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"Virtual Restoration" from an Architectonic and Constructive Interpretation of Villa of Livia

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We often see virtual reconstructions of roman monuments that are made without taking into account available knowledge of historical architecture and construction. This paper presents a case study of the villa of Livia at Prima Porta, which virtual reconstruction involved a multi-disciplinary effort, including architecture, engineering, computer design and archaeology. The result is a real-time multiuser domain application, which can be seen at the Roman National Museum, at the Diocletian Bath in Rome.

Keywords: virtual reconstruction, roman architecture, virtual reality

1. Introduction

Virtual reconstructions made with computer graphics techniques often lack proper references and underpinning scientific analyses. A literature review reveals that the virtual reconstructions of cultural heritage made using computer graphics techniques, often lack scientific rigor and lose sight of existing knowledge. All too often, the criteria used for reconstruction are not accessible, there is no transparency regarding the process, nor is there an analysis of the validity of the reconstruction hypothesis, even when the modeling is carried out by scientists. Virtual reconstructions, being increasingly used to disseminate knowledge on cultural heritage, can result in the misinformation of a large public with these flaws.

To develop a virtual model, it is important to propose a coherent geometry and aesthetic model from a formal point of view, but it is also important to take into account the constructive aspects that determine shapes. Architectural knowledge is thus essential in all aspects of the reconstruction, such as covers, dimensions of building elements, water drainage system, etc.

This paper presents how architectural principles were applied to produce a virtual reconstructive hypothesis for the Villa of Livia at *Prima Porta*, Rome.

The research project is part of the author's phD, carried out at the Virtual Heritage Lab of the Institute of Technologies Applied to Cultural Heritage (CNR, Italy) aimed at providing a hypothetical reconstruction of the Villa of Livia from the Augustan age.

The archaeological complex of the Villa of Livia at Prima Porta (AAVV, 2007) is located at the IXth mile of the via Flaminia. Although never positively verified, the villa is supposed to have belonged to Livia Drusilla, wife of Ottaviano Augusto. The villa was built between 30 and 25 b.C., on a previous structure of the Republican age and it was in use at least until the Severan age (MESSINEO, 1991). The villa was first conceived as an Imperial Villa country residence, and its apparent simplicity hides the political and artistic conception of the first Roman Emperor.

2. Roman architecture: the importance of modules and standards

Roman architecture is characterized by the strong codification of language and architectural features, with given modules and proportions determining forms over entire periods. This leads to the creation of industrial production in the imperial age, where every element can be used repetitively.

For example when, in the seventeenth century one column of the Pantheon's portico case had to be replaced, it was possible to use a column from an ancient Roman Tiber's warehouse, that had exactly the same size (40 Roman feet). In fact, two other columns of the same size would have been available from the Baths of Alessandro Severo (PERKINS, 1974; WILSON JONES, 2003).

The Fundamental Security Theorem of limit analysis (HEYMAN 1999) indicates that the "equilibrium approach" provides the proper theoretical framework to understand the ancient structures.

The emphasis on geometry developed by builders, such as Vitruvius, is essentially correct in the sense that it linked aesthetics with stability. The safety of a masonry structure depends on its geometry, regardless of its size.

In his sixth book, Vitruvius emphasized the importance of modular structures, stating that the major concern that an architect must respect the form and proportions of buildings. Understanding these canons is critical for the reading and interpretation of Roman architecture: roman architects had utilized proportions and geometry in order to create a set of construction rules.

Following a similar approach, we developed a library of virtual architectural elements and textures. These served as building blocks for construction of the 3d models.

3. Methodology

A field survey based on a series of integrated technologies (laser scanner, photomodelling, photogrammetry, DGPS and so on) generated a complete database of present status. The degraded remaining vestiges of the site do not however provide sufficient information on their own to base the reconstruction work. It was thus necessary to develop a comprehensive methodology to produce a reconstruction hypothesis (VICO *et al.*, 2006).

Knowledge of roman architecture is introduced as a key aspect of the methodology. In a nutshell, the methodology relies on understanding that making a virtual model requires to follow the same criteria as real architecture: structural stability, functionality, and suitability of building materials.

There method aims at resolving two related issues: one is the interpretation of partially disappeared architecture and the other is its virtual reconstruction (BARCELÓ *et al.*, 2000). The ground in which both issues can be tackled is the humanistic and scientific knowledge, which are the base for the analysis, interpretation, and virtual restoration of the architectural heritage.

The methodology follows three stages. First stage: Documentation and data collection. Bibliographic and documental research which includes the review of all sources that can support the virtual reconstruction and that will be included in the project.

Second stage: elaboration of topographic virtual model at an urban level, which represents the generic volumes, topography, and rough landscape. This stage relies on some static calculations and construction theory, although to a limited extent.

Third stage: creation of a photorealistic virtual model of the monument. In this stage, the concepts that constitute the generative structure of the model are shown to the user, who is thus able to check the reliability of the displayed hypothesis in real time.

The user can directly visualize the sources of information underpinning the reconstruction by navigating close to an object. Three levels of certainty are distinguished: the first include the data with highest reliability: data that comes from archeological sites. The second level includes data that can be deduced from literature and other document. All reconstruction elements that can be reconstructed from philological research also belong to this category.

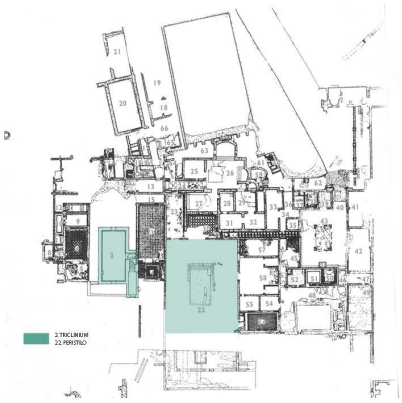

Figure 1: *Villa of Livia current state planimetry (SAR).*

At the third level all the elements based on our own hypotheses are collected: elements derived from technical considerations, structures and archeological remains, symmetry and metric considerations and, finally, elements which derived from considerations on composition. In the case of roman architecture, most of the reconstruction belongs to the third level. Even if less reliable, our knowledge of roman construction principles and technical capacity allows us to formulate plausible hypotheses.

4. Results

Implementing the approach described above allowed to propose a plausible reconstruction hypothesis for the villa of Livia at *Prima Porta*. In this section, we introduce results for two areas of the villa: the triclinium semisubterraneo and the peristilo 25.

Triclinium semisubterraneo

This space measures approximately 40 x 20 r.f. Walls are made with opus caementicium with tufo, and an insulating curtain of tegulae mammatae. The room was covered by a barrel vault, partially preserved before the nineteenth century remakes. "Garden frescoes", dated between 20 and 10 a.C., are very similar to Auditorium of Maecenas in Rome, and they are the oldest attestation of this type of paintings (Figure 1).

Questions arising when proposing a reconstruction hypothesis dealt with the function and meaning of the room, its illumination and ventilation, location and design of the access, and its integration with the rest of the building.

We used the static graphics method to test previous hypotheses about the level of the ground outside the *triclinium* and the shape of the vault (figure 3). It was indeed originally thought that the room stood alone, above ground. However, the discovery of *Tegulae mammatae* traces proved the presence of ground in contact with walls. Furthermore, terrain is found to be crucial to counteract

Figure 2: *Virtual reconstruction of Triclinium semisubterraneo, the Villa of Livia.*

the effect of vault: despite their rigidity, wall thickness is not enough to support the vault, unless we consider the help of the terrain or of lateral arches to support the vault's force. One long wall is in contact to terrain, the other one has lateral arches (figure 3).

Sulze (SULZE, 1932) had drawn the vault based on the remains founded in 1863, setting a height of 3,58. In order to make the virtual model, I studied the original level of the ancient terrain, to determine the height of the vault, access, lighting and ventilation. The barrel vault had to be lowered in order not to emerge from the ground of the above garden. The height proposed by Sulze is not realistic from a constructive point of view: given ground level in the Augustan era, the space as proposed by Sulze could not have natural light, unless provided with overhead openings like *Mecenate's auditorium* (figure 4) but no trace of such opening was found.

With a height of 5,27 we can open two windows at the top of the shorter walls of the room (N-S), ensuring cross-ventilation, and direct light to the fresco. Regarding the fresco, at the centre is a Pinus pinea with *Punica granatum* and *Cydonia oblonga*, with other smaller size plants. The Pine could be a symbolic reference to Attis and the goddess Cybele and pomegranate combined with *Cydonia*, symbolize the binomial fertility -immortality, citing the first to Proserpine and the second one the myth of the Esperides garden at the end of the known world. According to Caneva (CANEVA, 2005), these botanical elements have a strong symbolic value with numerous iconographic allusions to mythology, funeral rituals, and cycles of rebirth and regeneration. The proposed position of the windows ensure a direct illumination of the main features of the fresco, highlighting the symbolic

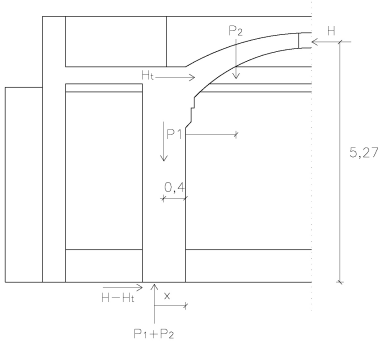

Figure 3: *Analysis for the Hypothesis for the triclinium vault of the Villa of Livia.*

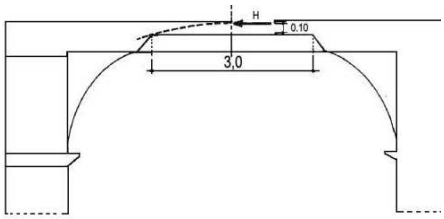

Figure 4: *Proposed lowered vault covering the triclinium vault of the Villa of Livia.*

significance of decorations. The proposed vault, is also compatible with the access as currently observed.

Peristilo 25

The open area is 22 x 18 meters (figure 1). The zone around the natatio measures 5x3 modules, and followed golden rectangle proportion. The proposed portico is indicated by Vitruvius for columns of less than 15 r.f. tall (Figure 6). According to this proportions, the portico should have had five columns on the short side. The intercolumniation measures 1 and 2/3 of the frame module (10 feet) and 6 ½ the diameter of the column measured at the imoscapo; column module is 1/9 of its height. Based on remains found in the Villa, and following a logical construction criteria, a portico of 5x6 ionic columns has proposed. The height of these columns reaches 14 feet, and is used as modular distance intercolumniation (figure 6).

The height of the portico is determined by the height of the columns, but also the surrounding spaces (figure 7), determining the design of the cover (WILSON JONES, 2003). In this case, the solution proposed follows the proportions for Ionic portico of 5x6 columns, but also resolves connection of confining roofs.

Conclusions

The wide dissemination of virtual reconstruction technologies for architectural and archaeological heritage has many unresolved issues. For this reason it is essential to establish a scientific process to substantiate the assumptions made to develop reconstructive three-dimensional models.

In our work, particular attention was paid to the clarity of the approach and to the possibility for the viewer to confront the methodology and sources used. All

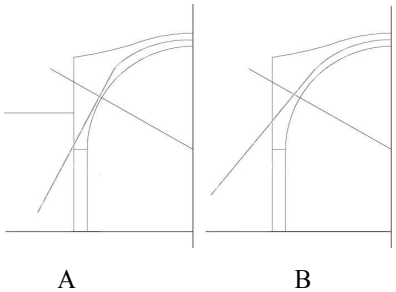

Figure 5: *Static graphics triclinium's vault of the Villa of Livia. A: Static graphics hypothesis considering terrain. B: Static graphics hypothesis without terrain*

Figure 6: *Virtual reconstruction of Peristilo 25 of the Villa of Livia.*

hypothesis and data used in the virtual reconstruction are accessible, ensuring the replicability and transparence of the reconstruction process, following a scientific protocol. A legend also explains the levels of reliability for each reconstructed element: low, medium and high.

Once the virtual reconstruction is finished, all the generated information becomes part of the documentation regarding the building. The model output is a synthetic, accessible and suggestive document that contributes to progress in analyzing the building. It gathers a large amount of data that traditionally were unconnected.

The validation of the virtual reconstruction presented in this paper through the knowledge of historical construction, is made feasible by the strong standardization of Roman architecture, and on the validity of traditional proportional rules.

Virtual reconstruction models can be seen as virtual restorations. The virtual model does not cause any damage to the vestiges of the monument, since the restoration is performed on the original image and not on the original element itself, overcoming the limits of traditional restoration.

Once they are developed, digital models can provide substantial support. From a technical point of view, they can support decision making prior to restoration. They facilitate the diagnosis of different structures and constructive techniques of the past. They complete and complement the existent graphic documentation of ruins and vestiges. From a historic point of view, the models allow to represent the building through the ages, following the succession of interventions. Finally, from a methodological angle, models offer elements of analysis for the study, and represervation of the architectonic heritage.

Virtual reconstructions are also opened and interactive tools for dissemination. The user can access the model as many times as necessary to generate new images or to modify and improve the design as new information is made available or new hypothesis proposed. Virtual models are made with commercial software (3DStudio, Photoshop) and do not need special computers.

The example of the virtual reconstruction of the Villa of Livia illustrates the relevance of multidisciplinary approaches: architecture, computer design, building

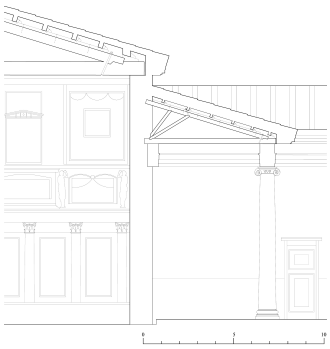

Figure 7: *Section of the reconstruction hypothesis for the Peristilo 25 of the Villa of Livia.*

engineering, and art history, that can provide relevant information and analytical skills to a field that has been traditionally developed by archaeologists. This contribution improves our understanding and opens new research ways for future.

Given its strong interpretative element, it is however important to frame this kind of work in the context of agreed principles, such as the Charter of London and Sevilla Principles. These documents are an important starting point to address the issue of virtual restoration of architecture and transparency of data, also analyzing the instruments used to regulate the real and virtual interventions. It will surely evolve as more experience is gained in this field of work.

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