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

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Abstract

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 to some extent to a 'time machine' which offers 'journeys to the past'. This paper sets out to give a brief description of a reconstruction task already accomplished that used CAD software. The reconstruction in question involved the buildings which make up the Roman Villa of Freiria in São Domingos de Rana, Cascais, Portugal.

The graphics procedures used in this research work are described, viz., archaeological survey of the structures carried out in the course of field work, conversion of data into digital format and three-dimensional modelling, criteria and limitations on the reconstruction of structures and, finally, analysis and manipulation of the space.

Since the work is not quite complete the conclusions presented at the end of this paper relate to interim results and convey some concerns about the next developments to be implemented.

Key words: 3D Model; Virtual Scenarios; Recreation of Social, Urban and Architectural Environments; Visualization of a Recreated Space.

1 Introduction

The research was driven, in general, by a desire to see the potential inherent to virtual reality tools, and specifically to assess their applicability to three-dimensional modelling in the sphere of architecture and archaeology. In fact, as a way of justifying all the theoretical development of the earlier stages, it was decided to apply the knowledge acquired by creating a virtual three-dimensional model to an actual case study, in time and space - the Freiria Roman Villa.

The state-of-the-art was reviewed, guided by and archaeological research methodology. A traditional systematization process ascertained that the first stage to tackling the problem was field work. Analysis of finds allowed theories to be formulated (about the construction, too) and representations were established in the context of these inferences that permit the disclosure of these ideas. This sequence is summarized in the table below; it was repeated as often as new discoveries rendered it necessary (Fig. 1).

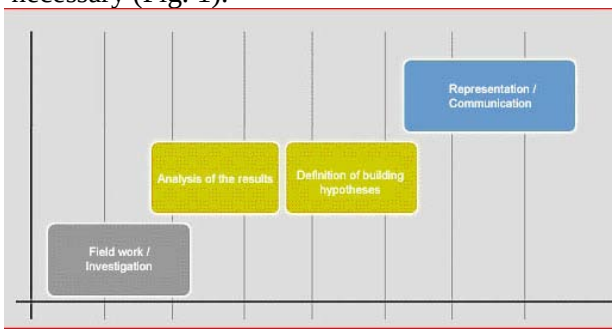

Figure 1. Regular procedure in archaeological research.

The proposal is to dynamize the traditional research process by enlisting the aid of additional computer search tools to develop three-dimensional models. This will make it possible to incorporate information at earlier stages of the analysis and so foster interactivity between the find and the proposal, as well as promoting guidelines for optimizing the field work (Fig. 2).

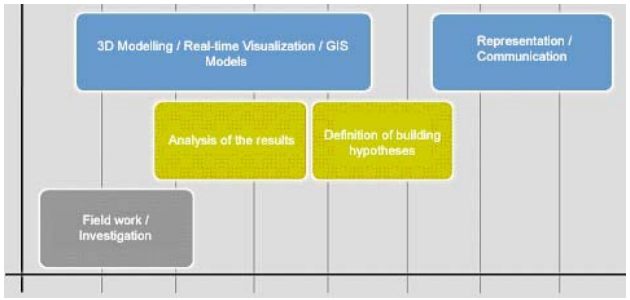

Figure 2. Short-term progress of research.

The model is used to visualize and disseminate the field work and also – mainly, in fact – as a working tool to test and 'manipulate' theories.

2 Goals

The following objectives were established for the experimental work:

- to use the potential of three-dimensional modelling and visualization to give a new perspective to archaeological research;
- to use the three-dimensional model in a virtual reality setting, adding items of ambience to give a more realistic idea of the space;
- to create a working method that enables three-dimensional modelling to be a regular tool in archaeological research as a way of refining construction hypotheses of an object or space.

3 Case study

The object chosen to create the virtual model is the group of structures that comprise the Roman Villa of Casal da Freiria in São Domingos de Rana, near Lisbon, Portugal (Fig. 3).

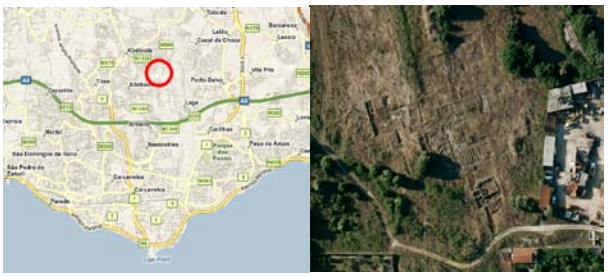

Figure 3. Location of Freiria.

The first news about the site was given by Virgílio Correia in 1912, mentioning there being surface traces. It was only in 1985 that archaeologists José d'Encarnação and Guilherme Cardoso embarked on field work leading to the systematic investigation of the locale[1] [2] [3].

After the first drillings it was possible to show that these buildings had been occupied for a period of over 300 years, from the 1st to the 4th century AD[4].

The site consists of (Fig. 4):

1 – Domus – manor house – which was constructed around a central courtyard, according to Roman social organization;

Infrastructures needed for day to day life, and these were arranged around a second courtyard and consisted of[5]:

2 – Storehouses/press, outbuildings related to farm work;

3 – Houses and servants quarters (cells);

4 – Baths; and,

5 – Barn.

Despite the information provided by the excavations about the built area, the true extent of the pars rustica is still unknown[6] [7].

[1] Guilherme Cardoso and josé d'Encarnação, *Espaço Cidadela: Cascais no tempo dos Romanos* (Câmara Municipal de Cascais, Instituto Português do Património Cultural, 1986).

[2] Guilherme Cardoso, *Carta arqueológica do concelho de Cascais* (Câmara Municipal de Cascais, 1991).

[3] Guilherme Cardoso and José d'Encarnação, *Cascais Romana: Catálogo da Exposição Temporária* (Associação Cultural de Cascais, 2002).

[4] Guilherme Cardoso and José d'Encarnação, "Notas sobre a ocupação proto-histórica na *villa* romana de Freiria", (*Revista de Guimarães*, vol. Especial, 1999): 741-*757*

[5] Guilherme Cardoso and José d'Encarnação, "A villa romana de Freiria e o seu enquadramento rural", (Separata de *Historia Antigua, vol. X-XI* Ediciones Universidad Salamanca, 1993).

Figure 4. Aerial view of the *villa*.

The importance of this archaeological site stems not so much from the wealth of its owners[8], normally reflected in the quality of the items found, but from the discovery of a rare example of a barn in the Iberian Peninsula.

4 Survey Data

Modelling of the buildings required gathering graphic data on them, and this basically amounted to drawings and photos obtained during the archaeological campaigns.
The drawings represented two types of survey: topographical and archaeological.
The archaeological survey was a systematization of the procedures involved in the excavation work[9]. The excavation grid is divided into 2x2 metre squares covering the areas to be excavated. The structure is copied onto graph paper in the proportion 100 to 5 (i.e. scale 1: 20), to record all the main points of the object

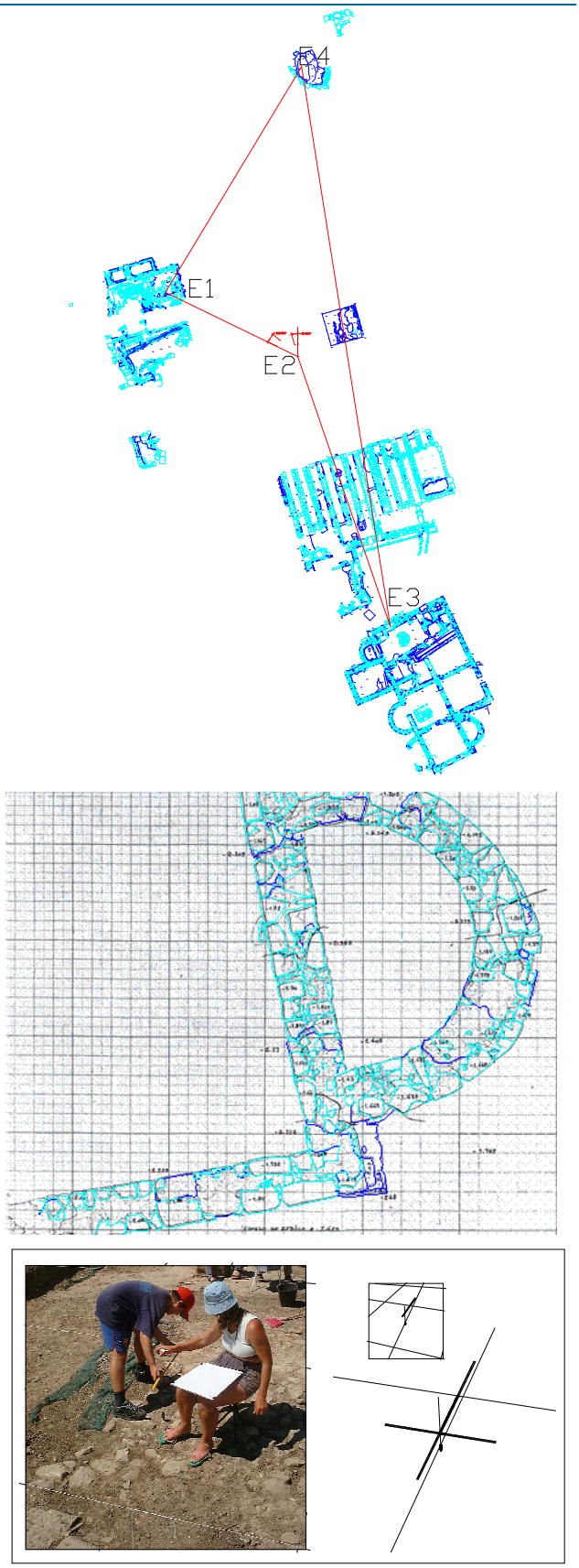

Figure 5. Archaeological survey of Freiria: data obtained between 1995 and 2001.

[6] Jean-Pierre Brun, "Production de l'huile et du vin en lusitanie romaine", (*Conimbriga* XXXVI, 1997): 45-72.

[7] Guilherme Cardoso and José d'Encarnação, "Economia agrícola da região de Olisipo: O exemplo do lagar de azeite da villa romana de Freiria", (*Économie et territoire en Lusitanie romaine*, 1999): 391-401.

[8] Guilherme Cardoso, "Um tesouro monetário do Baixo Império na villa de Freiria (Cascais)", (*O Arqueólogo Português*, Série IV, 13/15 1995-1997): 393-413.

[9] Rodrigues, *A técnica alemã de escavação arqueológica*. (Separata de Lucerna, Vol. I, nº 3-4 Edições Marânus, 1985).

by measuring to the limits of the grid, cutting down the error resulting from a perspective observation.
The field drawings were then converted to digital format in one file to give a detailed record of the group as whole, which was georeferenced so as to place the structures on their sites (Fig. 5).
The topographical data were obtained in two ways: field survey at the request of the archaeologists so as to be able to provide information on the group to programme the field work [topographer, José António de Oliveira]; and examination of the town hall's land register to find details about the land surface on a scale of 1:100 (Fig. 6).
The photographic survey [®Guilherme Cardoso] is the outcome of painstaking field work and enables us to see the details of the site, with particular reference to the vertical component. For this the place and orientation of the photographs were marked on the layout scheme (Fig. 7).

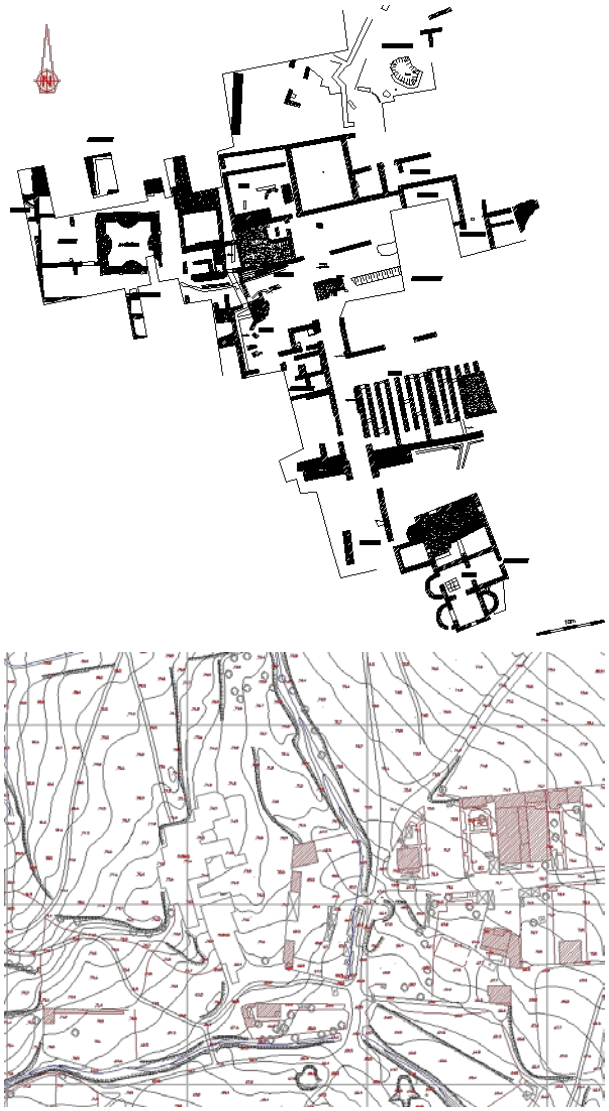

Figure 6. Topographical survey of Freiria.

Figure 7. Photographic survey of Freiria.

5 Three-dimensional modelling – Construction of the space

The modelling of Freiria needed the data collected previously to be harmonized in a single system Fig. 8). The demands made of the software as a modelling tool were[10]:

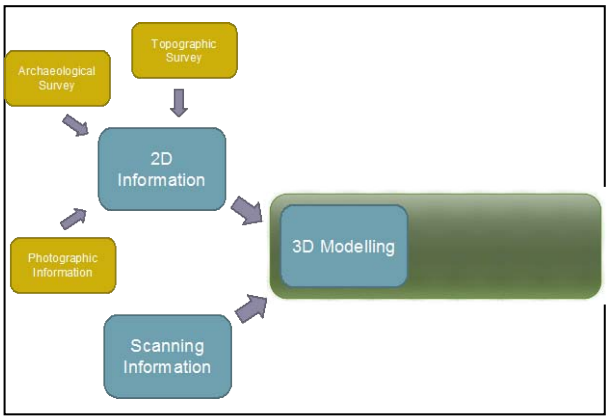

Figure 8. Diagram of modelling method.

- to allow the manipulation of meshes (vertices, lines, faces and objects);
- to enable the import of meshes (for scanned surveys);
- to enable the texturing of models (texture map and bump map, at least);
- to have a tool to create a topography based on 3D lines, or similar (essential).

And as working software it would be useful if it offered[11]:

- easy and intuitive link with the model structuring;
- support for a lot of types of texturing (personalization of textures);
- the possibility of creating a library of extra items to add to the scene (tools, furniture, clothes, vegetation, etc.);
- integration of an artificial intelligence engine that could define customized scripts (individual and mass); and finally,
- good quality graphics and performance in real time.

For this level of performance the best solution was found to be to do the modelling in two stages, using two software programmes with different scope: one for the visualization, and the other for manipulation. Care was taken to ensure their compatibility. The first step was thus to build the structures in 3ds Max® (©Autodesk™, Inc.) and afterwards to export them to a game engine. This satisfies all the demands established without requiring in-depth knowledge of programming.

We used Gamebryo™ from Emergent Game Technologies (Fig. 9), as a case study. This choice was based on the following factors:

- ease of editing with the map creator (freeware);
- inclusion of a vegetation generator – SpeedTree™;
- having published games, one of them with a library of objects related to the period being studied – Oblivion™;
- free use if not for commercial gain.

Figure 9. Examples of virtual interaction – Emergent Game Technologies.

The three-dimensional modelling was taken in separate steps - support, existing and proposed - and started off by creating the terrain. The first measure was to simplify the TIN to make the system more operational. For this a two-metre mesh (based on the grid used for the archaeological survey) was superimposed to 'conform' with the terrain. The result was just as accurate and much easier to manipulate (Fig. 10), and it was only necessary to check the periphery of the grid.

The present walls of the Freiria buildings were added to this support. Similarly, the structures were simplified to make the model more operational[12]. This simplification was designed to remove excess elements inside the walls, being based on the topographical survey data (Fig. 11).

[10] Michael Morrison, *Becoming a Computer Animator*. (1ª Ed. EUA: Sams, 1994).

[11] Michael Abrash, *Michael Abrash's Graphics Programming Black Book Special Edition.* (The Coriolis Group, Scottsdale Arizona, 1997).

[12] Mario Russo, *Polygonal Modeling: Basic and Advanced Techniques.* (Wordware Publishing, Inc., 2005).

Basically, the most prominent details in the archaeological survey were extruded and used as texture elements on the walls (also extruded) of the buildings drawn in the topographical survey (Fig. 12).

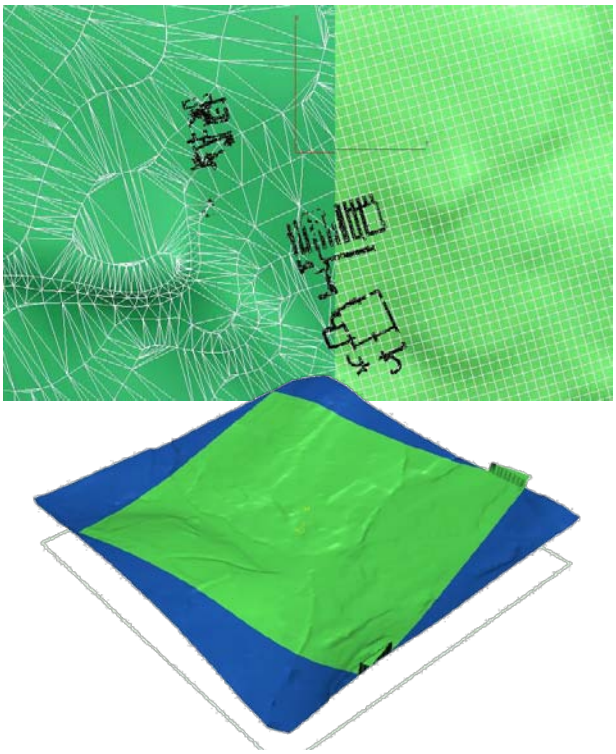

Figure 10. Conversion of the topographical survey into geometry and adjustment of the grid.

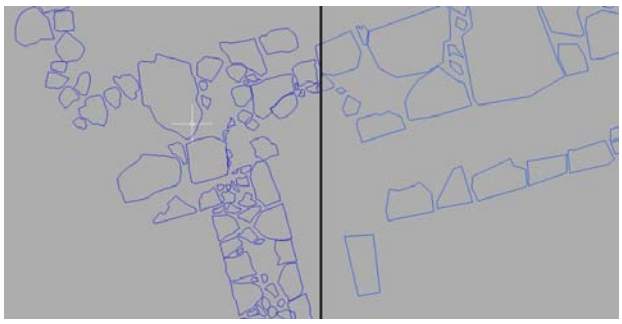

Figure 11. Original file (left) and optimized (right).

Finally, the details of the structure were adjusted on the basis of the photographic survey (Fig. 13). And so a detailed model of the present state was obtained (Fig. 14)

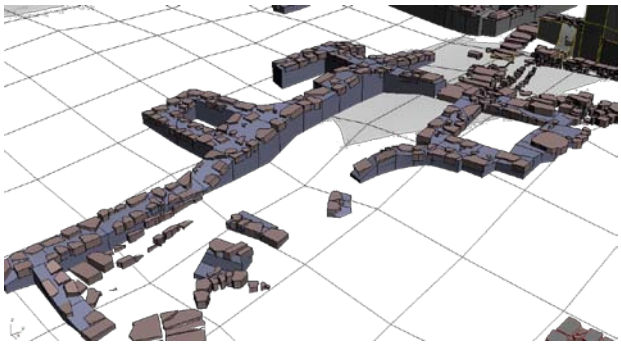

Figure 12. Example of integration of existing details into the support.

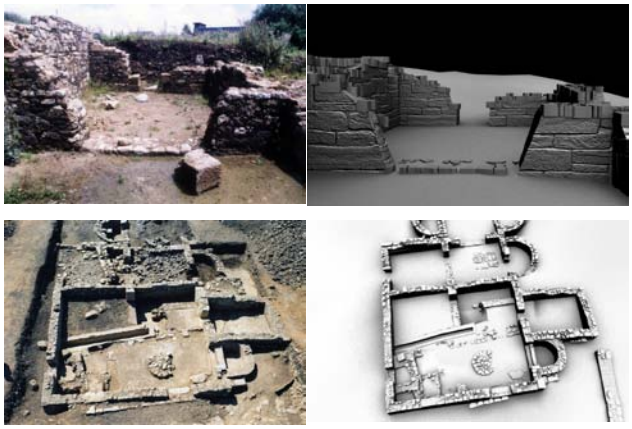

Figure 13. Checking the model by comparison with the photographic survey.

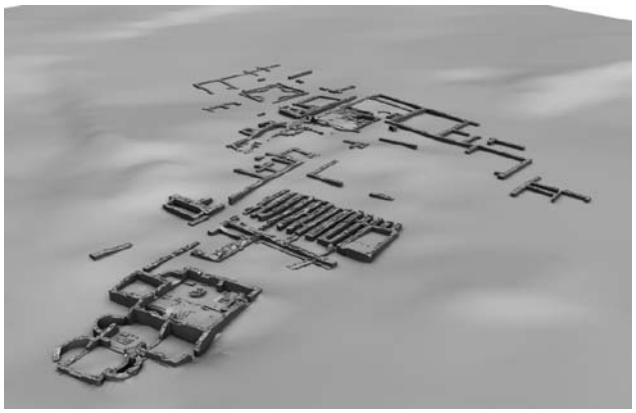

Figure 14. Freiria site as it is today – modelling render.

6 Three-dimensional modelling – Reconstruction the space

As shown by the preceding description, for this stage we had a tool that made a rather deeper archaeological search possible, especially in relation to the theoretical reconstruction of the archaeological area. It was possible to have a support model produced according to the remains and traces found on the ground, which allowed several interpretations to be considered and appraised as new inferences were drawn[13] [14]. This affords the scientific community a way of discussing aspects related to the unwritten social behaviours of the past[15] (Fig. 15).

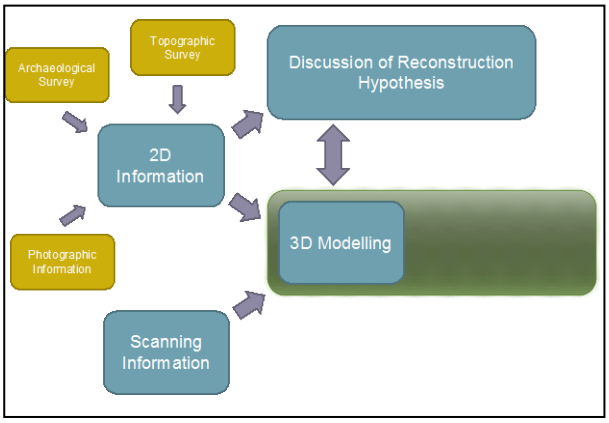

Figure 15. Contribution of three-dimensional modelling to the visualization of the unwritten past.

The first step in the creation of the three-dimensional model of the Freiria site was to concentrate on the barn since this is the structure about which there is the greatest consensus as to its vertical component[16], according to the views and opinions of the archaeologists in charge of the campaigns (Fig. 16).

This was the first, quite limited, visualization of what this feature of the Freiria site may have looked like at time it was used by the inhabitants. As we were used to examine the area with its limited three-dimensional component, this result displays the matching of the verticality of the model in its entirety[17], which is why references that would be in proportion to a human scale were used more or less throughout. It was found that if a smaller size was ascribed to the buildings the effect was to have spaces that were inadequate for their function.

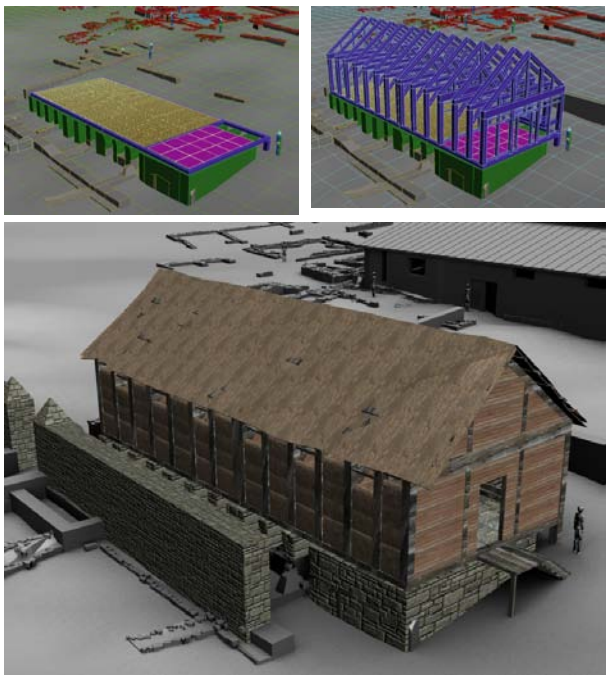

Figure 16. The Freiria barn.

Other analyses and discussions were triggered by this model and there are still some details that are open to question, such as modes of entry to the buildings, how much importance should be given to the differences noted in the pavements/floors, and other issues that may be solved as the field work continues. And so the concern was to split the model into different components - what exists

[13] David Macaulay, *A cidade: Planificação e Construção de uma Cidade Romana.* (Houghton Mifflin Co., 1978).

[14] Jorge Alarcão, *Introdução ao estudo da CASA ROMANA*, (Cadernos de Arqueologia e Arte 4, Faculdade de Letras de Coimbra Gráfica de Coimbra, 1985).

[15] Sophie Madeleine, *Reconstitution virtuelle d'une rue romaine.* (Pre-proceedings of Virtual Retrospect 2005, 8-10 Nov, Biarritz-France, 2005): 50-54.

[16] Guy de la Bédoyère,. *The Buildings of Roman Britain*, (Batsford, London 1991).

[17] José Melón et al., *Problems when generating Virtual Models representing real objects: Hondarribia walls.* (Pre-proceedings of Virtual Retrospect 2005, 8-10 Nov, Biarritz-France. 2005): 3-7.

and what is suggested - so that it can be established as the basis for a work of scientific archaeological visualization[18].

7 Three-dimensional modelling – Manipulation of the space

Even though the modelling followed the procedures of a scientific study, this work intended the outcome to be an interactive scenario that users could manipulate so as to interact with the inhabitants as they go about their lives. So, after the virtual reconstruction of the model of the Freiria Villa, it was exported to a game engine, to get to know the area when it was being fully used.
As mentioned above, the choice of the game engine – Gamebryo™ from Emergent Game Technologies – was based on its ability to customize libraries of data related to the period being studied. So once the Freiria model had been imported extra objects were added – vegetation and other details appropriate to the rural setting (Fig. 17).

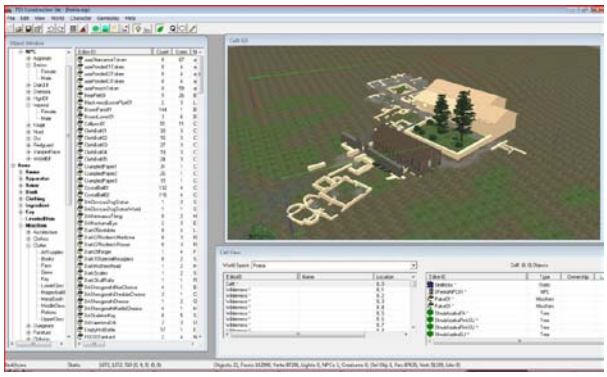

Figure 17. The Freiria buildings – TES Construction Set (Oblivion).

Finally, we added artificial intelligence in the form of avatars (Fig. 18). This was probably the least explored aspect of the entire manipulation and it should be further tested. The main interest lies in experimenting with the number of characters and the function each should have – slave, master, etc. And it would also be useful to give them tasks to see how the space might have been appropriated: daily trips from home to place of work – the farm, pastures, etc. This will also have to be thought through with the archaeologists.
Though not yet finished, it is felt that this work has contributed to integrated research by introducing another scientific expertise - CAD - capable of helping our understanding of the unwritten past (Fig. 19).

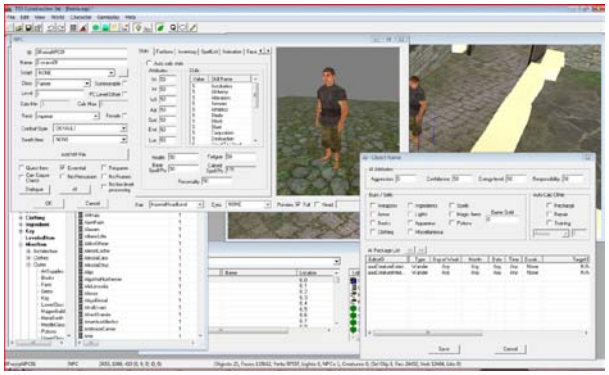

Figure 18. An inhabitant of Freiria (NPC)– TES Construction Set (Oblivion).

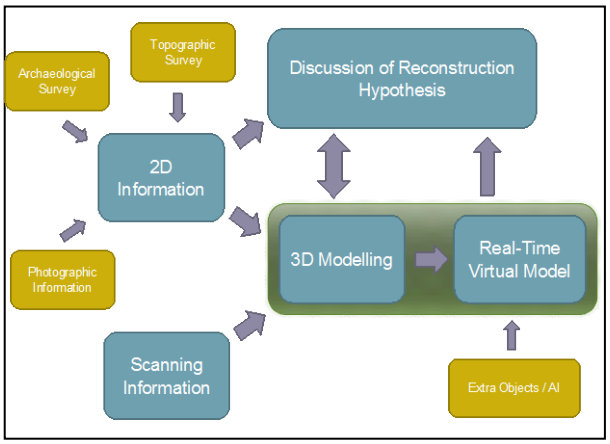

Figure 19. Contribution of three-dimensional modelling to the manipulation and understanding of past scenarios.

8 Conclusions

Scientific research is always clouded by uncertainty due to insufficient data. An intrinsic part of the research process is the formulation of

[18] Horn et al., *Interactive k-D Tree GPU Raytracing*, (Symposium on Interactive 3D Graphics, 2007).

inferences based on traces and remains and on knowledge of other, similar, examples.
A lot of these theories – speculations – are accompanied by two-dimensional images. Drawing is the most efficient way of comparing ideas since it is much easier to establish reasoning about a physical item when there is a graphic representation of it. But two-dimensional representations simply represent an idea and a point of view.
Three-dimensional models are a way of depicting one or more theories which is ideal for an archaeological object whether this is a single item, a town or a civilization. They are perfectly compatible with new archaeological surveying techniques – laser scanners, white light scanners, photogrammetry, and so forth[19] – and enable a more effective transition from the real to the virtual. Pencil and paper, ruler and tape measure are increasingly becoming part of History.
These were the premises that raised the question of the utility of a three-dimensional model as a support tool for archaeological research instead of merely allowing a representation of a theory.

The use of a game engine to ensure visual quality in real time and the use of editing game mapping software which is highly intuitive and comes complete with a set of tools that can be easily adapted to the work in question enabled us to achieve our objectives: quality of the setting in re-creating a past scenario.
It cannot be said that the creation of the model for this work has in fact responded definitively to the questions posed, but the inclusion of another expert in modelling and three-dimensional animation helped the research team to experiment and discuss the results of their theories in a totally fresh way.
The interim results[20] are definitely promising, and could be disseminated and discussed within the scientific community as a way of promoting unwritten knowledge of the past by 'Making History Interactive'.

[19] Vieira et al., *3D Models obtained through Laser Scanner*. (Pre-proceedings of Virtual Retrospect 2005, 8-10 Nov, Biarritz-France, 2005): 15-16.

[20] For more information, go to:
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