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Digital museums of the imagined architecture: an integrated approach to the definition of cultural heritage's knowledge paths

Musei digitali dell'architettura immaginata: un approccio integrato per la definizione di percorsi di conoscenza del patrimonio culturale

The aim of this work is to highlight a multidisciplinary approach to define new ways of knowledge of architectures and urban contexts that were drawn but never built. In particular, the focus is on a set of 18th century representations, created in the field of scenic illusion. The work was firstly carried out in order to define the structure of a Digital Museum Ontology, a complex semantic resource able to store documents of various typologies. Then, it was elaborated a digital museum project, which starting from existing images will introduce to an interactive way of experiencing the heritage in question. This experimentation has the intent of finding a best practice for the creation of virtual exhibitions.

Il presente lavoro intende mettere in luce un approccio multidisciplinare nella definizione di inedite modalità di fruizione di architetture e contesti urbani prefigurati attraverso il disegno e mai realizzati. L'attenzione è stata rivolta ad un insieme di rappresentazioni prodotte nel XVIII secolo per il mondo dell'illusione scenica. Si è lavorato alla definizione della struttura di una Digital Museum Ontology quale risorsa semantica complessa in grado di accogliere una variegata tipologia di documenti. A valle di tale lavoro si colloca la elaborazione progettuale di un museo digitale che parte dalle immagini esistenti per introdurre ad una fruizione multimediale e multimodale del patrimonio indagato. La sperimentazione proposta ha l'intento di identificare una best practice nella realizzazione di virtual exhibitions.

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1. INTRODUCTION

This work intends to highlight a new type of approach to the creation of digital museum tours, based on the interaction of different disciplinary areas. In particular, this study aims to define new ways of knowledge of architectures and urban contexts that were drawn but never built. This work focused principally on architectural and urban representations, built on geometric and analytic bases, that were created in the 18th century, for the world of scenic illusion, by the Galli-Bibiena a true dynasty of set-designers and architects. The purpose was to define new forms of communication through which experts could make people of different ages and backgrounds understand and aware of the history of architecture and that of urban contexts. The research has an experimental nature, and from a methodological point of view, it contemplates the organic integration of different competences in different steps chronologically overlapped: from data collection to historical and archival research, from digitalization to solid modeling, from the creation of ontology resources to exhibition design. Following this methodology it was possible to elaborate a project of a digital museum which, starting from existing images, introduces to an interactive way of experiencing the heritage in question.

2. ONTOLOGY-BASED MODELS FOR THE MANAGEMENT OF CULTURAL HERITAGE RESOURCES: THE DIGITAL MUSEUM ONTOLOG

The exploitation of ICT technologies is a common practice in the management of cultural heritage resources (Biagetti, 2016).
The digitalization of document aims both to preserve the original documents and make them available and accessible to a wide number of users. Such action is in line with the digitalization and conservation policies of historical archives, adopted both in Europe and internationally (European Commission). The definition of an ontology-based model, populated by using digitalized documents, provides a valuable knowledge resource. Indeed the researchers are able to manage the ontological model in a collaborative way. Furthermore, the integration of multiple archives and the relative composition of a complex semantic resource is able to highlight connections between the various documents and even in different fields located in different archives (national and international), this is definitely an added value of this approach.
Many examples of ontologies for the cultural heritage deal with the historical and artistic aspects (Hernández, 2008, September), while some ontological projects aim to also represent other aspects of the cultural heritage such as complex spatial data (Noardo, 2016).
The creation of these resources is still an isolated process with respect to the design and staging of the archaeological site museum. Usually the ontological resources are created in addition to the project provided by the experts of museum/archaeological exhibitions.
In this paper we propose an integrated approach to the definition of a digital museum, this approach aims to improve the management of the complex nature of the cultural heritage domain, by proposing a general method to define, populate and manage the digital museum model.
Recently many studies show that the definition of a model based on ontologies, which can be shared and integrated with existing ontologies related to cultural heritage, is the most appropriate approach to represent knowledge and facilitate the preservation and enhancement of the information with respect to traditional database (Hyvönen, 2012). Although much has been done in relation to the digitization of documentary sources, there are still few ontological resources to fully exploit the potential of the semantic representation of this kind of information.
Considering that modern technologies allow to digitize not only documents, but also images, sounds, 3D reproductions of buildings and so on, such an approach can be applied to the creation of digital museums that can be located in a single place, widespread in the territory or virtual, as in the case-study examined in this paper. The digital Museums are able to provide a 360° experience that can provide users with a series of complex information through the use of technologically advanced instruments.
For this purpose we present the Digital Museum Ontology (DMO). To developing this ontology first have been analyzed existing ontologies related to cultural heritage, second have been analyzed scanned documents, and finally, with the help of the domain experts (art-history expert, digital representation expert ,museum-exhibit expert), have been defined the main concepts of the DMO.
The defined concepts are divided into three main areas: the historical-artistic area, the area of digital representation and finally the area relating to the design of the digital museum. The first area consists of concepts such as work Name, Author, Historic Period, Artistic Movement, Artwork Description and Location (both original and current if it exists).
Regarding digital representation it is inserted as an instance in the concept Representation (the digital representations are contained in files that can be directly stored in the ontology).
The concepts related to the design of the museum represent the innovation of the DMO, in fact, these concepts have been defined with the aim of creating museum itineraries divided into subject areas. This areas have different topics as the type of the exhibition or its site (for example the creation of disseminated museums in a particular geographic area) or also monothematic itineraries that concern only the architecture, the theater, the painting, etc.
In DMO the constituent elements of the museum are described to allow you to store not only the characteristics of the artwork itself, but the nature of museum design, so that it can also be applied to instances added later (fig. 1). To achieve this purpose some properties (object property) have been introduced, these properties link the concepts related to historical-artistic area with those of the digital representation area and those that are part of the digital-museum areas.
In particular the property is_part_of has as domain the concepts Opera (historical-artistic area) and Representation (area of digital representation) and as range the concept Path (area of digital museum design). This property allows describe the thematic paths provided within the digital museum.
Another fundamental concept of DMO ontology is Typology which allows you to describe the type of artwork (painting, sculpture, architecture, scenic design, music, literature, poetry).

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Through the use of this concept as range of the type property that has as its domain the concepts: Opera, Representation and Path, is possible to create thematic itineraries (setting path, sculpture path, architecture path etc.).
The DMO ontology aims to describe both the cultural heritage in all its aspects, their digital renderings and the museum installations of which these works are part.

3. HISTORICAL AND CRITICAL RECONSTRUCTION, ARCHIVES SOURCES, ICONOGRAPHIC REPERTOIRES

The experimental case study to define a digital museum path, based on the DMO ontology already illustrated, is represented by the conspicuous set of drawings of the Galli da Bibiena, a true dynasty of set-designers and architects that was active between the 17th and 18th century all across Europe. The idea at the basis of this project was to reconstruct, starting from the drawings, urban spaces composed of imaginary architecture, characterizing it in its virtual (or virtually possible) materiality, and making it available for exploration.
The first stage of the research focused on the analysis of the available resources from a historic and critical point of view, to then create an iconographic collection to work on.
In consideration of the great and various production of the Bibiena, this research focused mainly on the corpus of drawings, which regards the architectural aspect of stage design, from the collection in the New York Metropolitan Museum of Art. These drawings, which in the majority of the cases do not display any date or signature of the artist, nor attributions to the opera they were created for, have a series of problematics, the main of which is the impossibility of observing and framing them in their original context; for this reason, the problem of the attribution was intentionally omitted. In the specific case of the Bibiena's drawings, artistic historiography has committed for a long time to the biographic and stylistic identification of the family members. However, despite the evident validity of that direction of research, one can only agree with the divergent indications of the Swedish academic Pjet Bjurström (Perrelli, 2013), who considers the attribution issue as overrated, since "… the quest for the individual hand is just what remains of the Romantic attitude towards the artist, which was not felt by the Galli da Bibiena and the people of that time" (Muraro and Povoledo 2008, p. XVI); all of this without taking into consideration the fact that the great amount of commissions the family used to receive, forced them to be surrounded by a large group of collaborators, whose great specialization makes it hard, if not impossible, and at this point maybe even inconsequential, to identify the hand of the artist.
The collection in New York includes 116 drawings, all attributed to the family or their 'team' — in rare cases some of them are signed with the word Bibiena —, mainly coming from private American collections, and shows an iconographic set of projects that ranges from royal palaces (interiors and exteriors, regal rooms, libraries, corridors, courtyards, gardens) to theaters, churches and chapels, altars, tombs and catafalques and set drawings.
These last ones are nineteen scenarios, created in a time frame that spans form the end of the 17th century to the end of the 18th century, that were selected as the object of this study, particularly focusing the attention on the nine projects attributed to Giuseppe and his team, which are important since they show some representational subjects — interior and exterior spaces, corridors — typical of the scenic invention, but that also have important implications on the architecture of that time.
The marvelous creations of the Bibiena inevitably influence the architectonic practices of their time, rapidly changing the creative vision of different architects of that century and anticipating those architectonic shapes that characterized the passage from baroque tradition to neoclassicism.
However, this is not a unilateral exchange since the Bibienas' architectonic style often derives from real architecture, even though it presents creative, and often redundant elements. We cannot deny the fact that imaginary and real architecture influence each other through the exchange of ideas and impressions, so that the drawing on paper feeds the creative impulse while the real construction feeds imagination.

Fig. 1. Digital Museum Ontology.

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Giuseppe, third son of Ferdinando, is the most important exponent of the second generation of the Bibiena family. He reveals himself to be an excellent designer, who inherited the best graphical characteristic of his father and his uncle, Francesco: he has the attention for the clearness of spatial structures of his father and the ability to create majestic architectures of his uncle. In addition to these, there are his particularly clear lines and sfumato, which sometimes appear cold-hearted, but that actually make his drawings closer to the concreteness of the project of the built architecture.
In the nine drawings of the examined collection that are attributed to Giuseppe, he designed different settings: some of them, like the stage set designs of the figures 2, 3 and 4, represent exterior spaces that are only seen from a central point of view, in which the element of the central plan pavilion (or villa), the dome, the symmetrical balustrades, the colonnade corridors with coupled, smooth or solomonic columns, are repeated.
Some others, such as in figures 5 and 6, represent interior spaces and passageways, with the 'angled perspective' typical of his father.
It is interesting to observe how captions, especially in the titles of drawings and incisions, present a specific terminology that tend to result codified, revealing the close relationship between the theatrical architect's creative activity and the data that they collect from literary and cultural traditions they are inspired by for their stage designs. It can then be highlighted the fact that terms such as 'magnificent' and 'monumental' are applied and repeated constantly in cases of scenes that allude to the epiphany of sovereignty (Cusatelli G., 2002).

4. INFOGRAPHIC REPRESENTATION AND VIRTUAL MODELLING

With the aim to define a digital museum path, the particular geometrical structure of the examined drawings permitted us to investigate using the critical instruments of the representation, elaborating virtual models of the architecture and urban spaces drawn by the Bibienas.
In other words, it is possible to highlight in a more complete way the set of architectural shapes and urban spaces that have often been thought through, of which it would be hard to have a clear idea with any other interpretative analysis (Chiarenza 2016). Investigating with operations of reverse perspective, possible thanks to a strict methodical setting, we can see in their wholeness the spatial and metrical qualities of

Fig. 2. Giuseppe Galli Bibiena (1695-1757). Design for Stage Set: Centralized Villa with Cupola and Colonnaded Wings. Metropolitan Museum of Art (NY).
Fig. 3: Giuseppe Galli Bibiena (1695-1757). Designs for Components of Stage Sets. Metropolitan Museum of Art (NY).
Fig. 4. Giuseppe Galli Bibiena (1695-1757). Design for a Stage Set: The Gallery of a Magnificent Palace Decorated with Mirrors. Metropolitan Museum of Art (NY).

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those acrobatic buildings, enclosed in the fixity of an image. This research is even more significant if we consider that the architectures we have in the representations are pure fantasy, but at the same time the result of the architect-artist's inventiveness

In this paper, as an example of the method used, the work on a Design for a Stage Set with a Monumental Arcaded Courtyard is shown. It is attributed to Giuseppe Galli Bibiena and preserved in the Metropolitan Museum in New York.

The drawing shows a wide covered path, probably just a passage, arranged in an angled perspective that allows a glance, through wide arches, to an open air patio, placed on a slightly taller elevation, beyond which there are, repeatedly according to a strict modular scheme, the architectural elements of the type in which the represented architecture is articulated.

The architectural space is closed on top by a coffered ceiling divided in wide frameworks whose order is regulated by the columns' distance. The decorative interpretation is very variegated but at the same time moderate. So the large octagonal coffers are embellished with geometrical figures, the same as for the intrados of the arches; the mural hatches are adorned with raised pattern medallions and the arches' keys enriched with projecting shields surmounted by moving patterns. The moldings, from the classical orders, are varied in the pedestals by unusual curved profiles. The first floor route crosses a bigger space that runs orthogonally, and exceptional solutions at the intersection of these spaces are adopted, to give the scene the character of elegant magnificence, such as the doubling of the thickness of the arches, or the insertion, in the angles, of niches with statues and busts.

When trying to apply a reverse perspective procedure to the image studied it is important to analyse the composition with greater attention compared to its geometrical structure. It is easy, first of all, to see that the perspective structure of the image is vertical. All the vertical edges drawn, in fact, are parallel mutually and with the picture plane. The setting of the drawing, furthermore, follows the basic setting of the angle scene, presenting an X-shaped architectural plan, for which the right angle is 45° compared to the picture plane. In this way, the vanishing points of each of the principal straight lines, mutually orthogonal, will be placed on the 90° circle of view at the intersection with the horizon.

This circumstance eases the determination of the internal orientation of the reference in the picture plan (view center, horizon and observer distance) and easily allows us to trace it; in fact, extending the straight lines of the two bundles – which in reality would be mutually orthogonal – we find two 45° vanishing points, that will be crossed by the horizon, and will turn out to be orthogonal to the vertical lines. The same two vanishing points are the external points of the diameter of the 90° circle of view, with center in their middle point (view center). The ground line has been considered to be the horizontal line at the base of the drawing, as it was the praxis used for the reverse perspective procedure applied to scenic sketches (fig. 7).

So we proceeded to a reverse perspective representation, paying particular attention to the proportional articulation of the architectural order. Apart from the pedestal, which represents an exceptional element that cannot be referred to the traditional rule, only minimum changes have appeared, which can be considered negligible compared to the correct proportion (fig.8). To determine the latter, we've derived height and base of the column and, following the rule in the theoretical essay by Ferdinando Galli Bibiena (Galli Bibiena, 1711), we moved on to the proportioning of the different parts of the order. Unimportant inaccuracies due to the painting instrument have been left out, or approximated following the correct proportions. More freedom has been exercised in the representation of the decorations, for which the ink traces of the drawing have sketches of ideas which are voluntarily undefined and adapted, with less precision, to the strictly calculated basic perspective pattern. All of the elements have been redesigned on the basis of a critical investigation based on similar documentary sources, and a critical reading of the treatises of the Bibiena themselves.

To offer an image that could have concreteness, it seemed appropriate to reproportion some elements, especially the ornamental ones in order to regulate the clear inaccuracies. This redefinition allowed us to represent with geometrical strictness each and every

Fig. 5. Giuseppe Galli Bibiena (1695-1757). Designs for Stage Set: Three Pavillions in Background with "Oriental" (Ogival) Cupolas. Metropolitan Museum of Art (NY).

Fig. 6. Giuseppe Galli Bibiena (1695-1757). Design for a Stage Set with a Monumental Arcaded Courtyard. Metropolitan Museum of Art (NY).

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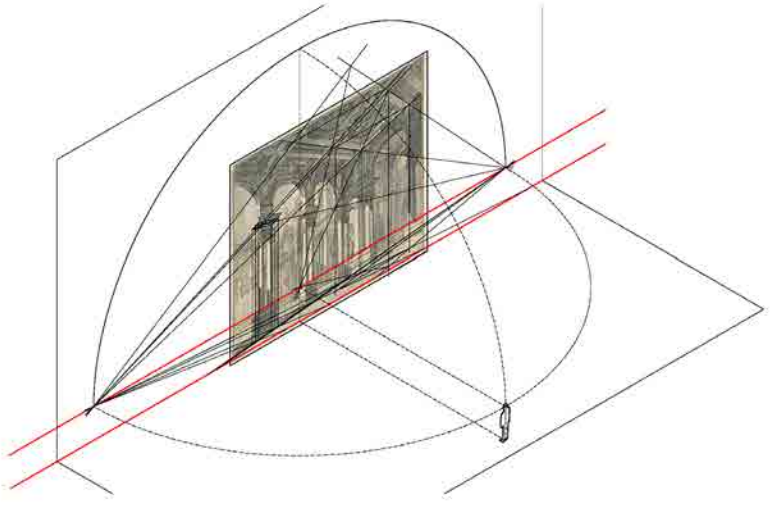

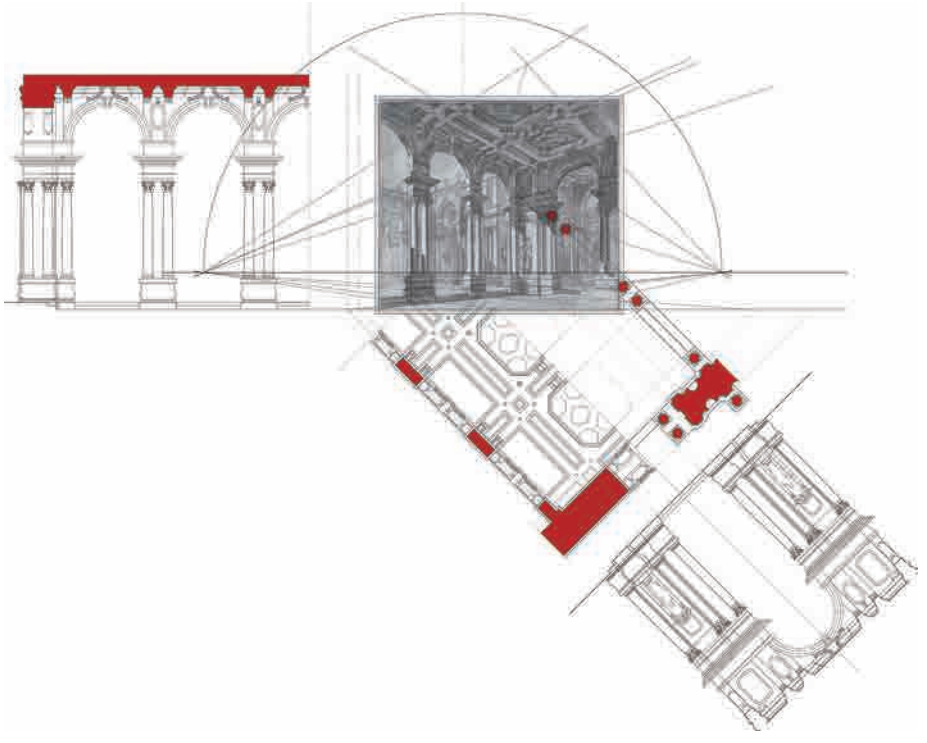

Fig. 7. Axonometric scheme of the perspective reference.
Fig. 8. Reverse perspective: the plan and one of the internal elevations from the Giuseppe Galli Bibiena drawing 'Design for a Stage Set with a Monumental Arcaded Courtyard' (elaborated by Stefano Chiarenza).

part of the imaginary apparatus, and to achieve a defined space through architectural drawings in orthogonal projection (figures 9 and 10), starting from which a solid infographic model could be built (fig.11). This kind of 3D modeling, obviously, catches the visible part of the space, extending it only to the portions that can be hypothesized in relation to the modular nature of the structure. Through the solid model it was possible to move the point of view through an architecture that was somehow real, or at least explorable in its spatial architectural values.

5. THE EXHIBITION DESIGN AND THE DIGITAL PRESENTATION

Until the first decades of the last century museum architectures have influenced the exhibitions, especially their spatial organization, but nowadays the exhibition design has reached total compositional freedom, supported by the latest technological know-how, crossing physical limits towards virtuality (Accardi, 2011).
Contemporary museums are to be included among the most effective means of communication and dis-

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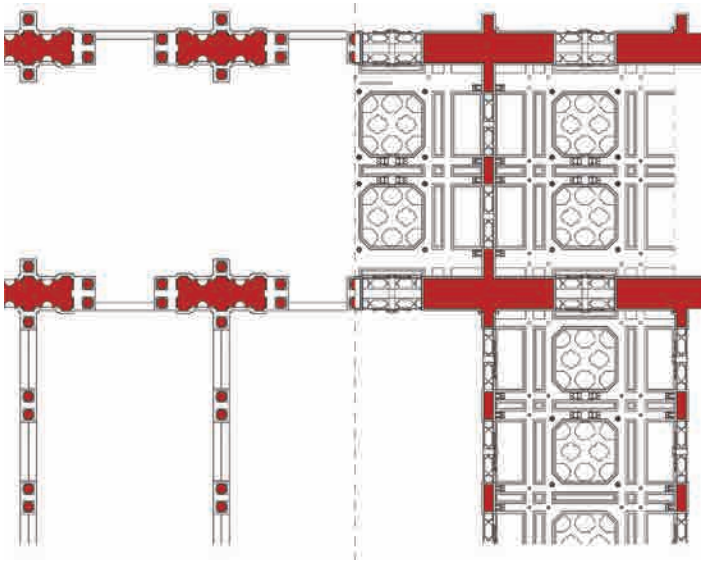

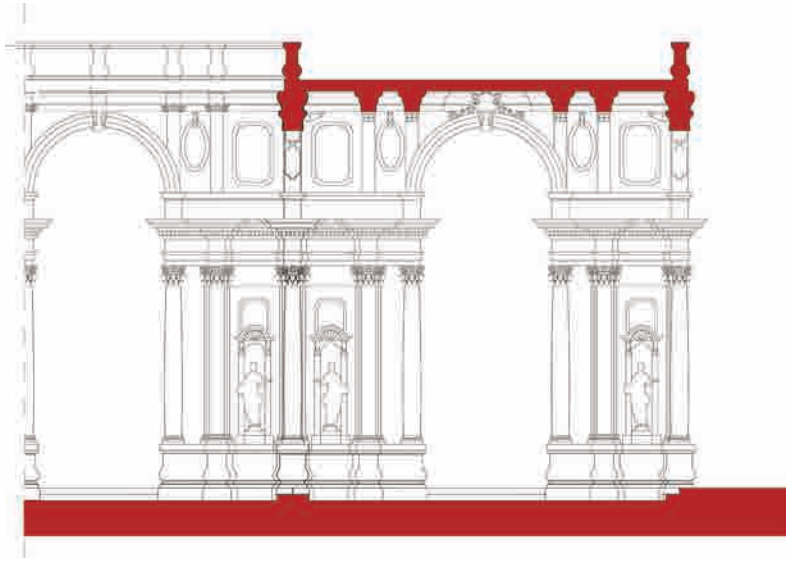

Fig. 9. Detail of the plan.
Fig. 10. Detail of an elevation.

closure, alongside other mass media, since they attract people and establish a deep relationship with them, not only based on the semiophore power of objects (Pomian, 1997), but also on specific strategies of interpretation supported by a graphic, oral, written, iconic and gestural language which today is fully integrated with the use of ICTs.
Although virtuality represents an important way of enriching the visit, it has to be considered that the public still demands to see the objects in person, experiencing them actively, interactively and creatively (Mazzanti, 2016).
In this multidisciplinary research, and in parallel with the configuration of the DMO, large space was given to the musealisation process of described artworks, because they cannot be experienced by the public in a concrete and direct way since they are scenic representations. Knowing that the mere observation of these drawings cannot evoke the scenic and emotional effect that they created on the stage (Riccòmini, 2000), it was decided to design the traditional exhibitions integrated with the use of virtual modeling, so that they could reproduce the awesomeness of the Bibiena's creations and document their structural peculiarities, their transformations and innovations, and highlight the illusoriness of spaces (Bentini, 2000).
The support provided by virtual technologies is necessary for giving back to contemporaneity those results of a fervid creativity, that were left in the 'drawing status' (project), and for these reasons it requires a reconstruction of the context of the original use and provenance.
It is not only about reverse perspective and redraw, but it is a cultural mediation to increase the value of the artwork and its comprehension, making it more appealing for the public who, thanks to virtual technologies, can decide to experience them in a simulated environment or directly in a museum.
Among other things, knowing that the 'hands-on' practices continue to be one of the most effective strategies of cultural learning, we can presume how the 3D modeling of a non-existing or never built architecture, besides completing the perceptual, sensorial and immersive aspects of the visit, could open to the possibility of creating tactile supports of communication (scale models of various re-configurations) fundamental to make the experience accessible to a wider audience, including people with disabilities (especially those with a visual impairment), since they risk being excluded from the usual communication strategies adopted by museums and Web platforms (figures 12 and 13).
The duality of technological innovation and museographical tradition is fundamental, since relegating the objects in depots and replacing them virtually or with

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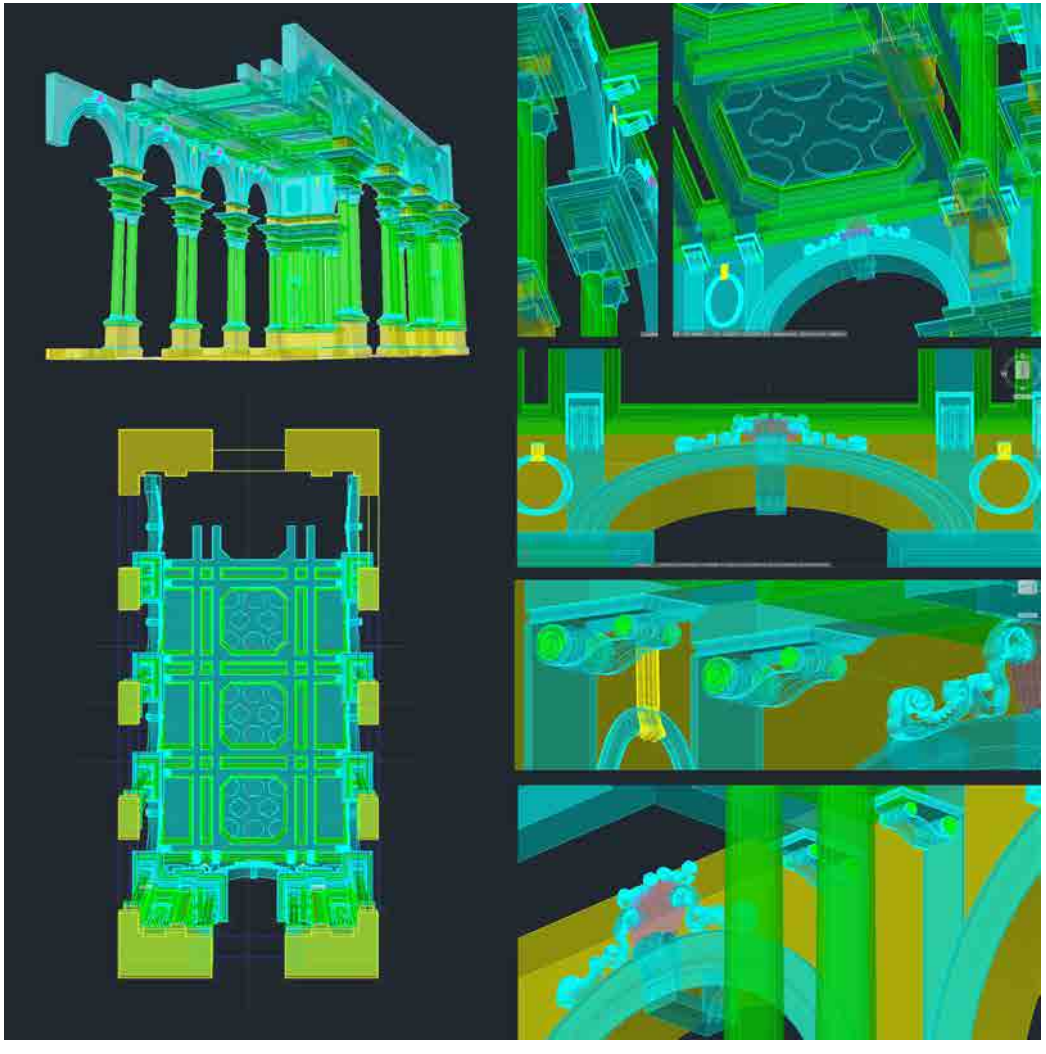

Fig. 11. Views from the infographic model of the 'Design for a Stage Set with a Monumental Arcaded Courtyard' (elaborated by Stefano Chiarenza).

interactive instruments and displays is not enough. Even though the most popular trend in the modern exhibitions is to provide the public a full immersion experience, the bombardment of images and videos, as a result of virtual or augmented reality, can lower the level of attention due to an apparent overload of information, which may reduce the public's curiosity, or worse, it may suppress their will of repeating the experience.

Considering the typology of the artworks taken into consideration, we structured a potential visit experience: a Virtual Exhibition. An innovative project was conceived, whose aim is to develop a best integrative practice in order to achieve the integration between the materiality of the 'exposed things' and the evanescence of the reconstructions and evocations (figures 14 and 15). Those digital technologies applicable to this specific case must allow the user to learn more about the work in an independent way, and to create connections between this and other similar realities and objects, including those situated in other areas. The so-called New Media contribute to examine the nature and the meaning of the objects, they add what is missing, they clarify the evolutions and rebuild the surrounding context, letting the public actively play a role in the exhibition with the help of specific interaction instruments (videos, digital video-guides, interactive stations and displays, immersive theaters and holograms) able to strengthen the memorization of the information and the acquisition of the meanings of objects (Carman, 2002).

This experience wants to define the best practice to be applied for similar archives of documents that are not easy to gather together physically in a single collection. Therefore the tour must be composed of two experimental fields that are apparently opposite, but that are actually strictly interconnected:

1) a social inclusive platform, accessible from PCs, tablets and smartphones, which allows the user to visit and explore a digital exhibition, with drawings, paintings, scale models, etc., stimulating a 'cultural heritage

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learning' that can virtually simulate what would happen in three different real contexts: archival context (libraries, archives), based on a direct contact with original documents and motivated by the pleasure of discovery; open air cultural context (parks, archeological sites, monumental sites, historical centers, etc.) in which the learning experience is strictly connected to a total immersion in an environment where long time ago historical deeds took place; indoor museum context, which is based on the interpretation of ideas, opinions and experiences starting from the collections (Zipsane, 2007);
2) a tour in person, that takes place in a physical environment created to host a temporary or permanent exhibition, structured in an integrated form according to what has been expressed above.

6. CONCLUSIONS AND FINAL RESULTS

The first results of this research, here explained with a case study, highlighted the validity of an approach that aims to improve the control of the cultural heritage's complex nature, making it accessible through different channels to both expert users and the public.
In particular, the creation of an ontology resource represented the overall framework on which are grafted the results of the disciplinary researches. With the definition of the ontology we intended to provide a management tool for complex resources alongside the more specific exhibit design enhanced by digital and virtual representations. This last ones, extracted from two-dimensional drawings, represented an original and unexplored documentation which, alongside images, enhance the communicative potential of the resource.

Figg. 12-13. MARQ, Museo Arqueólogico di Alicante, exhibition design by Boris Micka (GPD): integration of digital technologies in the exhibits and an example of 'hands-on' displays (photo: Aldo R. D. Accardi)

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The development of the DMO model based on ontology, which can be shared and integrated with other existing ontologies related to the cultural heritage, revealed itself to be the most indicated instrument, compared to traditional databases, to provide knowledge and facilitate the conservation and valorization of the information. It was then created a general method to define, fill up and manage this resource through the participation of a researchers community from different fields. The archive was then used for the philological analysis and the three-dimensional reconstructions of the models that, themselves, have become part of the database. An added value is the integration of different archives, and the consequent creation of a complex semantic resource able to highlight the connections among the various documents of different areas of interest (national and international). The graphic elaboration of the three-dimensional models, with the help of this new channel and the use of images, sounds, material models etc., allowed the conception of virtual indoor and outdoor tours. These, who refer to a single place or to different areas, can offer a complete experience of the investigated heritage, transmitting complex information through the use of technologically advanced instruments.
This research highlights the importance of a multidisciplinary approach and proposes experimental process that aims to identify a best practice in creating virtual exhibitions.

Fig. 14. MAXXI, Rome, design by Zaha Hadid, exhibition design by Aldo Aymonino (Seste Engineering), render: connections between digital tools, 3D modeling and traditional museography (© A. Aymonino).

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NOTE

The paragraphs 1, 4 and 6 have been written by Stefano Chiarenza; the paragraph 2 has been written by Noemi Scarpato; the paragraph 3 by Rosalinda Inglisa and the paragraph 5 by Aldo R. D. Accardi.

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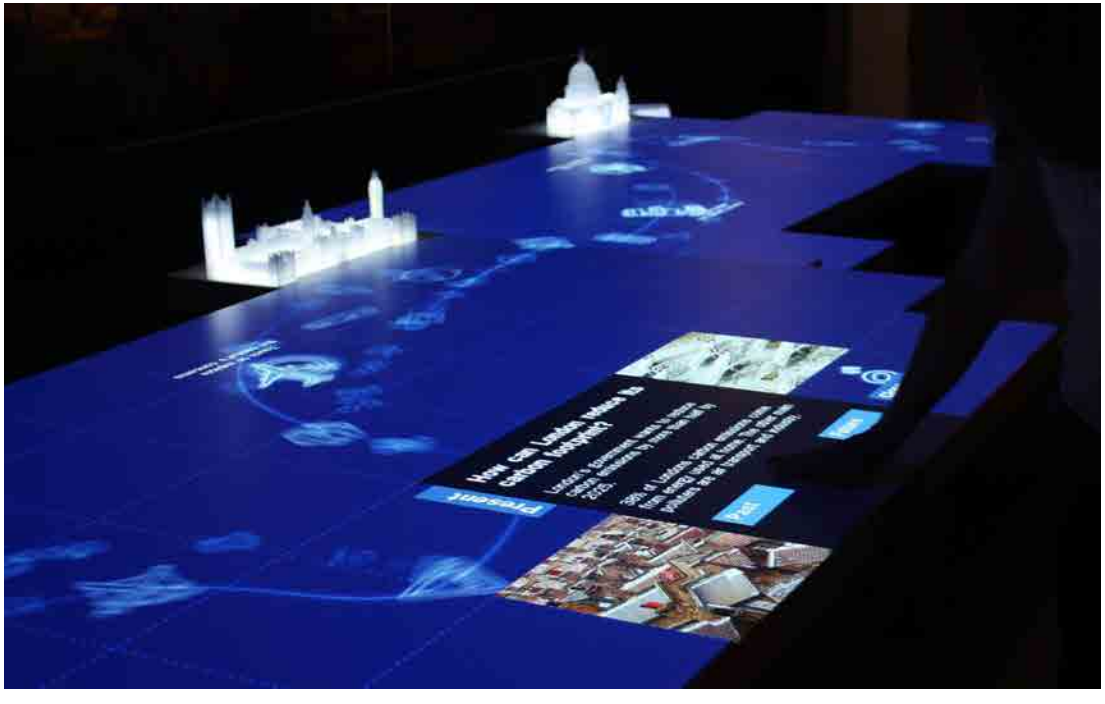

Fig. 15. Museum Of London, Modern London Gallery: interactive desk (so-called 'interactive river') and scale models reproducing the monuments of modern London (photo: Aldo R. D. Accardi).