On using state of the art computer games engines to visualize archaeological structures in interactive teaching and research.

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Abstract:

The AERIA (Antikensammlung Erlangen Internet Archive) Project is currently developing visualization platforms for architectural reconstructions of both greek and roman buildings.
The purpose of our work is to provide virtual interactive walkthroughs of structures of archaeological interest for both teaching and research, via the Internet. In our presentation we implement techniques provided by computer-game-engines. The objective is to create virtual worlds without the need to employ expensive CAD software. We demonstrate that game engines can easily be adapted to the needs of archaeological science.
This method was first introduced during an exhibition in the year 2000 in Rosenheim (Landesausstellung für Archäologie) "Die Römer zwischen Nordmeer und Alpen".
In our contribution we focus on the following reconstructions:
- Römerlager Marktbreit (Imperial Roman Fortress in Bavaria);
-Legrena 17 (a huge farmhouse in Attica during the classical period). Both virtual worlds are based on a modification of the Quake2 render engine.
-The throne of Apollon Hyakinthios in Amyklai near Sparta. This scenarion is based on a Quake2 and the Morrowind engine.
-The palace of Nestor in Pylos rendered with the Halflife engine.

Keywords: Architecture, Reconstruction, Visualization, Interactive, Walk-Through

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In the following pages we attempt to give an overview of our usage of computer games in archaeological visualization. During our experimentations with different games engines we came across very different scenarios in which such software can be used. We use games mainly for the rendering of reconstructions of ancient buildings with several target audiences ranging from school classes at public exhibitions, seminar sessions in the classroom with students of archaeology and public talks about latest research results. It is not within the scope of this article to give hints how to build an archaeologically sound model or to advise the reader on how to adjust his or her data to the different engines. However, beginning with early games with the need for highly specialized geometry files, we show that with newer games at least common graphics interchange formats are supported. We will give our view that it is possible nowadays to show almost any piece of archaeological 3D data with modern games and so avoid the need for expensive specialized solutions. The work presented in the following pages was carried out by both authors alone: all programming was done by Martin Meister, both the authors are responsible for graphics and design. All virtual worlds are based on 2D reconstruction drawings by Martin Boss.

The AERIA-Project originally started in 1994 as an electronic archive for the historic photo collection of the Erlangen Antikensammlung (collection of antiquities). Since then it has been expanded into a full scale virtual museum, with an online display of all parts (Collection of Greek and Roman Antiquities, Gallery of plaster-casts and photo-archive) of the collection[1]. Nevertheless, an online museum should not be restricted to simply mirroring the museum artefacts in terms of providing pictures or video files. The statement of 1857: "Der Gewinn, welchen das unmittelbare Anschauen verspricht," remains valid today and cannot be substituted by looking at electronic images (Boss 1993:597ff.)[2]. Even the most extensive museum cannot recreate the atmosphere of an ancient building in operation. For example, the Ishtar-gate at the Pergamon Museum in Berlin gives an impression of the size of the museum rather than that of ancient Babylon. Here a virtual museum has genuine advantages, because it can show more than the actual state of preservation in virtual reconstruction. So in our case, the AERIA-Project at Erlangen can show the palace of Nestor in distant Greece without owning a single part of it for display.

From 1999 onwards AERIA has been developing visualization platforms for architectural reconstructions of both Greek and Roman buildings. First steps with still images and some short animated clips (reconstruction of geometric architecture at Perachora and Eretria[3]) were carried out with a 3D computer aided design[4] (CAD) package called LightWave[5]. However, as one cannot change the viewpoint or path, the disadvantage of pre-rendered views lies in their static nature.

The exhibition "Die Römer zwischen Nordmeer und Alpen" at Rosenheim (Wamser 2000:435ff.) during the year 2000 offered the opportunity to experiment with real-time and interactive virtual 3D reconstructions of the Roman legionary fortress at Marktbreit and a wider spectrum of viewers. In view of the huge number of school classes visiting the exhibition and the fact that most children today are

familiar with computer games, a modification based on a first person action game or so-called shooter (FPS), Quake2[6], was developed.

At this point a definition of our notion of a (game) engine is apt. An engine is the core module of a software package that deals with the rendering of geometry from the memory of the computer or graphics card directly to the screen. It creates a transparent layer that wraps around the hardware and enables the user to process geometric shapes. In the game industry this division of, on the one hand, geometry and, on the other hand, the render engine existed from early on. Games manufacturers license graphics engines for their software and do not have to programme low-level graphics functionality at all. Instead, they concentrate on the nature of their game and the visual artwork, such as geometric shapes and textures. Consequently, the game community[7] is able to create modifications, changing the appearance and behaviour of these games with the aid of the game manufacturer but the engine cannot be altered. Our research is situated at exactly this point because we want to change the geometry displayed and hide most of the gaming aspects. Here, while a modification normally focuses on changing gameplay, textures and geometry, it was necessary for us to programme a modification module in the form of a dynamic link library (DLL) for Quake2 that made shooting and killing impossible, thus transforming the game into a visualization tool.

During the exhibition at Rosenheim the modified game offered four virtual spaces called maps, displaying various places within the camp (maingate, Fabrica, Principia and Praetorium), which could be explored in detail by free individual movement (figure 1-2).

Fig. 1. Fabrica at the Roman legionary fortress at Marktbreit; outside view.

Fig. 2. Principia at the Roman legionary fortress at Marktbreit; inside the central courtyard.

In retrospect it proved to be a good addition to the real plaster-models which stood nearby. Additionally, the difference between virtual and physical reconstruction became very evident. While plaster models always stay the same scale, size and texture, the virtual model can be easily altered, individual viewpoints can be found and the materials can be changed by altering the texture mapping with the click of a button.

The Greek farmhouse at Legrena (Lohmann 1993) was the next model to be built (figure 3-4).

Fig. 3. Classical Greek Farmhouse at Legrena; outside view.

Fig. 4. Classical Greek Farmhouse at Legrena; the oilpress in the central courtyard.

The purpose of this reconstruction, also written as a map for Quake2, was to test its usability as a more scientific visualization tool for teaching in university lectures. This unexcavated site was chosen because it is hardly visible today and its remains are unattractive for tourism as it lies almost forgotten on the road to the famous sights at Sunion. Nevertheless, the economic wealth of Athens in Classical times was based on such Attic farmsteads and oil mills. Using the limited abilities of the Quake2 render engine, it was possible to show the spatial relationships of the various buildings and to evaluate their functional relationship. The reconstruction of Legrena also shed new light on the controversial interpretation of the great tower bases found on such farms. Just like the Roman camp mentioned above, the textures provided with the original game were sufficient to give a basic impression of walls, roofs, wooden structures and even simple machinery such as the oil press. But it also became clear that this engine is not suited or built to display plants and trees. Therefore the garden lacks the crucial vegetation and its appearance in the map remains unfinished and bare.

Another weakness of the Quake2 engine lies in the limited number of possible surfaces that correspond to the binary space partitioning (BSP) algorithm employed. This algorithm most efficiently displays indoor geometry, which results in a restriction of the complexity of the building to be reconstructed. Furthermore, poor performance and rendering flaws occur when attempting to build large outdoor maps. Due to the given reasons, the next experiment was carried out using the Halflife[8] game engine, which is an enhanced and modified Quake2 engine released a few months later. Here, a modification can be kept simple (only geometry) because where Quake2 needed a modification (our specialized DLL) to prevent the shooting, in Halflife this part of scripting is less important because by default players are not equipped with any weapon. The site to be reconstructed was the so-called Palace of Nestor in Pylos, Greece (Blegen 1966)[9], and the subject to be investigated was the number of storeys at various locations throughout the building (figure 5-6).

Fig. 5. Mycenian Palace at Pylos; outside view.

Fig. 6. Mycenian Palace at Pylos; looking from rooftop into the central courtyard.

In reality only the foundations of the palace are preserved and the remains of several staircases give a hint of further floors. During the 1950s the excavator Carl Blegen and his draftsman Piet de Jong used these remains in their reconstruction drawings and duplicated the layout of the ground level at the level above. But it is more likely that larger rooms, such as the central megaron and its anteroom, are higher than the narrow chambers in the wings. On the other hand, some parts of the palace such as later storage annexes certainly lacked an upper level. This is theoretically discussed on the AERIA-site with traditional 3D CAD imaging, whereas the virtual 3D reconstruction was carried out as proof of the concept. By freely walking through the building, the usefulness of our reconstruction becomes clear because it gives a plausible explanation of possible configurations of storeys. This experience is enhanced by an advantage of the BSP game engines: they feature physical simulation of light by means of radiosity algorithms that are pre-computed and subsequently shaded on the textures. Realistically lit rooms were one of the main reasons for the submersive atmosphere of the reconstructed palace, even if the possibility to apply pseudorealistic textures for wall paintings for example was not applied and so the maximum detail was not exploited.

As a result, the virtual palace gives visitors a better visual clue than it might have done with simple CAD data viewers. When looking at Pylos in reality, its rather erratic and complex labyrinth of foundation-walls does not provide the amount of information that our reconstruction is able to give.

Nevertheless, with the main buildings of Nestor's palace the maximum complexity in Half-life was again reached, especially because the map was planned with huge outdoor areas that do not comply with the design of the rendering algorithm (BSP). Furthermore, detailed modelling of complex geometry, as occurs while constructing elaborate column-capitels or statues, is not possible with these earlier BSP-engines, because the coordinate space is quantized during a pre-computed triangle generation step. As a result, only coarse structures can be visualized. This became an obstacle while creating a visual model of the Sanctuary of Apollon Hyakinthios at Amyklai, which is only preserved in a written description by the Roman writer Pausanias (Prückner 1992). This famous Thronos of Apollo could not be transferred into the gridded coordinate space of the early BSP games. As a consequence, our relatively fine model of the four main supports in the form of female Horai and

Charites failed to render correctly (figure 7). What is more, the work on the Thronos once again showed the weakness of the BSP engines when dealing with outdoor areas. Embedding a reconstructed building in its surrounding landscape is beyond its capabilities. In our case the top of the bronze-plated pole representing Apollo was about 49 feet high (15 metres) and is reported to have been visible from the Agora at Sparta, which is about 4 nautical miles (7 kilometres) away.

Despite the disadvantages, game engines have proved their worth not only for entertaining school classes but also in scientific discussions and lectures held at our institute since 1999. The possibility to change one's viewpoint and examine the objects on one's own, help one to confront the issues at hand directly. In this way reconstructions can be closely evaluated and their plausibility can be questioned from all possible directions. For example, problems arising from the layout of roofs or the spatial relationships of buildings are more easily observed early on and changes can be dealt with more efficiently than can be done with traditional 2D line-drawings (Martin 1976). It is important to note that no third party was involved in the development of these visualizations. As soon as it was clear how the reconstruction would be laid out it was constructed with the required geometry editors by the authors themselves.

With the arrival of new rendering technology and newly developed graphic cards, new computer games have emerged. They can rely on fast growing hardware performance allowing them to transform ever more triangles with every new graphics board arriving from the manufacturers. Morrowind[10] is a recent game that uses the commercial NetImmerse 3D engine[11], which incorporates both level of detail (LoD) and space partitioning techniques. Most important is the fact that complex CAD data, as produced by, for example, 3D Studio Max, can be imported into the game's editor by automated conversion. With this, the need to use specialized level-editors has become obsolete. For this reason, a second reconstruction of Amyklai was carried out using this engine (figure 8). Morrowind now enables us to give a highly triangulated view of Amyklai as a site lying on a hill in a countryside full of vegetation.

Fig. 7. The sanctuary of Apollon Hyakinthios at Amyklai, general view rendered with Quake2 engine.

Fig. 8. The sanctuary of Apollon Hyakinthios at Amyklai, general view at sunset rendered with Morrowind.

Apart from the graphic enhancements, different kinds of computer games offer different advantages. FPS games like Quake2 or Half-life basically do subtractions of hit-points when a player fights his way through monsters or human controlled opponents. Apart from pushing a chair to the side or throwing a handgrenade, further interaction with the virtual world is limited. Role playing games (RPG), on the other hand, offer a lot of interaction with both virtual characters and objects: books can be read, objects can be picked up, replaced and examined. Virtual characters are not simply shot at but talked to and learned from. All this can be converted easily to suit archaeological needs. With the virtual reconstruction of Amyklai for example, a book can contain the various reconstruction drawings done so far since 1852, another book can give the original text of Pausanias about the Thronos at Amyklai. Or even better: one might meet Pausianias himself or chat with a fellow traveller acting as a tour guide on his virtual pilgrimage. Examining the altar, one might pick up one of the offerings lying there and examine it: a pop-up box provides all known scientific background in pictures and text. All this can be done without altering the nature of the original game. All that the developer needs in order to add such information is already provided. The only requirement is to learn the editing software of the game that is supplied along with it. There one can specify new objects, give them properties and leave a description. Furthermore, one can define the behaviour of virtual characters and automatically check artificial intelligence scripts for consistency with the logical dependencies defined.

However, this form of interaction with the virtual reconstruction is not the only one that computer games can offer. While Morrowind is our most advanced example tested for scientific reconstruction, it is a single player game, while our FPS modifications offer a multiplayer mode. With Morrowind, having downloaded our modification from the internet, one can explore the building of Amyklai at home; the interaction remains restricted to the virtual characters and their predefined behaviour. With our reconstructions that use the Quake2 or Halflife engine, it is possible to lead whole schoolclasses through virtual buildings on a server at our institute via TCP/IP protocol over the internet. In this way we can monitor the log-on to a map and choose a modification of our control while forbidding weapons, shooting and death. In this way two visitors in different locations in the world are able to chat to each other as well as to ask questions to the scientists at Erlangen while exploring our reconstructions through the game built-in chat mode; interactivity is not restricted to computerized counterparts. Using multiplayer features a game becomes a platform of virtual communication with a scientific background.

In the future, we hope that advanced RPG games similar to Morrowind will provide similar multiplayer capabilities. In the year 2003 several promising games such as Halflife2[12] and Doom3[13] may prove useful for our needs depending on the context of use. There is certainly no doubt that the functionality that games already provide should be exploited by archaeologists. But there is also the need to carefully consider the purpose of the visualization. The amount of control and detail needed to convince researchers might be more than a game can provide, whereas the needs of public exhibitions and other educational displays may be less demanding. Overall such games are not only inexpensive but also provide the most up-to-date graphics and, in most cases, a good editing platform.

References

BLEGEN, C., 1966. The Palace of Nestor at Pylos in Western Messenia.

BOSS, M., 1993. Die Antikensammlung der Friedrich-Alexander-Universität. In *Die Friedrich-Alexander-Universität Erlangen-Nürnberg 1743-1993, Ausstellung im Stadtmuseum Erlangen:*597ff.

LOHMANN, H., 1993. Athene:95ff, 144ff, 515f. Abb. 30, 36 Taf. 98.

MARTIN, R., 1976. RA:205ff.

PRÜCKNER, H., 1992. Ein Thron für Apollo. In *Kotinos, Festschrift für E. Simon:*123ff. Taf 21.1 mit Lit.; Pausanias, Periegesis III 18.9ff.

WAMSER, L. (ed.), 2000. Die Römer zwischen Alpen und Nordmeer. *Katalog-Handbuch zur Landesausstellung des Freistaates Bayern*, Rosenheim, Kat. Nr. 250:435ff.

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[1] all references and abbreviations comply with DAI (German Archaeological Institute) guideline in: AA 1997, 611-628; all hypertext-links were active, when this article was written (May/June 2003); http://www.phil.uni-erlangen.de/~p1altar/aeriahome.html.

[2] http://www.phil.uni-erlangen.de/~p1altar/geschichte_html/geschichte.html#photosammlung;

[3] http://www.phil.uni-erlangen.de/~p1altar/ausstellung_html/lectures_html/perachora/perachora01.html.

[4] http://www.phil.uni-erlangen.de/~p1altar/forschungsstation.html.

[5] http://www.newtek.com.

[6] http://www.idsoftware.com/games/quake/quake2/.

[7] Fan communities for Quake2 and Halflife are found at http://www.planetquake.com and http://www.planethalflife.com.

[8] http://www.half-life.sierra.com.

[9] http://www.phil.uni-erlangen.de/~p1altar/ausstellung_html/lectures_html/pylos/pylos01.html

[10] http://www.elderscrolls.com.

[11] http://www.ndl.com.

[12] unreleased, published by http://www.sierra.com.

[13] unreleased, published by http://www.idsoftware.com.