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A 3D ENVIRONMENT TO REBUILD VIRTUALLY THE SO-CALLED *AUGUSTEUM* IN HERCULANEUM

1. Introduction

In the last years, the term Virtual Archaeology has been used mainly to identify the creation of 3D environments. Instead of highlighting the allusion/surrogate to an original object, as suggested by P. Reilly in 1990 (Reilly 1991), Virtual Archaeology is currently intended as 3D modelling; this approach has been successively restricted to data-acquisition and processing with the loss of the primary cognitive perspective. Thanks to the last generation of transportable and manageable laser scanners, data-acquisition and processing has become an easy task, while digital photogrammetry allows the creation of accurate and photorealistic 3D models. Currently 3D models have been used especially for communication and dissemination.

3D technologies are revolutionizing deeply the traditional approach to acquisition, storing, managing and sharing of archaeological and built heritage (Forte 2014; Remondino, Campana 2014). High accuracy 3D digitization is considered a common practice in cultural heritage domain since 3D data can provide answers to different questions related to the preservation, museum collections, virtual reconstructions, and dissemination.

The rapid spread of tools for 3D has raised new issues. One of these is the creation of centralized 3D archives for publication and distribution of 3D models (Koller, Frischer, Humphreys 2009). Another one, not less important, is the improvement of data-publication and data-visualization of high-resolution 3D models enriched with realistic details and related descriptions (Potenziani *et al.* 2015). As digital cultural heritage content is interlinked through many relations, new forms of data-sharing have been tested to increase the interactivity between data-providers, stakeholders, professionals, domain experts and general public (Forte 2014).

Large-scale production of 3D data, given the variety of processes involved and the complexity of relationships among digital and physical objects, requires an innovative knowledge management system. Metadata can correctly satisfy this new scientific requirement, as they store information about the life-cycle of a 3D object from the initial generation phase to later uses, storage and the possible reuses. Metadata allows to keep track of the instrument settings (calibration, tolerances and errors), the physical object (status, conditions) and the possibilities to improve or reprocess the model.

All these elements have been faced by 3DICONS, a three years' European project ended in 2015. The project had a twofold aim: providing high quality

3D models to the digital library Europeana and implementing a metadata schema able to record information about the physical three-dimensional artefact and its digital representation.

The paper aims at exploring how the archaeologists can improve their traditional work in a computational laboratory. The case-study selected is the recent virtual reconstruction of the so-called *Basilica* in Herculaneum carried out in the framework of 3DICONS Project. The monument is not visible with the exception of the southern side, only partially preserved. The building was explored in 18th century by Bourbons and, 250 years after its discovery, it is still largely unexplained. The identification and function of this structure have been disputed since its discovery.

Although still completely buried by the volcanic rock, safe for part of its entrance porch, the building is known thanks to the tunnels dug by its early excavators. Different scholars (Pagano 1996; Njabjerg 2002; Masursi 2008; Allroggen-Bedel 2010; Guidobaldi 2012) provided their reconstructions on the basis of two plans, drawn in 18th century, and few notes taken during the exploration; the majority of the archaeologists focused their research on the architectural elements of the building and its ancient function. Only one reconstruction is rendered by computer (Najbjerg 2002); it is based on real measurements of the visible parts. Recently a scale model has been carried out integrating the architectural structure with statues and frescoes (Masursi 2008).

The 3D model, carried out in 3DICONS Project, aims at highlighting some controversial parts of the reconstructions. Metadata associated to the digital replica describe the physical object and register all phases from data-acquisition to data-visualization. The metadata record, developed by 3DICONS Project, deals with the 3D process which includes 3D data capture, post-processing and the publication (D'Andrea, Fernie 2013). The most significant innovation introduced in the schema is the registration of the provenance and paradata. While provenance is a record of the technical processes involved in creating digital objects, paradata can be described as information about the human processes of understanding and interpretation; according to London Charter recommendations, paradata makes explicit the methodological premises and the research targets behind digitization; it enables for example alternative hypothesis and factual evidence supporting the reasoning behind the implementation of a 3D model.

The next paragraph deals with the history of the monument and, mainly, on the different proposals provided by archaeologists. Subsequently the paper focuses on the 3D reconstruction.

2. The so-called *Augusteum*

The monument is known in the literature with different names: *Porticus*, *Forum*, *Basilica*; the latest research identifies it as a building linked

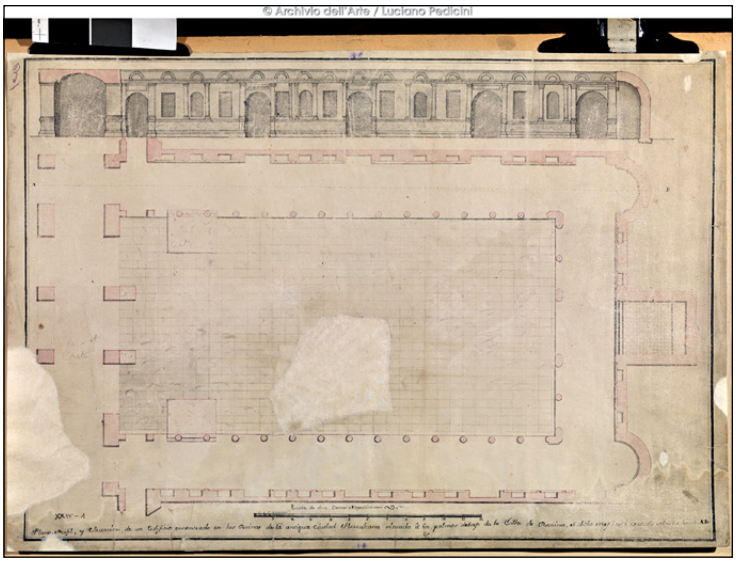

Fig. 1 – Plan view drawn by Bardet de Villeneuve.

to the imperial cult, precisely the *Augusteum* (Allroggen-Bedel 2008; Guidobaldi 2012), even if there is no epigraphic evidence which testifies this function. The building has been investigated only thanks to the well-known system of 18th century tunnels; therefore, it is still largely buried under the thick layer of volcanic deposit.

In 1744 Bardet de Villeneuve (who directed the excavations between 1741 and 1744) drew up three plans of the building. The monument had been excavated for the first time a few years earlier in 1739 by de Alcubierre; likely Bardet's plans were referred to maps drafted at that time, but partially preserved. This hypothesis, as pointed out (Allroggen-Bedel 2010), is supported by a number of significant inaccuracies. The three drawings represent the structure in its entirety; two of them reproduced the monument into a broader context of public buildings, included the theatre. At first glance it is clear the misplacement of the buildings: the theatre (rotated of 90°) and the porticus and front of *Collegio degli Augustali* and so-called *Basilica Noniana* that are too much distant each other, and, consequently, from the *decumanus maximus* (Najbjerg 2002). Even if the general map is incorrect, by contrast the *Augusteum* drawing is detailed and highly accurate; it also includes a front view of the western wall of the building (Fig. 1).

Between 1750 and 1751 J.-C. Bellicard and C.-N. Cochin visited Herculaneum. In their publication in 1754, there is a much more accurate plan

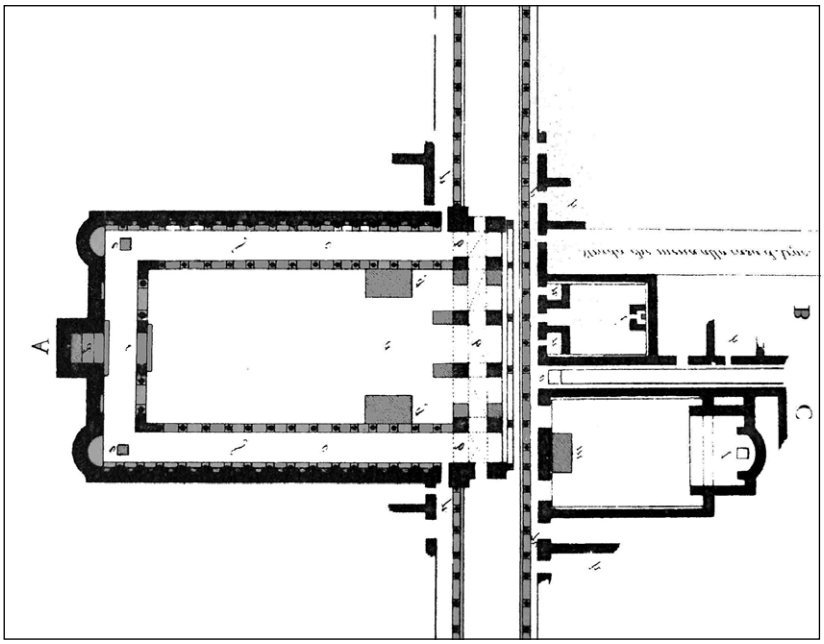

Fig. 2 – Plan view drawn by J.-C. Bellicard.

of the north-western area of the excavations (Fig. 2). The buildings are now put into a more correct spatial relationship. It is likely that the two gentlemen had access to the original excavation plans carried out by de Alcubierre and not long afterwards disappeared together with the general plan of excavations provided in 1759 by Weber. By comparing the plans of Bardet and Bellicard it is possible to suppose that the two surveyors have used different maps carried out by the early excavators (Allroggen-Bedel 2010).

An evocative representation of the building is in an engraving made by F. Morghen in 1835 (Fig. 3). The work is a bird's-eye view of the great porticoed building, with, inside, some statues in place, including the two equestrian statues of *M. Nonius Balbus* and his son (Allroggen-Bedel 2008) The two side bases on which the artist placed the statues (actually coming from the public area of the city) are an imagination. By checking the detailed map provided by Bardet survey, instead of the bases, there are two small platforms placed against the western and eastern walls of the porticos, and accessible by two steps. Probably these platforms were *tribunalia* rather than bases for statues (Guidobaldi 2012).

In the engraving (which represents the building completely dug up) there are some inaccuracies also of the long walls. The Bardet's map shows a detailed

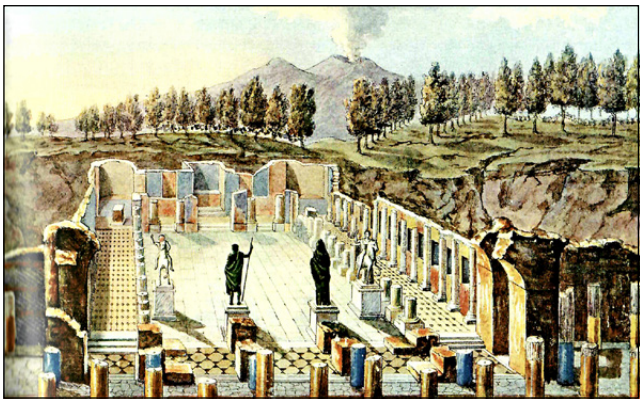

Fig. 3 – The engraving by F. Morghen (1835).

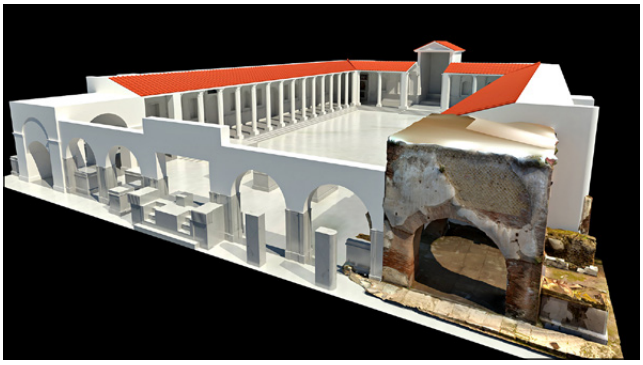

Fig. 4 – A view from SE of the building. The model shows all 3D rendered objects.

description of the western wall with five large curved niches opened to the ground alternated with groups of two or three small arched and rectangular niches (Allroggen-Bedel 2008). The large niches are surrounded by pilasters with Corinthian capitals and have on the top of the arc a rectangular space, filled, in the second niche, with the inscription of dedication of the *Augustales* (*CIL* X, 977) discovered in 1741 (not *in situ*).

The structure has been revisited by Pagano (1996) which provided an axonometric plan of the monument, but the first complete reconstruction is by Najbierg in 1997, published partially later (Najbjerg 2002).

The American scholar focused mainly on the comparison of the 18th century plans with the extant remains and therefore on the accuracy of the

previous maps. She checked the correctness of the geometry of the ancient drawings, but she found same mistakes in the reconstruction of the southern part of the monument. Thanks to the new survey Najbjerg identified seven openings in the south facade instead of fives as drawn by the Bourbon surveyors. Also, the reconstruction provided by Pagano, based on another survey of the extant remains, shows seven openings.

Najbjerg publishes a digital 3D reconstruction of the porticus with the aim to analyse better the spatial relationship of the building with the opposite *Collegio degli Augustali*. The model – known unfortunately only by the figures included in publication – is very essential and without any decoration.

On the basis of the Najbjerg's reconstruction L. Masturs i (2008) provided later a wooden model in 1:50 scale of the building. She enriched the plastic model by adding frescoes, statues and other decorative elements.

The correct assignment and positioning of the statues and frescoes is still debated. The Bourbons dug many tunnels simultaneously in several parts of the ancient Herculaneum and often they exploited these tunnels many times during the works. Therefore, they not always registered correctly the provenance of the objects they found (Torelli 2004).

As regard the *Basilica* only few data are surely correct. Inside the central *exedra* of the northern wall of the building, the excavators found a group of imperial statues in marble of which two seated (Augustus and Claudius) and a third one *loricata* (Titus). Other two statutes, representing Augustus and Claudius, were probably on the bases set in front of the niches (Torelli 2004). Also, the frescoes have had the same fate. As concerns the painted walls (readily detached by Bourbons), few data are available for a precise location. For example, four large pictures, whose surface is slightly concave, can be surely placed in the two niches of the bottom of the northern wall of the porticos. All statues and frescoes are currently stored in the Archaeological Museum of Naples.

3. The 3D model

The 3D model has been built on the base of the final architectural drawing processed by Mastursi which has reproduced digitally the reconstructions proposed by Najbjerg and Pagano. The CAD model has been integrated by the 3D model of the *quadrifrons*, still visible in the SE of the building, carried out by close-range photogrammetry.

The 2D CAD drawing has been analysed in order to check and correct the geometry of the features (self-intersections, dangles, etc.) and has been integrated, placed and rotated in order to have a better view of the structure of the temple itself in a 3D scene. Thanks to common 3D modelling tools (extrusion, loft, sweep, boolean operations, etc.) it has been possible to generate

surfaces and solids from the lines for both the general structure of the building and the several more detailed decorative elements such as capitals with acanthus leaves, column bases, altar cornices. 2D CAD plans, sections and elevations have been also used to support the creation of the building and its correct dimensional, formal and geometric characteristics.

Simultaneously the 3D model of the *quadrifrons* and of four statues, originally placed inside the *Augusteum*, have been carried out by mean of Structure from Motion technique (Forte 2014; Remondino, Campana 2014). This method permits, through the acquisition of several photos from different points of view, to reconstruct the 3D geometry of an object. For each statue 150-180 photos have been acquired and processed into Photoscan. The models are based on sparse point clouds of around 1-2 million tie points, for each statue. The point clouds have been cleaned up to remove points of noise and scaled through some reference targets placed into the scene. A 3D polygonal model (mesh) for each statue have been built from the dense point clouds and finally textured. The surface of the polygonal models (over 5 million faces) has been checked and edited to remove noise (self-intersecting triangles, non-manifold faces, etc.) due to interpolation errors and decimated to produce lighter models of around 20,000 faces.

The procedure has been used also for the four-sided portico. In this case, some targets have been placed into the scene and their coordinates have been measured by a Total Station to optimize the 3D reconstruction and give to the final model the real measures. A dense point cloud of about 7 million points and a textured mesh of 12 million faces have been produced. As for the statues, also this model has been edited in order to eliminate interpolation errors and decimate to produce a lighter model of 20,000 faces.

The decimation process has been performed by Geomagic Studio that allows to establish a maximum tolerance deviation that has been fixed at 4 cm for the portico and 0.5 cm for the statues.

Then all the 3D models have been imported into Rhinoceros for the integration of the CAD model with the statues and the *quadrifrons*. Rhinoceros has been considered as it uses a modelling approach based on NURBS (Non-Uniform Rational Basis Spline), suitable when the elements for the development of the model are represented by section lines, and as it can manage easily the whole structure of a CAD file format.

The integration has been based on the alignment of the models on the basis of common elements, as corners and edges of the two altars on the south-eastern side. It has been observed a difference of around 20 cm on horizontal plan and 30 cm on the height between the two models (Fig. 4).

Because of lack of many information about the surface, only two materials, white marble and white plaster, have been applied in order to have a realistic textured model of the building, while, according to the literature

Fig. 5 – The northern wall. In particular, the model shows the niches with statues and frescos.

information, the frescos have been placed into the two apses by texturing surfaces (Fig. 5). The only element not included into the original drawings, is the tiled roof of the peristyle which has been added in order to have a complete representation of the building.

4. Conclusions

Computer graphics and three-dimensional modelling techniques have extended the abilities of archaeologists in the visual reconstruction of ancient sites and monuments, reproduced with high level of realism. Although Virtual Archaeology is not a novelty in the panorama of the archaeological methods, no any requirement is needed to guarantee the accuracy and the effectiveness of the reconstruction; the strength of a model is based mainly on the capacity of the archaeologist to control the final result in terms of interpretation and hypothesis. Notwithstanding, by considering the range of technologies, instruments and methodologies available for data-capture and data-processing and the diversity of motivations and rationales behind any 3D digital replica, it is fundamental to register information about the way in which the 3D object has been created (provenance) and the rationale which has motivated the reconstruction (paradata).

Sharing 3D models is a fundamental task to increase cooperation and collaboration among scientific research teams. The 3D models of the so-called *Basilica* are available for free from the Europeana web-site. Different objects have been rendered: the cad model, the four statues, the *quadrifrons* and, finally, the complete integration of all models carried out. To facilitate the sharing and the interaction, all the 3D models are in 3D PDF format; an

high resolution model (.ply or .obj) can be required directly to the authors. Metadata enriched the digital cultural objects.

The increase of 3D objects online, freely accessible and downloadable, will encourage scholars to reuse the digital item and to analyse better and in detail the virtual reconstructions. This approach likely will restore the original meaning and spirit of the Virtual Archaeology.

The term Virtual Archaeology has been introduced for the first time in 1990, during the CAA conference, by P. Reilly (1991). In a pioneering period for the application of computer graphics to the archaeological research, the British scholar pointed out the importance of the virtual as allusion to a replica acting as a surrogate for an original. This concept involved other two basic elements, data-representation and data-management, which in turn implied the notion of simulation.

Virtual Archaeology is therefore a cognitive laboratory used by archaeologists to formulate and visualize different and alternative hypothesis. Thanks to this approach Virtual Archaeology is archaeology and not simply 3D data-acquisition and processing.

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ABSTRACT

Computer graphics and three-dimensional modelling techniques have extended the possibilities of archaeologists in the creation of virtual reconstruction of ancient sites and monuments. Modern computational systems allow the implementation of computer-generated scenarios tailored on human cognitive capacities. Although Virtual Archaeology is not a novelty in the panorama of archaeological methods, there is no agreement among scholars on the minimal parameters necessary to virtually rebuild an ancient context, nor is there any requirement needed to guarantee the accuracy and the effectiveness of the final reconstruction; the strength of a model is based mainly on the capacity of the archaeologist to check the final result in terms of comparison between interpretations and hypotheses. The paper aims at exploring how the archaeologists could perform their work in a computational laboratory thanks to shared 3D models. The case study selected is the recent virtual reconstruction of the so-called *Basilica* in Herculaneum, a monument – 250 years after its discovery – still largely unexplained. The building is completely buried by volcanic lava save for part of its entrance porch. It was extensively explored using tunnels and looted by its early excavators. Different scholars have rebuilt the monument mainly on the basis of two plans, drawn in the 18th century, and few notes taken by the archaeologists during the exploration. The 3D model, carried out by integrating cad modelling with close-range photogrammetry, is intended to highlight some controversial parts of the reconstructions. Metadata associated to the digital replica describe the physical object and register all phases from data-acquisition to data-visualization in order to allow the validation of the model and the use or re-use of the digital resource.