VIRTUAL RECONSTRUCTIONS IN ARCHAEOLOGY AND SOME ISSUES FOR CONSIDERATION
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ABSTRACT

In this article we will examine the current role of virtual reconstructions in archaeology. They provide a non-destructive means of exploring an archaeological model of an archaeological site, or a complex of monuments or even cultural objects. Not only their contribution to the archaeological research and in the understanding of the past from the wide public, but also some criticisms against them will be discussed. Furthermore, some ideas about the future work that can be undertaken will be presented.

Computer reconstructions in archaeology

Computer reconstruction in Archaeology is not something new. Some of the first archaeological computer reconstructions can be dated in the early eighties. The term "Virtual Archaeology" that refers to the use of Virtual Reality for archaeological research (Reilly, 1990; Barcelo et al., 2000) has been mentioned since the 1990s. Virtual Archaeology is related to three-dimensional computer reconstructions of archaeological interest. By the term 'archaeological computer reconstructions' we refer to the use of 2D and 3D computer models of monuments, excavations, landscapes and artifacts, made by graphic programs, such as AutoCAD, 3D Studio Max, Maya, Microstation.

In recent years the developments of the computer graphic programs have provided the archaeologists with very powerful tools for the visualization of various sights of different ancient cultures. The reconstructions of archaeological sites can offer to specialists, students and tourists ideas about the lives and the civilizations of earlier cultures. The archaeological data about them may be complicated, unclear, clouded for the human mind. However, with the aid of computer reconstructions a good opportunity is offered to reconstruct and visualize aspects, features of the data that otherwise would be difficult or even impossible to understand. The interactive models can be in a portable format on DVDs or CD-ROMs, in the World Wide Web or in an immersive virtual environment, such as the CAVE of the Foundation of the Hellenic World (Sideris, 2003).

This domain of virtual archaeological research aims to mimic 'real' space as closely as possible (Feiner et al.). When the archaeologists succeed in connecting archaeology and the potential of the graphic programs, they can produce remarkable three-dimensional computer reconstructions. Literally said, the computer reconstructions in the case of archaeology 'put the flesh in the bones'.

It is beyond the scope of this paper to carry out details concerning the methodology that is used for the creation of 3D models. However, a brief presentation of them is useful. Three-dimensional reconstructions entail the creation of a virtual model, by using computer graphic programs.
There are two different methods of creating models in computer graphic programs, solid and surface modelling. Solid modelling produces geometric primitives. It combines and manipulates them with Boolean operators, namely addition, subtraction and union, in order to define 'complex solid geometric shapes' (Burchard, Pitzer, 1999: 910). The buildings in 'solid modelling' are made with geometric solids that are combined in various ways. In 'surface modelling' the reconstructed object is formed by meshes of lines. "The surface model is typically based on polygonal surface patches and may include information about the nature and appearance of the surface in terms of color and texture" (Ryan 1996:97). Landscapes, scenes, monuments or artifacts can be constructed in this way.

One of the main problems of surface modelling is that surfaces do not have any detail or any other property other than the surface itself. In addition to this, solid models can embody the spatial relationships between interior and exterior faces of the same solid. Also, in solid models it is easy to link the data to the objects (Daniels, 1997). The main advantage of the surfaces versus the solids is that they are easier to manipulate.

After the creation of the model, the next step is the rendering. Appropriate textures are applied to the components of the model. Finally, in order for a realistic model to be produced, the lighting that will produce the affect of the shadows, which prevents our model from being 'flat', must be added (Burchard and Pitzer, 1999: 967). "This process can be enhanced by the photo-realism that can be provided by the computer model including realistic illumination and the presence of environmental factors such as smoke, dust or fog" (Chalmers and Stoddart 1996:87).

**Contribution of computer reconstructions to Archaeology**

The computer models are not just 'pretty pictures', but they offer several essential benefits to archaeological research. The reconstructions make possible the observation of some aspects of the data that without them, it would be very difficult to evaluate hypotheses concerning various archaeological questions.

They can offer valuable help during the excavation and the fieldwork. Sometimes, the partial destruction of the site excavated is required. An example of this case is stratigraphy. "A paradox of archaeology is that although excavation can be characterized as an observational discipline the archaeologist never actually sees the whole formation under examination" (Reily, 1991: 135). In order to investigate a layer, an archaeologist has to remove one by one all the overlying layers with their structures and findings from later phases. With the computer reconstructions it is possible to visualise the features of a site one by one in separate reconstructions or all together in a single reconstruction with multi-dimensional aspects (Colley et al., 1988; Kotsakis, 1989; Main et al., 1995; Lukesh, 1996). Computer reconstructions are the simplified views of the real world that make easier for the archaeologists to comprehend the archaeological data. Consequently, the process of understanding and interpreting the site would be easier for future researchers.

Furthermore, with the computer models the archaeologists have the possibility to capture all the information that comes to the light 'in situ' during the digging. The researchers reconstitute and re-examine the primary data from the excavation that could not -for some reasons- look at them and have the chance for a 'second look'. With a reconstruction model, the archaeologists have the chance to re-excavate the site and pay attention to details that may have not been noticed during the excavation.
During the development of a reconstruction model the archaeologists become familiar with the characteristics, the particularities and the deficiencies of the data upon which the model is based. During the modelling process the archaeologists have to confront various questions concerning the architecture and technical matters of the ancient structures. By answering, or trying to give answers to these questions, a better understanding of the form, the function, the scale, its position in the landscape, the area and interesting insights may appear.

Three-dimensional reconstructions have been additionally used for purposes of archaeological research. Sophisticated models have been created in order to examine archaeological theories. The visualisation of ancient sites has been attempted and theories about complex issues such as simulation of illumination (Lucet, 2000) have been tested. Various sophisticated techniques have been used and, apart from alternative reconstructions, accurate results have been produced (ibid.).

Sometimes three-dimensional reconstructions have been combined with other computer applications such as VRML (Virtual Reality Modeling Language) and GIS (Geographical Information Systems) (Goodrick and Harding, 2000). Such analysis provided archaeologists with meaningful results that they would otherwise be unable to acquire. Monuments are placed on a DTM (Digital Terrain Model) that is acquired from a digital map or otherwise reconstructions can reveal the symbolisms of the landscape, or even offer an explanatory view to settlement patterns or architectural elements that can present information and Travels to the Past (Rodriguez et al., 2000) and suggest proposals for research. Moreover, they can examine the relationships between the buildings of an architectural complex and test theoretical issues such as ‘impressiveness’ and visibility. An example of this case is the Virtual model of the city of Sagalassos (Martens et al., 2000).

Furthermore, reconstructions can offer considerable benefits for the non-specialists and the general public. Computer reconstructions can be used in interactive systems (Brogni et al., 2000) and allow access to the information about the reconstructed model, through a user-friendly interface. In the same context, reconstructions not only of single historical buildings, but also of whole cities can be created, showing its development, as well as providing information about it from various sources, manuscripts and paintings. They can disseminate the results of the archaeological research and offer an experience to the Past for the general public and a useful tool to the scientists for testing hypotheses (Kadobayashi et al., 2000). Also, they allow both the specialists and the general public to have access to a great deal of information rapidly. The most important is that these models are liable to change and this information can be updated anytime and easily if and when the researchers have new conclusions about the archaeological data. Apart form the aesthetic value of the computer-generated models they encourage the user to imagine and to think deeply about the relationships between the different kinds of information provided.

Moreover, three-dimensional archaeological reconstructions play an important role in the "plurality of interpretation" (Shanks and Hodder, 1995; Chalmers and Stoddart, 1996). With the virtual reconstructions archaeologists, or anyone interested, have the opportunity to navigate and see different views or pre-set paths of virtual structures, of which little evidence exists. Virtual reconstructions can give the chance to explore past worlds and learn more about the history of the sites visited. This has the potential not only to drive the archaeological research to new paths, away from the strict architectural analysis of the buildings, but also to test theories and create new ones.

Issues for consideration
Despite the advantages that the archaeological virtual reconstructions have, according to some researchers, they can prove to be a 'double-edged sword' (Eiteljorg II, 2000) and the power of graphic programs can hide dangers. It will now be examined what form these dangers can take.

'Virtual reality' (an oxymoron) cannot have the complexity of the real objects. Virtual archaeology—in the ontological sense, as translated from Greek dynaton (gr. δυνάτον=possible), it is "that in potential" (Aristotle, Analitici primi); in fact, in scholastic philosophy it is that exists in potential form and not in reality (Forte 2000).

In the past two decades, in some early examples of archaeological computer reconstructions, some high-quality reconstructions involve collaborations between archaeologists and programmers or architects. In these cases, there were problems of communication between these people with the archaeological theoretical knowledge and those people with the practical knowledge of computers. In most circumstances, the visualisation software itself was not accessible to archaeologists and therefore the computer scientists were interposed between them and their data. "The archaeologists did not have direct control of the modeling themselves" (Miller and Richards, 1994). In some cases, where the remains from the ancient era were fragmentary, because of later human or geological activity or because the buildings had been altered or rebuilt, it was probable that the Past was both misinterpreted and misrepresented. The visualization results were impressive, thus fulfilling their primary goal specifically the consumption from the general public, but without in turn, serving the archaeological research. Since then things have partially changed, but archaeological computer reconstructions continue to be criticized by some researchers.

The main problem is that advanced graphic systems that are used for computer reconstructions may sometimes be too realistic. Things can be difficult, especially when they are based on partial evidence, but nevertheless suggest an impression of good knowledge of the past. Indeed advanced graphic systems present the 'image' as true, giving the sense of misleading accuracy (Miller and Richards, 1994; Ryan, 1996). When the reconstructed item has a lot of missing elements then -obviously- archaeologists must use their imagination or rely on ethno-historical information on how similar cases might have looked like, in order to reconstruct it. However, in these cases, the result will not be an explanation of the past, but a personal and subjective way of seeing it. A very good 'image' can give the impression to the viewer that archaeologists know more than they actually know. Some products of computer reconstructions can be considered as scientifically accurate, because they seem to be accurate.

Even if there is a degree of accuracy, the one-sided view of the reconstructed site is still wrong. Computer reconstructions that offer only one aspect of the subject they examine and do not provide any alternative reconstructions, contradict the beliefs of archaeologists that there are many ways to examine the Past. In addition to that, every aspect and opinion in the archaeological ring is under continuous doubt and examination. There is only one aspect of the subject that has been reconstructed and no alternative reconstructions have been created. The public accepts the reconstructions as the undoubtedly correct ones, as an archaeological truth, even if the archaeological records do not verify them. The near-perfect visualization of images of the Past, sometimes are arbitrary and can make 'fantasies seem very real'. Not only the non-specialists, but -sometimes- also the specialists, the archaeologists, may have difficulties in understanding that the model is only a hypothetical reconstruction, that may be based on weak evidence.
Another thorny problem that has been indicated by some researchers is the tendency of the archaeological computer reconstructions to show the capabilities of the advanced graphic techniques, rather than serving archaeological aims. Especially with the latest photorealistic renderings that use textures and materials it is quite easy for confusion to be created between the realism of the reconstructions and the archaeological reality. The more technologically advanced and perfect are the reconstructions, the more the people believe they are real. For publicity reasons and simply as a way to test their developing technologies, large computer firms, such as IBM (reconstruction of the Saxon Minster of Winchester), have sponsored some archaeological computer projects. The outcome of these efforts has resulted in high-profile projects with perhaps little archaeological significance.

The computer reconstructions do not look for new techniques that will give answers to various archaeological problems. Their main preoccupation is to present the already known information by an attractive and impressive way to the public. Certain models are, as it is already said, in some degree arbitrary. Also, the computer reconstructions use 'tricks' like fog, smoke, clouds etc. in areas where the interpretation is difficult or even impossible. As a result, the archaeological questions and problems are 'covered' and remain without answers.

Virtual archaeology makes the reconstructions available to the people, but - often- they have reconstructed elements already known by the excavation process and the interpretation of the site. So, the reconstructions do not propose new solutions and do not present new insights. Accordingly, the archaeological study becomes monotonous, because it repeats itself and also looses its central meaning, continuous research and renewal. The archaeological computer models suffer greatly from not having clearly identified purposes. The design of every reconstruction model must be carried out according to the particular reason for which it has been created. A reconstruction model can be created for archaeological research during or after the excavation, for public presentation or for educational purposes.

Finally, the role that computer models play in the heritage industry should be mentioned. They have a potential marketing value. People that do not have any special knowledge about archaeology, history or architecture can easily understand a realistic visualization of a monument. The problem is that they can also be easily manipulated, because the computer models are 'dressed' with beautiful colors, shapes and textures that can mislead them.

In the case of the computer reconstructions in Geographical Information Systems, archaeologists can learn how to use the powerful cartographic programs, but great effort would be needed in order to acquire the background of a cartographer. Otherwise some serious mistakes can be made. "Given such a plethora of tools, it becomes all too easy to generate pretty but meaningless or even misleading maps" (Miller and Richards 1994).

**Outlook**

The graphic programs must be used carefully and always with the assistance of an archaeologist or even a tourist. So perhaps it will be helpful to mention some of the ways technology should be used to transform computer reconstructions into really useful and accurate views of the past.

Helpful for the archaeological research and interpretation would be the creation of interactive links between the data, the images and the user (Miller and Richards, 1994). The use of databases in a chrono-typological basis, with Virtual Reality Modeling Language can provide a cultural and historical context to
virtual worlds. Digital Libraries of ancient sites can be interconnected and automatically be updated every time that new excavation data or hypotheses come to light, could be tested and new computer environments constructed. An effort like this not only will promote the archaeological interpretation, but can also be used for distance learning and facilitate the global archaeological or even interdisciplinary research.

The archaeological interpretation will help the archaeologists distinguish knowledge from consideration, between the real and the imaginary. The viewer will be able to understand exactly what he sees and separate the existent remains from the hypothetical and the interpretation that the archaeologists were forced to do as part of the modeling process. It would be preferable if the viewer would see the remains before the images, because it is difficult to remove the image that he/she has seen from his or her memory.

Furthermore, the future reconstructions, in order to give an impulse to the archaeological research will present not only one reconstruction model, but also the alternative solutions for the same model. The role that the computer reconstructions could play in the future is an extension of their current role. The future advancement of the archaeological computer models will be just virtual environments that are used as presentation tools, but as explanatory tools (Barcelo 2000).

In the future, the role of computer reconstructions will be important on the condition that not only the general public, but also the scientists realize that the models are an imitation of the archaeological reality. Hopefully, they will be a simulation of it. But there is no way they can replace completely and be an exact copy of the reality. Additionally, the levels of certainty of a computer reconstruction will be clarified. In future reconstructions it will be obvious in which cases their creators were sure for the models they have produced and in which cases the models were a result of imagination. Also, the future creation of a theory that determines the limits, i.e. the beginning and the end of artistic "freedom" of the computer reconstructions is required. It is necessary to determine which features were actually identified by the archaeologists and which represent more tenuous interpretations that the modelers were forced to make as part of the modeling process. The process of 3D modeling has made virtual reconstructions appear realistic whether or not they accurately reflect how the architecture really appeared in the past. The 3D reconstruction models must be regarded with the appropriate criticism. It is important that the public knows about the history of each building. The public must be informed if there is possibility of alternative interpretations. This way, people are confronted with the data which will enable them to evaluate the models themselves. It is necessary that the interpretative elements of a reconstruction are clearly distinguishable from the initial excavated evidence.

**Conclusion**

The problems of archaeological reconstructions have been noted and criticized. Nowadays, much has changed and computer reconstructions can offer valuable help to archaeologists and provide useful insights and archaeological information to the general public.

Finally, it is a general truth that some problems still exist nowadays, but the effort for improvement continues. Despite all the obvious problems, as we have already mentioned, computer reconstructions can be used as a very valuable tool with further area for development both in practical and theoretical areas of archaeology, in the hands of archaeologists.

**REFERENCES**
By the term 'Primitives' we mean the box, sphere, cylinder, cone, wedge and torus.

An example is a computer simulation of Stonehenge which has explored the light and shadow effects and the symbolism behind them (Pasztor et al., 2000).

An example is the WWW Virtual museum of the city of Bologna, in Italy (Bonfigli and Guidazzoli, 2000).

E.g. reconstructions of the Temple Precinct from Roman Bath (Reilly 1992).

**BIBLIOGRAPHY**


