

# Towards a 3D Visualization Interface for Cultural Landscapes and Heritage Information

Arnoud de Boer, Hans Voorbij, and Leen Breure

Department of Information and Computing Sciences, Utrecht University, The Netherlands.

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## Abstract

The creation of realistic virtual environments of (almost) completely disappeared historical landscapes is a problematic matter. This is due to three reasons: data imperfection in historical sources, lack of well-suited automatic solutions supporting the creation of such virtual environments, and a poor definition of appropriate visualization, i.e. of what users perceive as realistic. We started from the premise that landscape painters and cartographers were able to capture the essential landscape characteristics without creating a very realistic representation. Proceeding in a similar way, we explore the potentials of *non-photorealistic (NPR)* representations for a 3D visualization interface. In this paper we explain the three problems that strongly impede the creation of realistic 3D virtual landscape reconstructions, and argue why we expect that these NPR representations are an appropriate method for presenting cultural landscape and heritage information to the broad public.

**Key words:** *virtual landscape reconstruction, 3D visualization interface, realistic experience*

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## 1 Introduction

Historical landscape paintings and old maps give us a visual impression of how a certain area looked like a certain time ago. These visual sources may give the modern observer a *historical sensation*, in the sense the Dutch cultural historian Johan Huizinga used this term: the impression of stepping into that specific time for a short moment.<sup>1</sup> The user may experience how realistically the historical landscape painter or cartographer rendered his own environment.

Using computer graphics and virtual reality technology, we are able to evoke the past by creating 3D virtual models of cultural heritage and historical landscapes.<sup>2</sup> This technology enables the modern user to explore a landscape of bygone days in a more accessible way than traditional works of art will allow.

In addition, by connecting objects in the virtual landscape to digital records in cultural heritage databases, we can create a visual search interface that discloses information about the historical landscape to the broad public in a very interactive and intuitive way, i.e. by enabling users to navigate to and to click on objects of their interest.

These two applications of virtual environments showing historical landscapes are the main objectives in our research project on 3D visualization of the Dutch cultural landscape:

1. Create an *as-realistic-as-required image* of the past representing how a historical landscape looked like in a certain period.
2. Design a *3D visualization interface* that enables a user to retrieve information from cultural heritage databases by interacting with the 3D virtual environment.

A cultural landscape represents the continuing interaction between nature and man. For that reason, it has changed continuously in the course of time. Some past landscape elements have completely disappeared. When this occurs,

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<sup>1</sup> Frank Ankersmit, *Sublime Historical Experience* (Stanford: Stanford University Press, 2005), 119-28.

<sup>2</sup> Paolo Cignoni and Roberto Scopigno, "Sampled 3D Models for CH Applications: A Viable and Enabling New Medium or just a Technological Exercise?," *Journal on Computing and Cultural Heritage* 1 (2008): 2.

historical sources are often the only basis for visualization.

Whereas the application of computer graphics technology and the use of photorealistic rendering are mature phenomena today, the creation of realistic virtual environments of completely disappeared landscapes is still problematic. This is due to three reasons: (1) imperfections in historical sources, (2) laborious and skillful modeling, and (3) ill-defined visualization requirements on what users perceive as realistic.

A large-scale 3D reconstruction of a historical landscape that fully covers a geographical area and captures its essential characteristics, demands therefore, that we deviate from the traditional approach of minute archaeological site reconstruction. We introduce two basic principles for our research:

1. Rely on historical maps and sources for landscape reconstruction *without* doing extensive research on archeological reality. In archaeological site reconstructions, a high degree of truthfulness is required, based on extensive preceding research. However, for the creation of a more general historical landscape impression, the preparatory research can be limited to the selection and interpretation of relevant historical sources (maps and images in particular) and the acquisition of information about the landscape development and structure.
2. Capture the landscape characteristics *without* surveying and detailed modeling. If the landscape has significantly changed (or completely disappeared), we are unable to survey the landscape topography. Then we should base our virtual landscape reconstruction on historical sources such as maps and drawings. However, due to missing or inaccurate evidence in this kind of documents, we are often unable to create a model that includes every detail, even if we had time to model it. As an alternative, we

search for methods to combine historical landscape data into a reconstruction that captures the essential characteristics as perceived through the sources.

Departing from one of our pilot projects, the 3D virtual reconstruction of Palace Honselaarsdijck (near Naaldwijk, The Netherlands) and its surrounding landscape, we will explain the three problems mentioned above in more depth and discuss our experiences. There are several more detailed research questions: What reliable information can we deduce from historical sources like maps, drawings and paintings? Which information is usable for a 3D visualization that provokes a historical sensation without using a photorealistic image? Which requirements should one meet when using these sources as input for GIS, image processing and 3D modeling software? Which details should we add to the virtual environment as such, to communicate information about the landscape and its decoration in a visual, clear, coherent and uniform way? If we start from the premise that landscape painters and cartographers were able to capture the essential landscape characteristics without a detailed rendering true to nature, can we proceed in a similar way to achieve a digital experience of the same physical reality?

These questions encouraged us to explore the potentials of *non-photorealistic (NPR)* representations for our 3D visualizations. We expect that 3D landscape models may offer a historical sensation, comparable with or even stronger than one gets with their 2D historical counterparts.

In this paper, we share our thoughts and arguments why we expect that these NPR representations are an appropriate method for presenting cultural landscape and heritage information to the broad public. In section 2, we will describe the problems encountered during the virtual reconstruction of Palace Honselaarsdijck and its surrounding landscape in our objective to create an as-realistic-as-required 3D visualization. In section 3, we will argue why we expect that the NPR representation is an effective way to present cultural landscape and heritage information to the broad public.

Finally, we provide some conclusions and future work in section 4.

## 2 Photorealism or approximated realism?

In computer graphics, photorealism refers to an image that is visually indistinguishable from reality. A study by Roussou suggests that photorealism is potentially the most important aspect of effective representations of virtual heritage.<sup>3</sup> Today, we are able to apply accurate survey and 3D modeling techniques, to realize photorealistic representations of tangible and observable relics of the past. For historical landscapes, however, and particularly if they have disappeared with the result that only few traces were left, we are forced to base our virtual reconstruction upon available historical sources and additional information.

In our pilot project concerning the virtual reconstruction of the former country estate of Palace Honselaarsdijck and its surroundings, we encountered three problems that strongly impeded the creation of photorealistic 3D virtual environments of historical landscapes and buildings, i.e.

1. Limited and imperfect information from historical sources, and therefore uncertainty in the historical situation, leaves us with gaps and inexactitudes for our 3D modeling software;
2. For want of suitable automatic solutions, laborious and skillful modeling of objects that have completely disappeared is needed, which makes large scale detailed and realistic 3D historical reconstructions unfeasible;
3. Up to now, there is little knowledge of what users perceive as realistic. Given these

<sup>3</sup> Maria Roussou, "The Components of Engagement in Virtual Heritage Environments," in *Proceedings of New Heritage: Cultural Heritage and New Media*, ed. Yehuda E. Kalay et al. (London: Routledge, 2007), 269.

limitations, we must aim at a perceptually smart model. However, it is yet unclear, what features are essential for a realistic user experience.

Palace Honselaarsdijck was a fortified building acquired by the Dutch governor (aka *stadtholder*) Frederick Henry in the early 17<sup>th</sup> century. He rebuilt and extended the country estate numerous times between 1621 and 1647 (see fig. 1 top). At the end of the French Revolution, this estate was nothing more than ruin. In 1815, King William I decided to demolish it. Today, the business estate De Honsel stands at the former location of Palace Honselaarsdijck (see fig. 1 bottom). The only remainder is the small outbuilding De Nederhof.



**Figure 1.** Palace Honselaarsdijck around 1683 (top) and the business estate De Honsel in 2009 (bottom).

Because the landscape has significantly changed, leaving few remaining topographic features of the historical situation, we are unable to collect reliable field survey data. Therefore, we have to base our virtual reconstruction upon historical sources (e.g. maps, drawings, paintings) depicting Palace Honselaarsdijck and its environment and some supplementary existent information. We started our pilot project with collecting digital

copies of these historical sources. Although they are largely available, they provide us with only limited and imperfect information. Many historical sources were custom-made, produced for a specific purpose. This implies that these sources include a measure of subjectivity. Cartographers created their maps according to purposive abstractions of the real world, leading to topographic, geometric and chronometric inaccuracies.<sup>4</sup> Landscape painters diverted their composition from the actual topography, as long as the location remained identifiable to their audience. See, e.g., Jan van Goyen's "View on Leiden from the Northeast", dated 1650 (see fig. 2).<sup>5</sup>



**Figure 2.** Jan van Goyen's "View on Leiden from the Northeast", dated 1650, in which the painting's composition deviates from the actual topography.

Using modern technology, we may produce a similar subjectivity, when we process and combine modern geographic data and historical sources. For example, topographic mapping of the main building footprint of Palace Honselaarsdijck from different non-identical drawings results in an approximated historical delineation. We need to transform a contemporary elevation map into a generalized elevation map that is consistent with the historical situation, before we can overlay it on the historical map. Figure 3 shows the Delfland map by the cartographer Kruikius (1712),

<sup>4</sup> Micheal Blakemore and John B. Harley, "The Search for Accuracy," *Concepts in the History of Cartography, Cartographica Monograph* 26 (1980), 55.

<sup>5</sup> Edwin Buijsen. *Between Fantasy and Reality: 17th Century Dutch Landscape Painting* (Baarn: De Prom, 1993), 46.

renowned for his relatively meticulous accuracy, combined with a current Dutch elevation map (AHN), visualized in ESRI ArcScene. The current flower auction hall distorts the visualization. It requires an adaptation of the AHN to the historical situation.

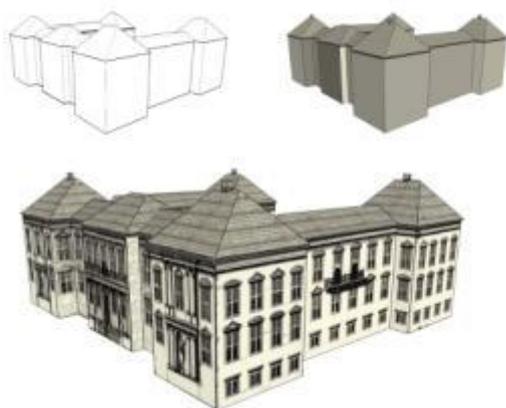


**Figure 3.** Distorted view on Palace Honselaarsdijck after combining the historical map by Kruikius from 1712 with the current Dutch elevation map (AHN). The flower auction hall (top right inset) causes the distortion.

This example shows that a photorealistic representation of a completely disappeared historical landscape cannot truly render reality. It is actually an approximated reality. The approximation results from imperfect data and the impossibility to validate the virtual landscape with its real world historical counterpart.

Alternatively, instead of using approximated and generalized input data for our 3D modeling software, we could choose to do more elaborated research and model every detail of our historical landscape by hand. However, everybody who does so will immediately experience that this is a very laborious and skillful task, which makes the construction of large 3D virtual environments unfeasible. Despite the increasing availability of user-friendly 3D modeling software (e.g. Google Sketchup), it requires perspective insight and modeling time to create realistic models. For example, the general outlines of the main building of Palace Honselaarsdijck's geometry (see fig. 4 top) can be put up in only a few minutes, but adding all the small details such as roof gutters, window frames and high quality textures (see fig. 4 bottom) takes significantly more time. Also mapping the complete parcellation of the

surrounding polder landscape (see underlying map of fig. 3) is a very laborious craft. So in general: adding more details takes increasingly more time.



**Figure 4.** A virtual reconstruction of Palace Honselaarsdijck, with different levels of detail in Google Sketchup: from wireframe (top) to high-detailed and textured model (bottom).

The problem of laborious and skillful modeling calls for semi-automatic solutions to create large-scale 3D virtual reconstructions of historical landscapes. For cityscapes, previous research explored an automated way to build-up and to model virtual city models.<sup>6</sup> Using sophisticated computer algorithms, one may create complex city structures in an automatic way through matching objects (such as roofs, windows, and walls) from a dedicated object library.<sup>7</sup> For landscape objects, the conditions seem to be different. They are often standing on isolated spots in the landscape. Unlike coherent city structures, they frequently display individual features, notably irregular and unique sizes and shapes. We explore the potential of a 3D object library of landscape-related historical buildings and artifacts for building up virtual landscapes in a more (semi)automatic or methodical way.

<sup>6</sup> Arne Schilling and Alexander Zipf, "Generation of VRML City Models for focus Based Tour Animations," in *Proceedings of the eighth international conference on 3D Web technology*, ed. Matthew T. Beitler (New York: ACM SIGGRAPH, 2003), 41.

<sup>7</sup> Robert G. Laycock and David Drinkwater, "Exploring Cultural Heritage Sites through Space and Time," *Journal on Computing and Cultural Heritage* 1 (2008): 4-7.

From the previous problems, we immediately come to the following questions. What are the requirements for the historical landscape objects in the object library? What characterizes each of these objects? Which level of detail and information is required in a virtual reconstruction in order to let the audience perceive it as realistic? "How good is good enough?" in this matter, after Perkins, who wonders what image quality for photorealistic simulations, is sufficient to act as a valid and reliable surrogate for real world conditions.<sup>8</sup> Related research shows that too realistic representations of non-contemporary (i.e. past and future) situations let users experience it as unbelievable or unconvincing.<sup>9</sup>

A realistic representation does not necessarily go together with an experience of realism, as Figure 5 shows. We created a virtual model of a Dutch polder landscape using two different types of atmospheres: a non-typical Dutch sky and a typical Dutch sky, as we know it from historical and modern images. Although we used a high image quality, the broad public will likely not experience the realistic rendering with the non-typical Dutch sky as a realistic image of a Dutch polder landscape.

In our future work, we will search for decisive variables that influence user experience of virtual reconstructions of historical landscapes. We will study how users perceive virtual environments of non-contemporary times, and collect dedicated information about what users presume to be characteristic and typical for a historical landscape. We expect that our work will contribute to the requirements scoping of image quality and level-of-detail for 3D virtual reconstructions of historical landscapes.

<sup>8</sup> Nathan H. Perkins, "Three Questions on the Use of Photo-realistic Simulations as Real World Surrogates," *Land Urban Planning* 21 (1992): 266.

<sup>9</sup> Katey Appleton and Andrew Lovett, "GIS-based Visualisation of Development Proposals - Reactions from Planning and Related Professionals," *Computers, Environment and Urban Systems* 29 (2005): 330-332; George Drettakis et al., "Design and Evaluation of a Real-World Virtual Environment for Architecture and Urban Planning," *Presence* 16 (2007): 328.



**Figure 5.** Realistic rendered snapshots of the same Dutch polder landscape with different types of atmospheres rendered in Vue7 Infinite: a non-typical Dutch sky (top) and a typical Dutch sky (bottom).

### 3 Non-photorealism coming close to photorealistic experience

Non-photorealism (NPR), considered as the counterpart of photorealism, uses artistic styles such as painting, drawing, and cartoons. Previous research described the potentials of NPR above photorealistic VEs for applications in virtual heritage<sup>10</sup> or landscape planning and cityscape

<sup>10</sup> Maria Roussou and George Drettakis, "Photorealism and Non-photorealism in Virtual Heritage Representation," in *Proceedings of the International Symposium on Virtual Reality, Archaeology, and Intelligent Cultural Heritage (VAST'03)*, ed. David B. Arnold et al., (Switzerland:

modeling.<sup>11</sup> In addition to NPR representations on basis of rendering algorithms, one may obtain a NPR image from *modeling*, *post-processing* or *abstract data visualization*.

*Modeling* concerning NPR refers to an emphasized and/or simplified representation of the essential characteristics of objects or characters. For example, cartoons and caricatures capture the characteristics of subjects without aiming at a photorealistic image, even though they may provoke an experience that comes close to viewing a (photo-) realistic image. One also observes this very phenomenon in historical maps. Cartographers applied exaggeration, generalization and symbolization according to the basic principles of cartographic language, i.e. communicate geographic information in a visual, uniform, coherent and clear way.<sup>12</sup>

For landscape related objects (in our case Palace Honselaarsdijck), one could choose to only model their main characteristics (e.g. the main palace building) and leave out less significant details (such as windows and roof gutters). In Figure 6, we placed the simplified main building of Palace Honselaarsdijck in its surrounding landscape, to visualize its dominant presence. The combination of realistic vegetation and atmospheres may provoke a realistic experience, in which the 'reality' of the vegetation and atmospheres is passed on to the more abstract building feature. However, one must be careful. Hyper-realistic objects could become counterproductive, as they

Eurographics Association, 2003), 59; Torre Zuk et al., "Visualizing Temporal Uncertainty in 3D Virtual Reconstructions," in *Proceedings of the 6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST'05)*, ed. Mark Mudge et al. (Italy: Eurographics Association, 2005), 101-103.

<sup>11</sup> Philip Paar, "Landscape Visualizations: Applications and Requirements of 3D Visualization Software for Environmental Planning," *Computers, Environment and Urban Systems* 30 (2006): 833; Jürgen Döllner and Maik Walther, "Real-Time Expressive Rendering of City Models," in *Seventh International Conference on Information Visualization (IV03)*, ed. Ebad Banissi et al. (Los Alamitos CA: IEEE Computer Society, 2003), 36-41.

<sup>12</sup> Philippe De Maeyer and Beata M. De Vliegheer, *Inleiding tot de Cartografie* (Gent: Academia Press, 2003), 119.

might suggest a higher measure of certainty with regard to the more abstract features.<sup>13</sup> The advantages of mixing abstract and realistic data are twofold: more efficient modeling (adding more details takes increasingly more time), and preventing information-overload for the audience, because insignificant details are left out and a clearer view is established. Furthermore, we expect this approach to improve user engagement. Because it combines the symbolic with the concrete and abstract, the mix of abstract and realistic data stimulates creative thinking, i.e. both right-brained-mode and left-brained-mode are stimulated in the thought process.<sup>14</sup> However, the question remains, what should be the required level-of-detail and image quality for perceived realism. We will undertake further experiments to find the decisive variables that influence the user's experience.



**Figure 6.** Realistic vegetation and atmospheres combined with the simplified main building of Palace Honselaarsdijck in one view. The realism of the vegetation is passed on to the abstract building feature.

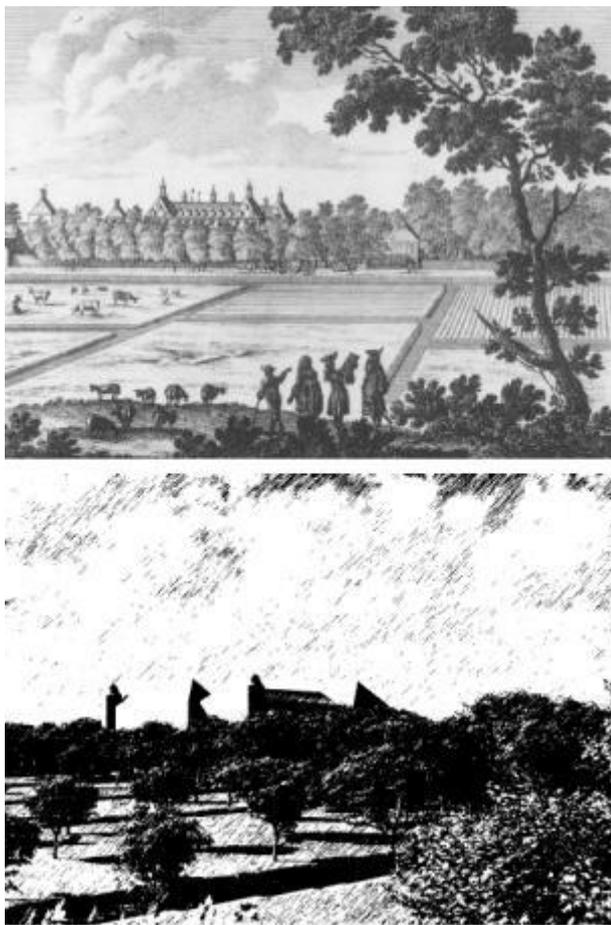
*Post-processing* concerning NPR refers to renderings of virtual environments that are processed using filters or other image processing techniques, e.g. palette knife, pen-ink-drawing or

aquarelle filters. One may use post-processing to evoke a certain period, selecting an artistic-style filter that corresponds to techniques that artists used in that specific time. Figure 7 top shows an ink painting of a View on Palace Honselaarsdijck dating from the 17<sup>th</sup> century, and Figure 7 bottom shows the post-processed render of Figure 6 using a pen-ink-drawing. The use of post-processing techniques may contribute to the realistic experience and help to evoke the feeling of being present in the past (i.e. *historical sensation*). Moreover, we can apply these techniques to NPR renderings, to underline the fact that we are not dealing with indisputable facts.<sup>15</sup> We may communicate uncertainties in our virtual environments by using e.g. sketchy or fuzzy edges, transparencies and saturations. It requires further experiments to test the effectiveness of such post-processing techniques in communicating information on specific times or on uncertainties.

<sup>13</sup> Paar, "Landscape Visualizations", 833.

<sup>14</sup> Ian D. Bishop, "The Role of Visual Realism in Communicating and Understanding Spatial Change and Process," in *Visualization in Geographic Information Systems*, ed. David J. Unwin and Hilary M. Hearnshaw (London: John Wiley, 1994), 63-64.

<sup>15</sup> Maria Roussou and George Drettakis, "Photorealism and Non-photorealism", 58.



**Figure 7.** Original 17<sup>th</sup> century pen-ink-painting of Palace Honselaarsdijck (top) and a post-processed render of our virtual reconstruction (bottom).

*Abstract data visualization* refers to communicating non-visible or hidden information by the use of overlays, e.g. text labels annotating virtual objects, or semi-transparent colored layers communicating differences in terrain heights or the measure of pollution. Will users better understand, for instance, the visualization of the relative heights of the different polders that surrounded Palace Honselaarsdijck, by using different graduated-colored grass textures, instead of using one single graduated-colored surface layer? Further research is required to determine ways in which we can mix realistic and abstract data, in

order to support cognitive processes of knowledge reconstruction.<sup>16</sup>

#### 4. Conclusion

In this paper, we described three problems we encountered during our pilot project on a realistic virtual reconstruction of Palace Honselaarsdijck and its surroundings: the imperfection of data, the absence of dedicated software solutions for semi-automatic modeling, and ill-defined visualization requirements. We noted that a high level of realistic *details* and a realistic *experience* do not necessarily go together. We changed our objective of creating a photorealistic 3D virtual reconstruction, to capturing the essential characteristics and using non-photorealism that comes close to a photorealistic experience. Considering NPR representation as an appropriate alternative to photorealistic visualization, we discussed the advantages of using non-photorealism for presenting virtual historical landscapes: more efficient modeling, preventing information-overload, improved user engagement and visualizing uncertainties.

We search for methods and techniques to create a 3D visualization interface that both gives a realistic experience to its users and serves as a user interface to retrieve information from cultural heritage databases. Our objective is to capture the essential landscape characteristics in a 3D virtual landscape reconstruction. Questions presenting themselves are: What exactly are the characteristics of a historical landscape, and how can we capture these in a 3D virtual reconstruction? What are decisive variables for a realistic experience and how does NPR contribute to user experience? What is the appropriate mix between realism and abstract data in a 3D visualization interface?

Our research agenda covers the following topics:

1. *Processing historical sources:* Which reliable information can we deduce from historical

<sup>16</sup> Terry A. Slocum et al., "Cognitive and Usability Issues in Geovisualization," *Cartography and Geographic Information Science* 28 (2001): 70.

sources like maps, drawings and paintings? Our research continues to focus on the efficient processing of historical sources and contemporary geographic data, in order to derive a digital terrain model that is consistent with the historical situation of a certain era. A central question is how to apply modern technologies - such as GIS and image processing software – in the conversion process of historical maps and drawings and retrieve appropriate input data for our 3D modeling software.

2. *Designing a historical supplement for a 3D object library:* How can we capture the characteristics of historical landscapes and its decoration? Which primary features of landscape-related historical objects should we include in our 3D object library? Preliminary to this is a sound understanding of what is generally considered as characteristic and typical for individual landscape objects and landscapes as a whole. We are in the process of designing user experiments, to derive these

essential features from user descriptions of landscape paintings and a limited set of historical objects.

3. *Mixing realistic and abstract data:* Which visualization methods are usable for a 3D visualization interface that provokes a historical sensation without using a photorealistic image? This interface could serve as a tool for retrieval of cultural landscape information in heritage repositories. Combining realistic and abstract data, one may achieve an appropriate description and explanation of the essential characteristics of cultural landscapes. This also requires user experiments, in order to determine which combinations of realistic and abstract data lead to visualizations that transfer heritage information in a coherent and clear way.

We expect that our research will contribute to the realization of large-scale 3D visualizations of cultural landscapes and the presentation of cultural heritage information to a broader public

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