Generation of virtual models of historical *tapial*[1] walls in Seville (Spain)

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Abstract. Virtual reality interactive representation of heritage is a very efficient means of dissemination and underlining the importance since it enables visualization in multiple formats via the Internet or on specially established devices available in information centres or exhibitions.
This work is presented as an indication of the possibilities of behaviour by applying innovative technology.
As an integral part of a more ambitious project, this work consists of the development of a GIS of the tapial walls of the Spanish province of Seville together with links which permit a virtual reality visualization of the most significant indexed elements.

1. Introduction

Within the framework of the National Plan of Scientific Research, Development and Technological Innovation 2004-2007, the R+D project "*Proposals Of Maintenance, Evaluation And Restoration For Rehabilitation Of Buildings And Urban Infrastructures With Historical Tapia Walls In The Province Of Seville*[2] *(Spain)"*, it has been considered appropriate to document the inventory items by applying the most advanced technology in 3D, not only as a scientific analysis[1] but also as an instrument of dissemination and underlining the importance.

The aims of the research project are much wider, however the focus of this dossier is on the set of activities directed at obtaining the texturized digital models and their configuration as a virtual reality system.

To illustrate this process, one of the recent discoveries has been taken as a reference: the city wall and barbican, uncovered in San Fernando Street in Seville city centre due to construction work on the new underground system. Based on this scenario, this work is aimed at describing the initial stages and the creation process of documentation in virtual reality of the archaeological remains fundamentally composed of tapial.

2. Description of the object under study

The archaeological remains, which we are interested in, are formed by the base of the defensive construction of southern zone of the city wall staked out with towers, a moat and a

[1] Constructive technique based on sand, lime and gravel rammed down layer by layer inside a plank mould to form a wall. Forerunners of Tabby in North America and surviving in Spain until the middle of the 20th century, its ecological characteristics have awakened a renewed current interest.

[2] R+D project financed by the General Management of Research of the Spanish Ministry of Education and Science, with reference BIA2004-01092, principal researcher Dra. Amparo Graciani García.

barbican whose origin dates back to the 12th century[3]. The interior of the city wall formed part of the Alcazar military complex and along the exterior of the barbican followed the Tagarete stream, giving rise to the strong erosion of its exterior face, a fact which determines, to a great extent, the technology employed in the survey of the geometry of the surfaces.

Figure 1. Partial image of the tapial barbican. Photo supplied by the author.

The city wall and barbican of Almohade origin, for historical reasons and constructive characteristics, constitute elements of enormous interest from the archaeological point of view: they concern a tapial wall commonly used in Almohade architecture.

Our paper focuses on the barbican given that the city wall appears mostly covered with brickwork and its surface shows no irregularities as seen in the barbican which makes its digital modelling a case of special interest.

3. Process of data collection

In accordance with the Paper of Krakow 2000 [2], where the current principles are found for the conservation and restoration of built heritage, the "appropriate technical options organised into a cognitive process which integrates the gathering of information and the in- depth knowledge of the building" must determine the decision of which technology to apply.

Depending on the agents of each intervention, the level of demand can be variable. However, concerning the said level we should bear in mind that the diverse degrees of documentation processes must be proportional to the historical interest in the architectural complex under examination and must be suitable for the purpose of the study [3].

Consequently, the case under study, upon the base of its historical interest, demands the application of all possible technical options currently available.

To this end, work has been developed in both a parallel and integrated way by applying the classic topographical methodology, photogrammetry and 3D scanning [4].

[3] The archaeological excavations are being directed by Dr. Mark Hunt Ortiz and coordinated bay D. Florentino Pozo Blázquez

3.1. Classic Topography

With the aim of georeferencing the whole work from the prearranged bases for the archaeological excavation and due to the necessity of offering the densest possible cover of points of control for the photograph registration, a topographical survey has been carried out with a total station Leica TCR-307 equipped with measurement by infrared radiation and laser which enables readings to be taken without a reflector prism.

3.2. Close-range photogrammetry

In order to obtain the textures, a close-range photogrammetrical sweep based on software and non-metric digital cameras has been carried out. The type of camera and the optics employed were: Sony DSC-F707, optic Carl Zeiss, of 5 Mega pixels. The calibration of the optics was obtained though specific software from photographic shots taken from a pattern calibrated to similar distances to those used in fieldwork.

Given the irregularity of the object under study, the possibilities of topological restrictions (axes, etc.) have been cast aside. In general, the shots have been restored from ten points of control for which frontal shots and simple photograph methodology have been employed. However, to increase the density of the model, multiple shots have been combined in order to seek the maximum perpendicularity between focal axes without exceeding the minimum value of 15º.

3.3. 3D laser scanner

In order to increase the density of the model, high-definition laser scanning has been carried out aimed at survey the surface geometry by means of a mesh of points with a point density of between 1 and 5 cm. The instrument used was a Cyrax scanner with a distance precision of 6 mm and an angle precision of 0.4 seconds. Seventeen models have been generated with an average mesh of 1000 *1000 points each.

The models obtained enable overlapping for which the adjustment by squared minimums of the clouds of points between each two models with cover (after proposing an initial position of the model) permitted the registration of models by pairs. The global registration by squared minimums of the relative positions of each pair of models leads to a global model of the whole excavation.

3.4. Registration of the coordinate system

Topography work carried out previously to that of the scanner enabled the establishment of a system of coordinates for the whole excavation. A small number of points were used in this system of coordinates in order to fix the coordinate system in the model of points thereby adopting general topographic work.

In this way, it is possible to overlap any earlier or later topographical work onto the model obtained, or to carry out verifications on it.

4. Digital modelling and allocation of textures

The surfaces for the definition of the set have been modelled from the clouds of digital points and the restored textures have been applied.

Figure 2. Interactive visualization on the Internet of a fragment of the barbican in VRML format.

Obtaining the cross-sections from the clouds of points has enormously facilitated the generation of the surfaces of the model, while for the application of real and restored textures, the contribution of photogrammetry has been essential. Traditional topographical total station is the principal link between the two more innovative techniques employed.

5. Presentation of virtual models

The result is presented in VRML format, which enables interactive visualization from numerous software platforms, in many cases freeware, establishing hyperlinks to those in the GIS of the overall project. In order to obtain the orthophotographs from the main positions based on the VRML models, a platform of software has been designed, views_predef ©, which gives access to normalized views of the model [5].

However, the degree of precision reached does not always correspond to the possibilities of real disclosures, which has thereby caused the necessary decomposition of the model into smaller fragments and their remodelling. In order to counteract the loss of quality when simplifying the models, a lighting study has been carried out which is suitable for the characteristics of the visualization desired.

References

[1] Santana, M., The Use Of Three-Dimensional Techniques Of documentation And Dissemination In Studying Built Heritage. Katholieke Universiteit Leuven (Belgium), 2003. ISBN 90-5682-380-9.
[2] Rivera Blanco, J. y Pérez Arroyo, S. Carta de Cracovia. Versión española. Valladolid (Spain), 2000.
[3] Brogiolo, G.P. 1988. Archeologia dell'edilizia storica. Como. Edizioni New Press.
[4] Beraldin, J.A., *Integration of Laser Scanning and Close-Range. Photogrammetry - The Last Decade and Beyond*, in XXth International Society for Photogrammetry and Remote Sensing (ISPRS) . Istambul 2004.
[5] Barrera, J.A. et al., *Realidad Virtual versus Sistemas de Representación Técnicos. Desde la percepción del modelo hacia la representación normalizada*, in VII congreso APEGA, Universidad de Alcalá. Guadalajara (Spain), 2003. ISBN 84-8138-603-0.