COMPUTER VISUALIZATIONS OF ARCHITECTURE

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Introduction

One of the most important parts of preservation of archaeological finds is their interpretation. On field the first interpretation of archaeological remains is subjective explanation based on experiences, knowledge and expectations of the archaeologist that places them in space and time and ascribe them their value. A quality interpretation provides also the broad public with proper understanding and evaluation of the remains and should encourage an emotional connection to the remains and induce respect and love towards the history of place and the desire to preserve and protect cultural heritage (Colquhoun 2005; Kohl, Eubanks 2008).

With the rapid development of computer graphic technologies, especially computer 3D graphics the opportunity has arisen to satisfy the needs of scientific as well as public presentation of interpretation in an efficient and captivating way. In a virtually rebuilt environment different scientific theories can be tested out as well as attractively presented to the public.

The scientific discipline that seeks to research and develop ways of using computer-based visualisation for the comprehensive management of archaeological heritage is called Virtual Archaeology. It includes virtual reconstruction, recreation, anastylosis and restoration of archaeological finds aiming to produce highly detailed images of the past (Principles of Seville 2008).

Disscusion

Computer 3d visualisations are usually created by professionals in the field of graphic design usually referred to as 3d artists. In this multidisciplinary cooperation between the latter and archaeologists is very commonly present a communication gap that results in a low quality representation. To avoid this it is of great importance that archaeologists know what kind of base data is best for the purpose of computer 3d visualisation and what scope the interpretation should take as well as what they intend the final product to be.

In order to provide the best possible ground data for such a visualisation different techniques of data acquisition can be introduced to the regular workflow of archaeological research procedures e.g. excavations. These can be precise though financially demanding remote or near range sensing techniques (Bryan 2006; Barber, Mills 2007; English Heritage 2010; Andrews, Bedford, Blake, Bryan, Cromwell 2010) or cost efficient photogrammetry methods (Schaich 2013; Robertson, Cipolla 2009). All of these result in a point cloud data which can be surfaced to generate a CAD model that is later used for reconstruction. If not available also more traditional manual or total station measurements may be employed. Another type of ground data is the result of non-invasive archaeological surveys like aerial and satellite photography, laser scanning [LIDAR (Light Detection and Ranging or Laser Imaging Detection and Ranging) and traditional 3d scanning] and geophysical surveys (electromagnetic conductivity, magnetic gradient, electric resistivity, ground penetrating radar - GPR), most often a multi-layered ground plan (Historic New England 2012; David 1995; Piro 2009).

This data is then passed to the graphic 3D artist and is together with the initial interpretation, which is based on previously acquired data of past and/or present research, in the process of building of a virtual environment of the past complemented with additional information resulting from: complementary research on the site such as geomorphologic, geographical, palinological, dendrochronologic, architectural, art history research etc.; very carefully studied and employed historical sources that provide a subjective comprehending of the subject and/or first-hand technical details; and analogies from contemporary era or present ethnographical structures of the area which share due to the same environmental circumstances e.g. similar architectural solutions in many instances.

A quality reconstruction of a virtual past environment encompasses three important sections: terrain, architecture and small items (Figure 6).

The first step in the study of a particular landscape is examining its topography, surface shape and its features. Further its inner structure must be determined in order to recognize the processes that shaped it. For this purpose various methods are used which are all efficiently combined in geomorphology that gives the best possible answers to how landscape looked like in a previous time period and consequently enables a historic model of the landscape to be built (Goudie 1990).

Figure 6. Reconstructed knife based on 3d scan and analogies and its implementation into the scene (7reasons Medien GmbH).

The results are also very useful in connection with archaeological deposits and understanding of post-depositional processes. Important parts in the landscape construction are also the anthropogenic features that sometimes even irreversibly change its appearance. These can be for example fields, roads, quarries etc. Depending on the desired effect these elements are either added to or extracted out of the terrain model or they are only displayed in the terrain texture (Figure 1).

Later, in an urban environment once the landscape has been established and the basic data extrapolation of the architectural remains was done (Figure 2) the next step is the definition of volumes and open spaces.

Very appropriate for this task are the aero-photography and the geophysical results since they usually cover a larger area of an undisturbed archaeological site or in some cases morphology of the ancient urban planning can be still visible in the modern city layout. The outlines of streets, larger architectural features like city defensive structures and public buildings were incorporated

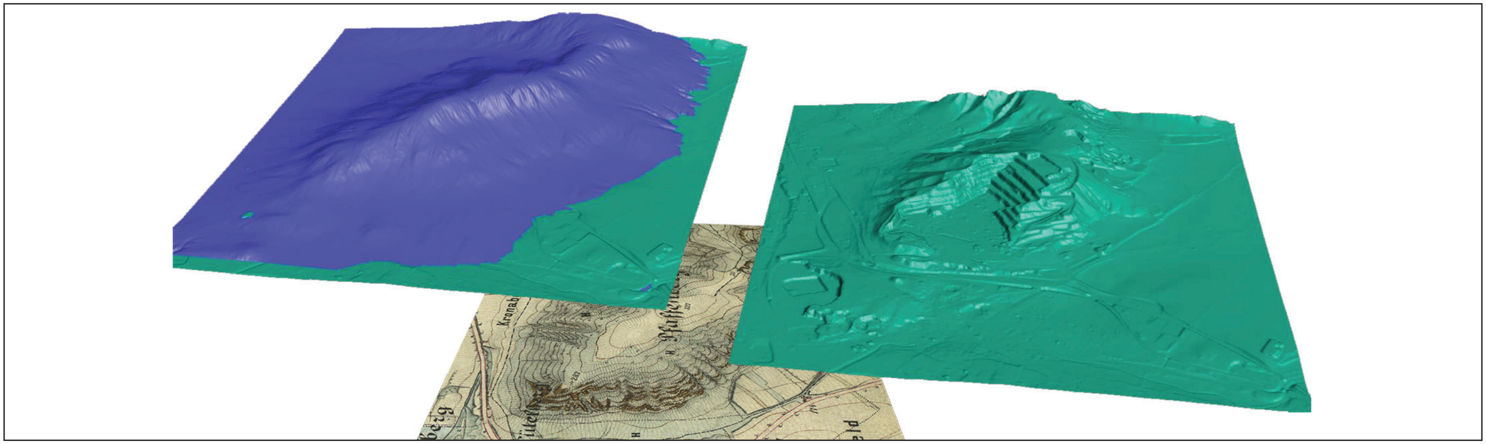

Figure 1. Modelling of an ancient terrain based on LIDAR scan and historical map. 7reasons Medien GmbH.

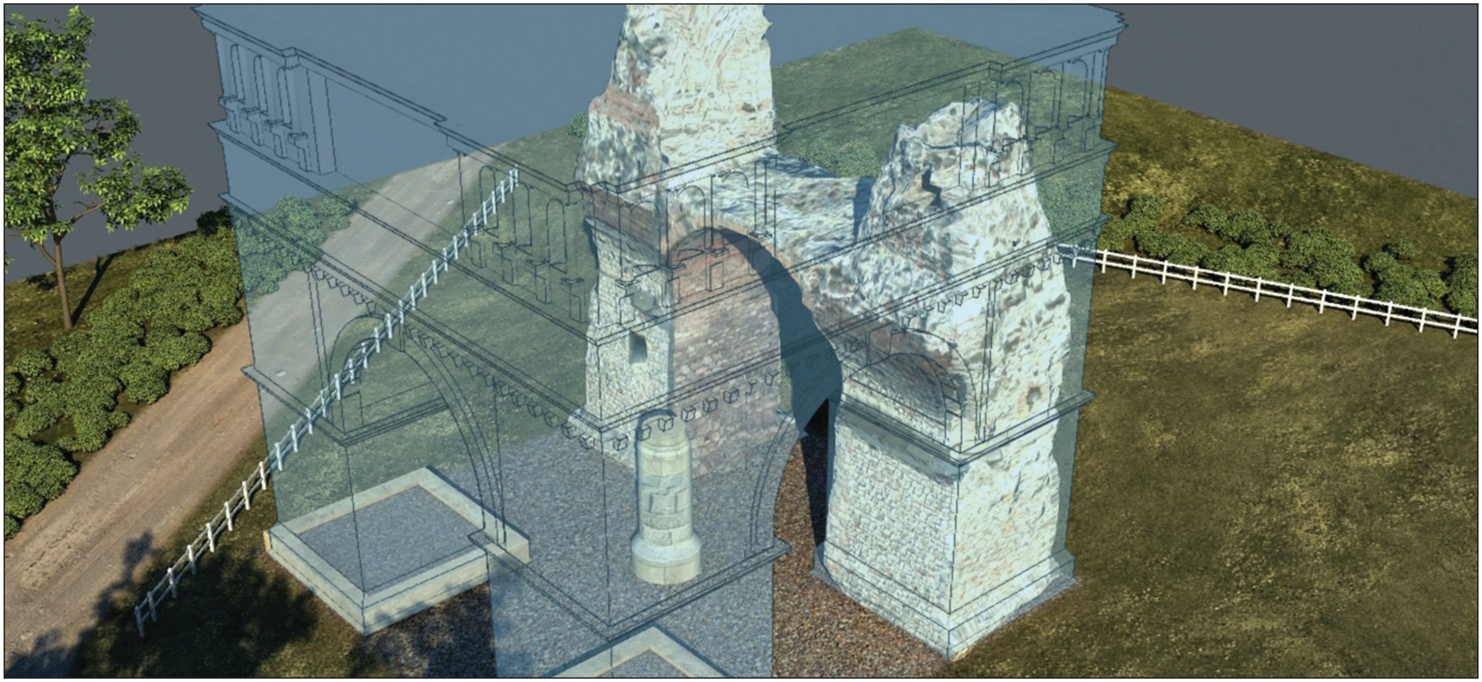

Figure 2. Extrapolation of data in the case of Heidentor in Carnuntum, Austria based on 3d scan of standing remains and analogies. 7reasons Medien GmbH.

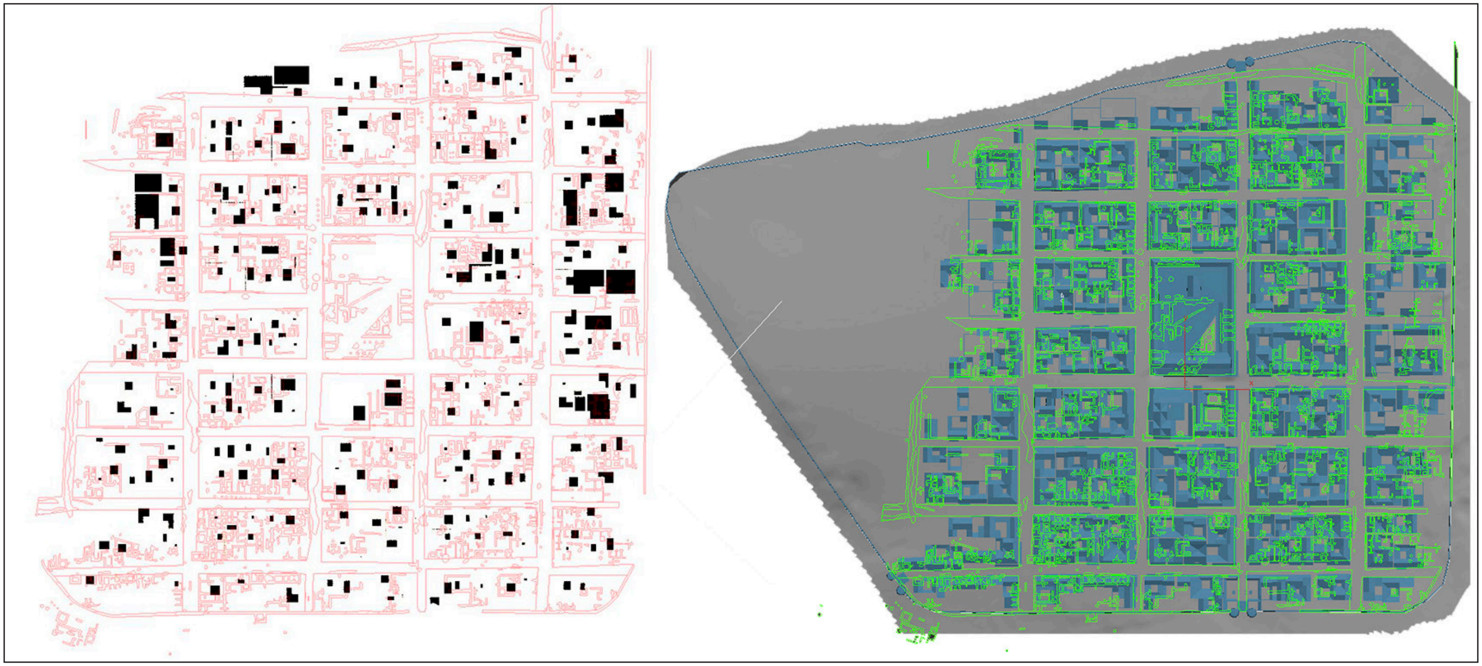

Figure 3. Defining open spaces and volumes in Ammaia, Portugal. 7reasons Medien GmbH.

into the settlements in later periods and survived to the present day. This visual evidence can be overlayed with the hypothetical interpretation to achieve a higher level of certainty.

In the example of the GPR results from the Roman site of Ammaia (Alto Alentejo, Portugal) first the street network was determined, following with the recognition of bigger public open spaces (forum, amphitheatre), insulas' division inside the city grid and at last domestic open spaces (*atria*, backyards). Afterwards volumes were defined taking into account the width and the direction of the buildings walls in order to differentiate the house boundaries (Figure 3).

Very often the urban distribution depends greatly on the function of the different objects. To determine these previous research, used sources and their interpretation must be taken into account. Of great help for ascertainment **of different functional city areas and specific buildings** are the found artefacts and analogies.

For example position of public buildings (temples, markets, administrative buildings, etc.) can be determined easier than the rest based on their siz e and prominent location. Similarly were factories or workshops traditionally located on the outskirts of the settlements due to generation of disturbing residues. Most of the buildings have depending on their function also a special form (Figure 4).

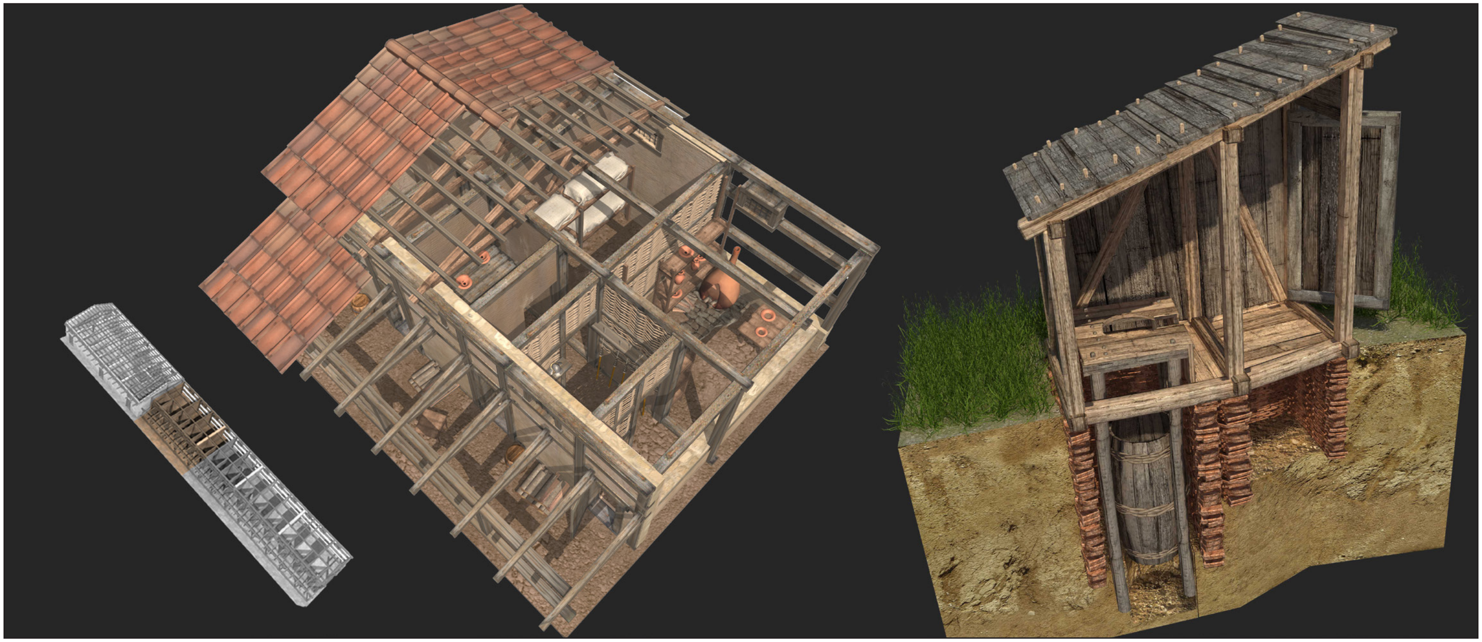

Figure 4. Functionality based building forms: left a military contubernium, right a latrine. 7reasons Medien GmbH.

With scientific guidance and through comparative studies local architectural typologies are developed and then integrated accordingly to chosen outlay into the existing terrain (Figure 5).

The difficulty of this process varies from site to site and depends on the time period. In contrast to rather well known Roman urbanism prehistoric sites are still one of the most difficult to plan.

To make an environment really believable it must be later enliven with vegetation, animals and people. This is all decided upon the purpose of the visualisation which dictates the level of detail that visualisation is going to achieve (Figure 7).

One of the advantages of reconstruction in the virtual environment is that it can evoke new theories of its appearance and possibilities and lead back to the *scientific transparency and re-traceability.*

This way they are testable by other researchers or professionals since the validity and therefore the scope of the conclusions produced by such visualisation depends largely on the ability of others to confirm or refute the results obtained (*Principles of Seville* 2008, Figure 8).

The visualisation itself can be represented in a photorealistic or non-photorealistic way (Figure 9). Photorealism requires a lot of attention to the smallest details or it simply does not seem convincing. On the other hand

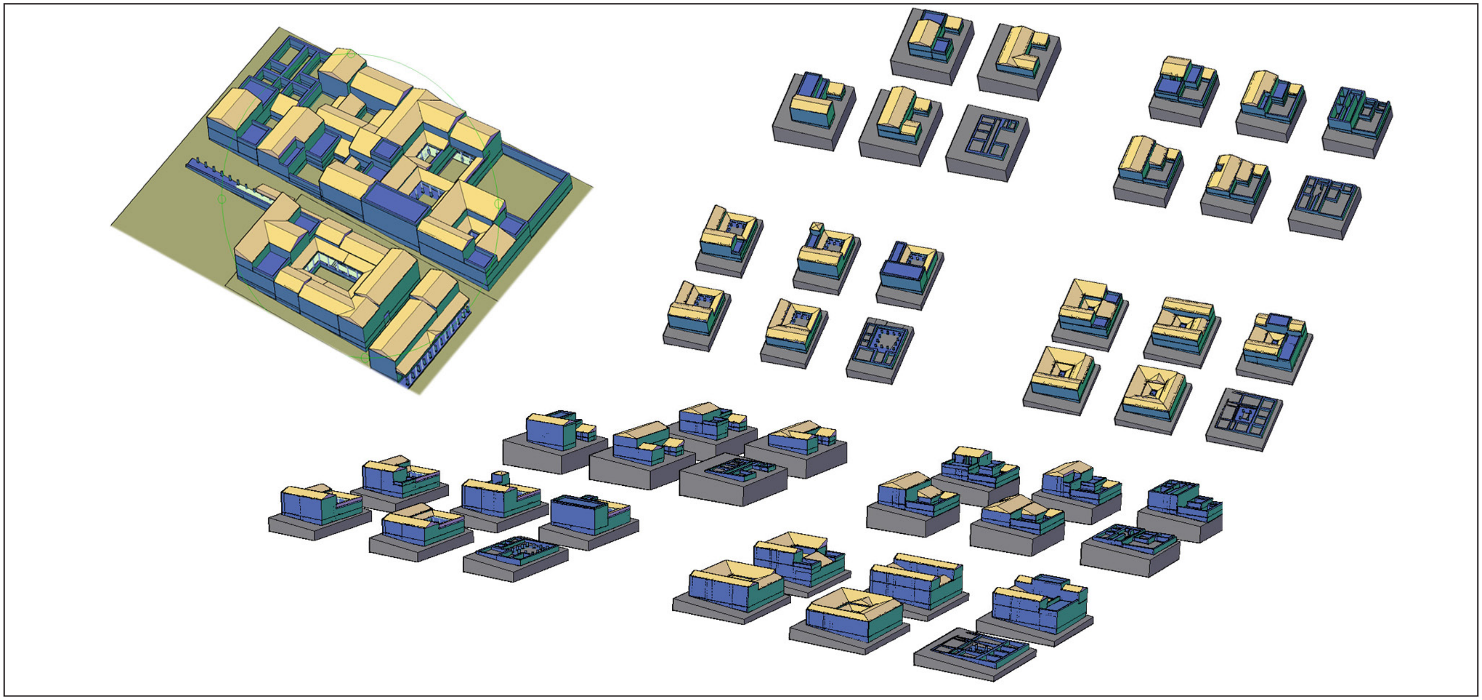

Figure 5. Typology of Roman houses in Ammaia, Portugal. 7reasons Medien GmbH.

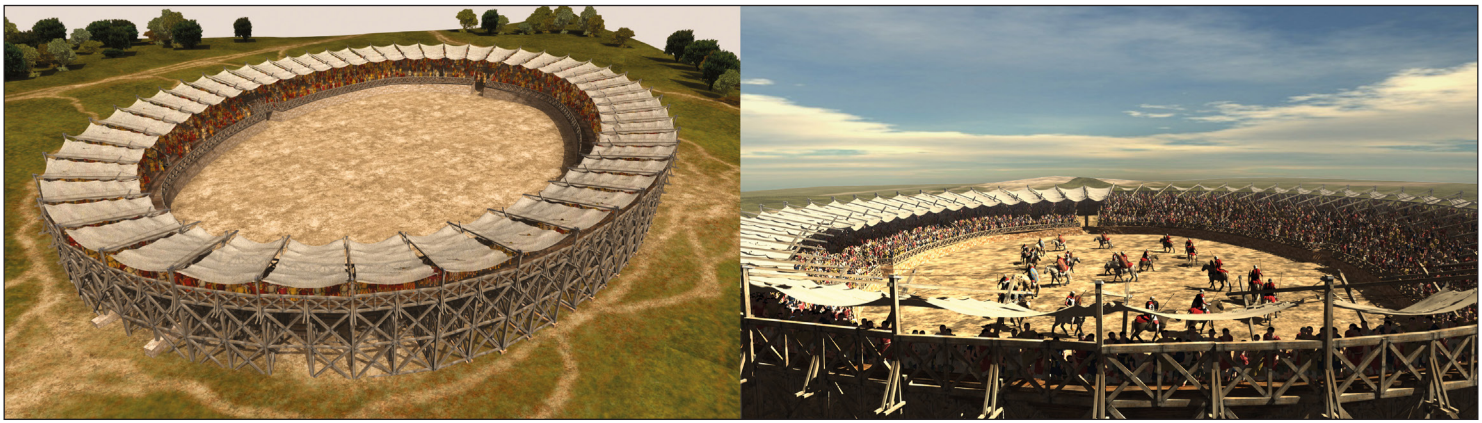

Figure 7. Scenes of the Roman amphitheater in Carnuntum Austria. 7reasons Medien GmbH.

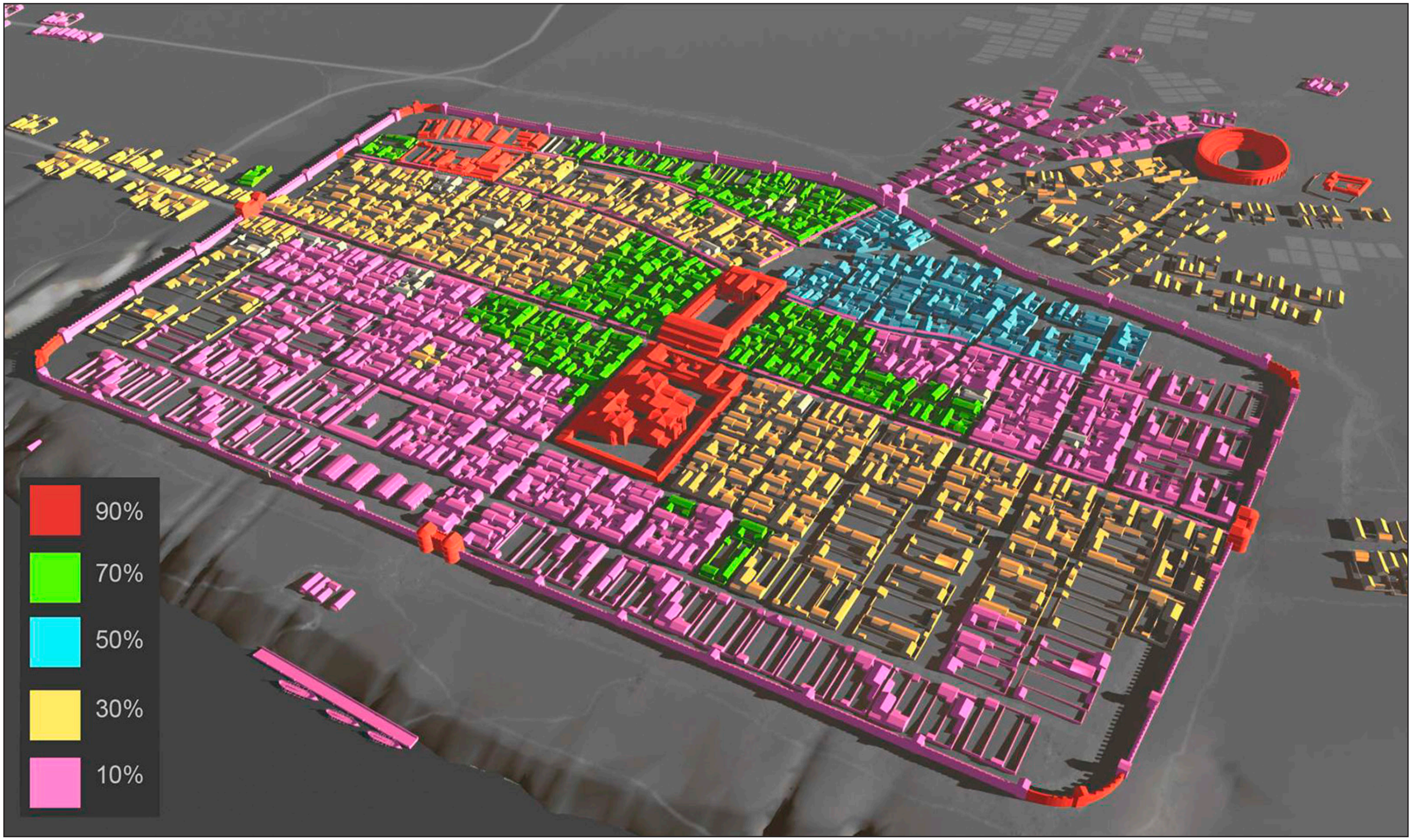

Figure 8. Levels of certainty in the virtual reconstruction of Carnuntum, Austria. 7reasons Medien GmbH.

non-photorealistic rendering gives a lot more expressive freedom as it focuses on a wide range of expressive styles based on painting and drawing. Its advantage is that the viewer is immediately confronted with an abstraction, which emphasizes the hypothetical aspect of the reconstruction (Roussou, Drettakis 2003). It can also focus his attention on important information with omittance of unimportant features (Klein, Li, Kazhdan, Correa, Finkelstein, Funkhouser 2000). In addition non-photorealistic computer graphics offer extensive control over expressivity, clarity, and aesthetic, thereby the resulting pictures can be more effective at conveying information and express a specific mood (Buchholz, Döllner, Nienhaus, Kirsch 2005). The final step is completing the visualisations with the selection of the wanted form that is going to be ready for distribution.

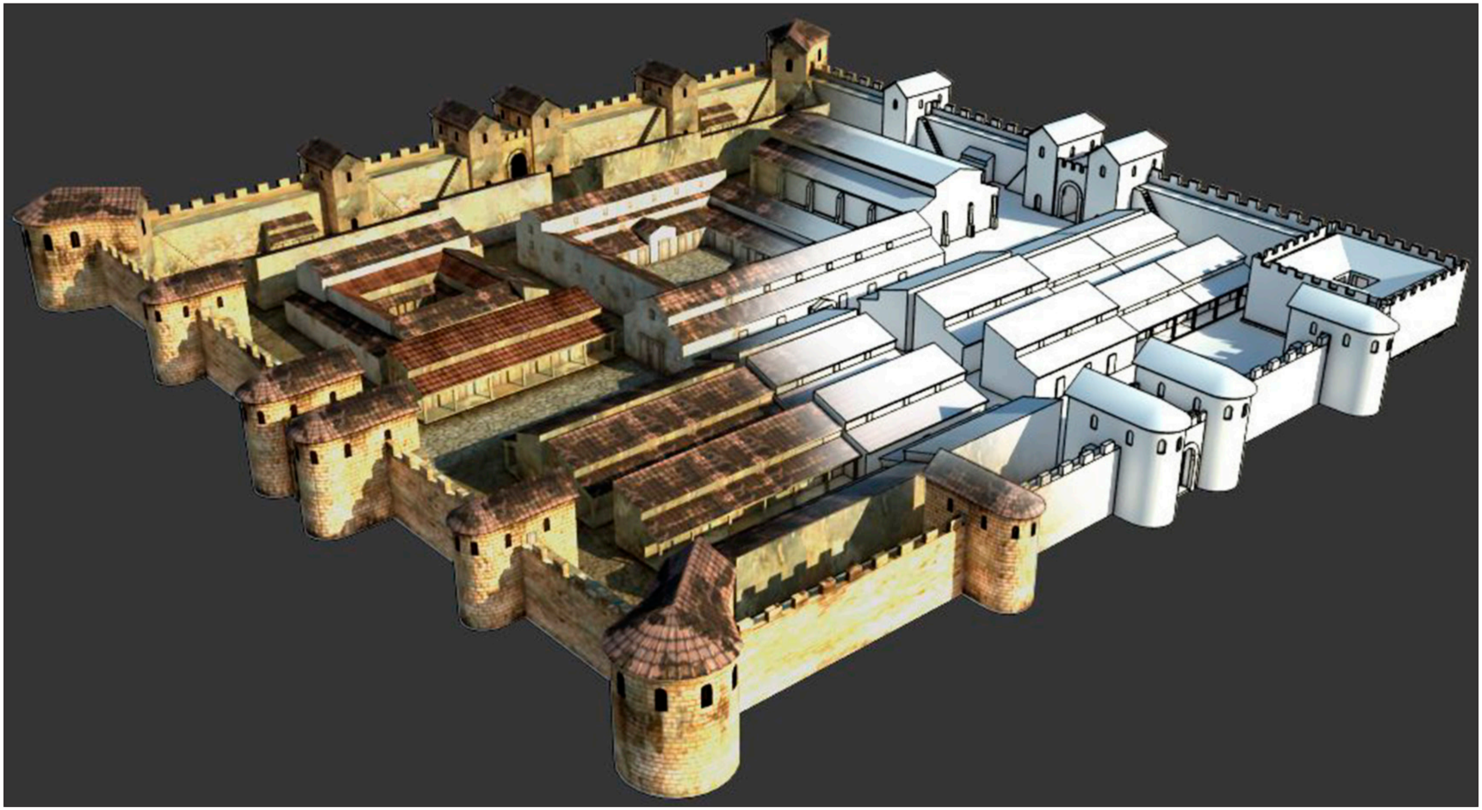

Figure 9. Photo-realistic vs. non-realistic rendering. Roman fortress on limes in Austria (7reasons Medien GmbH).

These range from a distributable 3D models, images and animations to the augmented and virtual reality applications and 3D prints (Figure 10). Howevere, after finishing the 3D model and making the final product the work of 3D artists does not conclude. Every model is subjected to constant changes due to technical enhancements, additional data and/or changed interpretations and thus consequently being improved.

Conclusion

Virtual archaeology projects have despite all the work already invested still great potential in research and presentation aspects of archaeological sites. As a research tool virtual presentation can strive for optimal effective use of hardware and retaining much needed high detail for plausible interpretations. As in presentation styles a

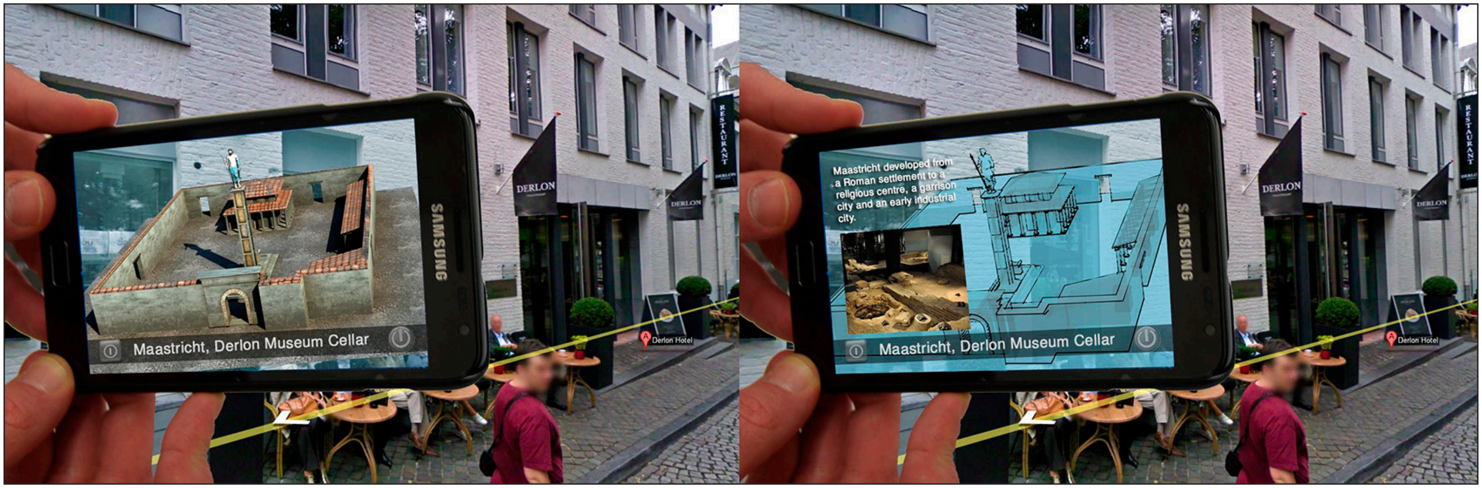

Figure 10. Augmented reality 7reasons Medien GmbH.

possible trend of increased interest in non-photo-realistic rendering is noticeable which opens a wide range of cognitive approaches for the presentation in this particular field of cultural heritage. All of these achievements would not be possible without constant effort for co-operation of all project collaborators from physical field workers over scientists to 3D artists as the result of such an interdisciplinary project always reflects the ability of communicating each others' individual findings and conclusions to the participating parties.In this context the essential problem is the so often present communication gap between scientists and 3D artists that can be bridged with basic bilateral training and development of to the situation accordingly adapted virtual applications. Eventually the solution to this nonetheless requires extensive practical work in order to determine and implement the best practice.

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