

## The virtual restoration of the former ducal chapel of San Ludovico in Parma

### *Il restauro virtuale della ex-cappella ducale di San Ludovico a Parma*

This text deals with the issues related to the fruition of illusory spaces and to the dissemination of cultural heritage through the illustration of an experience conducted by professors of DICATeA of the University of Parma in the context of an exhibition dedicated to Maria Luigia of Hapsburg. In this context, a digital model of the former church of St. Ludovico in its original configuration was created to be loaded on special visors that visitors of the exhibition can wear in order to virtually immerse themselves in a reality today largely changed.

The goal of this work is to show how a scientific approach, resulting from a strong synergy between different disciplines, can lead to the implementation of important tools aimed at knowledge, enhancement and communication of cultural heritage.

*Il contributo affronta le tematiche inerenti alla fruizione di spazi illusori e alla divulgazione del patrimonio culturale attraverso l'illustrazione di un'esperienza condotta da docenti del DICATeA dell'Università di Parma nell'ambito di una mostra dedicata a Maria Luigia d'Asburgo. In tale contesto si è provveduto alla realizzazione di un modello digitale della ex-chiesa di San Ludovico nella sua conformazione originale da caricare su appositi visori che i visitatori della mostra possono indossare al fine di immergersi virtualmente in una realtà oggi venuta meno in gran parte.*

*L'obiettivo del lavoro è quello di mostrare come un approccio scientifico frutto di una forte sinergia fra discipline differenti possa portare alla realizzazione di validi strumenti volti alla conoscenza, valorizzazione e comunicazione del patrimonio culturale.*



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**key-words:** Virtual reality, Augmented reality, Architectural survey, History of architecture, Cultural heritage

**parole chiave:** realtà virtuale, Realtà aumentata, Rilievo dell'Architettura, Storia dell'Architettura, Patrimonio culturale

## 1. INTRODUCTION

Today, the new digital technologies allow easily to simulate existing or imaginary three-dimensional worlds and enable more and more people to access illusory spaces in a direct and immediate way. For this reason, the whole universe gravitating around the dissemination of cultural heritage for the purposes of its enhancement (and protection) has begun taking advantage of these new forms of communication to his own ends.

As one can easily imagine, it is a topic as wide as delicate, which cannot be reduced to the simple resolution of software and/or hardware problems. The combination of terms such as informatics and dissemination is inevitably leading to the proliferation of operators capable of realizing more and more attractive products, thanks to the technical expertise with which they are built. Many times, however, these products are made without the necessary knowledge ensuring that the product itself is scientifically correct. The risk is that the knowledge of cultural heritage and its transmission to a broader audience are transformed into activities of eminently profitable characters in which the spectacular aspects overrules the correctness and reliability of the contents.

Through the illustration of an experience concretely realized on the initiatives for the two hundredth anniversary of the arrival in Parma of Marie Louise of Hapsburg, the aim of this work is to remark how a scientific approach resulting from intense synergy between different disciplines (in this case drawing, survey, geomatics, history of architecture and art history) is essential to carry out valid tools aimed at developing knowledge, enhancement and communication of cultural heritage. Starting from the beginning of 2016 in Parma were inaugurated as many as 16 exhibitions dedicated to Marie Louise of Hapsburg, second wife of Napoleon and later Duchess of Parma, Piacenza and Guastalla. It is one of the most emblematic figures in the development of arts and culture in the city. One of these exhibition has been set up inside the Galleria San Ludovico, once the church that the duchess had chosen as her ducal chapel. In the exhibition, the organizers have decided to bring back, inside the building, all the

paintings that were made for the chapel at the behest of Maria Luigia. For the first time after more than a century it is therefore possible to appreciate these artworks no longer decontextualized and distributed in several museums (or deposits) and public offices, but restored to their original location [1].

However, since the building only partially coincides with the one sought by the Duchess, the organizers of the exhibition requested to the DICATEA of the University of Parma to realize a sort of “virtual restoration” through the implementation of a complete digital model of the palatine chapel in its original shape, to be loaded on special devices (augmented glasses) distributed to visitors of the exhibition.

## 2. METHOD NOTES

As mentioned, a scientific process that aims at the realization of the digital model of a historical monument

to a state different from today must go together with a thorough knowledge of its historical and architectural history, its morphology and its current or past shape. Therefore, the realization of the virtual model of the former church of San Ludovico represents a sum of different activities that can be summarized in the historical research carried out on archive documents, in the iconographic research conducted on existing representations of the building, in its geometric and architectural survey and finally in the modelling of some of its parts. All these operations contribute equally to the construction of the corpus of cognitive data essential to the realization of a virtual model characterized by the maximum philological validity.

Necessarily, the methodological approach was interdisciplinary and it was divided into three main phases: a first phase of data collection (knowledge) was followed by a second step of interpolation of the various information collected (interpretation) and by a third



Fig. 1. The facade of the former church of St. Ludovico in its current configuration.

phase of graphic representation of the hypothesized reconstruction constituted by the realization of the veritable geometric-digital model. It is worth noting that, in general, these phases are characterized by a certain degree of subjectivity. The first phase (survey/knowledge) and the last one (construction of the model/representation) are essentially intellectual activities, characterized by a high degree of objectivity, for which it can mainly present technical problems. The second phase instead, not surprisingly called interpretation, constitutes the heart of the project, but is the one that inevitably presents the greatest degree of subjectivity often due to incompleteness of the historical sources. In this case, in order to counterbalance the documentary deficiencies and the consequent problems of interpretation, it was fundamental the comparison between the various disciplines involved, the direct observation of contemporary works and the knowledge of the social and cultural historical context.

### 3. THE COLLECTION OF KNOWLEDGE DATA

Since the discussion of all the data obtained from the documentary analysis would require too much space to be addressed in these pages, only some brief indications essential to the contextualization of the monument object of study will be provided.

When in 1816 Marie Louise arrived in Parma, she decided to transform and re-open to worship the ancient church of the Benedictine monastery of St. Paul, who only a few years before (1810) had been affected by the Napoleonic suppression of the religious orders, and to name it St. Ludovico. The analysis of two reports compiled by Nicola Bettoli in 1816 allows deducing how the works necessary to transform the church into the palatine chapel consisted not in the architectural transformation of the ancient existing structure, but rather in the remake of its decoration and furniture. Throughout the first half of the nineteenth century, St. Ludovico was constantly enriched by the construction of new structures, the contribution of new paintings and the construction of the monument to Adam Albrecht, Count of Neipperg and second husband of the Duchess.



Fig. 2. Pietro Mazza Del., Isidore-Laurent Deroy Lit., Lit. Formentin & C. imp., "Interno della Cappella Ducale di San Ludovico di Parma. Anno 1842".

As many other historic buildings originally dedicated to the cult, even the former church of St. Ludovico was affected by events that changed several times its use and conformation. Especially since 1905, i.e. when the building was converted into electrical workshop, the monument was gradually transformed and deprived of its decorative apparatus. The current configuration of the building, therefore, it is no longer what it once was: the choir was closed and incorporated into other buildings, the monument to Adam Albrecht Count of Neipperg was moved to the Steccata church, the numerous paintings that enriched the choir and the side chapels were scattered at various museums and public buildings, or even stacked in deposits, the altars and balustrades have disappeared, as well as the ducal stand, the stand of the chamberlains, the valuable organ Serassi and almost all the fixed furniture (choir stalls, balustrades, gates, etc.). Only after the transfer of the electrical workshop, the Municipality of Parma (the building owner) was able to restore the main part of the former church of St. Ludovico to convert it into an exhibition gallery for temporary exhibitions.

Some specific documents were considered essential, in addition to several archive documents, to reconstruct the internal structure of the palatine chapel at the time of its greatest splendor: the micro-plants of the temple drawn in the historical cartography of Parma (starting from the famous Iconografia della città di Parma realized at the end of the sixteenth century by Smeraldo Smeraldi, up to the Borbonic cadastre of 1853) and three lithographs taken from the drawings of Pietro Mazza and Giuseppe Naudin of 1842. These provide important information on the conformation of the choir, on the altar geometry, on the stand of the chamberlains and on a wide range of furniture and decorations. However, none of the lithographies allow to infer the aspect that the Ducal stand located above the entrance to the church had, since they reproduce views facing the choir. Consequently, the information for the reconstruction of the ducal stand, and more generally for the knowledge of the material properties of the entire building and its decoration and iconography, come mainly from receipts accounting, various documents and inventories of the middle of XIX century.

In order to realize the digital model on the basis of pre-

cise metrics data, an accurate geometric survey of the building in its current state was also conducted. Data collection was carried out through the use of laser scanner technology, which allowed obtaining metrics information about ninety percent of the final model surface. Along the central nave, in correspondence of each side chapel and in the area of the presbytery, were placed four scanning station, topographically connected together. The final point cloud consisted of more than two hundred million points.

At the same time, it has also carried out a high-definition photogrammetric survey of the Neipperg monument in order to virtually relocate it to its original position, within the central side-chapel located on the north side of the former church nave.

#### 4. THE REALIZATION OF THE MODEL AND THE INTERPRETATION OF KNOWLEDGE DATA

At the end of the data collection phase, before proceeding to the realization of the digital model, it was decided to interpret all the information retrieved through the historical and iconographic researches and through the survey. This step was based on a comparison between survey data and historiography data, on the direct observation of the building in its current configuration and on the analysis of coeval artworks and architectures. This phase of data interpretation, which is the added value of the whole project and - if properly conducted – ensures the scientific nature of the work, necessarily entailed a strong critical synthe-



Fig. 3. Snapshot of the point clouds obtained by the laser scanner survey of the interior of the former church of Saint Ludovico, now used as an exhibition gallery for temporary exhibitions.

sis of the various investigations. The conclusions drawn at the end of this phase, while presenting various degrees of reliability depending on the quantity and quality of information collected, allowed to organize in advance the implementation of the model.

In a nutshell, the virtual reconstruction of the church of San Ludovico under Maria Luigia was made from the geometric survey. First of all, point clouds have been decimated and reduced through the elimination of all incongruous parts (pylons supporting light sources, various plants, fixtures and furniture, etc.). Only after the simplification of the point clouds it has been possible to proceed to their transformation in a polygon model, which has then been perfected by means of solid modelling of missing parts. In this way it has been possible to virtually reconstruct almost all the original architectural features of the church and in particular the volume of the choir, now incorporated in a separate building, with its four side windows.

After finishing this first phase of modelling, on the basis of all the information obtained after the archive documents analysis it has been possible to reconstruct all the elements indispensable to reproduce as closely as possible the internal aspect of the building in the nineteenth century. To this end the stands of chamberlains located in the two side-chapels placed near the main entrance, the ducal stand located above the portal and all the furniture listed in the documents and/or present in the lithographs, such as the high altar, the altars of the side-chapels, the curtains on the windows, different balustrades and railings, chandeliers were rebuilt.

Finally, even the point clouds generated on the basis of the photogrammetric survey of the tomb of Neipperg, currently kept at the Steccata church, have been decimated and then transformed into a polygonal model. This one was then placed in the correct position inside the wider digital model of the Palatine Chapel. Even the model of the monument was then completed through the reconstruction of different elements such as access steps, the gate that closed the chapel and the crowning of the tax of the apse with its marble facing and its inscription as can be seen in the view designed by Peter Mazza.

## 5. THE FRUITION OF THE DIGITAL MODEL

The exceptional strength of the exhibition held at the former church of St. Ludovico is the fact that it had returned into the building all the paintings that, until recently, were scattered in different places of the city. For the first time after the final suppression of the ancient place of worship it is therefore possible to admire these works, some of which are specially restored, in their original context. Just this simple fact in itself justifies the success enjoyed by the exhibition, which has convinced the organizers to delay its closure. Being the visitor able to enjoy artworks realized with a precise end in the place for which they were designed, and not out of context inside a museum or an art gallery, a greater value to the works themselves and a returned dignity to the building itself has been obtained. In this

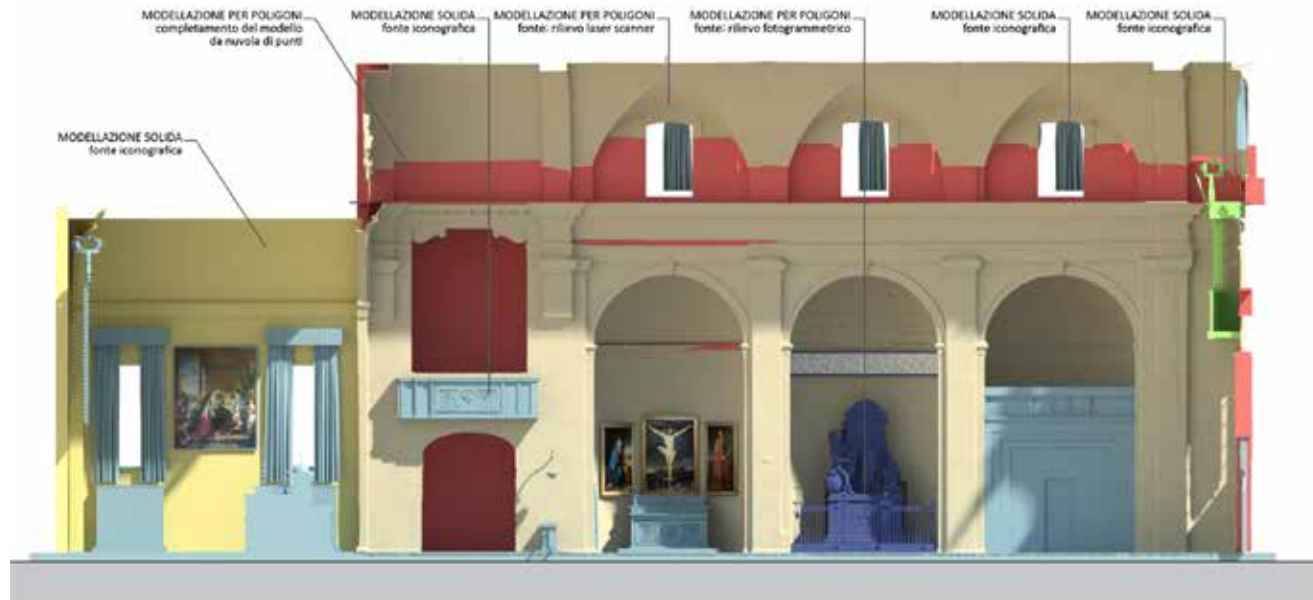
way, moreover, visitors can perceive atmosphere lost for over a century. Even if only for a short time, the building is back to be a place of worship. Perhaps for these reasons, many visitors have expressed the hope that the exhibition from temporary becomes permanent.

It is a commonplace to say that the church of St. Ludovico of Maria Luigia will exist anymore. Even if it was possible to restore the original appearance of the building and convert it back to the cult, the historical, social and cultural context is too changed because an operation of that kind can easily find sustainable justifications. Also, the exact restoration of the palatine chapel would be particularly onerous: in fact, the choir can be rebuilt only sacrificing two floors of municipal offices made in the middle of the last century in its original volume, the stands of the Chamberlains and



Fig. 4. The digital model of the tomb of Neipperg.

Fig. 5. Schematization of operations carried out for the realization of the digital model.



the ducal stand have been disrupted and dispersed, as well as all the altars and the railings that enriched the church in the mid-nineteenth century, together with much of the rich and numerous furnitures remembered by inventories. Only the paintings and the monument to Neipperg remain. For the latter it is difficult to think of a possible relocation, since it is preserved in the Steccata church for over a century.

For all these reasons this project was born in the first instance by the desire to produce a digital model in order to provide the visitors of the exhibition with the opportunity to live an experience of the building more immersive and able to simulate the original structure of the church. On the other hand, in the spirit of disclosure and use of innovative content of the project, the

implementation of the digital model is certainly not the main or final phase of the work. In fact, in recent years there has been a progressive diffusion of platforms and software libraries that allow, with minimum effort in terms of software coding, to develop virtual/increased reality applications extremely immersive and engaging also for a general public of non-specialists. If the digital content (represented in this case by the three-dimensional model) is designed properly, these applications do not even require a particularly high performance hardware equipment for the user.

In the specific case, the digital models were used as a support for the development of two different applications that can provide to the users of the exhibition an experience of virtual reality and an experience of

augmented reality.

Virtual reality applied to cultural heritage today is more and more concretised through the development of smartphone or tablet applications (especially in Android and iOS environment) which allows anyone with a compatible device to experiment with his own device the perception of virtual spaces. In particular, by the insertion of the device in a stereoscopic viewer, the visitor can try the experience to immerse themselves in a completely virtual environment. Today, these viewers are also available in extremely economical versions (in this regard just think of Google Cardboard viewers, the cost of which in many cases is no more than 5 €). The research team has so far developed a prototype application for smartphones (in Android environment)

which allows an immersive visit inside the three-dimensional reconstruction of the St. Ludovico church with low-cost viewers and a support of augmented reality. The prototype does not represent a product which is still sufficiently mature to be enjoyed by the public, but allows the researchers to experiment new forms of language and communication and to deepen, with greater awareness, the technical aspects related to architectural survey and its digital reconstruction. The app was developed in UNITY environment, integrating the control logic with scripts in C# language. The environment is extremely functional and easy to use for those who have (at least) little familiarity with object oriented programming (at least as long as the project does not involve extremely high levels of customization and excessively complex functional characteristics). Since the development environment has spread mainly with the aim of providing a graphical and physics simulation engine voted to entertainment, it can now boast a platform of users and developers extremely large and varied. This makes easy to find, often with freeware or open-source licenses, code libraries ready to use that in many cases almost perfectly respond to the needs of the project. However, despite the graphics engine is extremely powerful and optimized for its use in application for tablets and smartphones, the amount of data manageable by today's device, despite the exponential progress in this direction in recent years, requires a careful optimization of the geometry of the three-dimensional model. This implies the need of planning carefully all the three-dimensional reconstruction operations, since it must inevitably accept a level of approximation, in certain cases even very high, of architectural details. The modern graphics engines allow in part to overcome this limit by providing differentiated levels of detail. These graphic engines in fact loads into memory and processes different versions of the various three-dimensional elements that compose the scene, according to the distance of the virtual observer from the element itself. A further reduction in the level of detail of the digital model can also be obtained by a careful phase of texturing and light mapping of the model: in most cases, in fact, the observer can perceive different depth levels of the most minute elements of a scene only through color



Fig. 6. Photographic image of the exhibition (photo Carlo Gardini, 2016).

and shading information of the surface. As anticipated, the developed app currently includes two different operating modes: with the help of a stereoscopic viewer, the first section of the application allows an immersive visit in virtual reality within the reconstructed space of the church. By means of a controller connected to the smartphone, the user

can freely roam in the virtual space by controlling the various degrees of freedom of the virtual observer: in other words the observer can move sideways, forward or backward and, by enabling a specific function, also hovering upward (for example, to observe more closely a particular of the decorations of the vaults). By rotating the head, the accelerometers integrated into



Fig. 7. View of the digital model that has been loaded in the app, and that visitors can see through special viewers.

the smartphone interact with the rendering engine of the two stereoscopic views correctly orienting the perspective. Taking advantage of the multi-user gaming libraries supplied by UNITY, the app also provides the ability to perform virtual tour with multiple users in the same virtual space at the same time and interacting with each other. All this allows the user of the App a more social approach through the contents. This is imperative to attract large audiences.

Instead, a different application functionality allows the user to superimpose via augmented reality (using the Vuforia libraries, always in UNITY environment) the three-dimensional model, correctly placed in its original location, to the image seen through the camera of the device. In this way, the App makes it easier to read the transformations that have occurred within the real space of the former chapel subsequently to the displacement of the artworks (in particular of the monument to Neipperg). From the early stages of the project, this feature was designed to be integrated into the exhibition itinerary. This caused some additional difficulties since the three-dimensional model of the monument interacts, in the scene shot from the device, with the elements of the exhibition. In particular, within the area of the former chapel where it was originally placed the statue, there are some exhibitors, a showcase of considerable size and, in the entrance area, a long stele that provides several information to visitors. To make the perception of the monument the most realistic it was therefore experimented the insertion, as additional augmented content, of the entire model of the chapel, so that it overlaps the “noise” elements, hiding them completely. This, however, involves further difficulties: for example, in the edge zone of the model, often as a function of the brightness of the scene (and of the various characteristics of the device cameras) and of the observer’s point of view, the inclusion of the augmented elements in the real scene is perceived not properly integrated.

In the specific context of the exhibition the DICATeA of the University of Parma has collaborated with a private company[2], who made available to the public, during the opening period of the exhibition, a high number of last generation viewers with better characteristics than the cheapest models. Thanks to the collabora-



tion between the different disciplines involved in the department it has been possible to provide the private company not only the digital model of the building, but also all the additional historical information necessary to ensure that the multimedia application was scientifically correct. Once the work is finished, through an audio-viewer the visitor of the exhibition may attend the projection of a sort of documentary characterized by the presence of multiple multimedia content all characterized by cultural reliability: for example historical maps indicating the places frequented by Maria Luigia, historical information on the church and the artworks exposed in it, movies where actors in costume move within the digital model. During a break in the movie/guide the same virtual model also allows visitors to move freely inside the building and to be able to directly compare the differences between the current configuration of the former church and the same in its period of greatest splendour.

## 6. CONCLUSIONS

The experience of simulation of three-dimensional spaces that no longer exist or never realized it configure as an original form of participatory and truly immersive communication, able to achieve success and to easily be repeated without excessive costs in multiple experiences related to the dissemination of cultural heritage.

On the other hand, if it is true that the main objective of these experiences must always be to raise public awareness of the historical, artistic and architectural heritage making it more accessible and attractive, the experimentation in act has also allowed to develop some considerations, which resulted in an integrated survey methodology, able to develop an eminently scientific approach to the theme. Since the communication of spatiality, holy grail of survey and representation of architecture, can no longer disregard the new opportunities offered by technology, it is of the utmost importance, especially in this transitional phase, to deal critically any case in relation to the different methods of communication.



Fig. 8. Another view of the digital model in which visitors can see the choir which no longer exists and all the rich decoration and furnishing now dispersed.

**NOTES**

[1] The exhibition, entitled In the temple of the Duchess between real and virtual. Maria Luigia, St. Ludovico and Parma artists, has been promoted by the Assessorato alla Cultura del Comune di Parma and the Pinacoteca Stuard. Scientific curatorship: Alessandro Malinverni; designer of the exhibition: Alberto Nodolini.

[2] The company involved in the project is ARtGlass s.r.l. based in Monza.

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