Proceedings of the 8th International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation 'ARQUEOLÓGICA 2.0' in Valencia (Spain), Sept. 5 – 7, 2016

3D MODELING AND VIRTUAL APPLICATIONS FOR THE VALORIZATION OF HISTORICAL HERITAGE

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Abstract:

A large amount of 3D digital models, acquired with reality-based techniques or modelled with CAAD methods, are today part of archaeological studies. This new form of heritage documentation has deeply changed the traditional way of representing, studying and visualizing the remains of the past. At the same time, 3D digital documentation is rarely shared and easily accessible, so as the historical iconographic sources, text documents and other information used for interpreting remains and for validating 3D reconstructions. This paper describes the first results of an interdisciplinary project of 3D documentation and valorization of historical heritage, carried out in the archaeological site of Pausilypon (Naples, Italy). The final aim is to realize an integrated virtual tour of the site, developed in Unity 3D, based on 3D surveying products. This tour proposes a new way of presenting and visualizing results of archaeological studies and 3D documentation, collecting and overlapping different types of data in a unique and interactive virtual environment. Besides 360° equi-rectangular panoramic image and 3D models, heterogeneous material will help users to understand the interpretative process followed for the hypothetical CAAD reconstruction. These results will be mainly shared via web, for a larger dissemination of the work and for supporting future research on the site. In addition, for promoting the knowledge of the archaeological remains, a simplified and immersive tour will be developed for Virtual Reality devices.

Key words: Cultural Heritage, Documentation, 3D Modelling, 3D Reconstruction, Visualization, Valorization, Virtual Tour

1. Introduction

The drawing of ancient monuments has been, for centuries, a powerful instrument of knowledge in architecture and archeology. The development of several sensors and techniques for 3D digital surveying and documentation (Remondino 2011) is changing, in last years, the traditional way of recording and representing reality, following a new desire of visualizing and knowing the world through its three dimensions. This innovation has proved to be particularly relevant in those disciplines based on vision and on representation of archaeological artifacts as instruments for discovering and recomposing their ancient aspect. Traditional two-dimensional documentation (plans, sections, photos, etc.) is, in fact, always a partial representation of a conservative condition and it is the result of a work of selection, simplification and interpretations of artifacts. Nowadays technological evolution allows to produce and to preserve in digital archives a huge amount of geometrical, colorimetric and volumetric information, freezing the actual condition of remains. The aim of this paper is to show the developed methodology not only to acquire 3D digital information with multi-technique procedures, but also to share products. Besides the recent evolution of reality-based techniques and CAAD modelling tools, in last years the development of Virtual Reality (VR) applications is changing the traditional way to communicate and to disseminate archaeological results. In the presented case study, the interactivity and contents of applications are customized for different types of users, specifically scientists and non-expert users, respectively with research and promotional purposes.

2. Case study

The presented case study is the archaeological site of Pausilypon (Naples, Italy), where a project of 3D documentation, hypothetical reconstruction and virtual fruition of the area was carried out. The site (Fig. 1) preserves the remains of a spectacular maritime villa of Roman period, organized on three-level terraces. Best-preserved structures are on the upper terrace: a Theatre (47x22m) and an Odeon (23x25m).

On the lower terrace, thermal baths are the only artifacts today visible. The ancient villa was much more extended, but today only a little part is preserved or recognizable. The hypothetical reconstruction of the site is, for this reason, very difficult but also very important. So far the project is mainly focused on the two theatres of the public area. The Theatre, built following the Greek rules (above the natural slope of the hill), could host up

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to 2.000 people. On the opposite side of this area, there is a smaller Odeon which was originally covered.

Figure 1: General view of the archaeological area in Pausilypon.

3. 3D reality-based surveying and modelling

The survey of the area (ca 1 ha) required a multi-technique procedure. The entire area was firstly surveyed with a TOF laser scanner (Faro Focus 3D), planning and acquiring 29 medium resolution scans. This instrument has a range noise less than 1 mm for measurements up to 25 m. The scans alignment and registration were carried out with the proprietary software, using printed checkerboard targets and spheres, distributed within the field of view of the instrument. The final point cloud is of about 338 million points (Fig. 2). The main difficulties of the TLS survey were the handling of the large quantity of data as well as the colouring of the point cloud due to overlapping scans and low-res embedded camera.

Figure 2: Laser scanning point cloud.

The site's survey was also accomplished using terrestrial photogrammetry (Nocerino *et al.* 2014), in order to close gaps and to improve texture information of the TLS data. The photogrammetric acquisitions (ca 140 images) were performed with a Nikon D7000, coupled with a 24 mm lens, keeping a mean GSD less than 5 mm for a 1:50 drawing scale. The project was scaled using a scale bar located on the field and the final dense point cloud contains ca 30 mil. points (Fig. 3). The main difficulties were associated to the complex and large scenario, the vegetation occluding some areas of the site as well as the textureless surfaces.

The integration of TLS and photogrammetric point clouds was carried out keeping the laser data as reference. The resulting merged point cloud was the base of the site's documentation and conservation whereas it was decimated at 5 cm sampling step for VR and valorization purposes. The generated polygonal model presented topological errors due to different and complex surfaces, required a long post-processing phase and was finally textured for the successive valorization steps.

Figure 3: Photogrammetric dense point cloud.

4. Hypothetical 3D reconstruction

Recomposing the ancient aspect of artifacts has always been one of the main goal of archaeological studies. This practise showed to be powerful in communicating the value of fragmented spaces and architectures, difficult to recognize in their shapes and functions. The reconstructive process followed in this project started from the reality-based 3D models previously described, at the moment only for the Theatre. Initially geometrical features and constraints were extracted with planar sections from 3D models and compared with different descriptions and two-dimensional drawings of the area elaborated in different time periods, to analyse main differences between actual and previous conditions. Different sources (Fusco *et al.* 1842; Gunther 1913; Alvino 2001) describe the finding of the actual remains, the ancient aspect of the area and the first relevant restoration work of the 19th century. There were used to assemble the CAAD-based 3D hypothetical reconstruction of the structures (Fig. 4) which is taking into account the level of coherence between parts and elements today visible and corresponding descriptions and representations in the different periods (Guidi *et al.* 2014). In the final 3D reconstructive models, the use of different methods of representation will underline the different level of reliability of our hypothesis, based on the iconographical and bibliographical sources.

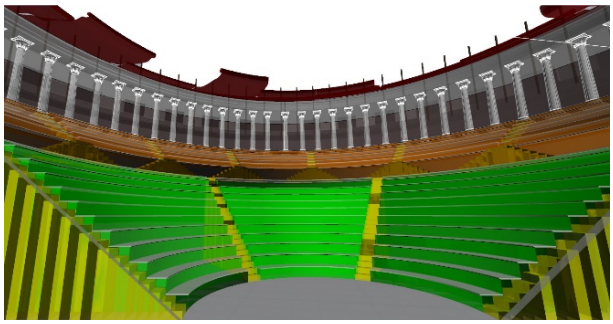


Figure 4: The CAAD-based hypothetical reconstruction of the Theatre based on the reality-based 3D model.

5. The virtual tour of Pausilypon

The development of a virtual tour of the site is the final step of the project with a disseminative and a promotional goal, considering different kinds of users (scientists and non-experts) and needs.

A first enriched virtual tour for scientists, based on the Unity3D engine and the aforementioned 3D contents, will be shared via web, accessible online and open. The 3D informations and references could in fact help researchers, not only for comparisons but also for validating theories and reconstructive hypoteses. Inside the virtual tour, user will be able to navigate and interact with different virtual environments:

- 360° equi-rectangualar panoramic images, acquired in different positions within the site. In every image, user can immersively explore the actual condition of the site. The visualization of the present state of this heritage is essential to compare and verify the achieved 3D results (Fig. 5).
- 3D reality-based data, overlapped to the panoramic images. The user can visualize the 3D data with its levels of details, holes, incoherences, geometrical and colorimetric results. This phase is important to evaluated results and data used for the following steps.
- References and other sources. This step represents the interpretative phase. Besides previous elements, other information (texts, bibliographical sources, historical drawing and photos, etc.) are part of this 3D environment. Principal geometries of 3D reconstructive model are also showed in this part, to verify coherence between our choices and corresponding references (Fig. 6).
- In this scaenario scientists working on similar task and research field can easily visualize and compare all data used in this project and can evaluate the realiability of the final 3D reconstructive model proposed.
- Final 3D virtual / hyphotetical reconstruction, overlapped to panoramic images.
- This environment contains starting and ending data (actual and original aspect of artifacts) of this project.

This last scaenario will be available also for a second simplified tour for not-expert users.

These contents will be shared for an immersive and interactive navigation through VR devices, with the main aim of promoting the knowledge of the historical heritage for its preservation.

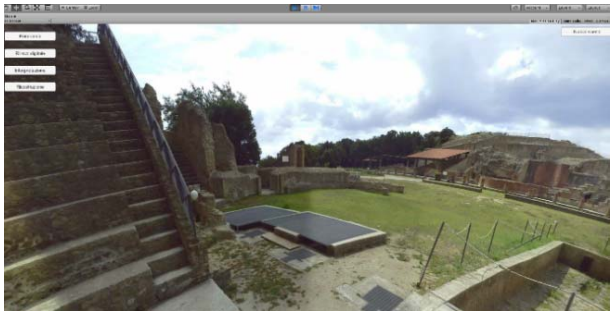
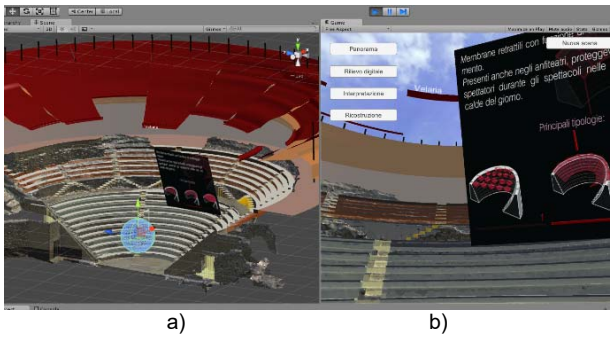


Figure 5: A panoramic view of the site inside Unity 3D gaming engine.



a) b)

Figure 6: Virtual environment in Unity 3D with 2D and 3D data: a) scene planning; b) gaming view.

6. Conclusions

The paper presented the on-going work for the 3D documentation and valorization of the Pausilypon site. After the 3D documentation and modeling phase, the digital products were inserted in a game engine for valorization and communication purposes.

Virtual applications are indeed showing, in last years, their capabilities to offer ineditos scenarios in the traditional way of exploring and interacting with real or modelled worlds.

Moreover immersive experiences could attract and increase interests of a large part of younger and non-experts users.

The last developed tour proposes a virtual immersive navigation into 360° panoramic images and, through user input, it offers the chance of visualizing the hypotetical reconstruction elaborated in this project.

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