future work.

Schreiber *et al.*, 2006. MultimediaN E-Culture Demonstrator, Nov. 2006.

Hyvonen *et al.*, 2007. CultureSampo - Finnish Culture on the Semantic Web, Nov. 2007.

Lee (ed.), 2007. *MIDAS Heritage - a data standard for the historic environment*, 2007.

Binding *et al.*, 2008. Semantic Interoperability in Archaeological Data sets: Data Mapping and Extraction via the CIDOC CRM, Sept. 2008.

Crofts *et al.*, 2008. *Definition of the CIDOC Conceptual Reference Model*, Mar. 2008.

Sporleder *et al.*, 2006. Cleaning and enriching research data - the MITCH project, Feb. 2006.

Wednesday

Keywords: semantic web, RDF, relation extraction, cultural heritage, event-based recording

Natural Language Processing within the Archaeotools Project

Michael D. Charno[1], Stuart Jeffery[1], Julian D. Richards[1], Fabio Ciravegna[2], Stewart J. Waller[1], Sam Chapman[2], Ziqi Zhang[2]

1. Archaeology Data Service, University of York, United Kingdom
2. Natural Language Processing Research Group, University of Sheffield, United Kingdom

At CAA 2008, the first phase of the Archaeotools faceted classification browser in archaeology was discussed. This paper presents results from the second phase of the project. Archaeotools is a joint project between the Archaeology Data Service (ADS, http://ads.ahds.ac.uk) and the Natural Language Processing Research Group at the University of Sheffield (http://nlp.shef.ac.uk), funded under the UK's Arts and Humanities e-Science Research Grants Scheme, which itself is a collaboration between three major funding bodies, the AHRC, the EPSRC and the JISC. The Archaeotools project (http://ads.ahds.ac.uk/project/archaeotools) is specifically intended to enhance ADS's ArchSearch (http://ads.ahds.ac.uk/catalogue) facility with richer data resources and a more intuitive and informative browser system. To facilitate this process, the second phase of the project uses natural language processing (NLP) to tackle the problem accessing of semi-structured or unstructured, but highly valuable, archaeological data. This technique allows the extraction and classification of semantically meaningful data from these various types of texts. The underlying data set for this phase of this project comprises thousands of grey literature reports, a ubiquitous but unpublished corpus of archaeological material, and the digitized version of the Proceedings of the Society of Antiquaries of Scotland (PSAS). The Archaeotools project also makes use of external resources, such as thesauri served in XML by SKOS based web services developed by the AHRC funded Semantic Tools for Archaeology project (STAR) based at the University of Glamorgan (http://hypermedia.research.glam.ac.uk/kos/star). The NLP approach holds out the prospect of asking sophisticated questions of these data, such as "show me articles relating to excavation in the early twentieth century in Wales where Roman pottery was found." This paper will describe the complexities and difficulties of achieving this level of semantic utility as well as presenting the results to date.

Keywords: faceted classification, natural language processing, ontologies, semantic web

Session Summary

Wednesday, 8:30am-3:00pm, Patriot

Digital Humanities and Pedagogy

Chairs: ARNE FLATEN, Coastal Carolina University, United States of America
ALYSON GILL, Arkansas State University, United States of America
PAUL OLSEN, Coastal Carolina University, United States of America

Digital Humanities projects address a wide range of locations, periods, physical materials and technical innovations, and their methodologies are as diverse as the topics they cover. While many programs focus on in-the-field tools or secondary research applications, others emphasize the end user and the dissemination of their materials. End users can be primary or secondary students, undergraduates, the general public, or museum audiences, but designers of web pages, portable lecture/display units, or kiosks are concerned with platform appearance, accessibility, what materials are offered, and how intuitively the platform or interface functions. Digital Humanities projects also offer exceptional opportunities for collaborative research between faculty and students. The introduction of various hands-on technologies in the "classroom" can energize and heighten the learning experience.

Wednesday

The organizers of this session are interested in the diverse perspectives offered by data providers, producers, and end users of various Digital Humanities projects. These might include 3D models and virtual environments, GIS database construction and population, games, laser scanning, Podcasting, data retrieval matrices, software innovations, hardware installations for a variety of venues, or any combination thereof. Papers might address in-class methods and experiential learning, end user problems and solutions in various contexts, demographics, interdisciplinary opportunities and challenges, or any number of issues concerning the design, construction, implementation or use of Digital Humanities projects.

TOPICS: databases, 3D data capture and modeling, GIS, North American archaeology and digital technology, Open Source software in archaeology, photogrammetry and imaging, virtual museums, virtual reality

KEYWORDS: digital models, digital humanities, virtual environments

Schedule

8:30 – 9:00 "Using Computers in Romanian Archaeology: An Anthropological Approach," Cristian Francisc Schuster and Alexandru Morintz

9:00 – 9:20 "Reclaiming a Sense of Place: Geospatial Technologies and the Flat Rock Cemetery Project," Jeffrey Glover, Kathryn Jackson, and Johnny Waits

9:20 – 9:40 "Shadows of Canaveral: The Application of VR to a Post-World War II Subject," Lori C. Walters, Charles E. Hughes, and Eileen M. Smith

9:40 – 10:00 "Sharing Archaeological Collections: The Virtual Vault Project," Douglas W. Gann

Coffee break

10:15 – 10:35 "National Extensive Databases in Norway—Pitfalls in a Bright Future," Espen Uleberg and Mieko Matsumoto

10:35 – 10:55 "Developing an Intuitive GIS Interface for Archaeological Data at the Pyrgos Museum, Greece," Todd Brenningmeyer and Sara Franck

10:55 – 11:25 "Narrative and Content Combine in a Learning Game for Virtual Heritage," Jeffrey Jacobson, Kerry Handron, and Lynn Holden

11:25 – 11:45 "Outbreak: Best Practices and Potential for the Development of Games for Archaeology and History," Kevin Kee

Lunch

1:30 – 2:00 "Learning History with the Interactive Mobile game Mediacaching," Thomas van Reimersdahl, Luca Vezzadini, Giuseppe Donvito, and Reinhard Förtsch

2:00 – 2:20 "Learning, Access and Mobility (LAMB) for Cultural Heritage Education," Kari Uotila, Isto Huvila, Jari-Pekka Paalassalo, Ilkka Helenius, Jani Lindholm, Minna Lääperi, Laura Puolamäki, and Sirpa Wahlqvist

2:20 – 2:40 "Developing a Next-Generation Virtual Museum of Traditional Japanese Arts Based on Multi-View Image Analysis," Xin Yin and Hiromi T. Tanaka

2:40 – 3:00 "Exploring Thule Culture—Constructing Virtual Worlds for 3D Theaters," Richard M. Levy and Peter Dawson

Abstracts

Using Computers in Romanian Archaeology: An Anthropological Approach

Cristian Francisc Schuster and Alexandru Morintz
Vasile Parvan Institute of Archaeology, Romania

The use of computer science in Romanian archaeological research is quite recent. Its application in the real sense of the word began after 1989. The main cause of this delay was Romania's political isolation. This situation had a negative effect on Romanian archaeological research as a whole as it limited access to information and to scientific debate. The political changes from 1989 presented Romanian archaeology with a great challenge: the attempt to diminishing the then-existing difference. We will refer to this in our presentation, pointing to a series of positive and negative aspects. Starting in 1990, an explosive appearance of computers in various fields of activity took place in Romania. This phenomenon, no doubt positive, also had numerous negative connotations. The lack of a computer science culture led to only apparent progress, and the new potential was used only on a limited scale. Often, a computer was considered nothing more than a better typing machine. At the same time, the computer became an object of prestige; the existence of such a device on the desk of an archaeologist conferred a certain distinction! This situation, probably unavoidable has been partially overcome. It has became clear that the use of certain hardware can be beneficial only through the use of software adapted or adaptable to a certain field of research and that education in this direction is essential. Another problem closely related to the ones mentioned above consists in the approach, in the new context, of some anterior archaeological concepts. As G. Lock said, the computer changes the way in which we think about certain things. Thus, the use of databases, of 3D modeling etc., can change the angle of approach, and can lead to variations/shades of difference and even modifications of some previously existing concepts in Romanian archaeology. This is valid for the research carried out at the sites of Mironeşti, Hârşova, Pietrele, Pietroasa Mică, etc. Another aspect refers to the position that the archaeologist must adopt in the process of implementation of new technologies: should he take on new activities or should specialists in the field of computer sciences? Some archaeologists still refuse to implement new methods of research, others prefer to do it themselves, and only a few built up interdisciplinary teams. These different tendencies are directly connected to the understanding of the usefulness of new approaches by different generations of archaeologists, to financial resources, and to the his or her ability to work in a team. Still important in the adoption of new methods of research are the administrative hierarchy, the scientific hierarchy, and, unfortunately, the political one. Archaeological research in Romania must be more rapidly integrated in the European archaeological community.

Keywords: pedagogy, computer technologies, Romania

Reclaiming a Sense of Place: Geospatial Technologies and the Flat Rock Cemetery Project

Jeffrey Glover[1], Kathryn Jackson[2], and Johnny Waits[3]

1. Georgia State University, United States of America
2. Greater Atlanta Archaeological Society, United States of America
3. Flat Rock Archive, United States of America

The Flat Rock community in southern DeKalb County, Georgia (just outside Atlanta) is one of the oldest continually-occupied African-American communities in Georgia. Although history shows that many African-American communities in the South were broken apart as former slaves migrated north in search of jobs and a more equitable life, Flat Rock remained an intact community. This was largely due to the efforts of individuals who were able to purchase land and later sell it in small parcels to fellow community members. Proximity—both to ancestors and significant places—is a cross-culturally important component to the creation of a sense of community. Placed on the third highest point in DeKalb County, the Flat Rock Cemetery became such a place for the Flat Rock community. It contains burials dating from 1834

(three years prior to the official establishment of the community) through 1959. In the spring of 2008, Johnny Waits, president of the Flat Rock Archive, proposed a project to the members of Greater Atlanta Archaeological Society (GAAS) involving the clearing and mapping this historic cemetery. These initial meetings eventually led to the involvement of Georgia State University (GSU). Through the use of a total station, Jeffrey Glover of GSU and his students have been conducting research into the material culture of the cemetery. The objectives of this project, due to be finished in February 2009, include completion of the cemetery map and the subsequent connection of identified graves to the archival data collected by Mr. Waits. Relevant historic maps have been incorporated in order to illustrate how the Flat Rock area has changed over the years, namely how this area was forgotten by non-locals as it was dropped from maps postdating 1865. Data collected will be integrated with photographic images of tombstones and material offerings, and will be established on GSU's geospatial servers using ArcIMS. These interactive maps will be made accessible to visitors to the Flat Rock archive web site.

Keywords: heritage management, ArcIMS, community outreach, cemetery archaeology, historical archaeology

Shadows of Canaveral: The Application of VR to a Post-World War II Subject

Lori C. Walters, Charles E. Hughes, and Eileen M. Smith
University of Central Florida, United States of America

Wednesday

Less than a generation ago, Cape Canaveral rivaled New York City as the world's most recognizable skyline. When a photo of the row of gantries appeared on the front page of a newspaper or on the evening news there was no guessing as to the locale—everyone immediately knew it was Cape Canaveral. Its skyline was unmistakable, bright orange gantries rising up from pristine Florida sands. Each gantry tower stood as a sentinel awaiting the next launch in our nascent exploration of space. Most of these historic launch structures have long since been demolished and sold for scrap. The final tower along ICBM Row fell to demolition in August 2005. It was the last "building" of Cape Canaveral's original skyline. While it would be financially impossible to physically resurrect Cape Canaveral to its former glory, the application of virtual reality can assist in recreating the past. The youth of today and tomorrow are grounded in visual learning. How better can we inspire today's digital natives to understand the past? *Shadows of Canaveral* is an ongoing project undertaken by the Media Convergence Laboratory at the University of Central Florida. *Shadows of Canaveral* is a 3D, interactive and immersive journey through time utilizing the backdrop of historic Cape Canaveral. Visitors to the project's website explore key moments in the history of the Cape through its launch pads, mission control, assembly areas, and launch vehicles. Their exploration goes beyond the gates at the Cape and extends to an examination of the larger historical picture and culture of the era. This post-World War II topic provides us with a rich and diverse resource of historical data: still photography, film, blueprints and, most importantly, oral history. The men and women who worked at the Cape have been an invaluable resource in the accuracy of physical details and the greater Cape culture. To date the project has completed experiences based on the first launch from the Cape in 1950 and John Glenn's orbital Mercury flight in 1962, and is preparing for a third phase examining the flights of Project Gemini.

Keywords: virtual reality, virtual heritage, Cape Canaveral, oral history

Sharing Archaeological Collections: The Virtual Vault Project

Douglas W. Gann
Center for Desert Archaeology, United States of America

The Virtual Vault is a internet-based exhibit featuring collections from the Arizona State Museum's (ASM) Pottery Vault, a climate-controlled curation facility that houses the world's largest collection of whole vessels from the American Southwest. This exhibit enables visitors to "virtually" access the pottery collection through digital renderings of the vault, the vessels contained within the vault, and relevant prehistoric archaeological sites, as well as interviews with anthropologists, conservators, and Native American artists. Development of the Virtual Vault proceeds in conjunction with "The Pottery Project," a landmark permanent exhibition at ASM that incorporates the Pottery Vault itself, a state-of-the-art Conservation Facility, and an Interpretive Gallery. Capitalizing on emerging technologies, this effort is creating an engaging virtual database of ASM's pottery collection that conveys a wealth of interpretive and contextual information not delivered by traditional exhibition mechanisms. The necessity for a globally accessible three-dimensional ceramics database emerged as the Pottery Vault Project progressed. Originally conceived as an open storage facility that would enable visitors to view ASM's vessel collection in its entirety, design of the Pottery Vault was ultimately structured around architectural constraints, conservation concerns, and the sheer enormity of the collection, which dictated compact storage units. Development of a browser allowing visitors to virtually explore the collection via an onsite interpretive display soon commenced. The adaptability of this powerful asset for professional purposes and educational outreach was immediately apparent. The Center for Desert Archaeology has been investigating applications of profile modeling, an innovative technique enabling rapid, low-cost digitization of three-dimensional objects. This revolutionary method quickly creates photo-realistic digital models of objects using calibrated digital photography rather than LIDAR scanning. Furthermore, this technique creates an actual three-dimensional object model with true metric properties, rather than a sequenced animation provided by the now familiar QTVR "pesudo-virtual" image files. Combined with the Center's previous work in three-dimensional modeling of ancient places, these two techniques create an exhibit where archaeological and humanities researchers as well as the general public will be able to examine over 2000 examples of some of the finest ancient and ethnographic examples of Native American ceramics. The Virtual Vault is being developed on an Open Source model which utilizes Javascript, PhP and a MySql database to prototype a delivery model for sharing a wide variety of artifact types. The resulting exhibit "makes history interactive" by providing users with unprecedented access to a wide range of ancient and historic objects. Should this model

prove successful, the Center for Desert Archaeology will provide source code and relevant documentation to encourage other institutions to capitalize upon this technology to engage the primary theme of this year's CAA conference.

Keywords: profile modeling, 3D, virtual museum

National Extensive Databases in Norway—Pitfalls in a Bright Future

Espen Uleberg and Mieko Matsumoto
Museum of Cultural History, University of Oslo, Norway

A common database system for the five archaeological university museums in Norway is now being established. The museums have had consecutive projects since 1992. The database will in different ways be available for researchers/students, cultural heritage management authorities and the general public. One common system is a great benefit, but it needs a unified understanding of the information value. Earlier, all archaeologists in Norway were at one of the five archaeological museums. Today, with several institutions involved and higher demands for public access, it becomes more important to explain the origin and qualify the available information. The original artifact catalogues, as they were written from 1829 and onwards, have been transferred to a database. This gives an insight in how terms have varied over time, and reflects the research history. Searches, however, depend on a common platform for input and update. The unique research traditions at each museum in Norway have to be described and systematized in order to facilitate searches in all collections simultaneously. Descriptions of how the information in the databases has been gathered should be readily available as well as manuals with definitions. Considering the amount of data, general understanding of the construction is more realistic than building a large metadata set. The database system will be a primary source for all researchers and students. The easily accessible information can change how research is conducted. It can stimulate new ideas and an idea can be corroborated or not by known finds. Text and images make it easier to select relevant objects for study. In this way, the material is more accessible and material studies become more efficient. On the other hand, the inspiration that often comes from meticulous work with large quantities of artifacts is regrettably slipping away. Cultural heritage management will also benefit greatly from the museum database, which enables users to find facts quickly. Ongoing processes to decentralize management will leave more decisions to people with less specialized backgrounds, who need to be able to evaluate the quality of the information available. The general public has internet access to the museum collections. The original texts are written to give concise descriptions. This is sufficient for some users, but good narratives and innovative use of new media are necessary to reach out to broader audiences. In all aspects, an extensive database system is an invaluable tool as a starting point. But it should be remembered that a database is a source that must be treated as critically as any other. It is a secondary source compared with the artifacts themselves. All users need a general understanding of the quality of the data. The database systems can lead the research away from

the primary sources and this requires a critical attitude to the secondary digital ones. Attention is required to avoid the pitfalls that lie along this road.

KEYWORDS: database, Norway, data quality, primary sources

Developing an Intuitive GIS Interface for Archaeological Data at the Pyrgos Museum, Greece

TODD BRENNINGMEYER[1] and SARA FRANCK[2]

1. Maryville University, United States of America
2. University of Minnesota, United States of America

GIS provides a robust foundation for developing interactive museum installations and web based educational tools. The challenging and often overlooked aspect of developing such applications is the usability and cartographic quality of the final product. The function of traditional GIS tools, including zoom, pan, and identify buttons, are not intuitive to the average user. Users unaccustomed to traditional desktop or web based spatial tools desire immediate feedback, rapid data loading and views of the areas of interest that are cartographically pleasing and interactive. These concerns were examined while planning the development of a new interactive installation for the Pyrgos museum, Greece (opening 2009). This project, undertaken in collaboration with the Greek Ministry of Culture, was developed to provide an interactive computer installation for Byzantine, Frankish, and pre-modern sites of the prefecture of Eleia, Greece. The goal is to provide users with digital access to settlement data at a range of scales and levels of detail. Users browse settlements by type and period. Detailed information, including typical floor plans, architectural decoration, and section and perspective drawings, is available to users. Aerial photographs, satellite imagery, and rectified maps provide base layers for examination of regional patterns. 2D and 3D visualizations of settlements provide additional information about site layouts and organization on a local level. The application relies on a variety of GIS data sources that are served to the interface in a spherical Mercator projection, which has become the standard for web based mapping applications such as Google Maps, Yahoo Maps and Microsoft's Virtual Earth. The use of this projection made data from these providers available to our project. A mosaic of Hellenic Army Geographical Survey (HAGS) maps was created and divided into 256x256 pixel tiles at standard zoom levels. This "slippery map" rapidly serves a very large raster in multiple resolutions. Background data depicting the terrain, vegetation and road networks of the region were generated using Mapnik, an Open Source cartographic product and a combination of data from the OpenStreetMap project and information compiled from the HAGS maps. Data for individual sites was compiled in a central database system using PostgreSQL and PostGIS. This information is served through an interface developed using Open Source libraries for Adobe Flash CS3. The robust vector handling capabilities of Flash allowed us to provide an interactive and appealing interface for the user. Likewise, the use of Flash will enable the museum to easily distribute this data through the internet in the future without concerns about browser compatibility. Through

this application, visitors to the museum can quickly and easily query archaeological and architectural data. The results of their queries are available on a monitor and can be projected in a large format on an adjacent wall via an LCD projector, which accommodates larger groups. The installation is both a learning tool for users and a living catalogue of sites, structures and settlements for the region.

Keywords: Flash, GIS, museum installation, Open Source

Narrative and Content Combine in a Learning Game for Virtual Heritage

Jeffrey Jacobson[1], Kerry Handron[2], and Lynn Holden[1]

1. PublicVR, Boston, United States of America
2. Carnegie Museum of Natural History, Pittsburgh, United States of America

The nature and quality of a user's interaction with a virtual heritage application is the dominant factor in satisfaction, learning, and meaning-making. We find the "game" paradigm an efficient and familiar way for the user to interact with the virtual model and supporting information. For this to work, the goals of the game and the historical content must be very tightly coupled. Accordingly, we developed Gates of Horus, an educational game based on a notional Egyptian Temple and a virtual teacher-priest. The student prompts the priest to explain key features of the temple, while the priest tests the student's understanding by asking his own questions, and rewards accurate responses by allowing the student to go further into the temple. He or she "wins" by answering a final set of questions in the inner sanctuary, which elicits spoken praise from the divine image of the temple god (Horus). Gates of Horus' narrative structure is compatible with the Egyptians' emphasis on scholarship as the best way to engage with the world, which to them was a blend of physical, cultural, and mythic. More literally, scholarship was also the primary way to rise in the social order and to be allowed into the more important areas of most temples. Gates of Horus plays equally well on a desktop computer and in visually immersive (dome) displays, from one-person mini-domes to all-digital planetarium theaters. The software and source materials are all free to the public, and require only low-cost equipment to employ. See http://publicvr.org and look for the CaveUT and Egypt projects. Forty-Seven middle-school students (ages 11-13) played Gates of Horus at the Carnegie Museum of Natural History as part of a larger learning study. Overall, students learned well compared to a no-treatment control group ($P < 0.01$"). Importantly, all students played the game with rapt attention for 45 to 60 minutes, and most reported that they enjoyed the experience. The game offers no points, no prizes, and no competition, but rewards students' study with more materials to study. We believe a game-like narrative structure, properly used, is an effective way to motivate students to mentally and emotionally engage with the material.

Keywords: VR, education, experiment, game, Dome

Outbreak: Best Practices and Potential for the Development of Games for Archaeology and History

KEVIN KEE
Brock University, Canada

Archaeologists and historians need to take computer games seriously. A form of historical engagement with a reach measured each year in the billions of dollars, games have the potential to draw players into our disciplines, and turn gamers into students of archaeology and history. The "history" games that dominate the market, however, are only tangentially concerned with the content of archaeology and history, and the practice of studying these. The solution to the problem of "bad history" in games may be for archaeologists, historians and their colleagues to build these interactive environments. In this paper we reflect on one such experiment: the development of *Outbreak*, a strategy game that engages the 1885 smallpox epidemic in Montreal. Based on historian Michael Bliss's best-selling *Plague*, and developed in tandem with *The Year of the Plague / L'Année de la variole*, a documentary film to be aired on the Discovery Channel and Radio-Canada in the Fall of 2009, *Outbreak* challenges the player to stop the 1885 epidemic using the tools and information available in the late nineteenth century. In the paper we reflect on the opportunities and costs of (i) building games for learning that overturn the established conventions of typical online games, (ii) working with student development teams, and (iii) working with private-sector partners. Drawing on our experience with *Outbreak* we articulate both best practices, and best potential, for the development of archaeology and history games in the academy.

Wednesday

KEYWORDS: pedagogy, games

Learning History with the Interactive Mobile Game Mediacaching

THOMAS VAN REIMERSDAHL[1], LUCA VEZZADINI[2], GIUSEPPE DONVITO[2], and REINHARD FÖRTSCH[3]
1. Center for Applied Informatics, University of Cologne, Germany
2. Virtual Reality & Multi Media Park, Torino, Italy
3. Institute of Archaeology, University of Cologne, Germany

Today's mobile phones are evolving more and more towards powerful multimedia computers with integrated global positioning (GPS) systems. Mobile telecommunication service providers compete among themselves for faster internet connections at decreasing costs. The global market share of the new generation of mobile phones has resulted in a real need for appealing applications making use of the feature-rich functionalities in serious user scenarios. *Mediacaching* is a new modern day treasure hunting game tailored to Java-enabled mobile phones. Various creative possibilities enable users to set up multimedia gaming experiences in different contexts (for instance, eTourism, eLearning, and Archaeology). In contrast to the similar paper-based Geocaching game, Mediacaching includes multimedia content, 3D experiences and collaborative location-

aware services on the current generation of mobile phones. The basic idea of Mediacaching is to hide virtual multimedia treasures at geographic locations and to guide the gamer via one or several stations to the target location with appealing location-aware explanations and multimedia content. In this way, the gamer gets to know the surroundings, as well as the involved stations of the track, from a new point of view with multimedia explanations and textual information. In such a way, historical knowledge can be made visible at the real locations in a kind of mobile virtual museum on the user's mobile phone. Depending on the included textual information users can be attracted to go inside a real museum to see and to learn more about the real objects. One concrete example on how to learn history with Mediacaching in a Roman city could be the following historical game. After an introduction at the starting point about the historical background of the game, the mobile application guides the user (with a GPS system) to the next stations and the geographic coordinate of real relicts of a Roman water pipe. There the gamer is shown a video containing interesting information about the object's origin and its importance in antiquity. To illustrate the architectural concept and the course of the water pipe from the water sources in rural surroundings, the mobile application visualizes the 3D reconstruction of the water pipe on the mobile phone together with additional information about some statistics and pictures of other parts of the remains. After that 3D exploration, some questions will be asked to check the learning curve of the user and to activate the next station of the treasure hunt. After each station the user can log his personal experience with his mobile's camera to produce some feedback for the game producer and other potential players; this in turn will be presented on the Mediacaching web site. In the final paper we will explain the Mediacaching workflows in more detail and we will demonstrate how to make local history interactive with Mediacaching and how to apply it in other historical and archaeological scenarios. Mediacaching is available at http://www.mediacaching.org and can be freely used for attracting mobile phone users to learn history and archaeology.

Keywords: mobile multimedia application, mobile 3D visualization, serious gaming, location-aware gaming, virtual museum

Learning, Access, and Mobility (LAMB) for Cultural Heritage Education

Kari Uotila[1,2], Isto Huvila[3], Jari-Pekka Paalassalo[4], Ilkka Helenius[4], Jani Lindholm[4], Minna Lääperi[5], Laura Puolamäki[2], Sirpa Wahlqvist[5]

1. Muuritutkimus company, Finland
2. University of Turku, Finland
3. Åbo Akademi University, Finland
4. Turku University of Applied Sciences, Finland
5. Eura commun, Finland

Applications of mobile information technology has become more commonplace in cultural heritage sites. There has been, however, significantly little research on how these applications adapt to the activities and needs of their users. User contexts and needs are not known very well (Owen, 2005), nor are the applications typically, with some exceptions (e.g. Vlahakis 2004, Correia 2005), designed for user-created content and functionalities (Attewell & Savill-Smith, 2004; Attewell 2005). Further, a need for adapting a comprehensive framework for mobile pedagogics has been acknowledged as a priority (Trifonova 2003; Brasher 2005). The present paper discusses the results of an R&D project (fi PULU) in south western Finland to develop a general purpose mobile application framework for elementary and grammar schools with a special emphasis on distributed content creation and a usage model anchored in the convergence of pedagogics and location-based cultural heritage information. Since the beginning of 2001, the LAMB project and its predecessors have studied, developed and evaluated several different technological and content design approaches starting from stand-alone applications on palmtop computers, tablet PCs, and smart phones to modern small light-weight portable tablet computers. The technological focus of the effort has been to develop a simple and robust position-aware multiplatform software application based on a simple general purpose data model based on locations. According to the expectations of adaptability, the LAMB software is designed to be portable and adaptable from one context of use to another (Attewell 2005). The Java application designed for the LAMB project can be run on diverse portable computers and used by a group of pupils together. Interactions with the application are recorded on the device and the teacher can afterwards evaluate pupil input and device use data. The software is based on freely available and Open Source components. An important aspect of the system is that it can be updated and maintained on site by the local staff without extensive technical knowledge. A central issue of many mobile cultural heritage applications is that interaction and participation in content creation has been limited either by the lack of content creation functionality and documented workflows or by the complexity and cost of required tools (Economou *et al.* 2008). Besides the design of a technology platform, the special emphasis of the LAMB project has been on developing open content creation and delivery model suitable for schools and cultural heritage education. Sharing of content modules is built on an open web based platform. Openness is based on designing and identifying efficient workflows for multiple simultaneous content creators with simple approachable tools, and on educating teachers to produce and share content including interactive quizzes, videos, audio, photos, illustrations, hypertext and geographic information.

Keywords: mobile applications, education, schools, user participation

Developing a Next-Generation Virtual Museum of Traditional Japanese Arts Based on Multi-View Image Analysis

Xin Yin and Hiromi T. Tanaka
Ritsumeikan University, Japan

The last decade has seen some development of techniques related to the "Virtual Museum." The so-called next-generation virtual museum discussed here is capable of providing not only visual information but also other sensory information: hearing, touch, taste, and smell. We aim at showing some virtual objects related to Japanese traditional art, such as the six-hundred-year old theatrical art of *noh* play, *ukiyo-e* (Japanese woodblock prints) and *hangi* (woodblocks used for printing *ukiyo-e* and books); *noh* masks and costumes are considered precious cultural objects of Japan. The senses of taste and smell are not as important for this type of object, so the next-generation virtual museum we developed offers hearing and touch. To construct 3D shapes of objects, first, 3D point clouds are obtained with a 3D laser scanner. Then, the point clouds are aligned to create a 3D shape model, using pattern matching algorithms or commercial software. To render the appearance of these objects, multi-view images are measured by using a 4-axe machine that can put the camera and lighting on arbitrary positions of a half-sphere dome. The parameters for rendering anisotropy reflection are extracted from these multi-view images. Then, objects are rendered in real time using the proposed rendering algorithm. The key idea of this rendering algorithm is mixing two orthogonal directions to simulate anisotropy reflection. To synthesize touch sense, the surface micro-structure data whose resolution is 2.0 μm are measured by using a 3D digital microscope. The friction phenomenon between the finger and the object surface is simulated and the strain in a soft robot finger is also measured to evaluate the result. Then, the sense of touch signal is synthesized and shown by using vibration devices (Yin *et al.* 2008). Finally, a next-generation virtual museum prototype is constructed by the 3D visual display, speakers, the force feedback device called PHANTOM, and vibration-type touch feeling device. Some demo videos about this system can be found in http://www.cv.ci.ritsumei.ac.jp/haptic/eh2009/. As noted above, this next-generation virtual museum is expected to feature all five senses so that the user gets a more realistic sensation. Thus far, we have seen good progress in the study of visual information and now we can add the sense of touch to the virtual museum. More work still needs to be done, however, in order to make the sense of touch more realistic and to add the senses of taste and smell to the virtual museum.

Yin, Xin, Kazuyoshi Nomura, and Hiromi T. Tanaka, 2008. "Cutaneous Tactile Synthesis for Cultural Heritage Exhibition." In *Proceedings of the 9th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage, VAST 2008*, pp. 63-68, Porto, Portugal, Dec. 2008.

Keywords: virtual museum, Japanese art, modeling, rendering, haptic

Wednesday

Exploring Thule Culture—Constructing Virtual Worlds for 3D Theaters

Richard M. Levy and Peter Dawson
University of Calgary, Canada

Issues that emerged while developing a virtual world experience for a large-scale 3D projection will be presented. In 2008-2009, Dessault Systemes is sponsoring a competition for virtual 3D content that will be shown in Paris at La Geode, the world's largest virtual reality center. Located in the Parc de la Villette at the Cité des Sciences et de l'Industrie in Paris, La Geode houses a spherical theatre with a newly designed 3D projection system. Installed in 2007, the 180° screen that is over 25m wide provides attendees with a unique 3D immersive experience of past worlds and civilizations. As one of ten competitors selected to create a virtual world, I will showcase Thule culture to a large public audience and present the factors which constrained the development of the virtual world. Specifically, I will discuss how competition requirements (hardware and software, user interaction, and financial resources) confined the development of a virtual world created for a public audience. Critical factors which shaped the response to this competition included the demand by the competition guidelines for a storyline that would provide the armature for a shared ten-minute experience. Unlike a video game where the user is intimately involved in decisions on navigation and exploration, in a theatre experience, a narrator guides the experience for several hundred attendees in the audience. The possibility of unlimited input from the audience must be constrained to a very narrow range of choices. Ultimately, a virtual journey or mini-saga was used to limit the gameplay. From a virtual kayak, we experience the North, where we learn about the myths and lives of the Thule people. As a world that must both educate and entertain, a number of traditional myths are presented; each myth or story is linked to an object of historical and cultural significance. Creating these objects relies on both laser scanning and 3D computer modeling techniques. Because of the unique characteristics of the 1000 m2 hemispherical-screen, consideration must be given to the distinctive visual experiences of the audience. For maximum visual impact, projection of 3D stereoscopic images requires the simultaneous display of objects in both the foreground and background, restricting the strategy used to display content. In addition, distributing computing within a cluster that supports 6 banks of projectors must also be considered in creating a workable solution for the Geode theatre. For the Geode Theatre, frame rates of 120hz are required, given the specific programming demands of a PC cluster and the restrictions dictated by the passive video display system. Finally, strategies needed to support the project given limited financial support and time constraints will be discussed. Intellectual property, object creation, script writing, and production values are other factors that were weighed in creating a virtual world for la Geode in Paris.

KEYWORDS: virtual reality, high Arctic, virtual environments

Session Summary

Wednesday, 8:30am–11:45am, Constitution

Workshop: Practical Resources and Integrated Services for Preserving Cultural Heritage

Chair: Stephen Stead, Paveprime LTD, United Kingdom

Organizers: Michael Ashley, Cultural Heritage Imaging, United States of America

Mark Mudge, Cultural Heritage Imaging, United States of America

Cinzia Perlingieri, University "l'Orientale" of Naples, University of California, Berkeley, United States of America

Carla Schroer, Cultural Heritage Imaging, United States of America

Themes addressed:

- Data acquisition and recording techniques for Cultural Heritage
- Documentation and Spatial Information Management
- Standards and documentation for Cultural Heritage
- Internet-based Cultural Heritage applications
- e-Libraries and e-Learning in Cultural Heritage
- Reports, activities and Integration of related disciplines and techniques

Purpose and benefits of this workshop: This workshop will take a holistic approach to comprehensive workflows that integrate best practices in the creation, management and preservation of digital resources for CH. We will explore the diverse standards for documenting cultural heritage sites, which can ensure 1) reliability of the resources; 2) open access to high quality resources; 3) long-term preservation; and 4) sharing and interoperability. Our aims for this workshop are three-fold, as is its structure.

Hour One: Discuss and debate decision-making principles for digital informatics in cultural heritage documentation and preservation. What standards of practice mind both sides of the cultural/digital gap? Where are the decision-points in preservation workflows, and what are the alternatives? What technological solutions are of lowest risk and highest impact for heritage documentation? We will point to real-world standards in practice that are effective and will seek from the workshop participants other examples and resources in this critical domain.

Hour Two: Defining the digital universe of technological tools and practices already in use in cultural heritage. While best practices and standards are useful when followed, the majority of legacy information for cultural heritage is squirreled away in hard drives, outdated software applications and outmoded methodologies. We raise this issue for discussion and offer an action plan for collecting a comprehensive list of risk areas and solutions for the digital deluge that is already upon us. We will outline mitigation, migration, archiving and repository strategies, and push for contributions from all participants.

Hour Three: Empirical provenance and process history. Documenting the decision-steps in archaeological fieldwork and digital informatics - from photography, lab work, scanning, modeling, etc - are essential to building context, evaluating reliability and accuracy, as well as providing transparency and scientific replicability. Documenting documentation is rarely done to a sufficient level, for it is time consuming and the perceived, present value is minimal. The CIDOC-CRM, an ISO standard, now includes options for "empirical provenance,'" where the entire process history of any event can be recorded and evaluated. We will demonstrate the phenomenal value of this approach to field and lab recording, and offer up solutions that make this documentation painless and immediately valuable.

Outcomes: Participants will come away with strategies for coping with their own digital deluges, as well as key opportunities to contribute to a growing network of digital heritage informatics professionals who are dedicated to the long term sustainability of our cultural past and digital future. We will work to integrate the outcomes from this workshop into existing working groups as well as form a new working community to carry on these particular subject areas.

Who should attend: Anyone interested in digital documentation and preservation strategies for cultural heritage are encouraged to attend.

Topics: CIDOC and other digital standards, databases, data management systems and other field applications, other

Keywords: cooperation, integration, standards, requirements, digital

Session Summary

Wednesday, 8:30am-10:00am, Liberty

ECAI: Technology for Recreating the Past

Chair: Jiang Wu, University of Arizona, United States of America

A special panel with three international leaders in the fields of humanities, linguistics and robotics bring examples of recent research and findings. Timothy Tangherlini shows how GIS can be used for folklore with unexpected results. Ruzena Bajcsy gives a demonstration of her current research on immersive photography while Fan I-chun shows how the large National Digital Archive of Academia Sinica can be exploited.

Schedule

8:30-8:50	"Folklore Excavations: Machine Learning and Historical GIS in a Folklore Corpus," Timothy Tangherlini
8:50-9:10	"Taiwan and Mainland China's Folklore Religion in Terms of GIS and GPS," I-Chun Fan
9:10-9:30	"Tele-Immersive Environments: Meeting History in the Present," Ruzena Bajcsy
9:30-10:00	Discussion

Abstracts

Folklore Excavations: Machine Learning and Historical GIS in a Folklore Corpus

Timothy Tangherlini
University of California, Los Angeles, United States of America

We present preliminary findings from the application of statistical analysis of folklore data in GIS and from the application of unsupervised machine learning on this large corpus. For GIS analysis of the data, stories are linked to geographic places in two ways—through internal mention of places, and through the places of story collection. The study corpus, collected in Denmark by Evald Tang Kristensen, spans forty years from 1870-1910, and comprises 6,500 storytellers and 250,000 stories. This study is based on a much smaller subset of 340 storytellers and 1,000 stories. Several examples are given of both the application of standard GIS tools to folklore "event" data, as well as from machine learning. Unlike many applications of machine learning to the "clustering" of Humanities data, the geographic referents related to each story allows us to project the data clusters onto historic maps in the GIS. Fortunately, the Danish cadastral survey has georeferenced a series of high-resolution maps from 1880-1890. Subsequent statistical analysis of the characteristics of the story clusters projected onto these historical maps (e.g. Standard Deviational Ellipse) reveals interesting patterns in the relationship between stories and the environment, be it natural or man-made.

Keywords: georeferencing, folklore, GIS

Taiwan and Mainland China's Folklore Religion in Terms of GIS and GPS

I-Chun Fan
Academia Sinica, People's Republic of China

Abstract text not available as of press time.

Tele-Immersive Environments: Meeting History in the Present

Ruzena Bajcsy
CITRIS, University of California, Berkeley, United States of America

In this presentation we shall describe the technical challenges of the creation of tele-immersive environments. In particular we shall describe real-time data acquisition; real-time reconstruction of three dimensional environments, and people in it; real-time dynamically changing display depending on the user's needs; dynamical resource allocation and tradeoffs between the data transmission, bandwidth and data display; and the need for context dependent data compression. We shall document some of our applications in arts (dance) and in scientific collaboration. Finally we shall show the outstanding research agenda that comes about from this type of infrastructure.

Keywords: immersive environments

Session Summary

Wednesday, 10:15am-11:45am, Liberty

ECAI: Text, Artifact, and Narrative

Chair: Ruth Mostern, University of California, Merced, United States of America

The final panel of the ECAI series deals with how narrative can be traced along the mercantile routes. The textual tradition of Sanskrit moving from India into Central Asia is being digitized as a means of dealing with cultural heritage. Vietnam gives an example of how inscriptions become essential to a study of history.

Schedule

10:15-10:35 "Silk Road—Path of Transmission of Avalokitesvara," Dorothy Wong
10:35-10:55 "A Sanskrit Buddhist Canon for the Twenty-First Century," Miroj Shakya
10:55-11:15 "Mapping Buddhism in Vietnam," Hau Le Choung
11:15-11:45 Discussion

Wednesday

Abstracts

Silk Road—Path of Transmission of Avalokiteśvara

Dorothy Wong
University of Virginia, United States of America

This is a pilot project to explore the path of transmission of Avalokiteśvara (the Bodhisattva of Compassion) on the Silk Road. By focusing on one class of data to populate the GIS, this project aims to (1) create a database with a new, interactive presentation, and (2) produce some key resources for a long-term project on the Silk Road. The Silk Road as a spatial template offers extraordinarily rich opportunities for exploring how digital technologies can enhance the understanding and interpretations of the history, art, culture, and religion of a large geographical area that crosses many political boundaries in the pre-modern era.

Keywords: Silk Road, GIS

A Sanskrit Buddhist Canon for the Twenty-First Century

Miroj Shakya
University of the West, United States of America

This paper focuses on the DSBC project, on the formation of the Sanskrit Buddhist Canon by exploring extant Sanskrit Buddhist printed texts in the twentieth century. Professor Lewis R. Lancaster, former President of

the University of the West and coordinator of the project, initiated the cooperation with Nagarjuna Institute in Nepal in digitizing the Sanskrit Buddhist Canon since 2003. The Sanskrit Canon can be easily made accessible to all. We are accelerating our work by broadening our support and applying the latest computer technologies. Currently we have placed 77 Sutras (Buddha vacana, the Word of the Buddha), 108 Stotras (Hymns), 6 Tantras (Vajrayana texts), and 107 Shastras (commentaries) texts online. Now, for the first time in history, the basic texts of Indian Buddhism are freely accessible and downloadable via the internet: http://www.uwest.edu/sanskritcanon/. The availability of all the Sanskrit Buddhist texts online will be an important milestone in Buddhist scholarship, and will be useful to educators and non-specialists. However, much effort and support will be needed to meet this distant goal. Future goals of DSBC Project are as follows:

- The categorization of a Digital Sanskrit Canon
- Creation of a comprehensive bibliography of Sanskrit Buddhist texts
- Creation of acomprehensive catalog of Sanskrit Buddhist texts
- Publication of the Digital Sanskrit Buddhist Canon-DSBC in DVDs
- Publication of a Diplomatic edition of unpublished Sanskrit texts from manuscripts
- Publication of the Sanskrit Buddhist Tripitaka Series (SBTS) in the near future

Keywords: Sanskrit Buddhist canon, online texts

Mapping Buddhism in Vietnam

Hau Le Choung
Vietnam Buddhist University, Vietnam

Abstract text not available as of press time.

Session Summary

Wednesday, 1:30pm-5:30pm, Liberty

Workshop: Web-Based GIS for Data Management and Dissemination

Chair: Elizabeth A. Lee, CyArk, United States of America

This workshop will be an introduction to using CyArk's web-based GIS system, SiteManager. CyArk Site Manager is an integrated suite of software that organizes, manages, and provides access to High Definition Documentation (HDD) and other cultural heritage data for heritage site managers, researchers and the public. CyArk Site Manager integrates seamlessly with the CyArk 3D Heritage Archive website, providing a global outlet for dissemination of data. All data are georeferenced to and accessible from appropriate maps and plans as well as from media pages. CyArk SiteManager allows site managers and researchers organized access to their own HDD data and the opportunity to further develop and annotate that data as ongoing needs require. Moreover, site managers and researchers may add other record data, such as scanned copies of old record site surveys, historical photographs, etc., to keep all such record data of their site in one organized digital archive.

The workshop will provide sufficient training such that participants will understand the functionality of SiteManager and will be able to utilize the software following the workshop. Participants wishing to experience the hands-on portion of the workshop should bring their own wireless enabled computer. Workshop participants are not required to have any background in GIS. Minimal computer skills are encouraged.

Session Summary

Wednesday, 1:30pm-3:15pm, Colony

Poster Session 3

Abstracts

Architectural Analysis and 3D Reconstruction: A Case Study of Leopoli-Cencelle in Italy

Giovanna Liberotti, Corrado Alvaro, Daniele Nepi
University of Rome "La Sapienza," Italy

Wednesday

This poster focuses on the integration of data from laser scanning, GPS, and orthophotography, collected during the investigation of the medieval church of Leopoli-Cencelle. Cencelle is located within the territory of Tarquinia in the province of Viterbo, seventy kilometers north of Rome. As reported in the *Liber Pontificalis* of the Holy Ecumenical Roman Catholic Church, Leopoli-Cencelle was directly founded by Pope Leo IV (847 - 855) in the eighth year of his pontificate, on August 15, 854. The remains of a 740m long wall with three gates and seven towers are still evident on the top of the hill at 160m ASL. Following this evidence, archaeological excavations have been carried out since 1994 under the direction of Professors Letizia Ermini Pani and Francesca Romana Stasolla (Medieval Archaeology and Topography, University of Rome, "La Sapienza"). Various relevant findings, such as housing structures, fortified residential areas, and workshops, have also been unearthed. Together with this evidence the road network of the town has been also partially discovered. One of the most interesting monuments of Leopoli-Cencelle is the three naves church, built in the twelfth century, with the remains of the bell tower and of an underground crypt. This complex has been surveyed both with laser scanning LEICA HDS 3000 and with orthophotography. Laser scanning data have been collected in several scans with a resolution of about 5mm; orthophotos have been performed with a commercial software and digitalized using CAD software; all data have been positioned on UTM world-standard coordinate system using LEICA GPS, and a DEM has been produced. According to this documentation and to the new data coming from the excavations, a 3D reconstruction of the building will be presented together with a discussion on the importance of these methodological approaches and on the archaeological implications arising from their adoption.

Keywords: laser scanning, GPS, orthophotography

Costanziaco Project: An Integrated Archaeological Approach to the Study of Settlements in the Northern Venetian Lagoon

Daniela Cottica[1], Arianna Traviglia[2], and Luigi Fozzati[2]

1. Università Ca'Foscari Venezia, Italy
2. Soprintendenza per i Beni Archeologici del Friuli Venezia Giulia, Italy

The Costanziaco Project is a new interdisciplinary, multi-period archaeological project focused on the study of an ancient settlement in the Northern Lagoon of Venice, known in medieval and later documentary sources as Costancianus. At present the site is partly submerged: of the ancient group of islands that formed Costancianus only two strips of land still survive. These are the abandoned islands of Sant'Ariano and La Cura, located towards the mainland fringe of the Lagoon of Venice. Past unsystematic investigations revealed the area's historical potential, supported by the amount of archaeological finds brought to light, ranging from the Roman period to the seventeenth century C.E. The environment of the area is overwhelming and dictates research strategies: the natural landscape is characterized by the presence of shallows that emerge from the water during low tides, covered by vegetation of brackish water ("barene"). The whole area is a natural reserve, which implies that extensive archaeological excavation is not possible. Therefore an integrated research agenda has been set up: this combines the study of archive data with aerial photos, satellite images, surface and underwater survey, stratigraphic excavation, and artifact analysis. All stages of research are supported by the use of remote sensing and GIS technologies for the analysis of the cultural and natural landscapes of the Lagoon. The GIS components of the project in particular are fundamental for storage, retrieval, integration and analysis of the vast range of information derived from the last decades of ground-based archaeological research in the area as well as the forthcoming results of the ongoing project. The GIS aspect incorporates an already wide range of distinct data types (e.g., modern topographic maps, historic cartography, RS imagery) and it will be further developed with the acquisition of other data sets (excavation records, environmental data etc.). A multi-sensor, multi-scalar, and multi-temporal RS data collection including airborne and space-based imagery, ranging from the earliest aerial photography (1954) to the most recent high-resolution satellite imagery (2004), plays a decisive role in the investigation of the original extension of the lost islands and supports the detection of traces both in the still-exposed land and in the submerged areas of barene, which can be related to the remains of the infrastructures and buildings of the ancient settlements. RS data (especially HR satellite images) are treated to improve the visibility of the traces: different processes are adopted according to the types of environment, identifying from time to time the ones which best fit the goal of emphasizing features that can be related to the archaeological past of the islands. Identified traces are mapped, as well as information coming from ancient cartography. Ground truthing activities, including ground validation of processing and verification of ancient sites identified in the imagery, are in progress and their results currently under evaluation. The contribution will illustrate preliminary results of research

in progress and discuss how the GIS platform allows integrating, comparing and complementing different methodologies, data-sets and analytical approaches.

KEYWORDS: Costanziaco, Venetian lagoon (Italy), Roman to post-medieval Venice, GIS, HR satellite images

Large Complex Archaeological Sites Exploration: Representation and Interface Perspectives

CAMILLO TREVISAN[1] and FAUSTO BREVI[2]

1. University IUAV of Venezia, Italy
2. Politecnico di Milano, Italy

The poster results from recent Italian research, in which five researchers groups were involved, aimed to build a virtual model of the "Templum Claudianum" in Rome. The research, named "New integrated methods and technologies for documentation and restoration of Mediterranean archaeological and monumental complexes," was focused mainly on the virtual model of an archaeological hypothesis, because at present there are no remains of the temple (although some ashlars travertine blocks on which rests are nowadays still visible). Indeed from that work a new research project should act as a case study useful to verify the goal to set up a 3D digital model as the unique reference interface in a virtual reality environment to get information organized in several different ways. This is because an archaeological site typically has geometrical data from the remains, geometrical data for a reconstructive speculation (or even more than one), pictures, texts, etc. These data could also be fitted in a GIS database. We will be focused on the integration of data from the ruins collected with an integrated photos and 3D data survey with data built interactively as a theoretical model. The use of some different hw and sw configurations with analysis on weakness and strength of Open Source and commercial tools has been explored. That means the needs to explore either the user interface effectiveness (immersivity and semi-immersivity representation, natural and transparent interface, users collaboration), either the way to represent intrinsically heterogeneous data, evaluating some different end-user cultural backgrounds.

KEYWORDS: virtual reality, 3D model visualization, 2D and 3D representation from real data

Wednesday

Modeling Lithic Distribution through GIS: A Case Study from Thessaly, Greece

LIA KARIMALI[1], DIMITRIS ALEXAKIS[2], and MARILENA KOKKINAKI[1]

1. Institute for Mediterranean Studies (I.M.S.) / Foundation of Research & Technology (F.O.R.T.H.), Greece
2. Aristotle University of Thessaloniki, Greece

Until recently, distribution modeling of lithic material in the Aegean was based on theoretical grounds and single-site data. In our view, a more comprehensive picture of how exchange systems operated in the past can be obtained if a comparative, interregional approach is used. In our study we attempted to create an inter-site comparative module for examining lithic procurement strategies at Neolithic sites of Thessaly, Greece. Our

study showed the existence of a double system of lithic distribution in Thessaly, running in direct relation to the topography, the obsidian network falls off as one moves towards the west. The chocolate flint network falls off as one moves towards the coast. Such results stress the need to consider differences or similarities in the management of lithic materials as relevant to the management of the natural landscape (water, soil, stone resources) and site distribution patterns of the human landscape (site clustering, site neighbor distance, etc.). For this reason, a relational, three-layered database was designed for facilitating the management of a potentially expanded regional corpus of lithic data. By combining site-contextual and object-contextual information, as well as technologically-oriented object description (based on the principles of the *chaine operatoire* approach), the database aims to provide a dynamic interface for testing future models of lithic distribution. The database, along with GPS measurements and a number of digitized topographical and geological maps, constituted GIS input used as an information management tool to compile information with regard to the geo-morphological characteristics of the region through landscape analysis, while also taking into account the settlement patterns in the area. As a result, a new model of lithic distribution is proposed based on the results of this analysis.

Keywords: GIS, lithic distribution, Thessaly, landscape analysis

NetConnect—Integrated System in Visualizing Archaeological Spaces

Ruth Beusing and Axel G. Posluschny
Roman-Germanic Commission of the German Archaeological Institute, Germany

The EU-funded NetConnect project develops an integrated GIS-based application for managing and visualizing archaeological data in virtual and mobile visitor-site guides. Three early Iron Age Sites have been chosen as prototypes: the early Greek Colony Lokroi in Italy; the lake dwelling Biskupin in Poland; and the early Celtic Princely Site Glauberg in Germany. These three sites comparably show the development of proto-urban central places in different parts of Europe in an exemplary manner. All presentations—mobile and VR—are basically connected with and fed by an authoring and administration tool, a GIS-based PoI-Server. This allows installing and changing texts, images and 3D objects. Thus the progresses and developments in archaeological research can be attached to the information system immediately. The 3D reconstructions of the three archaeological sites will be presented in an interactive web-based game engine. A desktop derivative of an internet version is operable via Wii game controller. The GIS-based mobile guide is downloadable to most common mobiles and provides detailed information while moving on site. Audio information, images, and movies will be available and can be either downloaded to the mobile (version for old mobiles) or received directly from the PoI-Server via UMTS. The whole system is easily operable by content providers as well as end users and can be employed as integrated software for managing digital cultural heritage data as well as providing it to a general public. Partners are University of Calabria, Cosenza, Italy; Archaeological Institute, University of Warsaw, Poland; Roman-Germanic-Commission of the German Archaeological Institute,

Frankfurt, Germany; GraphiTech Foundation, Trento, Italy; VicomTech, San Sebastian, Spain; Glasgow School of Arts, Great Britain; and the Fraunhofer Institute for Digital Graphics, Darmstadt, Germany

KEYWORDS: VR, mobile guide, 3D reconstruction

An Open Source Approach for the Syrian Landscape Archaeology

SIMONE BONZANO

Freie Universität Berlin, Germany

Wednesday

A research project investigating the archaeological landscape assessment of the Northern Syria/South-eastern Anatolia for the middle and late Bronze Age is currently at the Vorderasiatische Institut of the Freie Universitaet Berlin. A part of the whole research project, supervised by Prof. Dr. Dominik Bonatz, aims to collect the settlements and findings place of the whole region focusing on the between Euphrates and Khabur in a GIS database. Our ultimate purpose is to show the landscape assessment in GIS and with 3D support, as well as to interrogate it through database query and perform environmental analyses of the landscape to enhance the comprehension of the settlements' asset and support planned archaeological surveys. Starting from these aims, with an Open Source GIS suite made of GRASS GIS, QGIS, LandSerf running on a Canonical® UBUNTU Linux Workstation, a specific research project was written using the analytical peculiarities of the selected GIS in the research processes, giving the GIS a role in the research also during the theoretical phase. GRASS offers a more than sixty different raster and forty vector analytical modules and different plug ins to be used in relation with external databases. The project uses the modules r.mapcalc (raster calculation), v.digit (topological vector editor), the wide range of Image Processing tools, and direct manipulation of the data on an external server. Those packages of functions allow GRASS to be one of the most powerful environmental assessment analytical tools for environmental assessment and relating it to the archaeological palimpsest and settlement networks. Besides the 3D analysis, users can choose embedded NVIZ or export data to PovRay or Virtual Terrain Project (this solution was chosen).

Specific attention was given to portability and the connectivity of it. The whole project was saved on an external drive, and geographical data in a SQLite file was saved to a local drive. This allowed the database to be used in the lab and in the field. SQLite's connectivity to MySQL was used to draw from a related database, by Dr. Daniela Crasso of the TOPOI project, concerned with excavations, inscriptions, and findings in the region. Thanks to GRASS's QGIS plug-in, the database can be ported to Mac OS and Windows platforms, allowing different users access to the data and field use through laptops or netbooks.

KEYWORDS: Syria, GIS, GRASS, Open Source, landscape archaeology

Potential of an Intra-site GIS in the Excavation of a Submerged Wreck: the Napoleonic Brigantine Mercure Case Study

Mariangela Nicolardi, Arianna Traviglia, and Carlo Beltrame
Università Ca'Foscari Venezia, Italy

The reconstruction of the layout of a shipwreck, starting from a correct spatial interpretation of its structural remains and of its content that are lying on the floor of the sea, is one of the more interesting research topics dealt with in the discipline of marine archaeology. A shipwreck changes a ship from a highly structured and architecturally organized logic system to an apparently chaotic distribution of artifacts. This is the result of the action of pre-depositional (cultural), depositional (causes of the shipwreck) and post-depositional (natural factors, that is chemical, physical and biological, as well as cultural factors) processes, which are typical in underwater deposits. Identifying the grouping characteristics of archaeological patterns (clusters), related to certain types of finds, in some cases can reflect the same spatial associations that the objects themselves had on board the ship before the wreck. In the same way, they can also bring light to the dynamics of the shipwreck and those concerning the destruction of the hull and agents that "disturbed" (scrambling devices) or "removed" (extracting filters) during the post-depositional phase. The latter are among the most important factors responsible for the alteration of the original and spatial structure of the ship and the formation of wreckage evidence that archaeology faces at the moment of discovery. Focusing attention on the importance given to the position of the finds inside a wreck, the creation of a GIS is proposed here for managing excavation data coming from a modern-age context. The case study is the *Mercurio*, a brick belonging to the Italic Kingdom. It exploded due to unknown causes during the battle at Grado in 1812, about seven miles from Punta Tagliamento (north of the Veneto Region, Italy), between two small fleets, one Italo-French and the other English. The wreck, since 2001, has been the object of excavations supervised by Carlo Beltrame of the Università Ca'Foscari Venezia. GIS enables a method of recording that is particularly suitable for the management of the vast amount of data produced during the excavation. In fact, this wreck stands out not only for a much wider range of typologies and materials compared to that of a classical-age wreck, but also for a considerable complexity in the recomposition of the internal compartments of the hull. What makes this work original is the proposal to experiment with an innovative archaeological investigative approach, through the use of selection queries, topological overlays, and 3D visualizations, aimed at producing new interpretative contexts related to understanding depositional and post-depositional processes that concern the formation of the *Mercurio* wreck. The results of queries into the spatial database have produced particular archaeological patterns represented in synoptic maps created on demand and characterized by a strong cognitive component, which is useful in the understanding and decoding of the distributions of mobile finds on the bottom of the sea and therefore within the archaeological deposit.

Keywords: maritime archaeology, GIS, database, shipwreck, Grado (Italy)

Strategic Use of Remote Sensing and GIS in AIA for Preservation of Cultural Heritage and Archaeological Landscapes

Arianna Traviglia
University of Sydney, Australia

In recent years Archaeological Impact Assessments (AIA), assessment studies initiated in response to development proposals that will potentially disturb or alter archaeological sites, are gradually becoming common, even compulsory, all over the world as the first stage of larger settlement expansion. The main rationale for conducting an AIA is to identify, using various sources ranging from archive data and publications to direct field work, possible archaeological resources that may be affected or disturbed during the project development and implementation. As part of standard procedures, remote sensing is increasingly adopted, and often required, as a tool of evaluation of the archaeological potential of a territory. Therefore remote sensing has developed from a supplementary source of information in the strict ambit of academic archaeological research to a key source of information used by professionals in support of development planning, infrastructure construction, etc. The role of the AIA in fact is not to prohibit or impede land use and development, but rather to assist the local authorities and private sector in making decisions that will ensure effective management of archaeological resources as well as optimal land use. Being just one of the multiple sources of information for Impact Assessment, remote sensing often requires the parallel creation of a GIS tool able to retrieve, analyze, and manage all of the other data for the production of inventories of the archaeological heritage. In this way GIS becomes a powerful risk prediction tool by ensuring each potential archaeological site is examined in a consistent manner, compatibility with other specialist assessments and ease of reference. In this poster, through several examples of application in different environments of Italy, general outlines of effective practices will be illustrated and critically discussed focusing on the use of satellite remote sensing. Spectral analysis can in fact increase the opportunity to detect information that otherwise would remain undetected. The adoption of Ikonos and QuickBird data in standard procedures have shown an augment of the detectable features with particular regards to certain specific types of environments, such as the Lagoons.

Keywords: archaeological impact assessments, GIS, remote sensing

Wednesday

Toward an Anthropology of Death: Reconstruction of Social Dynamics in Roman Necropoleis Using GIS and Epigraphy

Angela Paveggio, Arianna Traviglia, Giovannella Cresci Marrone, and Margherita Tirelli
Università Ca'Foscari Venezia, Italy

This poster will focus on the current state of a project of the University of Venice Ca' Foscari (Department of Antiquity and Near East Sciences) started in 2006, with the goal of analyzing the distribution patterns inside the necropoleis of the Roman town of Altinum (NE Italy) combining epigraphical research's methods and computer science. The research seeks to develop a complete and exhaustive study of the necropolis placed just out of the town, in the North side of the via Annia, and of the dynamics of its exploitation as a funeral area between the first century C.E. and the beginning of the second century B.C.E. Aspects such as the social class of the gravestone owners, their gender, economic condition, job, and the importance of the role that they played in the society were all fundamental elements which conditioned how space was used and a monument, erected aiming at perpetuating their memory. Therefore, it is also by studying the "society of the necropoleis" that an understanding of the ancient population of Altinum can be obtained. It is fundamental in this sense to combine the study of funerary inscriptions—from a textual, monumental and typological point of view— with the analysis of their spatial location. The location of a gravestone can provide supplementary information about the so-called "anthropology of death" and displays the strategies of self-representation of the social classes, the routines of the ritual and the modality of the funeral apportionment. The interpolation of topographical and epigraphic data in this way supports the reconstruction of the social dynamics which characterized the necropoleis. In the last year of the project, the number of examined finds has increased considerably (102 inscribed finds) and we have acquired new data sets for more in-depth analysis. The combined use of GIS and a database that has already been proved to be effective in previous research is further exploited for spatial and visibility analysis. By conjugating parameters such as location, extension of the enclosures, height of the monuments, social status of the owner, and family relationships we are defining the relationships among the different funerary areas in terms of visibility, hence achieving original information related to the economic conditions of the individuals. These significant new social-economic elements extrapolated by spatial queries are fostering new theories on the organization and development of the ancient necropolis, which can be considered a mirror of the society of the "living ones."

Wednesday

Keywords: GIS, database, Altino (Italy), epigraphy, Latin inscriptions

Virtual Rome

Valentina Vassallo[1], Sofia Pescarin[1], Luigi Calori[2], Carlo Camporesi[1], Marco Di Ioia[1], Maurizio Forte[3], Fabrizio Galeazzi[1], Silvano Imboden[2], Alessia Moro[1], Augusto Palombini[1], and Lola Vico[1]

1. CNR Instituto per le Tecnologie Applicate al Beni Culturall, Italy
2. CINECA, Italy
3. University of California, Merced, United States of America

The Virtual Rome Project is run by the Virtual Heritage Lab of the ITABC/CNR, in collaboration with CINECA, Seat Yellow Pages, Chamber of Commerce, and the Superintendence of Rome. The core of the work is the development of a VR Web GIS application with two online solutions: a front-end (VR webGIS) and a back-end (VR webLAB). The aim of the project is the interpretation, reconstruction, and 3D exploration of archaeological and potential past landscapes of Rome, all in a three-dimensional Open

Source environment, embedded in a web browser (Internet Explorer and Mozilla Firefox). The front-end lets the final user interactively explore the reconstructed space, linking the GIS functions to the VR features. The back-end tool was developed to construct a collaborative system for the integration of the reconstructed landscape: vegetation, 3D models, vectors, 3D terrain, and so on. Through its interface it is possible to manage all information that constitutes the 3D environment, which allows researchers, different professionals, and scholars to build up the virtual set (in relation to the historical landscape that you need). The Virtual Rome application allows to navigate and interact switching two different terrain models: the actual archaeological landscape and the second-century version. A realistic navigator lets the user fly and/or walk in the modern and Roman landscape and within the reconstructed monuments and buildings. The sites, monuments, and archaeological areas are connected with their context and are reconstructed in accordance with real and hypothetical topographies both for the present day and the past. At present the Rome landscape has been reconstructed with variable resolution and accuracy (generally 10-100 Mt, selected areas near via Flaminia, via Appia and Imperial Fora, with a resolution of 20cm). In order to build Open Source software based on the OpenSceneGraph library, a specific plug-in for web browsers was developed. The result is an impressive tool for visualizing the information relative to the archaeological and potential ancient landscape, as well as an interesting instrument that can share contents and realize a 3D cooperative environment for specialized virtual communities.

KEYWORDS: virtual reality, Open Source, OSG, OpenSceneGraph

Visualization of Culture Heritage Buildings and Monuments Using JAVA 3D

CARLOS ACEVEDO PARDO and ROLF GABLER-MIECK

HafenCity University Hamburg, Germany
Landesbetrieb Geoinformation und Vermessung Hamburg, Germany

The visualization of culture heritage buildings or monuments can be realized in different ways. Software such as 3D Studio Max or Maya (Autodesk) make it possible to visualize monuments as a combination of digital terrain models and topographical and geometrical data. With a material editor, light-systems and effects, each surface is assigned a texture map. A camera path can then be defined and a movie generated. An AVI-file can be shown on any computer with Windows Media Player or similar software. The result is a highly detailed model with a photo realistic effect which can be shown at any time. Using data from the textured model and exporting from 3D Studio Max to a VRML or 3DS file and using JAVA 3D, we can create a 3D real-time interactive visualization in three or four dimensions of a culture heritage building. The user can view and survey the building or monument at any possible angle. The software can be use at schools for a better understanding of history, at museums to visualize additional features, for tourism purpose, research, virtual world and internet.

- Displayed objects are arranged in separate content layers and managed by an embedded layer management
- Defined data records can be extracted from a table and shown in text fields
- HTML will be displayed on a standard browser, for better analysis and viewing of complex data and pictures
- Empirical data can be visualized as 3D diagrams in several ways
- Objects can be enlarged, translated, and rotated through a defined 3D-affine transformation, so that small objects in the model can be seen more clearly
- Individual complex geometries such as trees can be integrated as billboards
- Objects can be assigned to a path for animation inside the scene in a defined period of time (i.e. water rising, driving cars)
- JAVA/JAVA 3D is platform-independent and runs on Windows, Linux, and Mac
- 3D formats normally used, i.e., VRML97, OBJ and 3DS can be read and displayed
- 2D formats normally used, i.e., JPG, GIF, PNG for textures, billboards, etc., can be integrated
- JAVA 3D is easy to adapt and change according to different applications

Keywords: visualization, culture heritage, 3D modeling

Session Summary

Wednesday, 3:15pm-5:30pm, Tidewater B

Workshop: High-Definition 3D-Surface Scanning in Arts and Cultural Heritage

Chair: Bernd Breuckmann, Breuckmann GmbH, Germany
William Mongon, Accurex Measurement Inc., United States of America

Prior to the invention of photography, there was only limited possibility to capture the real world in an objective way, the main reason being that all kinds of literature and arts, especially paintings and sculptures, contain an intrinsic subjective component. Although photography, and later on digital image processing, have provided complete new possibilities for archiving and documentation tasks, any 2D-technique is inherently characterized by strong limitations to reproduce the three-dimensional world. However, within the last five years, advanced three-dimensional surface scanners have been developed, now opening the third dimension to digital image processing techniques.

The workshop will concentrate on topometrical high definition 3D-surface scanners, optimized for the requirements of arts and cultural heritage, allowing the three-dimensional digitization of art objects and paintings at the highest level of resolution and accuracy. Focus of attention will be given on the following applications:

- Digitization of archaeological finds with highest definition
- Documentation and archiving of archaeological treasures
- Generating a digital fingerprint of paintings, including texture and 3D-information
- 3D-data capture for the manufacturing of certified highly accurate copies

Covering these subjects, the workshop is equally addressed to archaeologists, anthropologists, paleontologists as well as photographers, computer scientists, restaurateurs, conservators. The workshop will consist of three parts:

- Part One will give an overview about the state of the art of high definition 3D-surface scanners
- In Part Two, two typical system configurations of high definition 3D-scanners are demonstrated.
- In Part Three, the audience can actively participate in the workshop

Participants without previous knowledge in the field of 3D-scanning will be given the opportunity to gain their first experience in scanning archaeological objects. Attendees already familiar or experienced with 3D-scanning can broaden their knowledge in this field by getting in touch with the latest developments.

Participants for Part Three should at least have some basic experience using a PC with the Windows operating system.

For the presentation in Part One of the workshop, there is no limit on the number of participants. The number of participants for Part Two should not exceed forty, and for Part Three it should be limited to twenty.

The first two parts of the workshop will take thirty minutes each, followed by a break of fifteen minutes. For the third interactive part, we suggest a length of sixty minutes. In total, the workshop will thus cover 135 minutes, including the break.

Topics: 3D data capture and modeling

Keywords: 3D data capturing, white light scanning, digital fingerprint of paintings, certified copies of archaeological treasures

Session Summary

Wednesday, 3:15pm-5:30pm, Tidewater C

Round Table. From Access to Collaboration and Synthesis: How Do We Get There?

Chair: Fraser D. Neiman, Thomas Jefferson Foundation, Monticello, United States of America

Participants: Worthy Martin, University of Virginia, United States of America
Steven Plog, University of Virginia, United States of America
Jillian Galle, Thomas Jefferson Foundation, Monticello, United States of America
Julian Richards, Archaeological Data Service, United Kingdom
Willeke Wendrich, University of California at Los Angeles, United States of America
Watkinson Charles, The American School of Classical Studies at Athens, Greece

Wednesday

Increasingly, archaeologists have found that their quests to understand the past and to evaluate that understanding objectively require comparative analysis of multiple sites and assemblages, scattered across temporal scales ranging from decades to millennia and at spatial scales ranging from single sites to entire continents. The emergence of web-enabled database technologies has solved the base-level problem of access to data. However, the simple feasibility of web access is not enough to advance historical understanding.

This roundtable session is devoted to a wide-ranging consideration of the serious additional obstacles that remain, the assessment of recent strategies designed to overcome some of them, and a consideration of novel strategies that might successfully address others. Among the outstanding issues we consider are the difficult problems of coalescing existing datasets into large-scale databases to facilitate comparative and synthetic analysis.

Although some commonalities exist in the intellectual organization of the content of digital resources, the categories, allowable value ranges and modes of expression of that content vary widely: some incidentally, many substantially. These varieties occur across the full range of conceptualization: data storage forms, indexing mechanisms, collection management techniques, finding-aid forms, base archaeological classification measurement protocols, and levels of data aggregation. To what extent might these problems be solved by the post-hoc use of ontologies in integrating existing datasets? Can large-scale collaborative projects that seek to collect and integrate data related to a particular region or problem, on scales that have been previously unimaginable in the discipline, encourage sharing of measurement protocols and the data that result from their application, along with comparative and synthetic analysis? In the wake of two decades of post modernism and the correlated disengagement of much of our discipline with comparative research and the computing and quantitative skills required to execute it on large amounts of data, how can we ensure that curious archaeologists everywhere can receive the technical training required to take advantage of the new analytical opportunities? How can we foster the wider understanding of the critical roles that digital data sharing and preservation play in professional ethics?

In considering these and other questions, we emphasize not only the technical issues, but the social and cultural ones as well. Panelist contributions will feature case studies designed to illustrate concretely the issues involved and to catalyze discussion with the audience.

Topics: databases, data management systems and other field applications

Keywords: data sharing, collaboration, synthesis

Session Summary

Wednesday, 3:15pm-5:30pm, Tidewater D

Workshop: CIDOC Archaeological Sites Working Group Meeting

Chair: Stephen Stead, Paveprime LTD, United Kingdom

The CIDOC Archaeological Sites Working Group has a number of exciting projects on the go. In this meeting we will report on progress and discuss issues that have been raised since the last meeting in Athens during September 2008. It is hoped that substantial progress can be made on a number of editing and compilation tasks during this session. Details of the agenda and all working documents are hosted on the CIDOC Forum at http://meta.se/cidocforum/. All interested parties are invited to join the forum and review the projects, documents and discussion and make their own contributions. Registration is free, easy to complete and allows access to the Working Groups own sub-forum. The current projects are:

Thesaurus of Period Names

The proposal is to develop a data model for storing the data necessary to provide inter-operability between regional and/or institutional cultural period thesauri. This would include the acquisition of sufficient test data to verify the data model is adequate and consider delivery mechanisms and data acquisition tools for the expansion and propagation of the resulting data set.

Standards in Use

This is intended to gather a list of different standards in use in archaeology. It will aid with digital preservation and help the targetting of scarce resources on the appropriate development areas. Mutliple levels of standards have been identified.

1. Technical standards (ISO 3166-1 alpha-2 country codes, ISO 3166-1 alpha-3)
2. File Formats (pdf, doc, docx)
3. Content Standards (CIDOC Core Data Standard)
4. Meta data and high level standards (Dublin Core, CIDOC Conceptual Reference Model)

Standard for the deposition of Archaeological archives

The purpose of this is to produce an international standard that individual countries and regions can use as a touchstone when defining their own deposition standards. This is particularly to support countries when issuing excavation licences which need to enforce the deposition of excavated materials and excavation records.

Revision of Core Data Standard

Editing of the revision to the 1995 draft to produce the *International Core Data Standard for Archaeological and Architectural Heritage*

Multilingual Thesauri of Archaeological site types

Development of this thesaurus using an online collaborative KOS system.

Meta-list of lists of thesauri

This is intended to provide a single point of discovery for terminology control. There is no intension to maintain a list of terminology control resources but provide pointers to lists that are maintained by other organizations.

Archaeological Implementations of the CIDOC CRM

Compile a list of archaeological CRM exemplars.

So come and take part in the development of these resources. All help is welcome as are new projects that you think should be taken under the CIDOC wing.

Topics: CIDOC and other digital standards, databases, other

Keywords: CIDOC, CIDOC CRM, thesauri, archive, digital preservation

Session Summary

Thursday, 8:30am–11:45am, Tidewater A

3D Modeling and Scanning Applications (General Session)

Chair: David Koller, University of Virginia, United States of America

Schedule

8:30 – 8:50 "Feature Preserving Simplification of Point Clouds from Large-Range Laser Scanners," D. Martin, Fco. Javier Melero, P. Cano, and J.C. Torres

8:50 – 9:10 "ISReal: Advanced Computer Graphics Methods for Archaeology," Philipp Slusallek, Michael Repplinger, Alexander Löffler, Dmitri Rubinstein, and Hilko Hoffmann

9:10 – 9:30 "Computer-Assisted Recovery Technology of Broken Rigid Objects and Its Applications in Terra Cotta Warriors and Horses," Mingquan Zhou, Zhongke Wu, and Wuyang Shui

9:30 – 9:50 "Integrated Computer Modeling of Archaeological Potsherd Pavement Site at Ajaba-Kajola, Southwestern Nigeria," Adekunle Abraham Adepelumi, Olajide Temitayo Ajigo, and Dele Ebenezer Falebitaa

Coffee break

10:15 – 10:35 "Digital Technologies and Cultural Heritage: the Muscatatuck Project," Nicoletta Adamo-Villani

10:35 – 10:55 "3D Model of an Ancient Literary 'Topos' Visualized in the Eighteenth Century: Pliny the Younger's Villa at Laurentum," Jerzy Miziolek

10:55 – 11:15 "Modeling the Masonry Surfaces of the Temple of Divus Claudius in Rome," Alfonso Ippolito

11:15 – 11:35 "Reliving the Past: 3D Models and Virtual Reality as Supporting Tools for Archaeology and the Reconstruction of Cultural Heritage: The Case Study of the Roman Villa of Freiria," Maria Helena Rua, and Pedro Alvito

Abstracts

Feature Preserving Simplification of Point Clouds from Large-Range Laser Scanners

D. Martin, Fco. Javier Melero, P. Cano, and J.C. Torres
Universidad de Granada, Spain

Large-range laser scanners provide a huge number of points that are not so easy to handle with laptops and current commercial software. Each laser capture can have several million points, and usually it is needed more than one to retrieve the complete surface. These digitalization devices are used for scanning large areas like buildings, walls or geological structures, and sometimes the point cloud provided by the scanner can be simplified in order to eliminate redundant or noisy points. The key point of this simplification process is to eliminate just those points that do not contribute in a significant manner to the overall shape of the digitalized model. E.g.: in a very simple house façade model, it might be enough if we had just the silhouette points and those that define the window and door frames, ignoring all points that are just on the nearly planar surface of the façade. For this purpose, we have tested several 3D simplification algorithms, some of them based of well-known 2D algorithms (like the Douglas-Peucker algorithm), and other pure 3D algorithms based on silhouettes and shape lines detection. We take advantage from the knowledge of the order in which the points are taken by the device, so we can easily determine whether two adjacent points belong to the same surface area or they lie in two distant surfaces. After simplifying the point cloud, it is necessary to triangulate it, and we are able to triangulate in a topologically coherent manner, so no overlapping triangles are generated. Furthermore, we have developed and algorithm that simplifies dynamically the point cloud in real time , so the number of rendered points depends on the distance from the observer to the point cloud, using just a small percentage of the whole data set if the virtual model is far from the virtual observer.

Keywords: 3D models, scanning, simplification

ISReal: Advanced Computer Graphics Methods for Archaeology

Philipp Slusallek[1,2], Michae Repplingerl[2], Alexander Löffler[2], Dmitri Rubinstein[2], and Hilko Hoffmann[1]

1. German Research Center for Artificial Intelligence (DFKI), Germany
2. Saarland University, Germany

The computer has become an indispensable tool in modern archaeology for measuring, recording, organizing, searching, and presenting results. Particularly important is the use of realistic and interactive 3D graphics: It allows to accurately capture and present the archaeological evidence within its current 3D environment as well as create 3D models of the historic location. Different possible reconstructions can be discussed and compared to the existing evidence within the same 3D model thus allowing to better evaluate scientific hypotheses. Given such interactive 3D models we can then apply a multitude of other simulation techniques from computer graphics and other fields, e.g., illumination, acoustic, and architectural simulations, to try to recreate the historic reality. Using the Internet we can make this data widely available and also more accessible to non-experts. While very promising, current graphics technology has also been a severely limiting factor. The realism of the virtual artifacts was often minimal, performance greatly limited the size of the historic models, and—not the least—significant graphics expertise has often been required to use existing tools. In this paper we present ISReal (Intelligent Simulated Reality), a joint project between the German Research Center for Artificial Intelligence (DFKI) and the Graphics Lab of Saarland University. Using standards where ever possible (e.g. X3D) and extending them where necessary, ISReal allows for interactively handling massive 3D models with very fine detail and a high degree of realism, including physical accurate materials and illumination. In addition, we extend our models to include semantic information and multi-agent technology to describe the functionality of devices and behavior of characters. Particularly, we will concentrate on the interactive rendering of highly complex and highly realistic models using Realtime Ray Tracing. We also demonstrate a collaborative, server-based approach that allows multiple users to explore and interact with large and realistic 3D model from a standard web browser. A distributed group of users can share a common view onto the model as well as an audio connection for collaborative sessions. Multiple groups or individuals can independently explore the same or some other models offered on a server. Semantic information can be integrated into the visualization and provide links to further resources, while comparing alternative models to each other. We will have live demonstrations of the ISReal software, which will be made available as OpenSource in the near future.

KEYWORDS: interactive 3D archeological models, Realtime ray tracing, collaborative reviews, server-based rendering

Computer-Assisted Recovery Technology of Broken Rigid Objects and Its Applications in Terra Cotta Warriors and Horses

MINGQUAN ZHOU, ZHONGKE WU, and WUYANG SHUI

College of Information Science and Technology, Beijing Normal University, People's Republic of China

With a long history, China has a rich and profound culture resource. Terra Cotta Warriors and Horses, which were discovered in 1974 near Xi'an, Shaanxi Province, are world renowned historical relics. Many fragments of Terra Cotta Warriors and Horses, such as incomplete heads and bodies of warriors and horses, were caused by erosion, lithosphere pressure, human's damage and other reasons. Traditional ways of restorations, process of classification and hand stitching are time-consuming and repetitive. Therefore, restoration of culture relics through computer technique is meaningful and necessary. Current approaches of matching can be divided into two types: (1) matching the relics based on region: two fragments have common surface, and the adjacency relation between two fragments is decided by matching the shape of surfaces. The ideal situation is that two surfaces are able to completely match. (2) Re-assembling the relics based on contour lines: two adjacency fragments have the same or similar edge, the relics is restored by matching and aligning between each other. The ideal situation is that surface is split into two sub-matching surface, which could match completely. Based on archaeologies, texture and color of excavated relics, particular the shape of the relics, the adjacency relation between relics could be decided. The restoration of Terra Cotta Warriors through computer science based on matching contours is a challenging question. An efficient approach is to be presented in this paper which

includes four steps: First, Data capturing and processing: Acquiring the 3D vertexes and topology of the relics and then making some processors on them, such as filtering, smooth, simplification, etc.; second, extracting contours of the 3D model acquired from the first step; Third, matching and assembling: By matching a common contour, the matrices of translation and rotation between two fragments are calculated, and then the fragments are re-assembled and aligned by transforming one model based on the matrixes. Forth, Post processing, editing the generated mesh in order to make them smoother. Up to now, the Terracotta Warriors and Horses have been discovered in three pits. These columns of soldiers, horses and chariots were tagged to form arrays when they were excavated. These arrays represent battle formation, which is very important for the research of Qin dynasty army and battles. However, due to some damage, these orders are now not complete or regular. Based on related historical documents about these order positions, a practical way of restoring the original order of The Terra Cotta Warriors and Horses is represented. Through using computer graphics technology, these battle formation scenes are reconstructed virtually.

Keywords: cultural heritage preservation, terra cotta warriors and horses, computer-assisted restoration system

Integrated Computer Modeling of Archaeological Potsherd Pavement Site at Ajaba-Kajola, Southwestern Nigeria

Adekunle Abraham Adepelumi, Olajide Temitayo Ajigo, and Dele Ebenezer Falebita

Obafemi Awolowo University, Nigeria

This paper describes the results of high spatial resolution magnetic, resistivity surveys, and computer modeling of the Neolithic potsherd pavement site located at Ajaba-Kajola in southwestern Nigeria. No detailed account of the archaeology studies of edge-laid potsherd pavement found in Ajaba-Kajola, southwestern Nigeria, has been published. However, potsherd pavements have long been a subject of interest in the archaeology of West Africa. The geophysical prospecting and computer modeling aimed to investigate the buried pavement patterns, and confirm the existence of the archaeological remains. The survey area covered 5000 km^2 meters. The data were acquired in grid form across the area while the traverse and station spacing of one meter was used for the data acquisition and computer modeling. For computer modeling purposes, the area was divided into a bin size of $1km^2$ and both magnetic and electrical resistivity data were acquired. The magnetic and electrical resistivity methods measured variations in the Earth's magnetic field and resistivity at the ground surface, which correspond to magnetic susceptibility and resistivity changes and contrast in the subsurface. The data were subjected to standard processing techniques. 2D and 2.5D computer simulation was done to image the subsurface structures that best fitted the data set using DIPRO, WinGLink and Magic filtering and modeling softwares. A large number of distinct magnetic anomalies of interest that depict edge-laid potsherds were delineated from the magnetic data. These structures are buried between 0.2 and 3.5m depth. The electrical survey results obtained corroborate the magnetic findings. The potsherd structures delineated

from both methods are similar. These structures derived from the integrated survey and computer modeling provides a clear image of edge laid herring-bone potsherd pavement structure that possibly dated 1500 years old. The integrated approach used in this study confirms the importance of such methods in mapping of buried ancient archaeological structures.

Keywords: potsherd pavement, modeling, magnetic, resistivity, Nigeria

Digital Technologies and Cultural Heritage: The Muscatatuck Project

Nicoletta Adamo-Villani
Purdue University, United States of America

The paper analyzes the development of a digital heritage project that uses VR as a documentation and communication tool for a variety of audiences. It also discusses general issues in creating virtual archaeology applications for the broad public. The project's objective is the development of an interactive tour of the Muscatatuck State Hospital Historic District (MSHHD) in Columbus, IN. The virtual tour is deliverable on CD-ROM for distribution to schools, and on the web for the general public. In addition, the tour is designed for display in immersive devices for museum exhibits. MSHDD, founded in 1920, was originally the Indiana Farm Colony for Feeble-Minded Youth. It covers an area of 576 acres and includes buildings of historic value built in Deco, Moderne, Industrial, and Twentieth-Century Functional architectural styles. In 2000, MSHHD was closed, and in 2005 the property was transferred to the Indiana Army National Guard (INARNG) to develop the MUTC (Muscatatuck Urban Training Center), a training facility for homeland security and natural disaster training. The plans for converting the area include major modifications to the site and the buildings. In 2006, INARNG agreed to several mitigation stipulations for the adverse effect INARNG will have on MSHHD. One stipulation was the creation of a photorealistic virtual tour to document and virtually preserve the historic site. A Purdue team, led by the author, was charged with the task of developing the tour. The team selected 3D animation and VR because of the advantages available with these technologies, including representational fidelity, immediacy of control, high level of active user participation, and presence. There are several techniques and devices for getting geometrical information about real 3D objects. However, as of now there are no fully automated methods: while most automated techniques involve limited user input, they require a substantial amount of interactive work to covert the resulting data into renderable structures. Therefore, the team decided to build all 3D models using commercial off-the-shelf modeling software. To provide accuracy and realism, the 3D objects were developed from maps, blueprints, photographs, and drawings, and were textured using procedural maps and digitally captured images. The models were then converted to VRML for web-based delivery and display in immersive environments. A main challenge posed by the project was the requirement of web delivery. Due to diverse network connections and computer performance, efficient representation of virtual objects is a fundamental factor for web presentations. Virtual scenes are always a simplification of reality and this is particularly true for web-based VR presentations

which have to balance between visual quality and rendering/data download speed. In the paper we discuss solutions adopted to overcome the quality/performance trade-off issue, including optimization techniques for converting 3D models to web-based format and Level of Detail (LOD). Furthermore, we discuss the problem of absence of a standardized interface for web 3D navigation and we suggest strategies to overcome this limitation. Finally, we describe the approach taken to display the tour on an immersive system with head-tracked stereo display.

Keywords: computer archaeology, cultural heritage, immersion, virtual reality, web

3D Model of an Ancient Literary "Topos" Visualized in the Eighteenth Century: Pliny the Younger's Villa at Laurentum

Jerzy Miziolek
Warsaw School of Social Sciences and Humanities, Poland

We propose to present and discuss a 3D model of Pliny's villa marittima based on a set of 32 large drawings executed by Giuseppe Manocchi and Vincenzo Brenna in Rome in the 1770s. The drawings, which have as yet been little studied, were commissioned by Count Stanislas Potocki and result from his deep fascination with archaeology and Pliny's famous description of the villa in his letter to Gallus. Potocki also knew the archaeological site at Castelporziano where the ancient villa of "la Pallombara" believed to be Pliny's was uncovered in the eighteenth century. The characteristic large peristyle as well as the nearby cryptoportico can also be seen in the drawings in question. Despite the possible impact of these excavations, the paper reconstruction of the villa and its interiors are more a reflection of late eighteenth-century antiquarian taste rather than a serious, archaeological approach. The aim of this project, started in 2006, is to bring Potocki's work out of oblivion, recreating his unique reconstruction with the use of digital technology. Thirty-two color sheets constitute an almost complete architectural design both of the villa itself and of its surrounding gardens, located in a still-wider spatial environment. The designs, with their two levels of measurement scales and containing numerous cross-sections of the main building and particular rooms, make it possible to reconstruct the vision of this Enlightenment scholar on a virtual building site. Seen separately, the drawings constitute, above all, a work of art of the highest quality and are a reflection of late eighteenth century archaeology. However, when owing to 3D programs they can be seen as a whole, they testify to Stanislas Potocki's exceptionally unified and well thought-out vision. We produced the first model of Pliny's villa in 2007; it was created in 3D Max format—high poly, high-resolution textures. The animation was done in PAL format (720x576) with 10 minutes total time of 3D animations. For the Williamsburg conference we have been working on a new, expanded version of the 3D Villa Laurentina, which will include renderings of all the rooms reconstructed by Potocki; the animation will be rendered in 1280×720 or 1920×1080 HD format. Technology used in the project: digital camera Hasselblad H3D-39Mpix; Intel Core Duo 2.1, 2GB Memory; 2 x 3GHz Quad-Core Intel Xeon, 4GB Memory. Apart from the 3D models closely linked to the

main scope of the Williamsburg Conference, there is a vast body of material, more or less seriously attached to archaeology, which is worth studying, and then, with the help of digital technology, being used for scholarly and educational purposes.

Keywords: villa, archaeology, drawings, reconstruction, visualization

Modeling the Masonry Surfaces of the Temple of Divus Claudius in Rome

Alfonso Ippolito
Institut für Ur- und Frühgeschichte, Christian-Albrechts-Universität Kiel, Germany

The aim of the survey of an architectural work is to penetrate its inner complexity, which is related to the type of construction. It is clear that an archaeological monument has its own peculiarity due to the unpredictability, precariousness, and incompleteness of its forms, as they have come down to us. This cannot be compared with the finished, symmetrical and regular structures of a modern building. The stages of the survey and its methods must be related to this peculiarity, in order to achieve a knowledge of the monument in depth, which can allow a critical interpretation of it and, lastly, a virtual reconstruction of its original forms. This means that there must be a mutual relationship between the monument, the techniques and the methods employed for the survey and the survey itself, in order to obtain from the elaborations the greatest quantity of data, the closest possible approximation of the monument, and a digital simulation. The process developed for this purpose aims to analyze the passage between the acquisition with 3D laser scanner of ancient Roman masonry and the three-dimensional reconstruction of their surfaces. The object is therefore the research of a process that can allow the reconstruction of surfaces whose characteristic is to be discontinuous and marked by the absence of repeated elements, in which every single piece becomes a peculiarity. The developed operations start from the acquisition of the point cloud using a 3D laser scanner and from high-resolution photographs to acquire another cloud of points. With the data from the 3D laser scanners elaborations have been carried out to obtain surfaces, employing different software and comparing them with the scan data. This first stage aims to evaluate the uncertainty, by considering the parameters of the instruments, accurateness of the scanners, and of the 3D modelers. In this stage the passage from the scan data to the definition of the surface has been analyzed, and, after that, the definition of the edges and the boundaries, evaluating the problem in the definition of the surface and analyzing the differences between the center and the edges. The following stages reflect the above mentioned considerations: evaluation of a method of scanning and of a definition of its parameters in order to obtain a virtual reconstruction closer to the real object; evaluation of the scan resolution, paying attention to the relationship between scan resolution and virtual surface; analysis of the noise; definition of the best reconstruction of the boundaries in the discontinuous surfaces; and texturing of the obtained surfaces with high-resolution photographs. At the same time the point clouds from photographs and those obtained through scanner laser have been analyzed, along with the surfaces obtained from the two

different point clouds. The last phase consists in the definition of the drawings necessary for the greatest possible understanding of the monument, which are obtained from the 3D model.

Keywords: archeological architecture survey, 3D scanners, uncertainty, edges and the boundaries, 3D surfaces

Reliving the Past: 3D Models and Virtual Reality as Supporting Tools for Archaeology and the Reconstruction of Cultural Heritage: The Case Study of the Roman Villa of Freiria

Maria Helena Rua and Pedro Alvito
Instituto Superior Técnico, Portugal

Virtual reality allows us to experience places that do not exist—parallels of the past, present and future. In archaeology it may be said to correspond in some way to a time machine which offers journeys to the past. This paper presents the work involved in creating the buildings that comprise the Roman Villa of Casal da Freiria, in São Domingos de Rana, Lisbon (Portugal). The modeling, presented in the results, was based on the remains found on the ground and on the opinions and reports of the archaeologists in charge of the campaigns. These buildings were occupied from the first to the fourth century C.E., and consist of a manor house, which, in typical Roman style, was constructed round a central courtyard and infrastructures needed for daily life. These were arranged around a second courtyard and consisted of servants' quarters (cells) and bath, and outbuildings related to farm work—presses and barn. Despite the information provided by the excavations about the built area, the true extent of the *pars rustica* is still unknown. The importance of this archaeological site stems not so much from the wealth of its owners, normally reflected in the quality of the items found, but by the discovery of a rare example of a barn in Iberia. The creation of the 3D model of the Freiria site was based on CAD software. It first focused on the building of the barn since it corresponds to the structure that most people agreed upon in relation to its vertical component. All the technical documents collected, on the site and in the laboratory, were used to help establish a model that would allow several interpretations to be assessed, to cater to new inferences which may enter the equation in the future. Even though the modeling followed the procedures of a scientific study, this project intended the outcome to be an interactive scenario that users could manipulate so as to visualize how the inhabitants went about their lives. So, after the virtual reconstruction of the model of the Freiria Villa, it was exported to a game engine, to learn about the area when it was being fully used. Even before the work is completed (for more information, see http://www.civil.ist.utl.pt/~hrua/celeiro/Freiria-Filme3.avi), the interim results so far obtained are definitely promising, and could be disseminated and discussed in the scientific community, as a way of promoting unwritten knowledge of the past by "Making History Interactive."

Keywords: 3D model, virtual scenarios, recreation of social, urban and architectural environments, visualization of a recreated space

Session Summary

Thursday, 8:30am–11:45am, Tidewater B

Computational Intelligence in Archaeology: Quantitative Methods and Other Approaches (General Session)

Chair: Juan Antonio Barcelo, Universitat Autonoma de Barcelona, Spain

Schedule

8:30 – 9:00	"Multitemporal Landscape History in Burgundy: An Innovative Application of Genealogy Software," Elizabeth A. Jones
9:00 – 9:20	"Continuity and Change: a Study of the Shape of Late Neolithic and Early Bronze Age Vessels from the Netherlands," Vincent Mom and Erik Drenth
9:20 – 9:40	"Cogitating Prehistoric Archaeological Landscape with Pattern Recognition," Prakash Sinha
9:40 – 10:00	"Dividing Time, Space, and Social Factors: A Multivariate Analysis of Early Bronze Age Funerals of the Unětice Culture," Martin Hinz
Coffee break	
10:15 – 10:35	"Dendro-similarity," Vincent Mom, Joachim Schultze, Sigrid Wrobel, and Dieter Eckstein
10:35 – 10:55	"The Effects of Electrochemical Reduction on the Subsurface Corrosion of Iron from Terrestrial Settings," Jason Lain Lunze
10:55 – 11:15	"Scientific Puzzle Solving: Current Techniques and Applications," Florian Kleber and Robert Sablatnig
11:15 – 11:45	Discussion

Abstracts

Multitemporal Landscape History in Burgundy: An Innovative Application of Genealogy Software

Elizabeth A. Jones

University of North Carolina at Chapel Hill, United States of America

Our research is tracking land-use change over the past three centuries in the rural Commune of Uxeau in Southern Burgundy, France. The land in Uxeau has been continuously farmed by smallholders for millennia,

maintaining a high productivity in all periods. We hope that by reconstructing historical land-use practices through both their social and physical aspects, we will uncover essential information on how people maintained the viability of this resilient landscape during periods of significant environmental, political, economic, social and cultural change. Many studies shaped by resiliency theory tend to focus on the collapse of socioecological systems. This research, based as it is on a positive example of long-term successful adaptation, will be especially useful in refining theory and informing models of sustainability for the future. An essential aspect of reconstructing past land use is the social, political and economic factors that drive land-use decisions. Finding this kind of historical data, especially for early periods, can be difficult. Records pertaining to land use and management are often sparse and inconsistent, and when one is researching at the level of individual farms, these problems are amplified. Parish and civil records of birth, marriages and death provide one type of consistent, year-to-year, source of data that has been seldom used in reconstructions of land-use change. In France these records contain information on the residence, occupation and social ties of not only the primary individuals named in the birth, marriage and death records, but also for the many others present as godparents, witnesses and mourners. This information can be invaluable for reconstructing past ecotypes. An ecotype (Mitterauer 1992:142-143) encompasses the following:

- The local environment and its range of available resources
- The particular resources that are extracted and the type of technology for doing so
- The sociocultural institutions for instituting and organizing the family as an integrated work force
- The local relations between peasant farmers and non-peasant groups (e.g. the nobility, village tradesmen and craftsmen, day-laborers, etc.)
- The interrelations between groups exploiting different resources within the same environment
- The relations of the local area to outside areas which include transportation networks, settlement patterns, and the macropolitical and economic systems

This presentation shows how the genealogy software, Family Tree Maker, normally used to trace a single modern family's genealogy, can be adapted to analyze the history of an entire parish. This allows one to study, over time, the farming households and their organization of labor, other social and economic ties both within the parish and beyond, and the distribution of occupations on the landscape. The occupational data often reflects land use, such a wool producer versus a hemp producer. When this data on farm families is connected through the cadastral records to the individual parcels of land in our GIS database, a thorough reconstruction of ecotypes over a period of centuries can be developed.

Mitterauer, Michael, 1992. "Peasant and Non-Peasant Family Forms in Relation to the Physical Environment and the Local Economy," in *Journal of Family History* 17(2):139-159.

Keywords: landscape history, GIS, agriculture, historical ecology, database

Continuity and Change: A Study of the Shape of Late Neolithic and Early Bronze Age Vessels from the Netherlands

Vincent Mom[1] and Erik Drenth[2]

1. DPP Foundation, The Netherlands
2. Archeomedia, Capelle aan den IJssel, The Netherlands

This paper discusses the results of an ongoing inquiry into the shape of Late Neolithic and Early Bronze Age vessels from the Netherlands. The aim of the investigation is to elaborate a new typology in order to gain more insight into the pottery development of the Single Grave Culture, the Bell Beaker Culture and the Barbed Wire Beaker Culture, c. 2800-2400, 2400-1900 resp. 1900-1600 cal B.C.E. To what extent was there continuity, or to put it differently, are there indications of abrupt changes? With a new typological classification it is hoped to shed more light on the chronology of the Late Neolithic and the Early Bronze Age in the Netherlands, and in addition to unveil the pottery's social-economic meaning. In former studies with respect to the pottery under consideration, a high degree of continuity was concluded (e.g. Lanting & Van der Waals 1976; Drenth & Hogestijn n.d.). These outcomes rest first and foremost upon decoration. Ornamentation is included in the present analysis, but it focuses, however, on another feature, i.e. vessel shape. Furthermore, by encompassing also extrinsic or contextual features (e.g. location and type of site, associations and stratigraphies) the paper discusses to what extent a classification seems useful and meaningful. The analysis of Late Neolithic and Early Bronze Age vessels from the Netherlands included well over 200 specimens. The shape comparisons were done using Secanto, a computer program that calculates the similarity of shapes of artifacts like vessels, arrow points and axes based on a numerical algorithm called the Sliced method (Shennan and Wilcock 1975). The dissimilarity is expressed as a "distance" between the objects, which, compared with the distance between the find spots of the objects, also gives interesting results.

Drenth, E. & J.W.H. Hogestijn, n.d.."Nieuwe ideeën over de oorsprong en ontwikkeling van klokbekers in Nederland," in J.H.F. Bloemers (ed.), *Tussen D26 en P14: Jan Albert Bakker 65 jaar,* Amsterdam, 33-146.

Lanting, J.N., & J.D. van der Waals, 1976. "Beaker culture relations in the Lower Rhine Basin," in J.N. Lanting & J.D. van der Waals (eds), *Glockenbechersymposion Oberried* 1974, Bussum/Haarlem, 1-80.

Keywords: shapes, continuity, Bell Beakers, Neolithic

Cogitating Prehistoric Archaeological Landscape with Pattern Recognition

Prakash Sinha
University of Allahabad, Allahabad, India

The brain works by extracting patterns of information from the senses and setting up models of what it thinks the world is like. These models are continually updated. At a more pragmatic level, the implication is that there is some complex structural thinking process which links the possible visual patterns. The basic question is how to identify them in archaeological evidence and to assign a rationale. The challenge is methodological. Application of quantitative method to archaeological variables hardly reveals cause and effect equations in the formation of archaeological landscapes including inter- and intra-site variations. This, indeed, provides pattern (s). Analysis in the social sciences in particular and in science in general is primarily based on the recognition of pattern (s). Providing a rationale to the generated patterns has to be determined by archaeologists. An attempt has been made in this paper to bring together the results obtained by the author, using quantitative methods from a number of case studies ranging from core/flake to blade industries in temporal and spatial dimensions. The reliability and validity of the result in any scientific research primarily depends upon the how the raw data or sample has been retrieved, hence a systematic sampling strategy should be followed in the archaeological field work. Multivariate techniques have been used to develop components that help us in recognizing patterns in archaeological evidence. Analysis of generated patterns in relation to archaeological context and analysis of analysis suggest behavioral as well as environmental causes behind the clustering of cultural material in both temporal and spatial dimensions and that plausibly gave rise to archaeological landscapes. The development of human behavior is not unilateral but rather multilateral, multi-structural and spiral in time and space.

Keywords: patterns, archaeological landscape, inter- and intra-site variations, temporal and spatial dimensions, multivariate techniquesl

Dividing Time, Space, and Social Factors: A Multivariate Analysis of Early Bronze Age Funerals of the Unětice Culture

Martin Hinz
Institut für Ur- und Frühgeschichte, Christian-Albrechts-Universität Kiel, Germany

Differences in the material remains of archaeological cultures can be generally ascribed to three gradients: time, space and social space. But these factors appear simultaneously in the inventories. Therefore distinguishing between their influences is difficult. However, only if these factors can be treated separately can we draw a correct picture of the changes in material culture along theses gradients. This study is a attempt to achieve such a distinction and analysis. It is based on approximately 800 graves of the Unětice Culture, the first Bronze Age culture of Central Europe. The instrument of choice were different methods of correspondence analysis, in its basic version an often-used tool, especially in German archaeology. But ecology contributes various further developments of this method, namely canonical correspondence analysis (Ter Braak 1986) and partial canonical correspondence analysis (Legendre and Legendre 2006). The first one makes it possible to emphasize certain factors; with the second, the influence of certain known factors can be diminished. The calculations were made with the statistical environment R, in particular with the vegan package (Oksanen *et al.* 2007). These methods were used to separate the temporal, spatial and social factors of change in burials as

well as to observe them individually. Afterwards the interrelationships were investigated. One of the results was that the social gradient is highly associated with the temporal because of the imitation of the higher social stratum by the lower one. This mechanism is well known in sociology owing to the work of Elias (1997) and Simmel (1895). In archaeology it has not widely been recognized until now. Also some questions about spatial distinction and its temporal progress could be answered better through the use of multivariate analysis in combination with a spatial approach rather than through conventional, merely subjective methods. A stronger spatial distinction of the Unětice groups located in the vicinity of the Harz mountains could be observed. These groups were likely to have been in intensive competition because of local salt resources and possibly also ore extraction. This could have led to an extreme urge for distinctive expression in material culture.

Elias, N., 1997. *Über den Prozeß der Zivilisation. Soziogenetische und psychogenetische Untersuchungen. Band I, Wandlungen des Verhaltens in den westlichen Oberschichten des Abendlandes* (Frankfurt a.M. 1997).

Legendre, P. and L. Legendre, 2006. *Numerical Ecology* (Amsterdam 2006).

Oksanen, J., R. Kindt, P. Legendre, B. O'Hara, M. Henry, and H. Stevens, 2007. *The vegan Package*. URL http://cran.r-project.org/web/packages/vegan/vegan.pdf,

Simmel, G., 1895. "Zur Psychologie der Mode. Soziologische Studie," *Die Zeit, Wiener Wochenschrift für Politik, Volkswirtschaft, Wissenschaft und Kunst* 5, 1985, 22-24.

Ter Braak, C., 1986. "Canonical Correspondence Analysis: a new eigenvector technique for multivariate direct gradient analysis," *Ecology* 67, 1986, 1167-1179.

Keywords: correspondence analysis, quantitative methods & statistics, theory & methods, Unětice culture, burials

Dendro-similarity

Vincent Mom[1], Joachim Schultze[2], Sigrid Wrobel[3], and Dieter Eckstein[4]

1. DPP Foundation, The Netherlands
2. Forschungsprojekt Haithabu, Archäologisches Landesmuseum Schloß Gottorf, Schleswig, Germany
3. Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Wood Technology and Wood Biology, Hamburg, Germany
4. University of Hamburg, Dept. of Wood Science, Division Wood Biology, Hamburg, Germany

Dendrochronologists, involved with the dating of archaeological, architectural or art historic wooden objects, are unavoidably confronted with the recurrent question, "which samples come from one and the same tree?" Answers can, for example, help decide on whether complex structures within a settlement were built at the same time, although the underlying wooden samples are lacking bark or sapwood. The same applies for re-used timbers or solitary timbers in an excavation stratum; by being possible to allocate them to a tree individual it can be clarified to which construction it originally belonged. Moreover, it will only then become possible to assess the amount of timber used for the construction of houses, fences, bridges and the like. The proto-urban settlement of Haithabu in Schleswig-Holstein (Northern Germany) is one of the largest Viking trading places presently known. Of the 25.5ha settlement area within the semi-circular rampart, about 5% has been excavated since the beginning of the twentieth century. Since the remains of Haithabu lie in a wetland area, many organic finds such as wood, bone, and leather were very well-preserved. Examples of such finds are boats, harbor constructions, and many remains of buildings, track ways, and fences. The dendrochronological dating of waterlogged wood enables us to reconstruct the different developmental phases of the settlement, but the amount of data poses a problem: more than 4,000 pieces of wood were dendrochronologically analyzed. The fact that two pieces of wood are (probably) from the same tree is additional information that is very useful in the process of reconstructing infra-structural objects. The Division of Wood Biology of the University of Hamburg has been involved in the dendrochronological dating of Haithabu since 1966. Most of the original data were collected in the pre-computer era and are now being digitized. To alleviate the problem mentioned above, we are looking for statistical methods to determine the chance that two pieces of wood are or are not from the same tree, according to the following steps:

1. Find an algorithm that maximizes the difference between samples of different trees ("diftree") , and minimizes the difference between samples from the same tree ("sametree").
2. Determine the shape of the statistical distributions for "diftree" and "sametree" samples.
3. See how useful the resulting answers ("the chance that these two pieces come from the same tree is XX%") are in practice.

After a short introduction, the algorithm as well as the preliminary results will be discussed. A live demonstration of the Dendrosimilarity Computer Program is part of the presentation.

Keywords: Haithabu, wood, dendro-similarity

The Effects of Electrochemical Reduction on the Subsurface Corrosion of Iron from Terrestrial Settings

Jason Lain Lunze
Virginia Museum of Natural History, United States of America

Thursday

The purpose of this preliminary paper is not to examine the pre-conservation surface corrosion products on iron artifacts from terrestrial sites but to address the affects of electrochemical reduction on the corrosion products which form along dislocation planes, grain boundaries, voids, substituted elements, and other pre-existing internal defects. The preservation of iron and steel artifacts by electrochemical reduction has been studied and summarized for artifacts that have been excavated from both marine and terrestrial archaeological sites (Hamilton, 1998; Plenderlieth and Werner, 1971). The method of electrochemical reduction employed in this study follows these previous works. The surface layers of corrosion on iron and steel artifacts have also been examined (Cook and Oh, 1998; and Oh *et al.*, 1999). These previous studies have set the stage for further

examination of the alteration of corrosion products after conservation. The internal defects and their alteration by corrosion mechanisms cannot be observed before or after treatment without damaging or destroying the examined artifact. In 1995 while dismantling a rubble stone wall on a vacant lot in Fluvanna County, Virginia, a large industrial iron bar was collected. This large iron bar which is an isolated artifact with limited further research potential was chosen as the source of study material as the examination of a historic artifact of known provenance through destructive means would not be easily justified. A section of the iron bar was cut from the sample forming three coupons before the conservation process was performed. These were then polished to better observe the samples physical structure in a reflected light microscope. These coupons were then etched with ammonia for the purpose of making grain boundaries and defects more visible in a subsequent analysis of the coupon's elemental and textural composition using a Scanning Electron Microscope/ and EDAX. A Second set of coupons was cut from the sample once it had been reduced. These coupons were polished with the same media as the first for analysis in a reflected light microscope. They were subsequently etched with ammonia for analysis with the Scanning Electron Microscope/ and EDAX. Preliminary data is presented in the form of elemental maps of remaining areas of corrosion and defects observed with the SEM/EDAX as well as reflected light microscope images as compared between the pre and post conservation coupons.

Cook, D.C and S.J. Oh, 1998. "The Protective Layer Formed on Steel after Long-term Atmospheric Exposure. Corrosion." 1998, Paper No. 343.

Hamilton, D. L., 1998. "Methods of Conserving Underwater Archaeological Material Culture." http://nautarch.tamu.edu/class/ANTH605.

Oh, S.J., D.C. Cook, S.J. Kwon, and H.E. Townsend, 1999. "Atmospheric Corrosion of Different Steels in Marine, Rural and Industrial Environments," in *Corrosion Science* 41(9), 1687-1702.

Plenderleith, H. J., and A. E.Werner, 1971. *The conservation of antiquities and works of art.* Oxford: Oxford University Press.

Keywords: iron corrosion, scanning electron microscopy/EDAX, electrochemical reduction, element maps, reflected light microscopy

Scientific Puzzle Solving: Current Techniques and Applications

Florian Kleber and Robert Sablatnig
Vienna University of Technology, Austria

An automated assembling of shredded/torn documents (2D) or broken pottery (3D) will support philologists, archaeologists and forensic experts. Especially if the amount of fragments is large (up to 1000), a human puzzle solver will not be feasible due to cost and time. Automated solving can be divided into shape-based matching techniques (apictorial) or techniques that analyze also the visual content of the fragments (pictorial). Therefore either image features or texture-based analysis is done. Depending on the application, shape-matching techniques are suitable for entities of the puzzle problem with small numbers of pieces (i.e. up to twenty) and they cannot be used with hundreds of fragments due to the complexity. Also artifacts like broken and lost pieces or overlapping parts of fragments increase the error rate of shape-based matching techniques. This paper presents an overview about puzzle-solving techniques and their applications. It will introduce the main problems in solving puzzles and will also focus on applications involving the assembly of fragmented (ancient) documents.

Keywords: puzzle, document analysis, reconstruction

Session Summary

Thursday, 8:30am–11:45am, Tidewater C

GIS Applications (General Session)

Chair: Maurizio Forte, University of California, Merced, United States of America

Schedule

8:30 – 9:00 "Multidisciplinary Integrative Georelational Database for Spatio-Temporal Analysis of Expansion Dynamics of Early Humans," Michael Märker, Volker Hochschild, and Zara Kanaeva

9:00 – 9:30 "Complex Social-Landscape's Data in GIS: A Cognitive-processual Methodology," Simone Bonzano

9:30 – 10:00 "From Pencil to Pentium: Digitizing the Classic Period Maya City of Chunchucmil, Yucatán, Mexico," Aline Magnoni and David Hixson

Coffee break

10:15 – 10:35 "Over the Hills and Far Away? Cost Surface-based Models of Prehistoric Settlement Hinterlands," Axel G. Posluschny

10:35 – 10:55 "Determining Function of Pompeian Sidewalk Features through GIS Analysis," Claire Jeanette Weiss

10:55 – 11:15 "Magura Uroiului (Hunedoara County, Romania) Archaeological Site from the Perspective of Landscape Archaeology," Liviu Maruia, Dorel Micle, Adrian Cintar, Angelica Balos, and Adriana Pescaru

11:15 – 11:45 "Analysing Conflicts: Battlefield Archaeology and Computers," Xavier Rubio Campillo

Abstracts

Multidisciplinary Integrative Georelational Database for Spatio-Temporal Analysis of Expansion Dynamics of Early Humans

Michael Märker, Volker Hochschild, and Zara Kanaeva

Universität Tübingen, Germany

During the last two million years, the geographic range of the human species expanded in several waves from its original African homeland to encompass Eurasia—and possibly back into Africa. Of these hominin species, only anatomically and behaviorally modern humans, Homo sapiens sapiens, have been able to

overcome the impediments imposed by the physical geography of this planet. Within a few tens of thousands of years, modern humans successfully inhabited the globe, settling in Australia, the Americas and even the polar regions. The project, "The Role of Culture in the Early Expansions of Humans," is funded by the Heidelberg Academy of Sciences and is projected to run for twenty years. The new research center's aim is to reconstruct the spatial and temporal patterns of the expansions of hominins between three million and 20,000 years ago in Africa and Eurasia. The main goal of the project is to explain the biotic and abiotic reasons for different hominin expansions. Implicit in the current working hypothesis is the assumption that the influence of changing environmental conditions decreased as the importance of cultural and technological innovations grew. To achieve these general objectives a spatial archaeological information system (RAIS) was developed and implemented. In the first step the RAIS will be fed with existing digital physiographic base data, archaeological filed information and palaeo-climatic information. Moreover, additive topographic information is derived by terrain analysis. Data mining technologies such as geo-statistics and "machine-based-learning" methods were utilized to derive relevant physiographic entities of potential archaeological field sites (predictive site modeling). Besides the predictive site modeling spatio-temporal point information such as vegetation-, climate-, soil-, hydrographic information will be reconstructed (Postdiction) and illustrated for relevant project intervals (20 000 BP - 3 Mio. BP). The information strata mentioned above will yield work hypothesis for the simulation of the expansion of early humans. These hypotheses will be tested with static cost, barrier and corridor analysis as well as landscape metrics in order to reconstruct potential expansion paths. Eventually, the expansion dynamics can be simulated using agent based models. In this paper we will present the general structure of RAIS, which is a web-based georelational database with imbedded analytical database functions and GIS operations. Moreover we will give a first application example from Southern Africa and Syria.

Keywords: expansion of early humans, spatial database, GIS, Africa

Complex Social Landscape's Data in GIS: A Cognitive-Processual Methodology

Simone Bonzano
Freie Universität Berlin, Germany

The highlands of the Eastern Anatolia, with their narrow valleys hidden among high peaks, have a long and complex settlements history, given by their diachronic changing assets and arrangements that maintained a certain continuity due to the existence of local power nodes scattered through the valleys, autonomous and sometimes isolated. To understand the regional settlement patterns it is important to focus on these little autonomous territorial systems (LTS), considering them as historical, social, political and economical agents of a complex regional system. Their analysis entails several problematic issues: handling big clusters of data;working on both the geography and the human/territory's dialectics; and interpolating together quantitative and qualitative results. In this research the GIS is focused on describing and marking the LTS

on the landscape. For this purpose, an integrated platform of GRASS GIS 6.3 and QGIS was selected. The reasons for this choice are primarily its powerful processing modules for raster (r.mapcalc) and vectors (v.digit), as well as the SQLite integration, which grants almost the same function as MySQL or PostgreSQL with a more user-friendly interface. The use of the platform can be described as an adaptive and post-processing (interpretative) use of GIS, by which the sites of the region are analyzed alongside historical and archaeological enquiries: the latter to draw the field of a database's table so as to describe the LTS, the former to build and show them on the landscape. In particular, the methodology called MARKER consists of construction of the settlement database and analyses of the settlement's features; fragmentation of the landscape in sensitive areas; extracting meanings from the environmental assessment; raster and vector operations to collect in one GIS entity and related database entry all of the meaningful data; and narrative description of the merged LTS.

This presentation presents the applications of the MARKER on the region around Lake Van. The results, which are presented in this paper, clarify its analytical potential to describe the local territorial system as landscape social agents, which were active in the diachronic change of the region. Accordingly with this methodology, the interpolation of interdisciplinary data permits us to surpass the given limits of the non-homogeneous distribution in space and time of the archaeological evidence.

KEYWORDS: GRASS, Anatolia, remote sensing, database, raster analysis

From Pencil to Pentium: Digitizing the Classic Period Maya City of Chunchucmil, Yucatán, Mexico

ALINE MAGNONI and DAVID HIXSON
Tulane University, New Orleans, United States of America

In this paper we present the large variety of techniques, tools, and technologies used for the recording, storage, processing, analysis, and visualization of the archaeological data of the Classic Period Maya city of Chunchucmil, Yucatán, Mexico. From pencil and paper maps, drawn by pace and compass using traditional Yucatecan landmarks, to high-tech remote sensing, GIS, and 3D technology, the Pakbeh Regional Economy Project has integrated a series of age-old methods with some of the latest software, resulting in a robust body of GIS, remote sensing, and multimedia data products. At its apogee, 400-600 C.E., Chunchucmil grew to become a sprawling urban center that housed between 31,000 to 43,000 residents over an area covering 20-25 km^2. Strategically located at the edge of several ecological zones, and only 27 km from the Gulf of Mexico, Chunchucmil became a specialized trading site and redistribution center for its region. Despite being located in an agriculturally stunted location (the driest portion of the entire Maya area—with limited soils) this city displayed the highest structural density of any Classic period Maya site. With hundreds of kilometers of boundary walls and more than a thousand residential groups (only counting the mapped portion of the

site), the work of recording and analyzing the abundant features of Chunchucmil has been quite challenging. Fortunately, the location of Chunchucmil in the arid landscape of northwest Yucatán has allowed our project to successfully use both recent and historic aerial photographs, AIRSAR (airborne synthetic aperture radar), and diachronic multispectral satellite imagery from NASA's LANDSAT satellites to reveal a wealth of archaeological data which would otherwise have remained undetected in the humid tropics.

Two GIS databases were created: one with Intergraph GeoMedia for intrasite features, and one in ArcGIS for the regional database of peripheral site locations and features. These GIS databases are used for the storage, analysis, and visualization of all the archaeological data collected at Chunchucmil. Finally, portions of the site were reconstructed using the Unreal Engine, a 3D visualization software, to create an immersive 3D real-time walkthrough of both the major and minor features of the site. In this paper, we will present a review of the challenges and advantages of each low-tech and high-tech tool as well as their integration in the analysis of the city of Chunchucmil.

Keywords: GIS, remote sensing, 3D visualization, Maya archaeology

Over the Hills and Far Away? Cost Surface-based Models of Prehistoric Settlement Hinterlands

Axel G. Posluschny

Roman-Germanic Commission of the German Archaeological Institute, Germany

The hinterland of prehistoric settlements played an important role for the agricultural livelihood of a community and for the economic exploitation of the natural environment in general. The size and the structure of these hinterland areas may have differed depending on the environment and on the needs of prehistoric people in different periods. These changes in the layout and in the size of a settlement's hinterland in a diachronic perspective (within a certain landscape) might reflect a change in settlement strategies and in the use of the natural environment for economic reasons. The proposed paper aims to compare the hinterland of prehistoric settlements from three different periods in several landscapes that have been investigated within the framework of the "Princely Sites" research project (http://www.fuerstensitze.de/1121). As part of a case study I would like to present the methodological background (comparing different approaches like different cost functions or different amounts of path search directions) of the cost surface-based definition of the economic hinterland areas. First results of the aforementioned comparison of the sizes and the layouts of the modeled areas will put a light on Late Bronze Age and Early Iron Age societies taking into account their natural environment.

Keywords: cost surface algorithms, hinterland, landscape archaeology, prehistoric economy

Determining Function of Pompeian Sidewalk Features through GIS Analysis

Claire Jeanette Weiss
Via Consolare Project, United States of America

Pompeii preserves a wealth of information regarding the daily lives of people living in the city prior to its demise in the eruption of Vesuvius in 79 CE. The final phase of the city presents significant possibilities for research into the social and municipal, the public and private, the commercial and religious aspects of daily life and social organization. In the shadow of such an abundance of information, small features can often be overlooked due to their diminutive size and apparent simplicity. It is often the case however, that such features are some of the most readily examined and simultaneously the most potentially instructive. Pompeian sidewalks, for instance, exhibit numerous features and attributes, indicating their indispensable utility in the ancient city. One of these characteristics is the presence of small holes chipped through the street-facing edge of curbstones. These holes exist on almost every sidewalk in the city and are consistently oriented toward the street, but have yet to be explained satisfactorily. Suggestions of their use are several. One such is that the cuts were created at the stone quarry for lifting or hauling. An alternative is that they may have been tethering points, either for the awnings of shops, or for animals being driven through the city. A more robust method of discerning their function must be employed to resolve this quandary. The function and use of the sidewalks in the highly socially-structured built environment of Pompeii would have directly affected the use of these holes, how they were allowed to impact the use of the sidewalks, access to doors, partitioning of space, and economic possibilities of the structures to which they were proximal. In this preliminary study, the sidewalks surrounding seven insulae of Pompeii (approximately 10% of sidewalks in the city) were examined in detail. The position of sidewalk holes, curbstones, and thresholds was recorded and used to construct a GIS database of their attributes and spatial relationships that was then tested for correlations. Through this method, it was found that, though their individual relationships are complex, sidewalk holes are placed preferentially near doorways along cart-accessible streets that were more directly connected to either city gates or the Forum. This suggests that the use of these holes was for the tethering of animals pulling carts, presumably with the intention of visiting or delivering goods to a house or business.

Keywords: Pompeii, sidewalks, pavements, GIS, roads

Magura Uroiului (Hunedoara County, Romania) Archaeological Site from the Perspective of Landscape Archaeology

Liviu Maruia[1], Dorel Micle[1], Adrian Cintar[1], Angelica Balos[2], and Adriana Pescaru[3]

1. West University of Timisoara, Romania
2. The Board of Culture, Cults and National Cultural Heritage of the Hunedoara County, Romania
3. University of Petrosani, Romania

The archaeological site of Magura Uroiului (Hunedoara County) is one of the most complex sites in Romania due to its geomorphologic qualities and continuously habitation from prehistory through the Middle Ages. It is a hill with volcanic origin and a series of natural platforms. It was a favorable place both for military fortifications, for civil settlements, and also for quarrying stone. In 2008 a wide-landscape archaeology study was started that includes a detailed digital cartography of the terrain and a 3D reconstruction of the whole archaeological complex and a paleomorphology study. Integrated remote sensing methods (satellite images analysis and geophysical prospects) were used. The first step was a detailed topographical measurement of the site's surface with the help of a total station (over 100 hectares) in order to reveal all micro-relief details, both natural and man-made. The second step was the editing of GIS spatial data, 2D and 3D graphic reconstructions. The third step was the analysis of the geomorphologic evolution of the terrain, the identification and interpretation of man-made features, the recognition of the ways of human intervention in the environment and of the causes and effects generated in the local ecosystem. The fourth step was a interdisciplinary analysis combining remote sensing and geophysical prospects in order to establish the exact inhabited areas, fortification system, road network, etc. Our study is meant to be a multidisciplinary analysis and aims to establish the relationship between man and environment, the difficult part being the extraordinary complexity of this site and its dimensions.

Keywords: GIS, total station, landscape archaeology, field archaeology, cultural heritage

Analyzing Conflicts: Battlefield Archaeology and Computers

Xavier Rubio Campillo
Universitat de Barcelona, Spain

The study of battlefields and other archaeological remains generated by human conflict is the aim of conflict archaeology. These researches are strongly linked to the analysis of terrain, as geographical features are usually decisive to explain the development and results of battles. GIS applications have been intensely used in conflict archaeology from its beginnings, as it allows the creation of hypothesis related to optimal routes, encampment zones and battlefields that could be chosen by the military commanders. Moreover, the particularities of the methodology designed to work on battlefields enforce the archaeologists to use computer analysis, as the location of the findings inside the huge space of a battlefield is the basic source of information in order to study an engagement. Finally spatial analysis is useful to understand the complex dynamics between terrain and human behavior that generated a battle. This paper will show the applications that have been used on two different projects in terms of least cost paths and spatial analysis developed under Open Source programs like GRASS. The first project was centered on locating Roman army encampments created during the Ilerda campaign of the Roman Civil War (49 B.C.E.). The aim of this research was to find, using GIS and terrain analysis, possible Roman encampments, as the zone where the campaign was fought is huge (300 squared kilometers), and a systematic field survey was almost impossible to make. The team integrated data coming

from Julius Caesar's *Commentaries* and archaeology of Roman camps to slope raster maps in order to detect the routes followed by the two armies during the campaign. Computer calculations were done for locating optimal paths through the addition of Roman armies behavior data to basic geographical information. This process narrowed the zones to be surveyed to a handful of hills, the only ones where a Roman army of 40,000 men could have been encamped. The other project was the excavation of a battlefield of the War of the Spanish Succession (Talamanca, 1714). Before the excavation slope analysis determined fords of the stream crossed by the attackers, in order to locate the zones where the battle was fought. Fieldworks involved the use of GPS to track archaeologist routes, as well as the exact position of findings coming from the battlefield. A spatial database was created with this information as well as landscape variables, and a complete set of terrain analysis and statistical computations (least cost paths, neighborhood algorithms, etc.) were made. This applications helped to understand the complex development of a battle of the eighteenth century were more than 5,000 soldiers were involved.

Keywords: GIS, battlefields, conflict archaeology, least cost paths

Session Summary

Thursday, 8:30am–11:45am, Tidewater D

Data Management (General Session)

Chair: Jeffrey Clark, North Dakota State University, United States of America

Schedule

8:30 – 9:00	"Complex Networks in Archaeology," Maximilian G. Schich
9:00 – 9:30	"An Interactive System for Storage, Analysis, Query and Visualization of Archaeological Pottery," Ana Luisa Martínez-Carrillo, Arturo Ruiz-Rodriguez, Francisco Mozas-Martinez, and Jose Manuel Valderrama-Zafra
9:30 – 10:00	"Deducing Event Chronology in an Archaeological Documentation System," Øyvind Eide, Jon Holmen, and Christian-Emil Ore
Coffee break	
10:15 – 10:35	"Structured Data—Vivid Archaeology," Karin Lund
10:35 – 10:55	"Storing and Structuring Archaeological Information," Håkan Thorén
10:55 – 11:15	"Web GIS-Supported Implementation of the CIDOC CRM," Gerald Hiebel and Klaus Hanke
11:15 – 11:45	"Project FNR 02/05/24—Espace & Patrimoine Culturel: Assessment, Critical Analysis, and Perspectives," Jean-Noël Anslijn, Frank Broniewski, Susanne Rick, and Foni Le Brun-Ricalens

Abstracts

Complex Networks in Archaeology

Maximilian G. Schich
Northeastern University, Boston, United States of America

In this talk we examine the complex network properties emerging in a wide range of archaeological data sets. Bringing together methods from the science of complex networks with art-historical expertise, and building on similar successes in other disciplines, such as physics, biology, and the social sciences, we will present a number of exemplary investigations which aim at the production of an entirely new big picture—independent of predefined concepts such as traditional periods or a too narrow focus of research. Throughout its history the discipline of archaeology has produced and continues to generate a number of large data sets, ranging

from relatively simple bibliographies and visual resource collections to more complicated excavation, museum and research databases. In huge collaborative efforts, the overlapping communities building these data sets strive to define the relevant data models, ontologies, vocabularies as well as the necessary query, display and processing rules. CIDOC CRM, Dublin Core or ULAN are only a few examples, which vary considerably in both application and perception by individual scholars. Starting from such definitions, archaeological data sets are put together by combining a number of heterogeneous sources in a process of local user activity, resulting in complex network properties which are often counterintuitive as well as unexpected. Understanding the emerging complex network structure and dynamics of archaeological data, we will be able to redefine our frame of reference, make sense of our sources and evaluate data collection strategies. Our study makes use of large existing legacy data sets, but is also prototypical for similar investigations in the growing *Giant Global Graph of the Semantic Web*, which contains ever more explicitly (semi-)structured data, subject to competing definitions and even more distributed local activity.

Keywords: complex networks, network analysis, network visualization

An Interactive System for Storage, Analysis, Query and Visualization of Archaeological Pottery

Ana Luisa Martínez-Carrillo[1], Arturo Ruiz-Rodriguez[1], Francisco Mozas-Martinez[2], and Jose Manuel Valderrama-Zafra[2]

1. Andalusian Center of Iberian Archaeology,University of Jaén, Spain
2. Department of Graphic Engineering, Design and Projects, University of Jaén, Spain

In this contribution is shown an interactive system for the storage, analysis, query and visualization of archaeological pottery. This system has been developed inside the CATA project (Archaeological Wheel Pottery of Andalusia), whose main aim is the creation of a reference array of pottery vessels accessible through the Internet. This collection is orientated to digitize, protect, and disseminate a sample of pottery vessels documented in archaeological interventions in Andalusia. The access is available to the general public as well as researches. This article illustrates the different steps in the design of the database, the query system, and multimedia applications oriented to the spreading of the information concerning to the archaeological treatment of ceramics.

Keywords: achaeological pottery, interactive system, multimedia applications

Deducing Event Chronology in an Archaeological Documentation System

Øyvind Eide, Jon Holmen, and Christian-Emil Ore

University of Oslo, Norway

In historically oriented research like archaeology, the determination of the chronology of events in the past plays an important role. For example, a burning of a house can seal off the layers physically below and give a partial relative dating of them. A well-known tool in this area is the Harris Matrix used to systematize the contexts and layers found in an excavation. In this paper we will discuss a related but more general tool for documenting and analyzing temporal entities. This tool is developed as a module of a four dimensional event-oriented documentation database based on the conceptual model CIDOC-CRM (ISO21127). The database is developed for an archaeological excavation project in western Norway. In addition to places, events and actors the database is designed to contain texts, images and maps used to document such entities. The system will contain a data set of events, their time-spans and relations between events. The system can detect conflicting dating, can increase precision of starts, ends, and durations of events, and finally can display a spatial and chronological overview. Given a time and a place within the data set, the system can display all possible chronologies for the events in the set. In the CIDOC-CRM there are basically two ways to express chronological information about events. They can be dated relative to each other: before, after, overlap etc (CRM properties P114, P117-120). The events are seen as wholes with a clear-cut beginning and end. The events can also be connected to a timeline through time-span(s). In this perspective the temporal extension of events are defined as two intervals on the timeline, one for the outer bound (P81 at sometime within) and one for the inner bound (P82 ongoing through). For each event, there will be a single possible state outside the outer bounds and inside the inner bounds: before, ongoing or after. Between the outer and inner bounds in each end of the event there are more than one possible state: before or ongoing and ongoing or after. The relations (CRM properties P114, P117-120) can be connected to the inner-outer bounds model. In this case the beginning must be some time between the "left" outer and inner bounds and the end between the "right" inner and outer bounds. Adding relations between the events has three major effects:

1. The number of possible overall states is reduced since the events are no longer independent.
2. The boundaries of time-spans of related events can be adjusted and gap between outer and inner boundaries reduced, reflecting the added information.
3. Conflicting information can be detected when adjustment of inner and outer boundaries results in inner extending outer.

So far, this tool has shown great potential for projects involving large amounts of archival material in preparation for new excavations. Further development includes the possibility of using other temporal constraints, such as durations, and exploring the potential of adding spatial constraints and constraints on actors.

Keywords: event, time-span, deduction, dating, chronology

Structured Data—Vivid Archaeology

Karin Lund
National Heritage Board Sweden, Sweden

The National Heritage Board in Sweden has a department solely dealing with contract archaeology, the Department for Archaeological Excavations. We have developed a GIS, Intrasis, which is a complete field documentation system used to collect field data as well as producing GIS analysis. The software was produced to meet the demand for efficient handling of field and find data for large-scale archaeological projects. All data inside Intrasis Explorer is stored in the same structured way, but archaeologists can use different templates when starting up a new project and can also alter the registration scheme and produce their own metadata, depending on the nature of the individual archaeological project. During the first couple of years, few changes where made to the standard template, although today it is more frequently done. Some external users of the Intrasis system do not allow changes to the standard template—they have instead embraced a company standard template, which facilitates comparative research between sites as well as a standard storage option. Intrasis Analysis provides the archaeologist with wizards, helping them to create analysis, e g distribution maps of selected data. When I am talking about the benefits of Intrasis, archaeologists often express a fear that the use of one single system could produce static archaeology. Field documentation and registration will be done according to what the system offers or allows—rather than reflecting actual needs. The individual scientific approach to the data will be lost. Everyone will produce the same kind of static distribution maps and there will be no adaptation of the site-specific archaeological data. Due to this contract archaeology will supposedly become a streamlined production process instead of creating new knowledge and information about our past. Looking back on eight years of use of the same system, I will argue that it is the other way round. Structured data give the possibility of different kind of research approaches, of interdisciplinary research and of independent archaeological interpretation. I will give some examples from some of our more than 3000 different projects that have used Intrasis. I will compare the types of information stored in Intrasis and show how the results are presented in different final products such as reports, books, articles and exhibitions.

Keywords: GIS, field data, database

Storing and Structuring Achaeological Information

Håkan Thorén
National Heritage Board, Sweden

An archaeological excavation often produces a huge amount of information, information that we as archaeologists must collect to be able to answer our questions and interpret our sites. The collecting process is a different story. This paper deals with how we keep photos, notes, plans and the rest of the documentation

during and after the excavation. Ten years ago we started to develop new software at the Swedish National Heritage Board. The development was started because our existing software was getting too old and there wasn't any software on the market that matched our requirements. The old software was based on a relational database. Information about features, finds, samples, and coordinates were stored in the database. The idea of storing the coded points from the total station measurements in the database was a bit progressive, but we felt that we required something other than the CAD plans that the software produced in order to be able to interpret our large quantity of data. Therefore the first demand for our new software was that it had to be a GIS. The second was a flexible data model. Today, ten years and thousands of excavations later, Intrasis has become one of the most used software packages for managing archaeological information. The object-oriented data model and the possibilities to easily import measurement data has become a success. The data model and the metadata setup make it possible to easily adapt the software to any excavation situation, and the object-oriented approach also makes it possible to store any number of relations between the different objects. In Intrasis, information is stored as objects that are divided into different information classes. A typical example of an Intrasis class is feature, artifact, sample, section, photo, and so on. These classes can be further divided into subclasses, depending on the complexity of the information that is going to be stored. The possibilities to completely change the metadata setup for the database and adapt it to site's excavation parameters explain why we now store more than 1,000 site databases. Most of the databases are different, but since all of them share the same data model they are comparable and easily analyzed and published on the Internet. The aim with this paper is to explain the advantages of an object-oriented data model for storing and structuring archaeological information.

Keywords: object-oriented, database, GIS, Intrasis

Web GIS-Supported Implementation of the CIDOC CRM

Gerald Hiebel and Klaus Hanke
University of Innsbruck, Austria

Thursday

Two years ago, the multidisciplinary project HiMAT was launched to research the history of mining in Tyrol. Ten disciplines from both humanities and natural sciences are organized in 14 project parts, four of which are archeological. For this project, an IT architecture was developed that consists of a document management system, a database and a Web GIS. The CIDOC CRM provides the concept for knowledge organization that is necessary to handle heterogeneous data related to cultural heritage. Out of the CIDOC CRM ten classes (HiMAT main classes) with subclasses and relevant properties were selected to represent the information. A common list of terms to be used within HiMAT was agreed upon and organized in a hierarchical thesaurus. The terms are handled as Types (E55) within the CIDOC CRM model. The upper levels in the hierarchy of terms are the ten HiMAT main classes. The thesaurus is expected to be extended as the project develops. Not only in humanities is knowledge often transferred with documents that are not formalized. In order to make this information accessible to all project parts a document management system was implemented at the start of the project. A Web GIS offers basic data on the regions, like topographic and historic maps, digital terrain models, ortho images and geographic names. In a next step we started to build up a relational database containing spatial objects, the terms of the thesaurus in their hierarchical structure and tables for HIMAT classes and relevant properties. One of the tables will contain information objects (E73) that have a link to the document management system to provide access to the documents. Geographic names (E48) of the Web-GIS are stored as spatial objects (E47) in the database and can be extended and related to other information through the Web GIS. In the first phase of the project we implemented the CIDOC CRM structure in a relational database (Oracle) because tools for maintenance, web access interfaces or connectivity to GIS are well established and standardized. This software setup corresponds to the IT infrastructure of the university where the system should be implemented and maintained after the developmental work is finished. In a future step, the information stored in the tables of the database could be moved to RDF storage as the structure of the tables provide an easy mapping. As Oracle has RDF storage, most of the developments done on the relational database, especially interfaces for input and output of data, including Web-GIS interfaces, could be used for the RDF storage as well. Implementations of the CIDOC-CRM are rare and the combination with a Web GIS interface facilitates visualization and data entry. The use of established and efficient tools allows an implementation with limited resources.

Keywords: CIDOC CRM, web-based spatial information systems, databases, GIS, Work in Progress (Project)

Project FNR 02/05/24—Espace & Patrimoine Culturel: Assessment, Critical Analysis, and Perspectives

Jean-Noël Anslijn[1], Frank Broniewski[2], Susanne Rick[3], and Foni Le Brun-Ricalens[4]

1. Service Public de Wallonie, Belgium
2. Metrico S.A.R.L., Luxembourg
3. Fonds National de la Recherche Luxembourg, Luxembourg
4. National d'Histoire et d'Art du Grand-Duché de Luxembourg, Luxembourg

Thursday

The aim of the Espace & Patrimoine Culturel R&D project (2003-2008) was to develop a computer-aided decision-making tool for use by government ministries, public works contractors (local authorities and administrations), building contractors, planning offices, and private individuals for the maintenance of a cultural heritage-oriented GIS. Existing and potential archaeological, historical, and architectural site locations may thus be taken into consideration during the planning and research stages of construction work. The project was led by the Musée National d'Histoire et d'Art with the financial support of the Fonds National de la Recherche (National Research Fund) in Luxembourg. The main objectives of the EPC project were:

1. Development of a scientific management tool for the national cultural heritage resource
2. Development of an administrative management tool for a national cultural heritage resource
3. Development of an information tool for the public
4. Development of a joint management tool for the territorial development of the country, taking into account cultural heritage constraints in order to study, protect, and preserve this endangered resource

The EPC project adopted the form of a GIS development based on a SMR data model (general inventory of the cultural resource) while multiple geostatistical analyses were carried out the produce the predictive modeling core. The results are diffused through an online map server accessible by any individual. The access level is controlled for privacy and protection reasons. From a technical perspective, the final version of the system uses Open Source solutions for the map-server interface, DBMS core, database interface, and server-side infrastructure, so as to guarantee the project's sustainability and to respond to the high efficiency of Open Source developments for predictive modeling calculations. However during the five-years term, both commercial software and Open Source solutions were used. The EPC data model approach was also designed to allow a potential interoperability with other systems, and neighboring countries' national or regional services in charge of cultural heritage management were consulted and visited. The EPC project has achieved its scheduled objectives, notably on the predictive modeling aspect, producing a map indicating archaeological potential (pilot zones), and testing the model nationwide, to analyse and assess the limitations and identify issues of the methodology. EPC has developed front-end interfaces (network-based interfaces and technologies) to provide rich cultural heritage content to the user: interactive maps (server backend application) and related synthetic documents (site information, cultural heritage analysis, and so forth). The objectives of this paper are to present a brief overview of this five-year development period, propose a critical analysis and assessment of this project, set the stage for further developments, and underline the opportunities offered to extend this study in current developments in the neighbouring Walloon Region, making these "heart of Europe" projects quite noticeable.

Keywords: SMR, GIS, government management, predictive modeling, spatial monitoring

Session Summary

Thursday, 8:30am-11:45am, Patriot

Seeing Beneath the Surface: Remote Sensing and Other Applications for Finding and Assessing Archaeological Sites (General Session)

Chair: Fraser D. Neiman, Department of Archaeology, Monticello, United States of America

Schedule

8:30 – 9:00 "Digital Dunes: Site Structure as seen in GPR from Saruq al-Hadid, UAE," Jason Thomas Herrmann

9:00 – 9:20 "Geophysical Prospection at Portus: An Evaluation of an Integrated Approach to Interpreting Subsurface Archaeological Features," Jessica Ogden, Kristian Strutt, Simon Keay, Graeme Earl, and Stephen Kay

9:20 – 9:40 "Ground Penetrating Radar, Historic Maps and GIS as Operative Tools in Swedish Urban Archaeology," Par Karlsson

9:40 – 10:00 "A New Grid Balancing Method for Geophysics Data," Jackson Cothren and Eileen Ernenwein

Coffee break

10:15 – 10:35 "Tracing Leveled Earthworks at Petersburg," Bruce W. Bevan

10:35 – 10:55 "Geophysical Analysis of a Historic Archaeological Site," William J. Chadwick

10:55 – 11:25 "Trenching On Trial: The Design of Effective and Efficient Trial Trenching Strategies for Discovering Archaeological Sites," Philip Verhagen and Arno Borsboom

11:25 – 11:55 Discussion

Abstracts

Digital Dunes: Site Structure as Seen in GPR from Saruq al-Hadid, UAE

Jason Thomas Herrmann
University of Arkansas, United States of America

Ground-penetrating radar has been a great success in generating detailed images of sub-surface features at Saruq al-Hadid, an Iron Age metal production site covering approximately one square kilometer of the desert in southern Dubai, UAE. Saruq al-Hadid features a 1.5 hectare mound covered with copper slag as well

as a rich material wealth including daggers, jewelry, fishhooks, jewelry, and ceramic and steatite vessels. To date, more than two hectares of the site have been surveyed with GPR, exposing layers of cultural materials interbedded with aeolian deposits that are up to seven meters deep. The ever-changing surface topography of the sands provides a unique challenge for survey, however, the character of the sands and the archaeological materials within offer the potential for unusually clear radargrams. For this reason, these data have been useful in locating buried archaeological deposits including individual artifacts, and in reconstructing site formation processes including sequences of deposition, episodes of erosion and site destruction from excavations prior to this survey.

Keywords: archaeological prospection, ground-penetrating radar, United Arab Emirates, Arabia

Geophysical Prospection at Portus: An Evaluation of an Integrated Approach to Interpreting Subsurface Archaeological Features

Jessica Ogden[1], Kristian Strutt[2,3], Simon Keay[3], Graeme Earl[3], and Stephen Kay[1]

1. British School at Rome, Italy
2. Archaeological Prospection Services of Southampton (APSS), United Kingdom
3. Department of Archaeology, University of Southampton, United Kingdom

Portus, located just north of the Tiber River, Italy, was the port of ancient Rome during the imperial period. The Portus Project is a current project funded by the Arts and Humanities Research Council (AHRC) in collaboration with the Soprintendenza per i Beni Archeologici di Ostia e Porto, and the Universities of Southampton and Cambridge, and is a flagship project of the British School at Rome (BSR). Extensive and intensive geophysical prospection has been employed at Portus within recent years, providing an integrated methodology for discerning the nature and extent of the archaeological remains of the port complex. Recent excavations have allowed for a reciprocal relationship between geophysical and archaeological research, and have paved the way for a regime of meaningful, integrated geophysical research at Portus. Increasingly, archaeo-geophysicists have begun to take an integrated approach to the use of multiple survey methods to investigate potential archaeological features. Here, many types of geophysical and archaeological survey methods have been employed, including magnetometry, electrical resistance, ground-penetrating radar, standing building, and micro-topographic survey, to survey the archaeological record, provide an immense volume of data to be compared and contrasted to the excavation data, and facilitate the interpretation of the archaeology at the site. Often when a multi-method approach is taken, the interpretations, analysis, and presentation of the resulting data is limited to side-by-side comparisons of gray-scaled graphical representations of the data. A distinction is made here between *integrated survey methodologies* and *integrated data analysis*. Recent developments in geophysical data analysis have suggested that in addition to a multi-method approach, data fusion techniques can offer meaningful insights into archaeological features and allow researchers to establish patterns between multivariate data sets that might otherwise go unnoticed. (Kvamme 2006a, 2006b, Neubauer *et al.* 1997, 2002,

Piro *et al.* 2000) The sheer quantity of data, as well as the nature of the archaeology at Portus, have provided an ideal site for the exploration of spatial data and remote-sensing analysis techniques, as well as the assessment of their utility within archaeo-geophysical research as whole. This research attempts to critically assess the field and data processing methodologies used and examine the applicability of a variety of mathematical and multivariate analysis approaches to the prospection results at Portus.

Kvamme, K. L., 2006a. "Integrating Multidimensional Geophysical Data." *Archaeological Prospection*, 13: 57-72.

Kvamme, K. L., 2006b. "Data Processing and Presentation," *Remote Sensing in Archaeology: An Explicitly North American Perspective*, Johnson (ed.) Tuscaloosa: University of Alabama Press, 235-250.

Neubauer, W. and A. Eder-Hinterleitner, 1997. "Resistivity and magnetics of the Roman town Carnuntum, Austria: an example of combined interpretation of prospection data." *Archaeological Prospection,* 4: 179-189.

Neubauer, W., A. Eder-Hinterleitner, S. Seren, and P. Melichar, 2002. "Georadar in the Roman Civil Town Carnuntum, Austria: An Approach for Archaeological Interpretation of GPR data." *Archaeological Prospection*, 9: 135-156.

Piro S., P. Mauriello, and F. Cammarano, 2000. "Quantitative integration of geophysical methods for archaeological prospection." *Archaeological Prospection*, 7: 203-213.

Keywords: geophysics, quantitative methods, GIS, integration, survey

Ground Penetrating Radar, Historic Maps, and GIS as Operative Tools in Swedish Urban Archaeology

Par Karlsson

National Heritage Board, Sweden

Thursday

Within the National Heritage Board's Archaeological Excavation Department, RAA UV, Sweden, we have developed a new approach in connection with trial excavations. The working methods are based on a combination of high resolution Ground-Penetrating Radar (GPR) data from the entire survey area and detailed analysis of historical maps in GIS. This has been done in order to raise awareness prior to the trial excavation regarding the preservation state of the archaeological remains on the site, thereby minimizing the risk of unnecessary destruction of archaeological remains in the context of the archaeological trial excavation. With this approach, the trial excavation trenches can be based on a completely different understanding than before. Field work can be performed with greater precision which allows for a greater cost efficiency while maintaining or increasing the scientific quality is given a larger space. Urban archaeology is an essential part of Swedish contract archaeology. The sphere of activity is to a great extent effected by vast modern destruction due to exploitation and a limited knowledge of the state of preservation on a detailed level. This, together with high demands and ambitions on scientific standards, occurs within more and more restrictions placed on time as well as financial resources. This has contributed to a situation where many rescue excavations are carried out with scientific targets based on a very small empirical knowledge base. The result is often that the archeologists encounter more unnecessary problems in the quest to take full advantage of the knowledge potential of the material. Likewise, it continues to contribute to a situation where the trial and the final rescue excavations are carried out with completely different field methods; trial excavations with an excavator and the emphasis on sections, and hand-dug final excavations with a documentation that emphasizes plan perspective. In many cases, it is difficult or impossible to merge documentation materials from the same site. This is obviously negative, both scientifically and financially. The National Heritage Board Archaeological Excavation Department, RAA UV, is the largest organization engaged in contract archaeology in Sweden. The organization has about 130 employees, including a number of natural science specialists, and operates throughout the country. This paper presents a new approach to trial excavation, based on close cooperation between archaeologists who are specialized in urban archaeology and a geophysicist with special experience in archaeological geophysical prospection. The presentation of the working method will be illustrated by examples from work performed in Swedish medieval and early modern cities.

Keywords: urban archaeology, ground-penetrating radar, historic maps, GIS

A New Grid Balancing Method for Geophysics Data

Jackson Cothren and Eileen Ernenwein
University of Arkansas, United States of America

A major component of the Cultural Resources Management (CRM) work conducted on military installations involves evaluation of prehistoric and historic archaeological sites for National Register of Historic Places (NRHP) eligibility in compliance with federal laws. Traditional methods for site evaluation based on hand excavation are costly, invasive, time consuming, and potentially unreliable. Recent research (conducted in the SERDP Project CS-1263 New Approaches to the Use and Integration of Multi-Sensor Remote Sensing for Historic Resource Identification and Evaluation) has led to new methods that provide exceptionally detailed, remotely sensed images of the subsurface, permitting accurate characterization of cultural deposits for a wide range of archaeological sites. This research has not only demonstrated that remote sensing (including satellite, aerial, and ground-based geophysical sensors) can produce a level of information about subsurface deposits far richer than that provided by highly invasive traditional approaches, but also that large-area (1-2 ha) surveys with multiple instruments are very cost effective; data acquisition typically requiring less than one week of field time. However, the inordinate amount of time required to manually process and fuse the disparate data sets produced by each instrument in the suite is a primary obstacle to much broader adoption and effective use of the methods developed during this research.

At present, fully processing and fusing data from a multi-sensor survey typically requires the expert-level use of seven or more commercial-off-the-shelf (COTS) software packages and hundreds of hours of repetitive work. Making remotely sensed information readily available to DoD CRM programs by streamlining data processing and integration will dramatically reduce labor costs and expertise requirements, and will provide enhanced information content and reliability of survey results (i.e., interpretations of images revealing subsurface cultural deposits). *ArchaeoMapper,* a new software package under development at the University of Arkansas, has the potential to greatly reduce the amount of work required to process and integrate ground based geophysical sensors and other remotely sensed imagery. One of the most time-consuming processes associated with ground-based geophysics methods is correcting the mismatches between edges across the grids in which the data is collected. These mismatches typically give the raw data a checkerboard appearance and prevent effective filtering and feature extraction. Traditional methods are based on iterative approaches in which edges are matched pair-wise until a satisfactory result is obtained. We present a new method (which will be provided as part of *ArchaeoMapper*) based on fitting bilinear and bicubic surfaces to individual grids and matching the edges in a single global step. This methods promises to automate edge matching in at least some geophysics data sets. We show results using actual geophysics data and compare it to iterative methods as well as existing, least squares based global methods.

Keywords: geophysics, edge matching, balance

Tracing Leveled Earthworks at Petersburg

Bruce W. Bevan
Geosight, United States of America

A geophysical survey has traced remnants of the earthen fortifications at the Petersburg, Virginia, battlefield; these earthworks were constructed during the U.S. Civil War in 1864. Trenches and pits dug during the year-long battle were revealed by several geophysical instruments. After the battle at Petersburg, some fortifications were leveled so that those areas could be farmed once again; those earthworks are now invisible at the surface. In the area of this geophysical survey, most of the now-refilled ditches and holes from the battle were detected; however, almost nothing of the parapets (earthen ridges) was revealed, for the soil from those ridges was removed in order to fill the ditches. Two different types of exploration were applied at the battlefield. During an initial survey, detailed maps were made of moderately small areas with many different geophysical instruments and techniques; this test revealed the density of buried features and showed the capabilities of the different methods. A later survey explored a large area with a single instrument and a wide spacing between lines of measurement; this survey allowed a good length of a fortification trench to be delineated in an efficient manner. Several factors simplified these surveys and made them successful: Most of the ground's surface is covered by grass (it was easy to walk in the area of survey); the area has been a park for over fifty years (there is relatively little modern trash); and the natural stratigraphy of the soil is simple and it

changes through archaeological depths (refilled holes, with their altered stratigraphy, were readily detected). Because of these favorable factors, the success of this survey was in the top ten percent of all surveys that might be done. The suitability of the different geophysical techniques was as follows (in decreasing order of success): Ground-penetrating radar, resistivity (mapping and pseudo-sections), EM induction (conductivity and susceptibility), magnetic (total field and gradient), seismic refraction, self-potential, and finally, aerial photography.

Keywords: U.S. Civil War, geophysical exploration

Geophysical Analysis of a Historic Archaeological Site

William J. Chadwick

John Milner Associates, Inc., United States of America

Ground-Penetrating Radar (GPR) is a non-invasive method of prospecting for historic features. In the U.S., this technique is typically used in farms and fallow fields that have undergone extensive periods of farming or areas that are currently paved. Those types of ground disturbance result in noise within the geophysical record. Upon completion of the geophysical prospection, excavation targets (anomalies) are usually identified and small excavation units are opened over those that are most promising. These excavation units typically range in size from 50x50cm to 2x2m in an attempt to expose enough of the anomaly to make a determination of its significance. The purpose of this study was to use GPR over a site where the locations of archaeological features are known. A GPR survey was conducted at a known site after the removal of a plow zone but before excavation. This study used a historic archaeological site identified during a Phase I reconnaissance archaeological survey. Phase I archaeological shovel testing identified an area that contained the remains of a historic structure and a midden within a fallow field. Subsequent to that survey, archaeologists returned to the site and mechanically stripped off the plow zone to expose those features identified during the first survey and to potentially locate additional features. The archaeologists relocated the features found during the initial testing and identified many more. The GPR survey after the mechanical stripping of the plow zone provided feature approximate depth information on those features identified during the stripping and the location of potential features not identified at the interface between the plow zone and substratum. This information led to the development of testing strategies based on volume for the excavation of features and additional testing. As an added benefit to that task, the survey allowed the opportunity to correlate the geophysical anomaly signatures of features directly to the different feature types exposed during the stripping.

Keywords: ground-penetrating radar, historic, archaeology, resource management

Trenching on Trial: The Design of Effective and Efficient Trial Trenching Strategies for Discovering Archaeological Sites

PHILIP VERHAGEN[1] and ARNO BORSBOOM[2]

1. ACVU-HBS, The Netherlands
2. Hazenberg Archeologie, The Netherlands

For several years, the issue of designing effective and efficient strategies for archaeological survey has been debated by Dutch archaeological heritage management. Archaeologists are increasingly aware of the risks of missing certain archaeological sites when using an ineffective strategy. Developers, however, are equally concerned about the efficiency of the survey methods chosen. They don't want to spend money on research based on methods that are no more effective than other, less expensive methods. Much of the debate until now has revolved around the appropriate use of core sampling for archaeological (subsurface) survey, an approach not commonly used outside the Netherlands. Core sampling has proven to be a successful survey strategy in many cases but is clearly limited in its abilities to detect archaeological remains (Verhagen, 2005). Sites with distinct features but with very few or no artifacts will in general not be detected by means of core sampling. Unfortunately, the alternative (but more expensive) method, trial trenching, is not without its problems. The rules that should be applied for designing an optimal strategy for site discovery in terms of trench width, trench length, trench spacing, area coverage, and configuration are poorly understood, in spite of some earlier research (Hey and Lacey, 2001). As a consequence, trial trenching strategies used in the Netherlands are currently based on personal experience and preference, rather than on quantitative methods and empirical data. The research presented in this paper is part of a project to establish guidelines for trial trenching in Dutch archaeological heritage management, as part of the Quality Norm for Dutch Archaeology (SIKB, 2006). These guidelines are intended to accompany an earlier guideline written for core sampling survey (Tol *et al.*, 2006). Given the lack of understanding of the role of the various factors involved, an analysis was made of the parameters influencing the success rate of trial trenching strategies for discovering archaeological sites with different characteristics (size, shape, feature density and artifact density). As no straightforward mathematical or statistical solutions to the problem are available, the discovery probabilities for different site types using various trenching strategies were then determined by means of simulations. The results obtained indicate that, contrary to general belief among Dutch archaeologists, relatively short trenches are most efficient for discovering archaeological sites, as they allow for shorter distances between trenches while maintaining the same area coverage. The paper will further discuss the implications of applying these new insights in a practical guideline.

Hey, G. and M. Lacey (2001). *Evaluation of Archaeological Decision-making Processes and Sampling Strategies*. Kent County Council/Oxford Archaeological Unit, Oxford.

SIKB. (2006). *Kwaliteitsnorm Nederlandse Archeologie versie 3.1*. SIKB, Gouda.

Tol, A.J., J.W.H.P. Verhagen, and M. Verbruggen (2006). *Leidraad inventariserend veldonderzoek*. Deel: karterend booronderzoek. SIKB, Gouda.

Verhagen, P. (2005). "Prospection Strategies and Archaeological Predictive Modeling," in M. van Leusen & H. Kamermans (eds.), *Predictive Modeling for Archaeological Heritage Management: a research agenda*. ROB, Amersfoort, 109-121.

Keywords: trial trenching, archeological heritage management, simulation

Session Summary

Thursday, 8:30am-11:45am, Liberty

Computer Applications in Maritime Sites

Chairs: ERIC DENNIS RAY, Program in Maritime Studies, East Carolina University, United States of America

PETER BRYSON CAMPBELL, Program in Maritime Studies, East Carolina University, United States of America

Maritime sites present a unique set of challenges to archaeologists. The sites are sometimes submerged, limiting time and equipment on-site. They are frequently inaccessible to the public, making effective outreach difficult. Added to these issues, ships are incredibly complex structures, consisting of a variety of quickly-decomposing organic materials arranged in non-uniform, complicated ways. Increasingly, high-tech methods are being used to overcome these challenges. Maritime archaeologists are using new surveying and rapid photogrammetric methods to rapidly survey sites at low-cost. Historical and archaeological data can now be visualized in new ways, allowing a better picture of what historic ships looked like, and how they were operated. The Internet is being harnessed for outreach, allowing the interested public to visit these inaccessible sites and connect with their maritime heritage. These computerized methods allow much greater accuracy and higher speeds of recording, at a low cost. They allow fragmentary or sparse data from the archaeological and historical record to be reconstructed into models of complete ships, providing new information about usage, construction, rigging, and performance about these vessels—even vessels that are heavily deteriorated or are only found in the historical record. Finally, all this data can be presented via virtual museums and the Internet, allowing public outreach with minimal site disturbance—a photograph requires no destruction of the site. This session explores the particulars of some of these new methods. Papers in this session will detail new applications of computerized technology in a maritime context, including research, data collection and surveying, photogrammetry, reconstruction and modeling, and outreach and presentation methods.

Thursday

TOPICS: 3D data capture and modeling, photogrammetry and imaging, high precision surveying, virtual museums

KEYWORDS: maritime, reconstruction, visualization, surveying, photogrammetry

Schedule

8:30 – 9:00 "The Nature and Potential Benefits of Geographic Information Systems in Submerged Cultural Resource Management," Gordon P. Watts, Jr.

9:00 – 9:20 "Site Digitization and Steps towards E-publication, Visualization and Comparative Data Analysis," Amer Bazl Khan

9:20 – 9:40 "Virtual 3D Approximation of a Phoenician Seventh-Century B.C.E. Boat: Mazarrón 1," Carlos Cabrera Tejedor

9:40 – 10:00 "Reconstruction of Archaeological Features in Mediterranean Coastal Environment by Means of Non-Invasive Techniques and its Digital Musealization," Gaetano Ranieri, Francesco Loddo, Alberto Godio, Stefano Stocco, Pietro Lucio Cosentino, Patrizia Capizzi, Paolo Messina, Alessandra Savini, Vittorio Bruno, Miguel Angel Cau, and Margherita Orfila

Coffee break

10:15 – 10:45 "3D Reconstruction of an Eighteen-Century Sloop," Eric Dennis Ray

10:45 – 11:15 "High Tech and Low-Cost Archaeological Recording: Total Station, Rhino CAD, and RhinoPhoto," Peter Campbell

11:15 – 11:45 "Archaeological Documentation and Reconstruction of the 17A Derelict Vessel, Back River, Georgia," Joshua A. Daniel

Abstracts

The Nature and Potential Benefits of GIS in Submerged Cultural Resource Management

Gordon P. Watts Jr.
Tidewater Atlantic Research, Inc. and Institute for International Maritime Research, Inc., United States of America

One of the most important aspects of effective data management is the ability to collect, store, and recall information. Traditionally submerged cultural resource managers have collected data in the form of literature, reports, photographs, maps, plans, and artifact collections. That type of information management system has been based on extensive hard copy files, a library of associated literature, and collections of historical and contemporary maps. Most state wide collections require considerable space and extensive personnel experience to function with any degree of efficiency. While those systems survive into the twenty-first century, the rapid development of GIS provides managers with a highly effective tool for resource management. A GIS can eliminate the necessity for maintaining cumbersome hard-copy collections and dramatically reduce the time it takes to identify and recall the data necessary to support management decisions. During the past decade Tidewater Atlantic Research, Inc. (TAR) and the Institute for International Maritime Research, Inc. (IIMR) have developed a number of GIS projects for both state and federal submerged cultural resource management programs. The first was constructed for the Charleston Harbor Project; a five-year Special Area Management Plan developed to focus management attention on the impact of development on the Charleston Harbor estuary system. In Virginia, the United States Army Engineer District, Norfolk, has the responsibility for navigation channels in the James River, one of the most historically sensitive waterways in the United States.

To assist the Corps in identifying and managing submerged cultural resources TAR developed a GIS for the James River and Hampton Roads. Working through the IIMR, TAR personnel produced a GIS that identified historically and archaeologically documented shipwrecks in Virginia waters that fall under the management authority of the Naval Historical Center (NHC) and the Commonwealth of Virginia. That GIS provided the historical and archaeological data necessary for both agencies to coordinate management issues. A similar system was developed for the NHC and the Georgia Department of Natural Resources. In conjunction with a Historic Archaeological Resources Protection plan for the Georgia Department of Natural Resources, TAR developed a GIS that focused on areas of submerged cultural resource sensitivity, previously surveyed areas, and known sites. Although much smaller in geographical scope, TAR personnel also developed a GIS for the Monitor National Marine Sanctuary. That GIS is based on the wreck site and identifies the location and nature of material generated by on-site investigation. An examination of those models illustrates the various attributes of a GIS and provides insight into how valuable a tool it can be for submerged cultural resource management programs and site-specific investigations. A review of the programs also illustrates the beneficial nature of this computer-based system of data storage, recovery and analysis. In a climate when budgets and personnel are being reduced and in many cases management responsibilities expanded, the benefits of using GIS becomes readily apparent. The increased ease with which a GIS can be created and utilized makes that system an even more attractive tool today.

KEYWORDS: GIS, submerged cultural resource management

Site Digitization and Steps Towards E-publication, Visualization and Comparative Data Analysis

AMER BAZL KHAN
Flinders University, Australia

This paper will discuss approaches towards the digitization of archaeological site data and discuss possibilities for e-publication, visualization and comparative data analysis. The Flinders University Maritime Archaeology Site Digitization (FUMASD) project began out of an attempt to digitize and publish archaeological field data from almost a decade of annual field schools run by the Maritime Archaeology Program at the University. A direct outcome of the FUMASD project has been to provide broader public and academic access to this data. The data archive for each field school consists of a range of electronic and hardcopy files. As part of the project all primary and historical hardcopy data have been scanned into PDF, TIFF, or JPEG format. With this document level data encapsulation a number of online publication options have been identified, such as a website, an online journal and a site register. Development of structured metadata has been investigated to further the comparative data analysis potential of this content. While a document level encapsulation is useful and easy to implement from an e-publication perspective, it has proved limiting for data analysis purposes. To complement the document scanning process an object or artifact level database was developed. In contrast

to the typical site level conceptualization used for many heritage management implementations this object level approach was aimed at enabling comparative data analysis and research at the artifact, or sub-site level. A number of technological solutions have been considered to address the e-publication, visualization and data analysis objectives of the project. Digitization of site plans was completed using Site Recorder 4.0. This enabled an XML export of artifact data and thus provided an object level data extraction pathway from the site data. Various visualization options were considered, including Google Earth integration and 2D visualization using SVG files. 3D visualization has not been attempted yet but is being considered using VRML or X3D. The site plan data extraction will be pushed into a relational or XML database and will be accessible through a web forms and reporting interface. Options are still being investigated for further developing this interface however PHP, JSP and .Net application server environments are being considered. Opportunities for Open Source integration and various online content delivery methods are being considered for the query and reporting front end. Applications for comparative object level data analysis is still being explored, however given the feedback received on this part of the project so far, the notion of object level data standardization has been brought into question within the archaeological research community at Flinders. This notion of standardization appears to challenge site specific and research focused requirements for data conceptualization. The needs for standardization to enable comparative analysis (and thus searchability) appear to be in direct conflict with the exploratory and unrestricted flexibility of independent archaeological research. While we continue to experiment with this, an extensible and standardized data type definition may be just the solution we are seeking to reconcile these apparently divergent needs.

Keywords: e-publication, visualization, data analysis, site digitization, data standardization

Virtual 3D Approximation of a Phoenician Seventh-Century B.C.E. Boat: Mazarrón 1

Carlos Cabrera Tejedor
Texas A&M University, United States of America

Unlike Greek and Roman shipbuilding, which is fairly well known through many examples, Phoenician shipbuilding remains largely a mystery. Shipwreck evidence explaining ancient Eastern Mediterranean ship construction is limited to only a few examples. Recent discoveries at Mazarrón beach in Spain, provide the best material to improve our understanding of Phoenician shipbuilding technology during the Iron Age. The wooden remains of Mazarrón 1 belong to a shipwreck that represents a very important link in the evolution of shipbuilding for many reasons: it is one of only two shipwrecks that we know of from the seventh century B.C.E. (the second one is the Mazarrón II, a twin ship that is still underwater); it is one of the few known ships that follow the Semitic shipbuilding tradition of pegged mortises and tenons (Cape Gelidonya and Uluburun shipwrecks); and finally, the ship has an additional assembling technique totally unknown until now. The purpose of this project was to analyze, in detail, the design and construction of this seventh-century B.C.E. Phoenician vessel and to present the construction details of the Mazarrón 1 hull. Without having the

real hard data of the vessel's wooden remains and by using only basic data (such as a few photos and essential measurements) a two-dimensional model was first created, and later a three-dimensional virtual model. After the approximation was made, the virtual results were compared with the real ship's remains. The results were so similar to reality that the validity of this method for reconstructing ancient vessels can be asserted. This paper will first present the construction details of the Mazarrón 1 hull through an approximation made using two different, but complementary, approaches: two-dimensional drawings that follow the nautical reconstruction techniques developed by Mr. Richard Steffy; and a virtual three-dimensional model created from the two-dimensional drawings and made with Rhinoceros software. Finally, the paper will demonstrate how accurate the results can be if the two presented approaches for the reconstruction of ancient vessels are applied.

Keywords: 3D modeling, shipbuilding, Phoenicians, Iron Age, Spain, Mazarrón

Reconstruction of Archaeological Features in Mediterranean Coastal Environment by Means of Non-Invasive Techniques and its Digital Musealization

Gaetano Ranieri[1], Francesco Loddo[1], Alberto Godio[2], Stefano Stocco[2], Pietro Lucio Cosentino[3], Patrizia Capizzi[3], Paolo Messina[3], Alessandra Savini[4], Vittorio Bruno[4], Miguel Angel Cau Ontiveros[5], and Margherita Orfila[6]

1. University of Cagliari, Italy
2. University of Turin, Italy
3. University of Palermo, Italy
4. University of Milan, Italy
5. University of Barcelona, Spain
6. University of Granada, Spain

Archaeological prospection and excavation of an ancient settlement is a slow, careful and consequently costly operation. In the Mediterranean region, cities were often built next to the coastline, in order to provide bases for trade along the most convenient pathway of the time: the sea. Prospection of such sites is particularly difficult and slow because these cities are buried or sunk into the sea. The need arises for a comprehensive prospection that can delineate the areas of further direct investigations. Results can also have a cultural and touristic value before the full site excavation by means of high resolution renderings and 3D digital representations of the subsurface. This work deals with the development and the application of an integrated methodology and visualization techniques for 3D rendering of geophysical data of the buried and submerged archaeological features in complex environment such as coastal planes. In this work we present the results from marine and ground geophysical prospection of the Phoenician, Punic and Roman city of Nora, in the South Coast of Sardinia and the Roman city of Pollentia, in the North East of the Mallorca Island. The lagoon, close to the city of Nora, was investigated with a continuous marine electrical resistivity tomography and with the sub-bottom profiler surveys to find features linked to the presence of the ancient harbor. Measures were carried out by means of a customized catamaran, appositely developed the for marine geophysical surveys in

shallow water. The data processing led to: 1) the reconstruction of resistivity sections and 3D renderings; 2) the comparison between the electrical and the sub bottom profiler survey results. This latter step permitted us to identify some structures related with the main features observed by the sub-bottom profiler; in particular we found a channel that could be the access to the ancient harbor. Near the lagoon in the surroundings of the ancient town a georadar survey was carried out in order to find the old amphitheater. The 3D reconstruction of old roads, aqueduct and of a small part of amphitheater was made in a critical environment. Digging exactly confirmed the reconstruction. In the Pollentia site, we stress the role of the geophysical investigation in unexplored areas to map the near surface archaeological features and exploit high-resolution information acquired by electrical and georadar investigation for a realistic 3D rendering of the main features, for a virtual museum of the buried settlements. The geophysical data pointed out the presence of several well-organized features that are related to the buried remains of the ancient walls of the town. Starting from the 3D rendering of the main geophysical anomalies, we applied techniques for virtual imaging of the ancient town. We tested both commercial and Open Source technologies. The former has a limited access to the model because it needs a dongle key and consequently doesn't allow wide-scale diffusion of the results, so we developed a software tool based on the Open Source VRML technology.

Keywords: geophysics, electrical tomography, georadar, sub-bottom profiler, virtual reconstruction

3D Reconstruction of an Eighteenth-Century Sloop

Eric Dennis Ray

East Carolina University, United States of America

Rapid 3D modeling tools adapted from the industrial design and engineering fields have allowed new inroads into the reconstruction of historic ships. This paper presents a method for rig reconstruction and sailing analysis of historic ships through a 3D reconstruction, using the eighteenth-century colonial sloop *Lady Washington* as a case study. Prior to the use of 3D modeling, rig reconstruction and sailing analysis was a time consuming method, and was very difficult to verify. Tank models or full-scale replicas were needed to test sailing performance and characteristics, as well as the validity of the rig reconstruction. This method uses the Rhinoceros modeling tool to reconstruct an eighteenth-century sloop and gather and idea of its performance characteristics. It can also provide an idea of the likelihood of various sail configurations. This method can be generalized for use on any historic sailing ship, whether the data source for the reconstruction is archaeological, historical, or pictorial.

Keywords: 3D reconstruction, maritime archaeology, historic ships

High Tech and Low-Cost Archaeological Recording: Total Station, Rhino CAD, and RhinoPhoto

PETER CAMPBELL
East Carolina University, United States of America

Tools from diverse fields such as engineering and geology have often been appropriated by archaeologists, but none have been as accessible and accurate as the computer technology available today. Programs and tools developed for other fields are creating cheap and fast methods for fieldwork in archaeology. Total stations, the Rhino CAD program, and RhinoPhoto are such technologies. Examining work over three archaeological projects, the ease and speed of recording archaeological sites with these technologies will be explored. Accuracy increases, while time and error decrease. With the benefits and limitations of the technologies understood, these methods can be used on most archaeological sites.

KEYWORDS: Total station, Rhino CAD, RhinoPhoto

Archaeological Documentation and Reconstruction of the 17A Derelict Vessel, Back River, Georgia

JOSHUA A. DANIEL
Tidewater Atlantic Research, Inc., United States of America

Due to the widening of the Highway 17 bridge over Back River, Georgia, the excavation of a late ninth-century bark (barque) was carried out by personnel from Tidewater Atlantic Research (TAR) of Washington, North Carolina under an agreement with Post, Buckley, Schuh & Jernigan. Because of the amount of hull structure that is only accessible by diving and the limited amount of time the remaining elements of the wreck were exposed at low tide, traditional approaches to mapping and documentation would not produce sufficient data in the time allotted for the field investigation. The decision was made to employ the Vulcan Spatial Measurement System for mapping. This system consisted of an optical receiver, a handheld computer for data collection, and two laser transmitters that would provide highly accurate, three-dimensional points for use in modeling the shipwreck digitally. Further, this system required no on-site grids or other reference structures that would be subject to disturbance by the intertidal elements. As excavation progressed, mapping and documentation was initiated. Following the ebb tide, the hull was washed clear of accumulated sediment and debris. Measured drawings were made of diagnostic features of the wreck. In addition, measurements of design and construction features were made to confirm and supplement subsequent laser mapping. Photographs were taken to record exposed sections of the hull. When recording and photography of the starboard side of the vessel were complete to the level of low water, the laser system was used to collect points identifying all exposed features. After exposed features were recorded and the data were verified, sections of planking were removed to record floors, futtocks, the upper seams of outer hull planking, and the upper

edge of the keel. In the submerged stern section of the vessel, divers continued to make measured drawings to document diagnostic features. Once the stern structure was understood and diagnostic features were identified, the laser system was again employed. Mapping underwater sections of the hull required extensions to the optical receiver and floating the data recorder in a waterproof vessel. Data collected using the Vulcan system was imported into Rhinoceros, a 3D Computer-Aided Design (CAD) program. Using approximately 3,000 points in conjunction with photographs and measured drawings, TAR personnel were able to accurately record and reconstruct the surviving remains of the vessel.

Keywords: shipwreck, three-dimensional mapping, lasers, Rhinoceros, reconstruction

Index

Workshops

Round Tables

Posters

Papers

Authors

A

B

C

E

F

L

M

N

O

P

R

S

V

W

List of E-mail Addresses

Acevedo Pardo, Carlos .... carlos.acevedo@hcu-hamburg.de
Adamo-Villani, Nicoletta .... nadamovi@purdue.edu
Adepelumi, Adekunle Abraham .... aadepelu@oauife.edu.ng

Weniger, Christian.......weniger@neanderthal.de
Werner, Klaus E.......kewerner@fastmail.fm
Whitcher Kansa, Sarah.......skansa@alexandriaarchive.org
Whitfield, Susan.......susan.whitfield@bl.uk
Whitley, Thomas G.......tomwhitley@brockington.org
Wilcox, William.......billwilcox@wilcox53.freeserve.co.uk
Wilkinson, Tony.......t.j.wilkinson@durham.ac.uk
Wilson, James W.......wilsonjw@jmu.edu
Wilson, Michael Dale.......mwilson@nhm.org
Wood, James.......jww3@psu.edu
Wong, Dorothy.......dcw7a@virginia.edu
Wrobel, Sigrid.......sigrid.wrobel@vti.bund.de
Wu, Jiang.......jiangwu@email.arizona.edu
Wu, Zhongke.......zwu@bnu.edu.cn
Wurmser, Laurent.......laurent.wurmser@breuckmann.com
Yano, Keiji.......yano@lt.ritsumei.ac.jp
Ye, Lexiang.......lexiangy@cs.ucr.edu
Yin, Xin.......yin@cv.ci.ritsumei.ac.jp
Zambanini, Sebastian.......zamba@prip.tuwien.ac.at
Zancajo, Julio.......jzancajo@usal.es
Zerneke, Jeanette.......jlz@berkeley.edu
Zhang, Ziqi.......Z.Zhang@dcs.shef.ac.uk
Zhou, Mingquan.......mqzhou@bnu.edu.cn
Zhu, Qiang.......qzhu@cs.ucr.edu

Notes