VR-based Information System for Managing the Uncertain in Archaeology. The NetConnect-Project

Ruth Beusing

NETConnect, Roman-Germanic-Commission of the German Archaeological Institute, Frankfurt/M.
ruth.beusing@me.com

Abstract

The paper illustrates the aims and the current state of the NetConnect project. The project develops web-based and mobile ICT solutions for three prominent cultural heritage sites in Europe. A short analysis of current Virtual Realities applied to cultural heritage precedes the description of the projects. The project is engaged in establishing an IT infrastructure with the capability of providing the public with a wide range of information and experiences, from interaction with on-site mobile applications to georeferenced real-time visualization systems. Moreover researchers and cultural heritage operators are enabled to update and edit content within the Virtual Reality by using an authoring tool. The aim is to promote a more entertaining and effective educational access to cultural heritage, which might concern the virtual and the real visitor on the site. The Roman-Germanic Commission is responsible for the Glauberg scenario in NetConnect. One focus is the visualization of uncertainties in the model.

Keywords

3D-reconstruction, uncertainties, Virtual Reality, Point of Interest (POI), 3D-GIS-Server

1. Introduction

Information and Communication Technology (ICT) is applied to archaeological data more and more often. The visual reconstruction of archaeological sites via digital models is frequently used in the field of computer graphics. Reliability and use of these models in culture historical contexts are vividly debated. Currently the results of these discussions do not sufficiently find a way into public information systems. The fascination of suggestive and powerful image-generation often prevails over the intelligent use of this medium and the possibilities it creates for the visualization of uncertainties in archaeological reconstruction. This problem has been addressed in several contributions (Forte 2000; Huvila 2006).

For the first time in archaeological research digital graphics give opportunities to visualize cultural remains in appropriate contexts involving spatial and temporal components. Moreover Information Managing Systems combine digital graphics with additional information – e.g. theories and propositions developed for the site and the inhabitant cultural groups. In the recent decades many projects have been developed focussing single sites. Huvila has detailed the history and development of Virtual Reality (VR) – use in Archaeology embedded in its theoretical framework (Huvila 2006, 55–104).

In the recent decade cumulating projects have been invented, which focused on a complex region, similar to approaches in different regions or special topics. Next to their individual research issues all these projects are interested in the digital dissemination of cultural heritage and the sustainability of the produced data. One of the most ambitious and promising projects in this field was the DigiCULT-project funded by the European Union (EU). The project digitized collections from museums and archives in Europe and the data was made available for the public over the internet (Huvila 2006, 2–4; Riedmann 2007). Moreover they intended to associate the data with corresponding information for different targeted user groups. The DigiCULT report of 2002 mentions the future perspective that in 2006 the governments will have "clarified the responsibilities of who is taking care of born-digital cultural resources" (Mulrenin and Szauer 2002, 58). Moreover, the authors were sure that by that time digitization policies would have provided " a clear road towards a critical mass of cultural heritage resources" (ibid.). We now know that this supposition was wrong. Many more projects dealing with the digitization of cultural heritage followed, e.g. Agamemnon, Archeoguide, EPOCH, Europeana, TNT, VENUS. Additionally some of them provide different approaches and tools for the digital exploration of cultural heritage.

The NetConnect Project funded by the EU-Culture 2000-Programme is one of these projects. The project aims to create interactive virtual environments of three Iron Age sites in Europe enriched with additional information. Archaeological prototypes for the virtual scenarios are Lokroi (Italy), Biskupin (Poland) and Glauberg (Germany). The three chosen sites are examples for the organization of power in different cultures. They can show differences and similarities between the sites and concurrent developments.

A consortium of archaeologists and technical partners works on the NetConnect project to develop 3D environments for web-, kiosk- and mobile application (NetConnect Consortium). The Consortium was formed in order to create cultural heritage content especially for the general public. On-site tourist information will be provided by a mobile application that works with several mobile systems (symbian, windows mobile). Moreover an interactive VR on the internet will be accessible in a real-time environment. Spatial data of the sites will be combined to archaeological documentation as well as digital 3D-reconstruction and historic information.

The Roman Germanic Commission of the German Archaeological Institute is responsible for the Glauberg Iron Age scenario. The focus of the Glauberg presentation is how human influences are expressed in a highly utilized natural environment. To the consortium a VR appeared to be an appropriate media to visualise this complex site with several settlements, a sanctuary, burial places and about 5m^2 of reconstructed landscape.

2. Screening and comparison

The construction of the complex landscape of the Glauberg demands some serious thoughts about the level of abstraction. Not everything an archaeologist or palaeobotanist can imagine is based on hard facts. On the other hand, some compromises need to be found in order to create a meaningful visualisation for the general public. For this reason we examined the existing approaches to the presentation of uncertainties in VR models, and subjected this collection to a serious evaluation. We aimed at including the multiple abilities of interactive VR in order to provide additional value beyond the mere digital 3D-reconstruction. Thus the formulation of archaeological standards was an initial demand for the archaeological partners in NetConnect.

For this reason we started to investigate the efforts that have been undertaken by other projects: an investigation and comparison of VR-productions has been prefixed to the development of the Glauberg VE. We intended to study the possibilities and limits of the state of art technology.

Expensive and elaborate conventional computer graphics, such as games and animated films have informed us about the visual and auditory behaviour of public users. Their influence on the development of archaeological computer applications is very high and promotes the creation of complex virtual realities. Many of them are highly suggestive due to quality design and realistic environments. But a higher degree of realism subsequently evokes less scientific correctness. Up to a certain degree this would be explainable by a better public understanding of what archaeologists do. However, it requires a critical approach to the presented sites and objects. Kantner states that in those models there would be an inherent danger of "misinterpreting the past" (Kantner 2000, 52).

Nearly none of the excavated prehistoric sites provides a complexity of information that allows a photo-realistic reconstruction. Archaeological research always *emphasizes* the lack of completeness and insists on dividing and highlighting certain and uncertain information within the same model. Digital 3D-reconstruction provides tools for the management and visualisation of uncertainties in archaeological data. The gap between the "insufficient" knowledge of archaeologists and the photo-realistic impression these models provide is often blurred.

Furthermore, photorealistic models might evoke an impression of an 'ideal world' and include the danger of an inappropriate glorification or minimisation of historical periods: e.g. the 3D model of a Bronze Age lake dwelling in Austria, which is reminiscent of the 19th-century romantic paintings of the Neolithic and Bronze Age Swiss lake sites (*Fig. 1*, Keutschach 2007). We have no idea indeed if the reedgrass really was that high or if the complete place was not trampled down and the houses rotten and torn.

Sometimes the interiors of prehistoric houses look like an interior studio design for land house style (*Fig. 2*). Too often virtual productions like those of Keutschach and Dürnberg (*Figs 1* and *2*) display a rustic cottage style but fail to communicate enough of the underlying scientific discourse. Here interactivity in the model might be one possibility to deal with

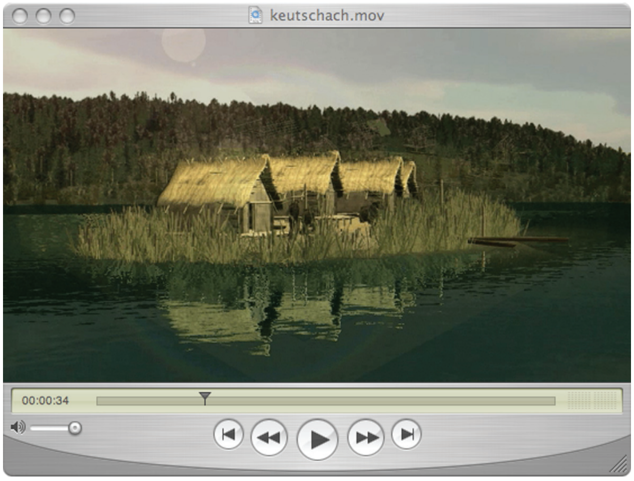


Fig. 1. Bronze Age lake dwellings from Keutschach.

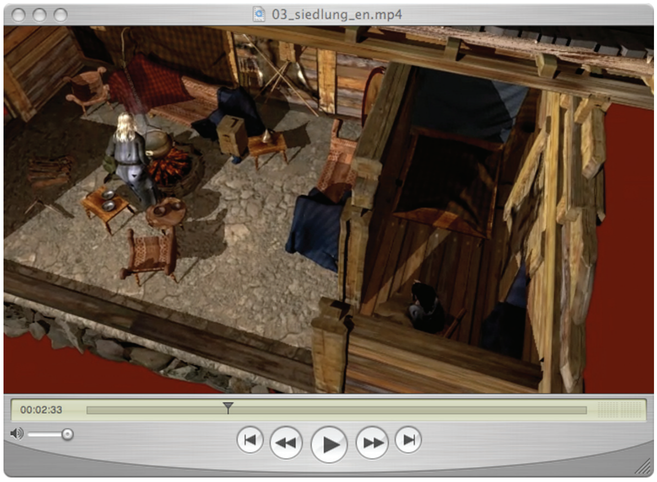


Fig. 2. Screenshot of 'The Celts', Dürnberg, Hallein.

Fig. 3. One reconstruction from the Aspendos Amphitheatre in Turkey.

Fig. 4. No alternative architecture in the Virtual Manching Oppidum.

these elements more creatively, e.g. let the user move all around the freely added interior of the site and only fix those objects that really were found in situ (*Fig. 2*, Hallein 2007), or also show some decayed furniture and dirt.

Missing information about uncertainty can give the impression of clear knowledge were there is none. In the following examples archaeologists and digital-graphic-designers chose only one of several possible solutions for roof reconstruction. There is not even a consideration of other opportunities (*Fig 3*, Aspendos 2006; *Fig. 4*, Manching 2006). The list of examples could easily be extended by further VR-productions. Modern applications can easily change roofings, e.g. in a movie sequence or in an interactive order.

Of course it is true that the explanatory power of images is much more impressive than that of texts and spoken words, but they are also more suggestive and omitting. For this reason techniques of visualisation should be seriously examined in order to estimate the suitability for their specific use in the scenario. Moreover, digital graphics combined with Geographic Information Systems, databases, ontology and others provide more powerful tools for archaeologists than any printed publication ever can. They also provide solutions to the problem of uncertainty.

Depending on the purpose of the application photorealistic reproduction is not always needed. This might prevent the unaware user from wrong suppositions. Further methods like the visualization of the architectural skeleton instead of the permanent, fully textured model (*Fig. 5*, Carnuntum 2007) can also provide a more realistic view of the archaeological reconstruction without the loss of suggestive quality.

Another solution to the uncertainty-problem can be found in the annotation of VRs by POI-Systems. This possibility is exemplarily shown in the Sipapu-

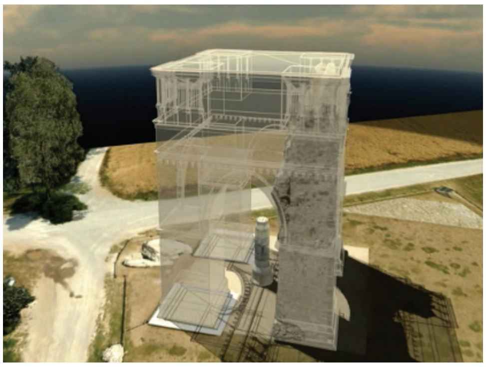


Fig. 5. Schematic reconstruction of Roman Heidentor *at Carnuntum.*

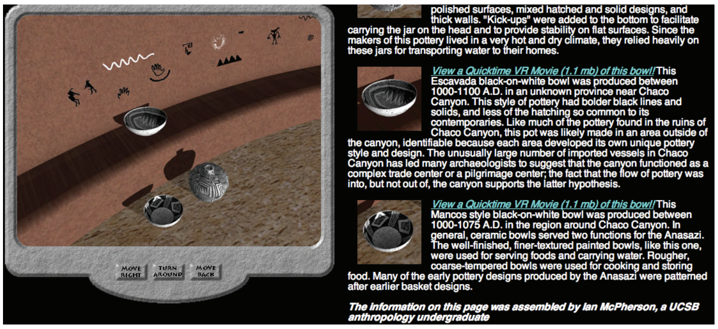


Fig. 6. Screenshot of a 3D house-model on the Sipapu-website.

website about south-western American Pueblo Indians. The 3D-model is enriched with additional information that can be selected in Points Of Interest (*Fig. 6*, Sipapu 2005). Most of the examples presented are movies without (m)any interactive features. Only the two online applications can be accessed interactively.

3. The Glauberg VR

Dealing with Iron Age Glauberg as with many other hill-forts bears several problems. The on-site situation suggests a very careful construction. While information on the recently excavated and well-documented sanctuary-area is comparably definite, the interpretation of the settlements and fortifications is much more uncertain. Slope erosion and the reuse of the fortification as a medieval castle caused enormous damage to Iron Age features. Apart from a few remnants of the fortification wall the whole plateau so far lacks Iron Age features. Thus the vast number of contemporary objects found in the ramparts of the medieval fort suggests the presence of intense settlement activity. The lack of documented features of the fortress made a digital VR the best solution for the reconstruction. Open-air-reconstructions with Iron Age houses would be inappropriate in this context. The VR at least provides the opportunity to highlight the uncertainties of the site.

More than 90 years of archaeological investigations on the Glauberg have brought to light many finds, features, facts and details about the people inhabiting the place. Analyses of the material remains suggest a diachronic model for the formation of the area and the progression of human activity. Moreover, social and economic structures and contacts of the inhabitants are an integral part of archaeological models. As long as these reflections are conceptualized in abstract models they are accessible only to a small group of professionals. In order to make these ideas accessible to a wider audience they have to be reasonable. The digital visualisation of an environment that demonstrates all constituent terms and conditions we know can be helpful. Nevertheless, a visual implementation of 'Iron Age conditions' at the Glauberg fortress bears special problems. Here features of buildings are completely supplanted and erased by more recent medieval earthworks. The discovery of three tons of Iron Age finds delivers some insight into settlement activity. Therefore a VR reconstruction of the Glauberg plateau showing no Iron Age buildings would be less representative of reality than one showing the recreated buildings designed for this project (*Fig. 7*).

Keeping in mind the analysis of the actual VR models in archaeology we set the goals for the Glauberg VR, the most important of which was the visualisation of uncertainties. But similar high ranking was the development of an administration/editing-tool for the application. This should be easy to use, even by the unskilled user. The administration- and annotation tool allows the uploading of data to the multimedia server (see below).

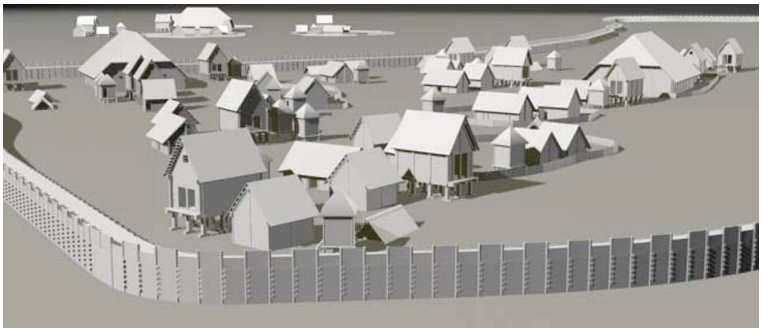


Fig. 7. High res. model of the Glauberg fortress from the south-west.

The Glauberg VR demonstrates different kinds of presentation/visualization of uncertainties in archaeological interpretation combined in one model. Metadata, visual and audible information will be utilized in the model. The user will be able to find out more about variations in architecture, environmental patterns and different aspects of social life. Web based underlying geographical information is used to navigate the site and digital reconstructions of specific buildings can be visited interactively.

At the current state two tasks have priorities: the construction of the appropriate buildings and the preparation of the geo-referenced terrain.

House-constructions from other Iron Age sites are used to compensate for the lack of house-features to create models at our site. For the fortress on the hill-top we chose some well documented features of the Heuneburg in Baden-Wurttemberg. Other house-features were taken from the vicinity of the Hunfeld-Mackenzell settlement, 30km east of the Glauberg, in order to have more suitable examples for Early Iron Age cultures in the low mountain range areas. The original place of the houses featured is mentioned.

For this reason we created different architectural models using the same floor plan. This can be exemplarily seen in *Figs 8* and *9*.

The digital terrain model is based on a LiDAR Scan of this area (*Fig. 10*). In order to use the LiDAR for the web application we had to simplify the model. The houses on the hill-top have been adjusted to the natural landscape and slope.

Surveys in the vicinity have shown further rural settlements on the fertile soils around the Glauberg (*Fig. 11*). Though original features were mainly eroded a few features remained. Some pit-houses and storage pits are also (re-)constructed *in-situ*. For all the erosion it was possible to trace an eight-post house at an excavation last year. These

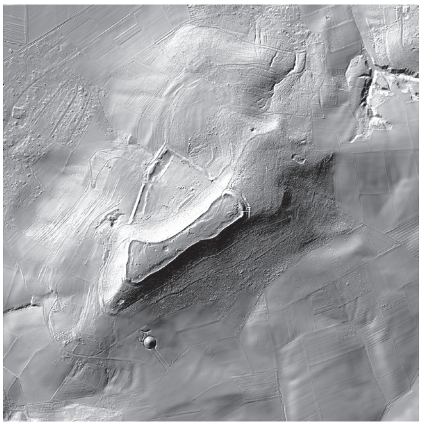


Fig. 10. Aerial scan of the Glauberg region.

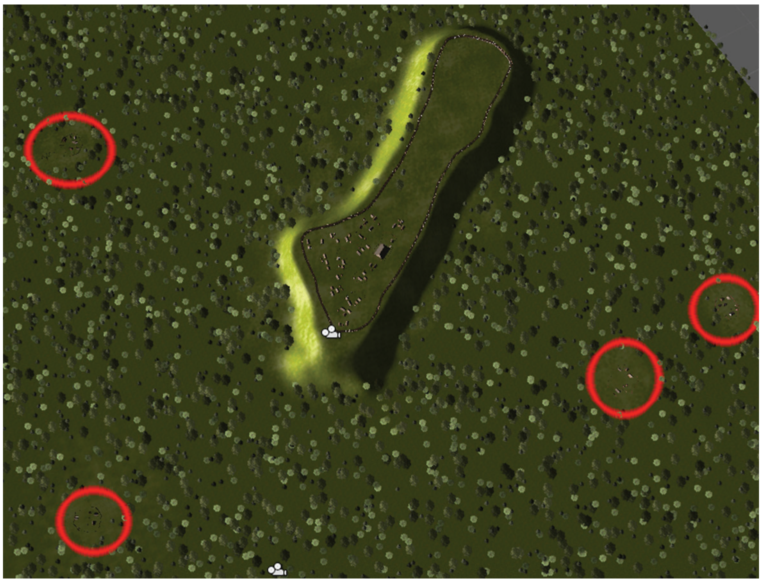
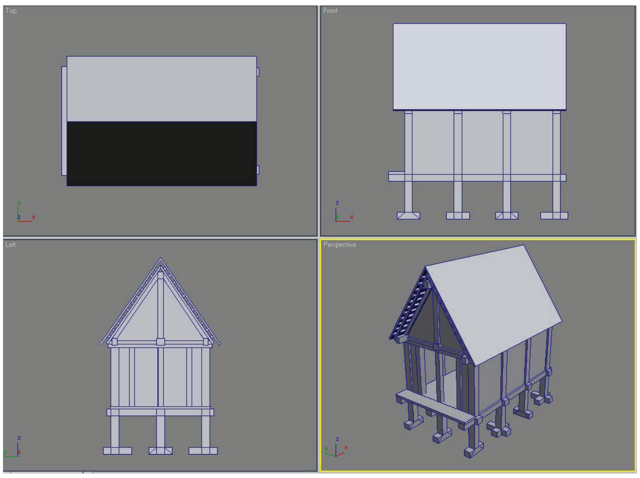
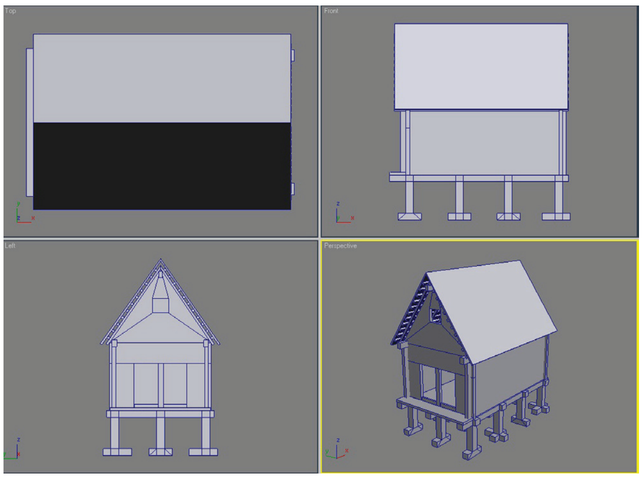


Fig. 11. Modelled settlements located in their geographically correct position.





Figs 8 and 9. Two different 3D models of the same house derived from the site Heuneburg in Baden-Württemberg (graphic design: Glasgow School of Arts).

first Iron Age house-remains from the Glauberg will also be digitally reconstructed. In order to distinguish between feature-based reconstruction and hypothetical details, different methods will be applied in order to visualise the differing degrees of documentation – up to the point of mere fiction. We are experimenting with colour change, nebula and interactive replacement of different textures.

The sanctuary is the best-researched part of the Glauberg. An earthwork of ditches and ramparts together with postholes and two burial mounds have been excavated in the recent years. Investigations by an astrophysicist have suggested the hypothesis that this might be a place of celestial observations. The scenario is meant to highlight this issue and suggest the pros of the theory in 3D visualization.

A third basic detail of the model is the environmental reconstruction of the area. To avoid a too photorealistic impression we divided the area into four 'ecological zones' to characterize typical features of the landscape. For each zone we have chosen a few typical plants, trees and bushes. The first zone includes areas around human habitats inside and within the vicinity of settlements. Here we have got beds of horticultural plants (pea, lentil, broad bean, etc), hedges of bushes like elder and snowball. The second zone describes areas under human control, like fields, and pasture areas. In the north-eastern and the southern part of the area a thick forest constiutes the third zone. The final zone represents the floodplains of the meandering river Nidder, to the west, which are overgrown with common sedge, loosely interrupted by groups of alder and willow.

With this approach we want to depict the enormous impact of man on the environment in the Early Iron Age.

4. NetConnect technology

The technical motivation for the project was to create simple and intuitive applications for the visualization of cultural heritage sites. For this purpose our technical partner "Fraunhofer IGD" developed a 3D-GIS-server, for storing and providing the geometry of the VR-components in different resolution levels, the semantics and the metadata. *Fig. 12* shows the components of the information system. Special attention has been paid to the administration tool that is intended to enable content providers to update data.

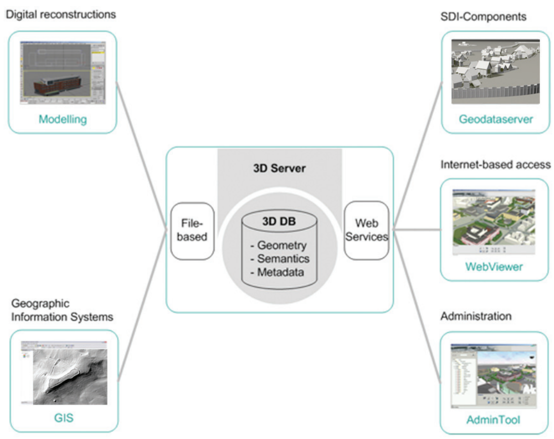


Fig. 12. Basic architecture of the 3D-web-server-technology (graphic: Markus Etz, Frauhofer IGD).

Together with an editable multimedia-server these two components build the core-infrastructure, both developed by our partners of Fraunhofer IGD. Using an application-dependent enhancement of semantics and behaviour the server supports the usage of most important interfaces and standards, both for 3D- and multimedia-objects. It is extendable to new components and functionalities and allows the conversion of most standard formats. The details of server abilities can be studied in *Fig. 13*. The multimedia-server component will be easily edited even by non-professional users via administration tools. Images, videos, audio clips and text can be uploaded, changed and adjusted to reflect new archaeological research results. Provided that a LAN-access is at hand both applications revert to the objects

Fig. 13. Details of server-technology (graphic: Markus Etz, Frauhofer IGD).

on the 3D- and multimedia server. Interoperability between both servers will be supplied by the POI structure.

For the mobile application we still face the problem, that a LAN-access is not yet available everywhere, especially at the Glauberg and Lokroi sites (Etz 2007). So we have to provide a second solution for a download to the device available at a bluetooth desk at the Glauberg or over the internet. We hope that the internet accessibility will be improved at the sites in the next few years.

The current state of the Glauberg model presents only one facet and it is being developed in the NetConnect-Project. Further work has to be done in landscape modelling and in the augmentation of the model. An evaluation of the models by the general public and expert users is planned. The results will be incorporated in a revision phase in 2009.

References

Barceló, Juan A. (2000). Visualizing what might be: an Introduction of Virtual Techniques in Archaeology. In: Juan A. Barceló, Maurizio Forte and Donald H. Sanders (eds.) *Virtual Reality in Archaeology, Annual Conference on Computer Applications and Quantitative Methods in Archaeology CAA 1998, Barcelona*. BAR International Series 843. Oxford: Archaeopress, 9–35.

Bertacchini, Piero A., Guiseppe Conti, Ruth Beusing, Raffaele De Amicis, Aleksander Bursche, Markus Etz, Daniel Holweg, Axel Posluschny, Assunta Tavernise, Maria T. Linaza and Douglas Pritchard (2007). Netconnect – Connecting European Culture Through New Technology. In: *Conference proceedings EVA – London 11th–13th July 2007.*

Etz, Markus (2007). MobileChase – Das Mobiltelefon als spielerischer Zugang zu Kulturinformationen. In: Michael Mangold, Peter Weibel and Julie Woletz (eds.) *Vom Betrachter zum Gestalter. Neue Medien in Museen – Strategien, Beispiele und Perspektiven für die Bildung*. Baden-Baden: Nomos.

Etz, Markus (2008). Die Kelten kehren zurück. Der Einsatz virtueller dreidimensianaler Rekonstruktionen im Kulturtourismus, *InnoVisions* 01/2008, 58–9. http://www.innovisions-magazin.de

Forte, Maurizio (2000), About Virtual Archaeology: Disorders, Cognitive Interactions and Virtuality, In: Juan A. Barceló, Maurizio Forte and Donald H. Sanders (eds.) *Virtual Reality in Archaelogy, Annual Conference on Computer Applications and Quantitative Methods in Archaeology CAA 1998, Barcelona*. BAR International Series 843. Oxford: Archaeopress, 247–235.

Huvila, Isto (2006). T*he Ecology of Information Work. A Case Study of Bridging Archaeological Work and Virtual Reality Based Knowledge Organisation*. Åbo: Åbo Akademis Förlag.

Kantner, John (2000), Realism vs. Reality, Creating Virtual Reconstruction s of Prehistoric Architecture. In: Juan A. Barceló, Maurizio Forte and Donald H. Sanders (ed.), *Virtual Reality in Archaeology, Annual Conference on Computer Applications and Quantitative Methods in Archaeology CAA 1998, Barcelona*. BAR International Series 843. Oxford: Archaeopress, 47–51.

Mulrenin, Andrea M. and Axel Szauer (2002). *The DigiCULT Report – Technological landscapes for tomorow's cultural economy. Unlocking the value of cultural heritage*. Vienna 2002. (http://digicult.salzburgresearch.at/downloads/dc_es_german_230602_screen.pdf).

Sietmann Richard (2007). Erbengemeinschaft Content-Digitalisierung in der EU, In: *c't,* 7, 19. März 2007, 44–45.

Projects

AGAMEMNON - http://services.txt.it/agamemnon/

ARCHEO-Guide - Augmented Reality-based Cultural Heritage On-site Guide, http://archeoguide.intranet.gr/project.htm

Aspendos 2006 - MiraLab – University of Geneva (prod.), Aspendos, Turkey, ERATO-project.

DigiCULT, Technology Challenges for Digital Culture, http://www.digicult.info/

Europeana - Connecting cultural heritage , http://www.europeana.eu/

Epoch, Network of Excellence in Open Cultural Heritage, http://www.epoch-net.org

Hallein (2007). 7reasons/Keltenmuseum Hallein (prod.), Kelten/The Celts/I Celti, Dürnberg, Hallein, (ISBN: 978-3-9501914-5-5), Salzburg 2007.

Keutschach (2007) - 7reasons, Gemeinde Keutschach, Universität Wien (prod.), Keutschach-Pfahlbausiedlung, Salzburg/Wien 2007.
Manching (2006). Archäologische Staatssammlung München, Arctron 3D GmbH (prod.), Die Keltenstadt Manching – Die Geschichte des keltischen Oppidums. Documentary film DVD.
Sipapu 2005 – Anasazi Architecture, webpage created by John Kantner, http://sipapu.gsu.edu/html/architecture.html
TNT - The Neanderthal Tools, http://www.the-neanderthal-tools.org/
VENUS - Virtual Exploration of Underwater Sites, http://piccard.esil.univmed.fr/venus/

Thanks to the NETConnect Consortium

Piero A. Bertaccini/A. Tavernise, Università della Calabria, Cosenza, Italy; Eva Klien/Markus Etz, Fraunhofer Institute for Computer Graphics, Darmstadt, Germany; Aleksander Bursche, Roksana Chowaniec Institute of Archaeology Warsaw, Poland; Maria T. Linaza, Asociación Centro de Interacción Visual y Comunicaciones – VICOMTech, San Sebastián, Spain; Guiseppe Conti, Fondazione Graphitech, Trento, Italy; Douglas Pritchard/Tom Maver, Glasgow School of Art, Glasgow, England, Ruth Beusing, Axel Posluschny Roman Geramnic Commission, Frankfurt, Germany.