Augmented Perception of the Past - The Case of Hellenistic Syracuse

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Abstract— **The aim of this paper is to present a real-time interaction system for ancient artifacts digitally restored in a virtual environment. Using commercial hardware and open source software, Augmented Reality versions of archaeological artifacts are experienced on mobile devices both in a real outdoor site as well as an indoor museum. The case study for this project is represented by two artifacts of Syracuse, Italy, a statue and an altar, dated back to Hellenistic time. Virtual replicas of the two artifacts were produced applying different techniques. Later the two projects became part of the same research plan aimed to virtually rebuild the most significant artistic and architectural features of Hellenistic Syracuse. Besides the simple production of 3D models, via laserscanning and 3D modelling, a digital process of visual improvement of the statue was preliminary carried out based on photographic documentation of some archetypes. The commercial framework for mobile devices, ARToolworks, has been used for developing Augmented Reality applications. Using a pattern that is recognized by the device, the virtual model is shown as it is in the real world. The novelty of this work is that graduate students in virtual archaeology and non computer programmers such as museum staff, could benefit of this work and implement such a system.**

Index Terms— **Augmented reality, Laser scanning, 3D Modelling, Real time interaction, Virtual heritage**

I. Introduction

In the last fifty years, the growing use of computer applications has become a main feature of archaeological research [1]. It can now influence interpretation procedures and revolutionize the language and contents of the study of the past.

From its first definition by Reilly in 1990 [2], virtual archaeology (VA) was intended as the use of digital reconstruction in archaeology. Recently, new communicative approaches to archaeological contents through the use of interactive strategies have been added [3]. 3D modeling is especially very useful for the identification, monitoring, conservation, restoration, and promotion of archaeological artefacts. In this context, 3D computer graphics can support archaeology and politics of cultural heritage by offering scholars a "sixth sense" for understanding the traces of the past, as it allows us to experience it [4]. 3D documentation of extant archaeological remains or building elements is an important part of collecting the necessary data for a virtual archaeology project. New developments facilitate this phase of documentation, including the obtaining of correct measurements and ground plans from photography, through the use of readily-available equipment. This is important in restoring archaeological remains when older phases are reconstructed in a virtual way. The original state, the restored state, and eventual in–between states can be recorded easily through photo–modeling technique [5].

In this paper a project of virtual archaeology focusing on two artefacts of Hellenistic Syracuse (3rd century BC) is presented. The two artifacts are a statue of a Telamon (Fig. 1) held at the Archaeological Museum of Syracuse and the altar of Hieron II (Fig. 2), to which probably the Telamon belonged, located in the western suburb of the city, in the so called ancient district of Neapolis. Virtual replicas of the two artifacts were produced applying different techniques as parts of two originally separated projects and with diverse goals: to monitor the degradation of the statue and to provide a more accurate reconstruction of the altar, that is an *unicum* without comparisons in the ancient Mediterranean. Later the two projects became part of the same research plan aimed to virtually rebuild the most significant buildings of Hellenistic Syracuse.

II. The Archeomatica Project

A state of the art experience in the field of digital archaeology is represented by Archeomatica Project [6],

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(a) (b)

Figure 1. (a) Telamon in a photograph of 1927; (b) Telamon in a recent photo.

Figure 2. Altar of Hieron II from the West. Red arrow indicates the feet currently preserved of one Telamon.

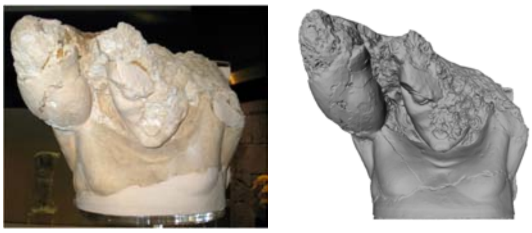
[7], a research program started out in late 2007 at the Image Processing Lab [8] of the University of Catania. The main aim of the project is to produce automatic systems of recognition and classification of graphic data, such as figurative pottery decoration, through the use of computer vision and pattern recognition techniques, and to develop virtual models of ancient artefacts with a high degree of accuracy using data from excavation, through application of laser scanner and 3D modeling techniques managed with open source software. This cognitive process is based on peer-to-peer exchange of knowledge between experts of computer science and archaeology working side by side. A further goal of this research program is to train graduate students as communication consultants for virtual archaeology projects, giving them the opportunity of attending stages with public institutions and of developing individual projects aimed to promotion of cultural heritage. At the same time, through seminars and practical workshops, the staff of museums and archaeological parks are trained in the use of software and hardware solutions for dealing with their work of knowledge dissemination.

III. Visual Improvement: the Telamon

The first case study is represented by a Late Classical Greek statue of a Telamon [9] coming from the south-western district of the ancient Syracuse, named Neapolis, where important public building as the theather and the altar of Hieron II are located. This statue, currently on display at the Archaeological Museum of Syracuse, is made out of local calcarenite plastered with a mix of marble dust and sand, and it is representing a satyr version of the titan, with typical hairy legs and pointed ears. Due to the materials used, the statue is subject to cyclical degradation and even the restoration attempts seem unsuccessful, as can be observed in Fig. 1. A virtual copy of the statue can be used to monitor the degradation and to present the statue in a new way.

The technique of 3D digital restoration of archaeological objects is perhaps the most common trend in interdisciplinary projects related to the interpretation and dissemination of archaeological knowledge. This is because of the potential that 3D has in subtracting the archaeological goods from the destructive effects of atmospheric agents, of pollution, of time, and, in some cases, of natural disasters and wars. The high–definition 3D laser scanner is an instrument that collects 3D data from a given surface or object in a systematic, automated manner, at a relatively high rate, in near real time using a laser ray to establish the surface coordinates. Over the last decade, this technology has been applied to archaeological research to construct geometric models with different characteristics [10]. Most archaeological work has been carried out to digitize objects of an intermediate size, such as settlement structures, statues, and vessels. The most recent projects have been focused on modeling structures during the excavation of archaeological sites, either of one limited zone [11] or the complete ensemble [12]. These studies have been carried out from the ground surface or using helicopters and airplanes [13].

The possibility of obtaining a virtual, exact replica of reality in a limited amount of time makes the laser scanning method ideal for studies of 3D digital restoration, where the virtual recomposition of fragmented elements, both physically and narratively, is fundamental [14]. In this field, the Archeomatica Project team of researchers has proposed integrating the Blender–based 3D modeling [15] and image–based 3D modeling with the laser scanning technique, in order to solve the problems of possible data voids connected with complex scanning. The laser scanner used is the compact and handy Next Engine [16], and it is very versatile especially when the objects to be scanned are placed in restricted spaces or cannot be removed. It is an optical triangulation scanner that offers a high degree of precision, allowing the creation of good three-dimensional models of real subjects. Since the Telamon was very large, a tripod was used with the scanner in manual mode. For the alignment process the software Meshlab [17] was used. It is rather suitable for this kind of work offering a wide range of specific filters to manipulate and improve data acquired in the previous



(a) (b)

Figure 3. (a) Statue of Telamon, from Syracuse Museum; (b) 3D model of the statue obtained with laser scanning technique.

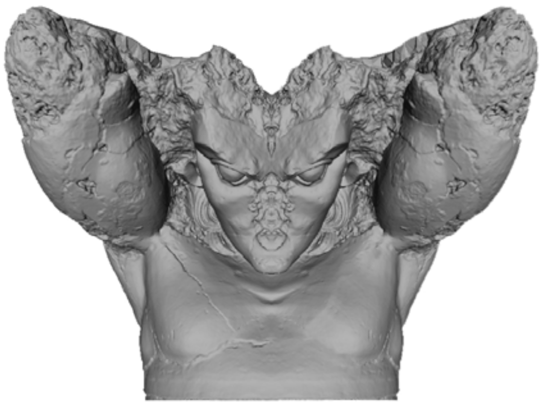


Figure 4. Restoration analysis in virtual environment of the Telamon acquired with laser scanning technique.

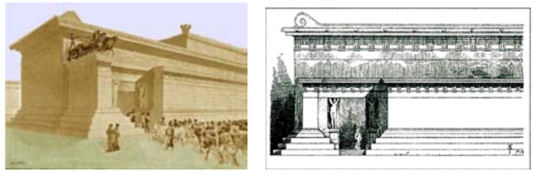
phase.

After filling gaps and data voids of 3D models (Fig. 3(b)), dark blotches and salt encrustations were removed from the surfaces of the models. One detached ear was fixed in its original position and the missing half part of the body was replaced by a mirror of the preserved one. In this way the overall appearance was optimized (Fig. 4).

IV. Archaeological 3D Modeling: the Altar

As clarified above, the second monument we worked on is strictly connected with the Telamon. The altar of Hieron II (Fig. 2) was built between 270 and 215 BC, by the will of Hieron II, king of Syracuse at the time [18]. Only its foundations,cut in the bedrock, remain. The superstructure was made of calcareous limestone blocks and was almost completely dismantled and re-used in the Spanish fortifications of the 16th century. On the north and south ends of the front, two symmetrically-placed ramps gave access to the central platform where animal sacrifices took place. Each ramp was preceded by an entrance: at least the northern entrance was flanked by two Telamons. On the right side, the feet of one statue are still visible. Besides two attempts of reconstructing it carried out by artists aiming to give general idea of this impressive structure, no further recostructions have been suggested until now (Fig. 5).

To test scholars' hypothesis about the altar and its use, an archaeological 3d modelling analysis has been carried out. Archaeological 3D modeling is basically the recreation of landscapes, architecture, and objects by digital means based upon the current state of the salvaged monuments integrated with the data coming from historical and archaeological researches using software for developing 3D models [19], without the application of reverse engineering methodology.



(a) (b)

Figure 5. Artistic reconstructions of the altar of Hieron II.

(a) (b)

Figure 6. (a) Virtual reconstruction of the altar; (b) 3D model of the Telamon placed in its hypothetical position in the virtual reconstruction of the altar.

The archaeological 3D modeling is not just a simple cognitive tool to reproduce virtually aspects of the past to improve the knowledge and the comprehension. It is also, above all, a methodology of recording all the archaeological data in a much more complete way than the traditional photography and drawing. It is a kind of virtual benchmark of the archaeologists' theories where the hypothesis is tested and corrected in order to produce a truthful image of something buried by time. A kind of "solid modeling to illustrate the monument" becoming "solid modeling to analyze the monument" [20]. For this reason, the privileged application field for this technique is the prehistoric archaeological research, where, the scarcity of iconographical sources and the poor state of conservation of the findings, makes extremely complex both the process of decoding the information and of transmitting the knowledge to the public. For reconstructing the altar the vectorialized plan was imported into Blender [15] and completed with elements deriving from iconographical fonts of contemporary architecture. Afterwards, the walls were extruded, thus realistically imitating the original building technique observed in the remaining rows of blocks. The texture used is procedural but modified and optimized in order to recall the Syracusan limestone, mainly used for the Greek buildings of the city (Fig. 6).

V. Augmented Reality

Virtual reality allows the 3D visualization of concepts, objects, or spaces and their contextualization through the creation of a visual framework in which data is displayed. VR also enables interaction with data organized in 3D, facilitating the interaction between operator, data, and information in order to enhance the sensorial perception [21]. It creates a virtual space that is a replica of the real space, where the information about every feature that constituted the different moments of life of the real space are "translated" into 3D data. The two crucial points of every project of VR are the selection of the information (pictures, drawings, geometrical measures) and the choice of which facets of the original object's nature must be captured and reconstructed. "Visual computer models should make clear their sources and the criteria on which they are based" [22]. In order to understand archaeological systems, much more than a visually "realistic" geometric model is needed. "Dynamism and interaction" are essential. A dynamic model is a model that changes in position, size, material properties, lighting, and viewing specification. If those changes are not static but respond to user input, we enter into the proper world of virtual reality, whose key feature is real-time (RT) interaction. Here real-time means that the computer is able to detect input and modify the virtual world "instantaneously" at user commands. By selectively transforming an object, that is, by interpolating shape transformations, archaeologists may be able to form an object hypothesis more quickly [23]. One field where the scholars in archaeology and computer science are recently getting involved is augmented reality (AR) where the simultaneous visualization of virtual data and the real world is performed [24]–[27]. One of the objectives of AR is to bring the computer out of the desktop environment and into the world of non professional users dealing with 3D applications. In contrast to VR, where the user is immersed in the world of the computer, AR incorporates the computer into the reality of the user. He can then interact with the real world in a natural way, with the computer providing information and assistance. It is then a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. The virtual world acts as an interface, which may not be used if it provides the same experience as face-to-face communication. AR enables users to go "beyond being there" and enhance the experience in order to achieve both the full interpretation of the traces of the past and the development of the best tool for the dissemination of their message [28].

VI. Experimental results

Final goal of our research project about Hellenistic Syracuse is to give an augmented reality experience to the visitors of the Archaeological Museum and of the Neapolis Archaeological Park, aimed to revive virtually both the Telamon and the altar as they were on common mobile devices. In this preliminary phase of our work we just focused on the case study of the Telamon. The environment developed provides new ways of information access at the Museum in a user-friendly way through the use of 3D-visualization on mobile devices [29], [30]. We have chosen as our device a common mobile Apple

Figure 7. The AR applied to the Telamon. The mobile phone gives the statue model when the pattern is found by the camera.

Iphone, with the commercial framework ARToolworks which provides an high level programming tool for developing AR. Once the three-dimensional statue is obtained, it is necessary to adapt it to the hardware limitations imposed by the device. The graphical engine inside the mobile device is able to handle three-dimensional environments without loss of data and without any delay within a certain threshold. This limit has a maximum of seven million polygons per second. However, the statue is composed of thirty-nine million polygons and must necessarily be reduced to fit within the limitations of the device, without compromising the aspect of the statue. For this operation, a filter contained in Meshlab software [17] called "Quadric Edge Collapse Decimation" has been used. This filter has been applied many times by halving the number of faces each time. This is preferable than making only one application of this filter with a single drastic decimation with bad results in terms of quality and shape of the final object.

ARToolworks is based on ARToolkit [31], an open source library for Augmented Reality that allows many easy-to-use functions of Computer Vision to be used for AR, the openGL library for high performance graphics and the rendering process. It gives the possibility to create Augmented Reality applications on any mobile device using a high level programming environment that allows the developer to set and manipulate the Video Tracking process and three-dimensional overlapping in a few simple steps without having to delve into the world of deep programming and the theory of Computer Vision. In fact we have chosen this tool because the aim of this paper is to allow the development of a new way interaction between visitors and cultural heritage in museums or archeological sites, through the use of a very common hardware as a mobile device. ARToolworks is integrated in Xcode, an Apple Integrated Development Environment; it uses only API approved by Apple and any application is "App-Store" compatible. Using a pattern that is recognized by the device, a three-dimensional model is associated with the pattern and the virtual model is shown like it is in the real world (Figs. 7 and 8).

(a) (b)

Figure 8. The augmented reality in the Museum. (a) the user in the Museum; (b) the display shows the restored version of the Telamon where the left arm is reconstructed.

VII. CONCLUSION

The encouraging results of the application of AR to archaeological evidence has demonstrated that it is possible to use another "sense" to decrypt the traces of the past: the three-dimensional recreation of ancient life and visual images are extremely effective in explaining the past because they allow us to experience it.

The potential of this approach in the future could be enhanced by investing much more in the five fundamental elements of an AR environment, namely virtuality (objects that don't exist in the real world can be viewed and examined), augmentation (real objects can be augmented by virtual annotations), cooperation (multiple users can see each other and cooperate in a natural way), independence (each user controls his own independent viewpoint), and individuality (displayed data can be different for each viewer) [32].

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