THE VIRTUAL MUSEUM OF THE VOTIVE DEPOSIT OF GARVÃO: AN EXPERIMENTAL APPROACH TOWARDS INTERACTIVE EXHIBITIONS

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Located in the south of Portugal, the Iron Age votive deposit of Garvão (Ourique, Beja) was first identified in the beginning of the 1980's. The massive deposition of objects on a slope of the Cerro do Castelo (a small hill in the centre of the modern village of Garvão – figure 13) had an intentional nature and has been associated to ritual practices. As the result of several archaeological campaigns, it was possible to recover a great number of archaeological artefacts (mainly pottery), which were purposely deposited and carefully arranged in order to optimize the available space (Beirão *et al.*, 1985; 1987). Archaeometric analyses performed on selected ceramic material (as part of the GODESS project: Garvão/Ourique iron age Deposit – Engaging science studies) allowed the recognition of the ceramic phase composition, ceramic manufacturing processes and origin of raw materials and improved the understanding of the importance of Garvão in this part of the Iberian Peninsula.
Despite its undeniable importance, so far it has been a challenge to satisfactorily publicly exhibit this vast archaeological collection. Therefore, the development of innovative digital tools emerged as a possible solution to overcome this problem. The focus of this work was the development and implementation of 3D technologies as a way to complement a traditional exhibition, installed in the Caetano de Mello Beirão Archaeological Centre (CACMB, Ourique), with multimedia content. Besides the creation of an interactive virtual museum, 3D technologies were also incorporated in the physical exhibition itself, with the use of Augmented Reality (AR) tools, Immersive Virtual Reality (IVR) and the 3D printing of replicas.
The development of these digital solutions took place as part of the IMAGOS/APOLLO project of the HERCULES Laboratory (University of Évora).

METHODOLOGY. DATA ACQUISITION

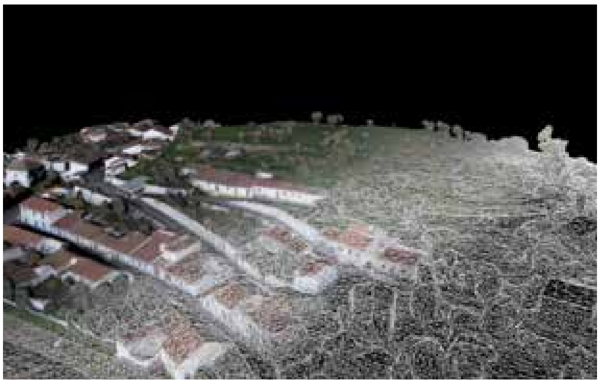
The first exhibition to be featured in this Virtual Museum is dedicated to the large containers (Faia, 2012) and censers (Silva, 2012) retrieved from the deposit. In order to do this, it was necessary to create digital 3D replicas of the objects. Preliminary analysis was conducted in order to determine the suitability of different three-dimensional data capture techniques. A small sample of pottery vessels was thus used to obtain a comparative analysis between photogrammetric recording and laser scanning. Comparison of the resulting 3D models highlighted the strengths and weaknesses of each of the capture techniques and established the usefulness of combining both, according to the morphological characteristics of the objects (figure 14).
The photogrammetric technique allows us to obtain 3D models with a high degree of photorealism as well as its usage in remarkably different scenarios, from small objects to land surfaces with hundreds of hectares. Thus, it presented itself as the most suitable solution for 3D scanning of larger ceramic artefacts as well as for the creation of the 3D model of the archaeological site of Cerro do Castelo (Garvão) (figure 15). The photogrammetric surveys of the ceramic artefacts were carried out both at the CEAACP facilities in Coimbra and at the CACMB archaeological storage in Ourique, using a Canon EOS 5D. The generation of tridimensional models from the set of photographs was processed using Agisoft Photoscan software. The creation of a DTM of the archaeological site was achieved through an aerial photogrammetric survey of the Cerro do Castelo, using a quadcopter Unmanned Aerial Vehicle (UAV) – DJI Phantom 2 Vision+. The post-processing phase was also conducted with Agisoft Photoscan, which enabled the creation of geo-referenced orthophotomosaics and Digital Elevation Models (DEM). The UAV was also used to capture aerial footage of the archaeological site, as well as a 360º panoramic image of the landscape, later featured in the Virtual Museum. Two capture sessions were conducted on site, in which 654 photographs vertical and oblique aerial were obtained, in order to produce a high resolution 3D model of 6.17 hectares.
In the cases where the morphology of the object rendered the application of photogrammetry problematic (or when extensive manual processing was required) a low-cost 3D laser scanner (NextEngine 3D Laser Scanner) was used. This technique was especially useful to deal with the small and detailed decorations of the ceramic censers.

METHODOLOGY. MODELLING THE MUSEUM ENVIRONMENT WITH COMPUTER GRAPHICS SOFTWARE

The virtual museum environment was entirely modelled and textured with computer graphics software – Maxon Cinema 4D. This software enables the creation of digital models through a wide range of manual and procedural modelling techniques (including parametric modelling, polygon, NURBS, or 3D sculpting tools, for example). It also proved essential both for the general layout and design of the Virtual Museum (i.e. the testing of different layouts of the exhibition space) as well as for the creation of digital models of a wide spectrum of secondary and decorative elements that were featured in the museum. The 3D human characters that populate the virtual exhibition for the purpose of recreating didactic scenes were modelled with MakeHuman, an open-source software specifically developed for this purpose.
The development of this virtual environment required extensive work to reduce and simplify 3D models, thus allowing the museum application to be quickly accessed from a browser and older computers with lower processing capabilities. Therefore, different technical solutions

13. Aerial view of Cerro do Castelo (Garvão).

14. Sample of digital replicas captured with photogrammetry and laser scanning.



15. Photogrammetric model of the archaeological site.

16. Interactive environment of the museum exhibition.

were tested, including the production of decimated 'low--poly' meshes from the originals and subsequent 'normal mapping', thereby producing 3D models with simple polygonal meshes and a high degree of detail. The simplification of 3D models and widespread compression of other elements (movies, images, etc.) of the virtual environment provided a considerable reduction in the hardware minimum requirements to access the museum.

METHODOLOGY. INTERACTIVE EXPLORATION WITH GAME-ENGINE SOFTWARE

All the models created using the different techniques described above were brought together in a single virtual interactive environment using game-engine software (Unity). The interactive elements of the environment (including the definition of inputs that allow navigation within this digital space) were programmed using scripts based on Javascript and C# programming languages. This virtual environment, much like a traditional computer game, is open to exploration and experimentation by the user/visitor, using a personal computer (figure 16). It can be accessed online or it can be downloaded and run as a standalone version, either on MacOS or Windows operative systems.
This platform's objective of facilitating public access to the heritage and enhancing their dissemination brought this cultural content to an audience as wide as possible. Unity proved to be a very suitable tool for this task, as it allows the user access to the museum from anywhere in the world from an Internet connection, via a web player. This feature takes on even greater importance considering the fact of Garvão and Ourique are located in large population centres remote areas, helping to combat exclusion, isolation and inaccessibility to the heritage of this region would be subject easily.

3D PRINTING

The 3D printing of replicas of the artefacts allows the public to have the opportunity to physically manipulate real-sized versions of the archaeological objects that would, otherwise, be beyond their reach (Allard, 2005). It has also the merit of allowing groups that are often marginalised from a traditional archaeological exhibition (i.e. the visual impaired) to have a deeper contact with the archaeological and cultural heritage. As such, the 3D model of a censer (figure 17) and the topographic model of the archaeological site were selected for printing in PLA (polylactic acid). The Digital Surface Model (DSM) of the archaeological site generated through aerial photography was processed (point classification associated with vegetation and architecture, extraction and interpolation) in order to create a Digital Terrain Model (DTM), which was later prepared for printing. The physical exhibition will incorporate this scaled model, which will be enhanced with a projection onto its surface of different layers of cartographic data (contour map, digital elevation model and orthophotomosaic) as well as the indication of points of interest.

17. Original (left) and 3D printed replica (right) of a censer.

AUGMENTED REALITY APPLICATIONS

Being virtual reconstruction one of the interesting potentialities of a virtual environment, the same solution can be implemented in the scope of a traditional museum exhibition using augmented reality technology (Ternie, 2012). At the physical exhibition, the visitor can, therefore, use a mobile device (smartphone or tablet) with Android operative system to download a dedicated app. Pointing at targets placed through the exhibition, 360º animated views of the artefacts and/or virtual reconstructions of the fragmented objects are displayed on the screen of the device. The AR tools have been developed with the Vuforia Unity extension.

IMMERSIVE VIRTUAL REALITY

As it has been shown before (Bruno, 2009) the use of virtual reality technologies in the field of cultural heritage allows a deeper fruition of the material remains of the past, potentially attracting new audiences. Hence, the virtual museum application has been adapted to be experienced in a Immersive VR environment using head-mounted displays (Oculus Rift). Virtual reality headsets will, thus, be available at the CACMB in Ourique, providing the visitor with a more immersive and interactive experience.

RESULTS

The work conducted has allowed us to test the applicability of different 3D technologies in the analysis and dissemination of archaeological heritage. It has tested and defined the whole pipeline from data capture to the production and implementation of ready to use models in virtual environments and in traditional exhibitions.
One of the main outputs of this project was the creation of the Virtual Museum. It was structured around six main thematic areas that the user can explore freely, interacting with the surrounding environment:

(1) Regional Contextualization: featuring a DTM of this region of Alentejo (created with displacement mapping from a height map), the main purpose of this area is to give the user more information about the geomorphological context of the archaeological site.
(2) History of the Archaeological Investigation of the Site: using various visual displays, the user can have a deeper understanding of the different archaeological and scientific investigations about this site and its materials, from its discovery to the present day.
(3) Pottery Production Techniques: as the vast majority of the retrieved material is composed by ceramic objects, there is a section of the Virtual Museum dedicated to explain the visitor the different techniques and stages of ceramic production in the 2nd Iron Age in the South of Portugal.
(4) 3D Technology: another section of the Museum is dedicated to the 3D tools involved in the creation of the Virtual Museum itself, explaining to the visitor the principles of photogrammetry, laser scanning and the process of aerial photogrammetric surveying.
(5) Exploration of the Site: there is an area where the user can explore the site itself, but using Points of Interest (POI) identified over the DTM. These POI are associated to pop-up menus with relevant information on the archaeological site that appear when the user places the mouse over the POI in question. This area is also surrounded by a 360º panoramic view of the neighbouring landscape.
(6) Exhibition Area: the first exhibition to be featured in the Virtual Museum displays some of the large containers and censers found in the votive deposit. By clicking in each of the objects, the user can access archaeological information about the artefact and freely manipulate it, observing the object from virtually every possible angle.

CONCLUSIONS

The development of a virtual museum presents itself as a versatile and interactive platform that enables the