

Digital technologies for the virtual reconstruction and projection of lost decorations: the case of the proscenium of the Farnese Theatre in Parma

Modern surveying technologies allow to obtain a digital copy of cultural assets. At the same time, digital technology allows to reconstruct virtually lost or destroyed architectures, as well as their decorative elements. To make this operation scientifically correct, it is fundamental to cross-reference and analyze as many sources as possible. Accurate documentation of the methodologies adopted is also essential to make the entire process clear, transparent and reliable.

This study is part of a wider research aimed at the documentation, valorization and dissemination of one of the most important 17th century theatres in Europe, the Farnese Theatre in Parma. The structure that we can see today is not the original one, but it is a 20th century reconstruction, since in 1944 the monument was almost completely destroyed in an Allied air raid.

The main purpose of this paper is to describe the complex process that allowed to reconstruct the

original decorations that covered the proscenium of the theatre before its destruction. In particular, the interpretation of the collected data, the digital reconstruction of the decorations and their mapping on the 3D model will be illustrated. Finally, the possible use of the textured 3D model for projection the decorations on the wooden proscenium will also be briefly introduced.



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Keywords:

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1. INTRODUCTION

Advanced digital technologies available today allow to obtain a virtual copy not only of existing artifacts but also of those that were destroyed or completely lost. Since the physical reconstruction of damaged heritage is not always possible and can be complex (as well as expensive), its virtual reconstruction represents an important tool in many fields of research (Pietroni et al., 2021). First of all, digital models are fundamental for the conservation of historical memory (Denker, 2017). They contribute to preserve the image of artifacts in their integrity and make them accessible to a wide range of users. Digital reconstructions represent also a valid support tool for the dissemination of knowledge. For example, they can be used for the elaboration of audiovisual material about the heritage. At the same time, they are also particularly useful for the communication of historical and cultural content through multimedia technologies. In this context, interesting applications of digital reconstructions are related to a particular form of augmented reality, known as video or projection mapping. This technique, non-invasive and completely reversible, allows the visualization of decorations that no longer exist, contributing to the improvement of readability and understanding of a historical artifact (Peters, 2018), (Giannetti et al., 2019). However, one of the most important application of the virtual reconstructions is in restoration. 3D models can be used to support restoration activities and are particularly useful for the digital prefiguration and simulation of interventions in a virtual environment (Gasperuzzo, 2019).

It is obvious that, in order to make the virtual reconstruction process scientifically correct, rigorous philological study is necessary. It must be conducted through the critical analysis and continuous comparison of all available historical sources (ICOMOS Charter, 2008).

It is also necessary to note that every operation aimed at the virtual reconstruction of heritage that no longer exists is inevitably subjective. In particular, when such an operation concerns historical artifacts, there may be numerous sources to draw

upon and each of these may be interpreted differently. In order to ensure scientific validity to the virtual reconstruction and to make the whole process as clear and transparent as possible (London Charter, 2009), adequate documentation of all its phases and of all the choices that are adopted becomes therefore fundamental (Apollonio et al., 2015).

This paper investigates the above-mentioned topics and is part of a wider research aimed at the documentation, valorization and preservation of a historical architecture of high artistic value: the 17th century Farnese Theatre in Parma (Mikolajewska, 2021). In this article, particular attention is paid to the use of digital technologies for the reconstruction of lost pictorial apparatus. In origin, the entire Farnese Theatre was covered by rich decorations (Fornari, 1994), which were completely destroyed during an air raid in 1944 (Gandolfi, 1980). In the 1950s, only the architectural structure of the theatre was rebuilt. Today, it is possible to see the original decorations only in the precious photographs that document the state of the monument before its destruction or in a few original fragments of the artifact that were reused for its reconstruction. Because of its characteristics and complexity, the Farnese Theatre represents an emblematic example of a historical monument on which to deal with the issue of virtual reconstruction.

2. THE CASE STUDY: THE FARNESE THEATRE IN PARMA

The Farnese Theatre in Parma, completed in 1619 and inaugurated 9 years later, is one of the most interesting examples of wooden theatres in Europe. The structure was built by Ranuccio I Farnese to pay tribute to the Grand Duke of Tuscany Cosimo II de' Medici. In origin, the theatre was characterized by rich decorative apparatus, both pictorial and sculptural. All wooden surfaces, the original false ceiling (now lost) and the walls of the room, were completely painted and there were also numerous statues placed in various locations. During the Second World War, the monument was almost completely destroyed by an Allied air raid

and only a few elements survived. The philological reconstruction of the theatre started in the 1950s and involved the architectural structure. Ten years later, restoration began also on the frescoes placed on the perimeter walls of the hall. Only the pictorial decorations that were originally painted on the wooden surfaces and the previously mentioned statues were not reconstructed.

Today, the theatre has the same configuration of the post-war reconstruction. Some traces of the original decorations are present in elements reused during the reconstruction of the artifact (visible for example in the central area of the entablature). These few elements, combined with other sources of different nature, provide important information for the virtual reconstruction of the original decoration of the theatre.

2.1 METHODOLOGICAL APPROACH

As previously mentioned, the entire Farnese Theatre was originally covered by a rich pictorial decoration. Although historical sources available today are numerous, they are not sufficient to provide a complete and detailed description of the entire pictorial apparatus. One of the most documented parts of the theatre is the proscenium. There are many sources of this area, including numerous detailed photographs, which allow to a more in-depth analysis of the elements. Not excluding the possibility of finding further sources in the future, at the moment it was decided to focus this operation only on the proscenium. To this aim, a specific workflow composed of four phases was followed.

The first phase involved knowledge acquisition on the case study. First of all, an integrated survey campaign of the monument was performed. At the same time, a research aimed at collecting historical sources (iconographic, documentary, written sources, etc.) was also carried out.

The second phase concerned the interpretation and processing of the collected data. The data acquired in the survey campaign were used for the elaboration of the 3D model of the theatre (which included the model of the fresco placed on the back wall of the hall, used for the elaboration of its orthophoto) (Zerbi et al., 2021) and all the

historical sources were critically analyzed in order to provide a solid basis for a philological reconstruction of the decoration. The third phase, explained in detail in this paper, focused on the digital reconstruction of the original pictorial apparatus of the proscenium. This operation concerned the creation of decorations as bidimensional images, then mapped on the 3D model. Particular attention was paid on making all operations always and easily implementable. This approach is essential in operations characterized by a certain level of subjectivity, related to the incompleteness and non-exhaustiveness of historical sources. Finally, in order to make the whole process as clear and transparent as possible, it seemed fundamental to carefully document all the choices and decisions related to the sources used. The final phase regarded the elaboration of a video mapping project aimed at the virtual projection of the decorations on the wooden proscenium.

3. DIGITAL RECONSTRUCTION OF THE ORIGINAL DECORATION OF THE PROSCENIUM

The reconstruction of elements that no longer exist is an extremely complex process. In order to make it as correct as possible from a philological standpoint, a deep knowledge of the artifact and an extremely interdisciplinary approach are essential. The analysis of the historical sources related to the Farnese Theatre highlighted that there are numerous representations of the monument, both documentary and photographic. Each source provides more or less significant information for digital reconstruction of the original decorative apparatus. Since it is not possible to illustrate in this paper the entire documentary corpus collected, only the main sources used in this process will be mentioned below:

- *Written sources*: the book by Marcello Buttigli (the first chronicler of the Farnese Theatre), elaborated after the 1628 inauguration of the monument. The author described meticulously the architectural structure and its pictorial decoration [Buttigli, 1629].



Fig. 1 - The proscenium of the Farnese Theatre in Parma.

- *Iconographic sources*: pictorial representations and historical architectural drawings. Among the rich corpus of graphic elaborates of the monument, were taken into consideration those drawn by: Giovanni Battista Aleotti (17th century), the Bibiena brothers (17th century), Louis Auguste Feneulle (18th century) and Louis-Hippolyte Lebas (19th century).

- *Photographic sources* (before 1944): photographs from the Alinari and Pinazzi collection. Other photographs taken during cultural events held inside the theatre, or from documentary campaigns carried out on the historical monuments, were also useful.

- *Plastic model*: the model of the theatre attributed to two craftsmen of the 19th century, Fanti and Rousseau.

- *Pictorial model*: the fresco placed on the back wall of the hall. Some recent studies demonstrated that the fresco represents a specular copy of the architectural structure of the proscenium [Zerbi et al., 2019]. Other frescoes placed on the perimeter walls of the hall and those painted at the church of San Paolo in Ferrara by the same painters who worked in the Farnese Theatre were also useful.

At the beginning of the entire process, a comparison of the current conformation of the proscenium



Fig. 2 - Details of some historical sources used in the digital reconstruction of the original proscenium decoration: project by G.B. Aleotti, painting by G. Contini, historical photograph (from Pinazzi private collection).

with the one before the 1944 destruction was carried out. This operation was performed by comparing the survey drawings produced from the 3D model with the best-known representations of the monument made in the 1770s by Louis Auguste Feneulle, supported by a critical analysis of the photographic sources. The comparison study showed that from the geometrical standpoint the current state of the proscenium corresponds to its

pre-reconstruction configuration and that only a few elements are different. This step was essential to verify the possibility of digital reconstruction of the original decorations. The accurate analysis conducted on the photographs allowed also to identify some elements of the proscenium that were not reconstructed during the 1950s. However, they are limited to few small elements, not particularly significant.

3.1 CRITICAL ANALYSIS OF THE DECORATION
From a methodological standpoint, the critical analysis of the original decorative apparatus of the proscenium was carried out in two phases. The first phase focused on the identification of the elements from a figurative point of view. To this aim, each element was analyzed in detail and compared to all available sources. The second phase concerned the identification of the elements colors. With regard to



Fig. 3 - Detail of the original proscenium decoration (entablature). Photograph from Pinazzi private collection.

Fig. 4 - Detail of the original proscenium decoration (pedestal). Photograph from Pinazzi private collection



philological criteria, this last step represented one of the most critical phases of the entire process. Starting from the lowest part of the proscenium, it was possible to identify the decorations present on the following parts of the structure:

- *Dados*. From the early 20th century photographs we can recognize a frame surrounded by a geometric decoration and, in some cases, by figures of animals. Inside the frames, there are often present masks or armor as well. It is interesting to note that Aleotti's drawings already included the project for the decoration of the proscenium. In the longitudinal section, in fact, it is possible to observe that this frame is present on each face of the dado (drawn in a schematic way). In the 19th century drawings of Lebas, the frame is more detailed. Also in those attributed to the Bibiena brothers this frame is present, adorned with armors and triumphs.

- *Pilasters*. The most characteristic element of the proscenium decoration is painted on the six pilasters. There are represented grotesques supported by muscular male figures and crowned at the top by graceful female figures holding cornucopias in their hands. Each pilaster is also characterized by a meander motif, present also around the aediculae.

An accurate comparison of historical photographs showed that the position of the figures changes on every pilaster (passing from a frontal pose to a back one), while some grotesques are repetitive. Unfortunately, the photographs recovered do not document the proscenium in its entirety. However, it seems reasonable to think that the grotesques painted on the pilasters were painted in a symmetrical way (in relation to the longitudinal axis of the theatre). As far as concern the comparison with the fresco placed on the back wall of the hall, it is possible to note that also in this case the pilasters are surmounted by female figures. Similar decorations are present also in the drawings produced by Aleotti and Lebas. As argued by Monica Fornari in the essay dedicated to the original pictorial apparatus of the theatre, in this element it is possible

to recognize the hand of the authors of the decoration, identified in the team of Ferrara painters guided by Andrea Ghirardoni (Fornari, 1993). From a stylistic point of view, the grotesques painted in Parma are very similar to those painted by Girolamo Grassaleoni and Ippolito Casoli (well-known collaborator of Ghirardoni) on some pillars of the church of San Paolo in Ferrara.

- *Architrave*. Another decorative element repeatedly present in the proscenium is a festoon. This motif, conceived by Aleotti and faithfully documented by Lebas, is composed of an intertwining of branches, leaves and fruits. The festoon is present in the entire development of the lower part of the architrave, alternated with the Corinthian capitals.

- *Frieze*. Another element that characterizes the proscenium, of which still today some traces can be seen next to the Farnese coat of arms, is the frieze. Buttigli described this part of the proscenium mentioning a ballet of dancing putti (Buttigli, 1629). The idea of this decoration probably dates back after the study drawings made by Aleotti, characterized in that part by completely different motifs. As shown in the fresco painted on the opposite side of the hall, in addition to the putti, there were other mythological figures, such as satyrs, nereids and tritons (Fornari, 1993).

- *Moldings*. The historic photographs allowed to identify also some smaller decorations, mainly present in the moldings. In particular, there were recognized elements such as dentil, ionic kyma, astragal, etc. These elements find a clear correspondence in color in the fresco hidden behind the loggias.

The second phase focused on chromatic analysis of the elements. An accurate comparison of all sources was essential and the final aim of this operation was to identify colors as reliable as possible. From this point of view, the historical photographs are completely useless, as they are made in black and white. In addition, there are no original elements in a good condition of preservation, which could be useful for



Fig. 5 - Detail of the orthophoto of the fresco placed on the back wall of the hall (entablature).

Fig. 6 - Detail of the 3D textured model of the proscenium with a reconstruction of elements clearly documented in the photographs taken before the destruction (grotesques).



colorimetric analysis. The principal sources used for the definition of the colors of the elements are:

- Fresco painted on the back wall of the hall. It can be considered more reliable thanks to the good stability of pigments. The fresco is also more detailed than the previously mentioned 19th century model of the theatre.
- Frescos painted on the other walls of the hall.
- Elements that survived the 1944 destruction of the monument.
- Decorations painted in the church of San Paolo in Ferrara by the same artists.
- Book of Buttigli (he wrote about the principal colors of the decoration).

3.2 RECONSTRUCTION OF THE DECORATIVE ELEMENTS

Once the identification phase of the figurative elements of the decoration was completed, it was possible to proceed with the digital reconstruction of the elements in a raster format. Then, the produced images were textured on the 3D model.

For the elaboration of the decorations a commercial software, Adobe Photoshop CC 2017, was used. Four different workflows were adopted.

The first workflow was adopted for the reconstruction of elements clearly documented in the monochromatic photographs taken before the destruction (for example grotesques, figures represented on the pillars, armors). First of all, each photo was scanned. Then, it was possible to define the contour lines of the elements. Next, these portions of the photographs were straightened and scaled. Finally, it was possible to define their chromatic aspect. To this end, one or more color layers were overlapped to the black and white image. The choice of keeping the monochrome image level separate from the color one was fundamental to allow the possibility of modifying them in the future.

The second workflow was used for the reconstruction of elements present only on low quality photographs, not completely legible (for example festoons and some decorations of moldings). In this case, the elements were reconstructed starting from the orthophoto of the fresco placed on the back wall of the hall. As mentioned before,

this painted composition represents a mirror copy of the wooden proscenium, making the fresco an adequate reference for this operation. First of all, it was necessary to define the element and its contour line on the orthophoto. Then, the element was scaled according to where it was going to be placed. The last operations focused on the optimization and homogenization of the elements from the chromatic point of view. To this end, parameters related to the brightness and contrast of the images were modified. Also in this case it was decided not to apply these parameters directly to the image but to other layers separate from the original one, to make it always possible to modify them.

The third workflow regarded the reconstruction of the principal materials of the decoration (porphyry, gold and marble). The fresco placed on the back wall of the hall was used again to create those images. In this case, sufficiently large portions in which these materials were present in the orthophoto were identified and cut out. The three images

thus obtained were used to generate as many patterns (images that can be copied repeatedly to complete specific areas). The marble and gold tones chosen were also compared with the decorations present in the previously mentioned church of San Paolo in Ferrara. This comparison showed that the tones identified in the orthophoto of the fresco are very similar to those present in the church, making the operation carried out more reliable.

The last workflow was adopted for the reconstruction of repetitive geometric elements (for example pedestal decorations, cornices and meanders). Starting from the historical photos, appropriately scaled, the contour lines of the decorations were vectorized. Then, the elements were colored using the previously mentioned patterns.

It must be noted that the illustrated workflows do not allow to reproduce the totality of the decoration in an always reliable manner. Due to the lack of adequate photographs, some elements are impossible to reconstruct in their original form. These ele-

Fig. 7 - Detail of the 3D textured model of the proscenium with a reconstruction of repetitive geometric elements (pedestal).



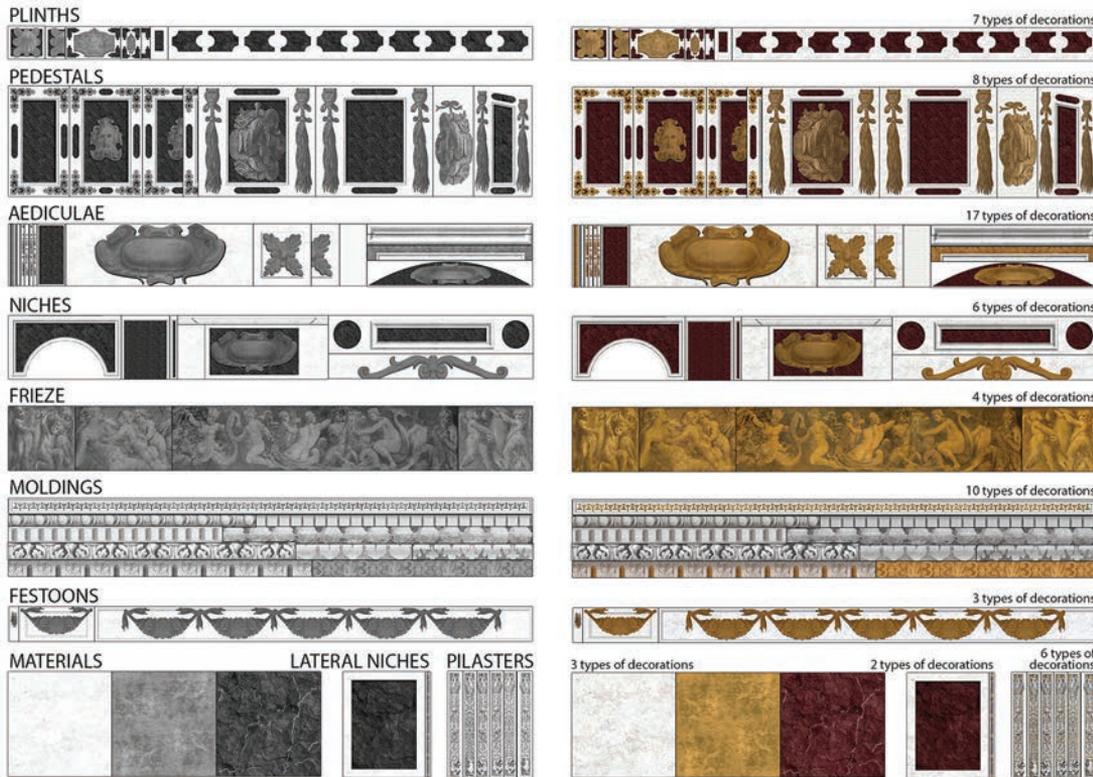
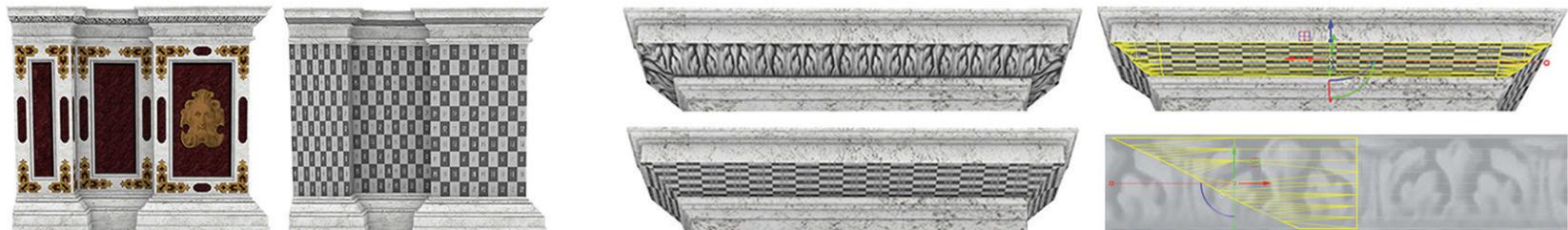


Fig. 8 - Types of decorative elements reconstructed for the specific parts of the proscenium (black and white and colored version).

Fig. 9 - Planar mapping of some faces of the pedestal (on the left) and custom mapping of a molding (on the right).



ments are related to the composition of the frieze, to the two pilasters placed in correspondence of the perimeter walls of the hall, to the masks painted on the pedestals and to the decorations of the plinth.

In order to avoid empty spaces in the final reconstruction of the decoration, it was chosen to operate through evocative integrations. As for the frieze, it was decided to reproduce the composition present on the fresco. Although not perfectly identical to the original composition, it reproduces the same colors and, above all, the same type of figures. The same reference was used for the masks. Although the photographs show different versions of the masks, the best solution seemed to be using and repeating the one painted in the fresco. For the two perimeter pilasters and for some of the figures present in the other four similar surfaces, it was decided to use the decorations already reconstructed for the corner pilasters (well documented in photographs). Finally, as far as the pictorial apparatus of the plinth is concerned, we do not have sufficient elements for its detailed reconstruction. For this reason, it was decided to vectorize only the contour lines, without specifying further formal elements of detail. Those areas were then colored using methods described above. Obviously, if more reliable documents emerge, it will always be possible to modify what was elaborated. In most cases, it was necessary to create *ad hoc* files for each face of the 3D model. This choice was motivated by the need to faithfully reproduce even the shading, painted by



Fig. 10 - Textured 3D model of the proscenium with the reconstruction of its original decoration.

artist in order to simulate three-dimensionality. It is sufficient to observe the pedestals. The painters simulated a central light source, placed in front of the proscenium, which generates many shades on the decorations. Therefore, each face of the pedestal is different, depending on its position with respect to the imaginary light source. In the entire process, particular attention was paid to the quality of the images produced. All images were generated in a .jpg format with a resolution of 300 dpi and an average weight of about 1 MB. A total of over two hundred images were made, consisting of approximately sixty types of different decorative elements.

3.3 TEXTURE MAPPING

Once the reconstruction of the images related to the decorative elements was completed, the last step necessary to define the hypothetical original state of the proscenium concerned mapping on the digital model. This operation was performed using the software adopted also in the modeling phase, Rhinoceros 6.0.

First of all, starting from the previously created images, more than 200 custom “materials” were created and placed in the Material Library. The patterns were used to implement materials such as porphyry, gold and marble. The other images were used to create additional materials defined for each face of the model. Then, it was possible to map them on the 3D model. For textures application, three different methods were adopted.

The first method involved all the flat surfaces of the model, for which *ad hoc* images were created (for example pedestals, pilasters, aediculae, friezes, etc.). Each image was applied to the surface of interest at a 1:1 scale, using planar mapping.

The second method involved all the complex surfaces (for example moldings) and was based on custom mapping. In this case, these surfaces were transformed into mesh surfaces to be projected onto a 2D plane (on which the textures to be projected on the model were placed). The position and scale of the meshes were then optimized according to the shape of the textures.

The third method involved the parts of the proscenium, which were painted in a fashion that simulated precious materials, such as porphyry, gold and marble. It involved all the surfaces of the model not subjected to the operations previously illustrated (both flat and three-dimensional). Depending on the area affected by the mapping, the scale parameters of the three materials most present in the theatre were modified. In particular, the “porphyry material” was mapped on the columns and the “gold material” on their bases and capitals. Finally, the “marble material” was applied to all other surfaces, completing the texturing of the digital model.

4. VIDEO MAPPING FOR THE VIRTUAL RECONSTRUCTION OF THE ORIGINAL DECORATIONS

The digital reconstruction of the proscenium decoration represents an extraordinary tool for the dissemination of knowledge about the monument. In addition to the traditional methods of communicating cultural content, today the most effective

solutions involve the use of multimedia technologies. In the specific field of virtual reconstructions, particular relevance has a form of augmented reality, commonly known as video mapping. This technique, non-invasive and completely reversible, can be useful for the visualization of decorations that no longer exist, making possible alternative use of a cultural asset. It is important to stress that to make this operation scientifically correct, an adequate philological study and an extremely multidisciplinary team are essential.

At present, visitors of the Farnese Theatre have few sources to fully understand what the decoration of the theatre may have looked like before its 1944 destruction. They can see its original aspect only in some items exposed under the bleachers: the 19th century model of the cavea (on which, only the main materials are reproduced), the 19th century painting by Contini (made anyway for purposes other than documentation), and some historical photographs (few photos in black and white). It is clear that these few elements are insufficient to allow the visitors to fully understand the extraordinariness of the original decorative apparatus of

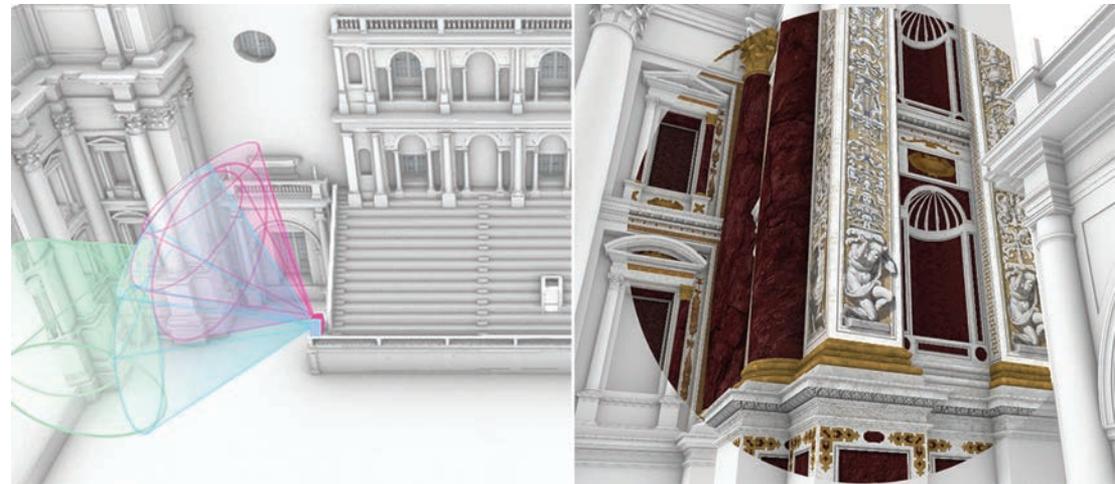


Fig. 11 - Digital reconstruction of the original proscenium decoration used for the projection of the pictorial apparatus on the wooden structure.

the monument. In this context, a video mapping performance allows to overcome the limitations imposed by the space reserved for the exhibition and to visualize the decoration directly on the wooden proscenium. This operation contributes to improve readability and understanding of this historical artifact and allows the communication of knowledge in an unconventional way. In addition, by bringing attention to the artifact, it contributes to its valorization.

On the basis of the accurate 3D model of the monument and of the digital reconstruction of the pictorial apparatus of the proscenium, it was possible to develop two projects aimed at the visualization of the original decorations on the wooden structure. The first project concerned a static performance and the second a dynamic one. Each solution required an accurate study of many aspects. In specific, the light conditions, the morphology, material and color of the surfaces involved in the projection, the number and type of devices, their placement inside the monument and the digital content were analyzed. Due to the ongoing pandemic situation, it was not yet possible to conduct the final on-site testing operations.

The methodology adopted required an interdisciplinary approach, considered essential when dealing with cultural heritage. Since it is structured from a scientific point of view, it may be adopted in other contexts with similar needs.

5. CONCLUSIONS AND FUTURE DEVELOPMENTS

The methodology adopted allowed to obtain the digital reconstruction of the original decoration of the proscenium that can be constantly expanded. It is characterized by strong communication advantages and is suitable both for historical-critical studies of the monument, the valorization of the artifact and for the dissemination of knowledge. From this standpoint, the textured model represents also a fundamental support for the project aimed at the visualization of the decorations on the wooden proscenium through the video mapping technique.

The methodology used in the phase of critical analysis and the digital reconstruction of the decoration can be easily adopted in other similar cases. As previously mentioned, when dealing with historical architecture, complete and exhaustive information is a rare occurrence. In the case of the Farnese Theatre, available sources were not sufficient for the reconstruction of the entire decoration of the monument (for example, the part of the loggias was not as well documented as the proscenium). On the other hand, the continuous comparison of any kind of documents is always fundamental to make the entire process scientifically correct. Since other useful sources could emerge at any time, it is essential to ensure an easy transformation and updating of all elements.

In relation to the future developments of this research, a deeper study of adequate solutions for the communication of the entire process is particularly interesting. At the moment, the textured 3D model of the proscenium is being experimented in the BIM environment. The main aim is to add all the qualitative and descriptive information about the reconstruction process to the 3D objects. This operation would make the entire process clearer and more transparent, in accordance with the indications of the London Charter. Finally, it would also allow to create a tool for easier management and consultation for the future users of the model.

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