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The Archeomatica Project: Towards a New Application of the Computer Graphics in Archaeology

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Abstract

In this paper the project Archeomatica of Catania University dedicated to Minoan civilization and Cretan culture is presented. The project carried out by experts of information technology and archaeological research provides the creation of realistic 3D models based on the data recorded during excavations that are digital upgradeable archives to add to the traditional graphic and photographic documentations.
In particular two case-studies of 3D reconstructions of monuments of prehistoric and proto-historic archaeology, realized by a "philological approach", are presented.

Categories and Subject Descriptors (according to ACM CCS):
Three-Dimensional Graphics and Realism I.3.7 [**Three-Dimensional Graphics and Realism**]: Virtual reality;
General Terms: 3D modelling, digital archaeology, Archeomatica

1. Introduction

Reconstructing the human presence in historical settings has recently become the aim of several scientific co-operations between archaeological and computer science personnel [RSAC06, PCG*06]. In particular, computer graphics help researchers to reconstruct original locations starting from a simple plan.

Digital Archaeology [DE] therefore improves the quality of the data available in classical archaeology [FPR*01, Gab06]. 3D modelling allows some of the most important buildings of the classical or near-eastern cultures to be reconstructed in order to diffuse knowledge about this world [sha, dig, vrl]. Despite a certain level of success, the reconstructions made to date have not been very detailed, and are usually inaccurate. In the last few years, several research projects have begun in order to provide optimal reconstructions that include all the data sets from the excavations. The most important projects concerning prehistoric research in the Mediterranean area have been carried out by the University of Bristol on Malta [CD05] and by the University of Southampton on Sicily [SSM07]. The basic idea is that archaeological 3D modelling adds the possibility of creating virtual reconstructions to the usual graphic and photographic documentation. These reconstructions help to show how the place originally looked.

The Archeomatica Project [arc] came into being due to a collaboration between the Centre of Cretan Archaeology [cac] and the Image processing Lab [ipl] of Catania University, and it aims to produce 3D models of prehistoric archaeological sites with a high level of accuracy, following the data gained during the excavations. Two case-studies of prehistoric and proto-historic periods have been made: the buildings of the open area at Ayia Triada (Crete) and Building B on the Polizzello Mountain acropolis (Mussomeli, Sicily). These two sites are very important exemplars of fundamental elements of Minoan culture and Cretan influences spread in central Mediterranean.

In the following sections some 3D reconstructions, elabo-

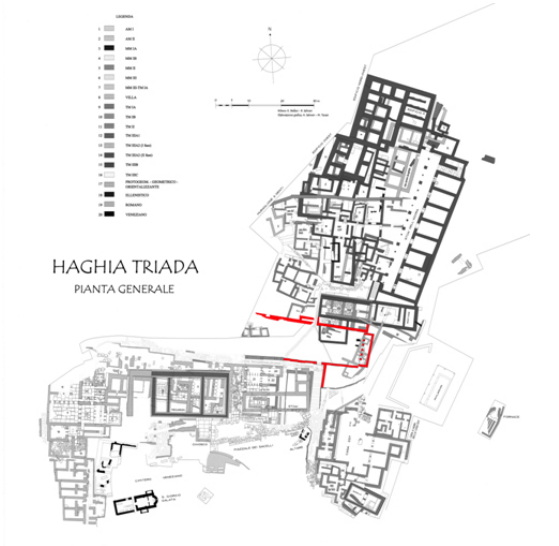
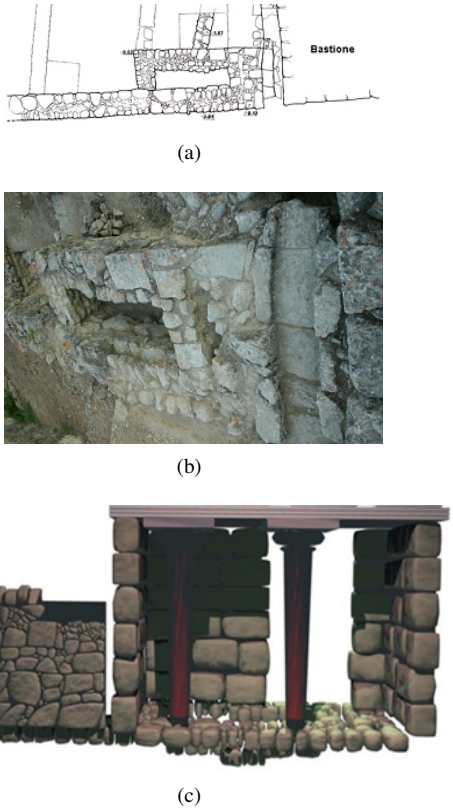


Figure 1: *Plan of Ayia Triada (Crete) with the indication of the open area between the Villa and the village.*



(a)

(b)

(c)

Figure 2: *a) Plan of the* propylon *b) The* propylon *from South c) Reconstruction of the* propylon *structures.*

rated with a profound attention to every particular that when could call "philological approach", will be presented with a description of the working method. The programme used was Blender [ble], a multi-task and open source software for modelling, rendering, animation, post-production, creation and reproduction of interactive 3D contents.

2. Ayia Triada (Crete)

The first example of 3D modelling and reconstruction consists of two buildings in the open area between the Villa and the so called village of Ayia Triada (Fig. 1). One of the most important Minoan sites, Ayia Triada has been studied for many years by the Centre of Cretan Archaeology in cooperation with the Italian Archaeological School of Athens. Recent excavations have provided new evidence for the interpretation of the crucial transitional area between the settlement and the noble quarter whose function and articulation was not previously well known ([La 06], [Mil08]). A complete analysis of the Minoan architecture through the study of frescoes and stone vases with relief decoration has suggested that the principal features of the two most important buildings were the *propylon* and the *stoa*.

2.1. *Propylon*

During excavations in summer 2006, the presence of a monumental doorway structured with a *propylon* localized in the middle of the north side of the open area was proved. This building had a monumental façade with two columns facing the open area and the Villa itself. Its rear prospect was related, but not in line with, a descending ramp which was the most important road of the village. The problem of the organisation of this monumental area was solved by the application of the 3D modelling technique.

The vectorialized plan was imported into Blender and completed with elements deriving from iconographical fonts (Fig. 2(a)). Afterwards, the walls were extruded, thus realistically imitating the original building technique observed in the remaining rows (Fig. 2(b)). The missing rows were also recreated together with other architectural features such as columns and horns of consecration (Fig. 2(c)). According to the principles of Minoan architecture, the columns were reconstructed with upside down *entasis* with a pillow-capital on top. On the upper part of the *propylon* a row of monumental horns of consecration were put in place, as have been found in many palatial and sacred Minoan sites. Furthermore, the walls were probably covered with a white plaster and the final parts of the projecting beams were covered with polychrome stucco. Concerning illumination, the raytracing software YafRay was used in the screenshots in order to obtain more realistic images, and in the videos the Blender rendering engine was used, which is slightly less effective but much faster.

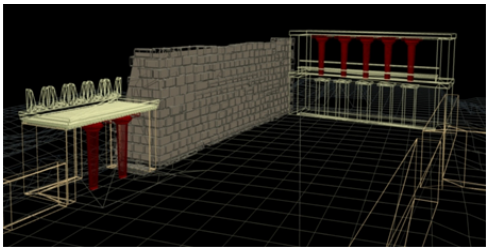


Figure 3: *Wireframe model of the buildings of the open area, the* propylon *and the* stoa*, and reconstruction with procedural textures of the Bastion south wall.*

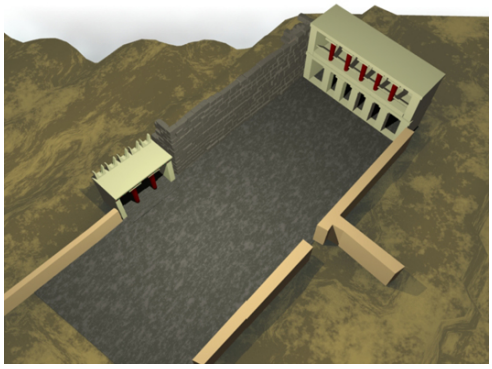
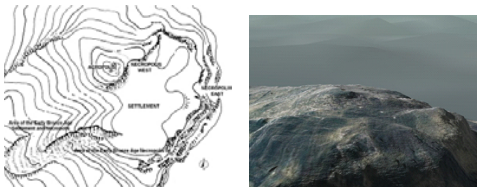


Figure 4: *3D model of the open area with the* propylon *and the stoa in bird's eye view.*



(a) (b)

Figure 5: *a) Plan of the Polizzello Mountain (CL, Italy); b) Visualscape of the Polizzello Mountain.*

2.2. *Stoa*

A re-examination of previous archaeological work suggested that a small two storied porch, or *stoa*, should be reconstructed on the eastern side of the open area, with the second level overlooking the large paved road towards the sea. In this case, iconographic data was fundamental for the interpretation of the typical elements of large-scale Minoan public architecture.

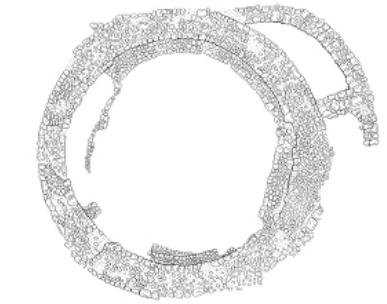
After the extrusion of the 2D image, object specific textures were applied to the wireframe model. The textures were created in a procedural way from primitives meshed so as to obtain diverse materials such as stucco, wood, stone and earth and the rendering engine suggested small variations on the surfaces in order to imitate the grain of each substance (Fig. 4). In the eastern half of the north side, the open area was bordered by a large building in megalithic blocks, erroneously interpreted as a bastion, which should instead be considered to be a store related to the royal villa. The reconstruction of the facade of the called bastion was realized by the creation of different solids related to every block, and the dimensions of each solid was generated inside a range derived from the measures of the stratum plan of the foundation row. For the creation of the wall, the same scheme of the foundation row was applied in every subsequent row, with a disturb element obtained with the Ken Perlin function. Furthermore an effect of surface subdivision was applied to the stones of the bastion wall to round the corners. The *stoa* and the *propylon* 3D models were located inside a virtual landscape created by starting from a grill with equidistant vertexes with a sub-polygonal displacement obtained by a texture generated using the Mussgrave algorithm.

3. Polizzello (CL), Italy

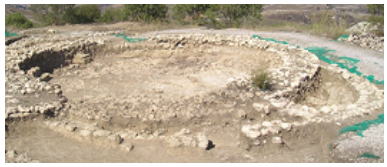
The second case study is the Sicilian site of Polizzello Mountain, in the territory of Mussomeli (CL), which has been investigated from 2000 by a joint mission of the Soprintendenza of Caltanissetta (dr. R. Panvini) and the University of Catania (prof. D. Palermo). The site, on the top of an 880m high mountain, is located on different plateaus and was frequented from the Xth to the IVth centuries BC. Its floruit was the VIIth and VIth centuries BC, when an important indigenous sanctuary with large precincts on the acropolis, known as Buildings A,B, C, D and E, was constructed ([Pal06], [Tan07]).

3.1. Building B

Building B was surely one of the most important structures of the VIIth-VIth centuries BC sanctuary. It was an open precinct 10m in diameter with access from the south side and a small semicircular room on the east. Built without any kind of concrete, the walls had external rows of rectangular blocks with roughly placed stones on the inside. There was a central hearth inside, and along the walls were stone furniture elements such as altars and benches. A large paved area was discovered outside by the access point. 255 objects were found on the floor of Building B, including vessels, weapons, clay models and exotic goods in amber, glass and ivory, divided into 17 groups of votive deposits, and found in excellent condition. Several of the most significant objects show a strong link with ancient Minoan religion and an important link between Polizzello Mountain and Crete was also shown by the discovery of a rare bronze helmet of Cretan type and of a couple of female ivory figurines of subdaedalic type. Building B and one of its votive deposits was chosen for the



(a)



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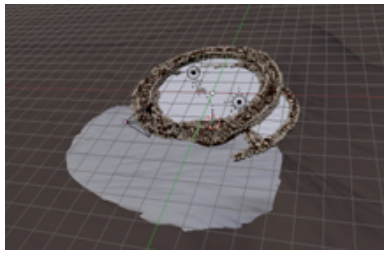

(c)

Figure 6: *a) Plan of the Building B b) The Building B from South c) 3D model of the Building B with its internal and external pavements*

realization of a 3D model on the basis of direct observation of the archaeological site.

The first step was the creation of a visualscape [Llo03] of Polizzello Mountain (Fig. 5) starting from a vectorialized IGM plan on a 1:25.000 scale imported into Blender (Fig. 5(a)). The different levels were transformed in NURBS, fixed in relation to the isohypses and merged into a wire-frame model. Procedural textures for determining a secondary disturb were applied to the model, and combined with a high resolution aerial picture (Fig. 5(b)). The digital version of the mountain with the schematic model of Building B allowed the appreciation of some factors that are not readable in a simple plan, such as dimension, altitude and exposure to light. The plan of Building B was vectorialized and imported into Blender (Fig. 6(c)). The graphic documentation of the walls and their building technique made during the excavation was very important for a realistic elaboration of the model (Fig. 6(b)). Every element of the building represented by a polygon was revised and extruded. Because

Figure 7: *3D model of the Building B with its furniture (hearth, bench, altar and votive deposition).*

(a) (b)

Figure 8: *a) The votive deposition n. 6 during the excavation b) The 3D model of the objects of the deposition in their original position.*

the building technique was based on the merging of earth and stones, a second 3D model based upon the schematic plan of Building B was created by applying procedural textures for the earth. Subsequently, the two models were intersected in order to let the stones emerge in a realistic way. For the textures of the inner floor and outside paved area photographic images straightened and extended with *Cad&Pillar* were applied to plain surfaces disturbed by a sub-polygonal displacement. Procedural textures generated by primitives to imitate materials like stone and earth were applied to the models of the floors in the 3D version of Building B. The central hearth, composed of a pile of ashes with fragments of a burned clay pan, was modelled using two specific photographic textures derived from pictures taken during the excavation. The raytracing software YafRay was applied to the model, located in the original position of the visulascape, in order to obtain a better quality image in daylight (Fig. 7).

3.2. Votive deposition n. 6

The original positions of the in situ objects of votive deposit n. 6 were located on the basis of individual drawings (Fig. 8(a)). Starting from these drawings, the principal volumes were extruded by modelling the extra parts. The textures were obtained from stereoscopic pictures combined in

a unique scheme and then applied to every model. A procedural texture was also applied to the virtual vessels in order to generate a normal mapping (Fig. 8(b)).

4. Conclusion and future work

In this paper two case-studies of 3D reconstructions of monuments of prehistoric and proto-historic archaeology, realized by a "philological approach", have been presented as part of the research project Archeomatica of Catania University. Archeomatica is a unique project of Digital Archaeology dedicated to Minoan civilization and Cretan culture carried out by experts of information technology and archaeological research. The creation of realistic 3D models based on the data recorded during excavations becomes very significant in the process of archaeological interpretation and understanding. Furthermore, the production of effective 3D models of archaeological structures and finds for a digital upgradeable archive could become an important alternative to traditional graphic and photographic documentation. Finally, this synergic experience has also aimed to define a common multidisciplinary language and develop a dialogue between information technology and archaeology and to improve the quality of their message to the outside world.

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