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Basilica in a Box. Proposal for a Contemporary Wunderkammer

La Basilica in una scatola. Proposta per una wunderkammer contemporanea

This article addresses the opportunities offered by technological innovations to increase accessibility to the knowledge of cultural goods. In particular, an experience to reshape a *wunderkammer* of the Basilica of Loreto in a multimedia key is presented. Using the potential of Augmented Reality/Virtuality and interactive media, the prototype for this 'table of wonders' represents an attempt to modify a model based on a 'passive' informational experience. In fact, the technologies implemented allow for interaction with the information related to the cultural good, activating new cognitive processes based mainly on an active, exploratory experience, thereby offering amplified, multi-sensory use.

L'articolo affronta il tema delle opportunità offerte dalle innovazioni tecnologiche per una amplificazione dell'accessibilità alla conoscenza dei beni culturali. In particolare viene presentata una esperienza di riedizione di una wunderkammer in chiave multimediale dedicata alla Basilica di Loreto. Sfruttando le potenzialità degli ambiti della Realtà/Virtualità Aumentata e dei Media interattivi, il prototipo di 'tavolo delle meraviglie' proposto rappresenta il tentativo di modificare un modello basato su un'esperienza informativa 'passiva'. Tali Tecnologie, infatti, permettono di interagire con le informazioni legate al bene culturale attivando nuovi processi cognitivi basati principalmente sull'esperire in maniera attiva ed esplorativa offrendo una fruizione amplificata e multisensoriali.

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parole chiave: *Patrimonio Culturale, Wunderkammer, Mixed Reality, Narrazione Visuale*

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1. PREMISE

In Italy, Europe, and the world there are numerous places and artefacts that, due to their historical/architectural richness, are the goal of many visitors, exactly like a museum exhibit. In other words, just like a museum, they constitute places of 'exposition' and tell about themselves.
And yet, precisely in virtue of their particularities, uniqueness, and complexity that they have to recount, these places and artefacts experience problems of information access. The visitor is either already 'cultured' or should try to gather and understand the information with much patience and time, through the use of paper guides, or at most, audio guides. In both cases, the user is required to have a large ability for abstraction and imagination.

From another point of view, in recognizing one of the greatest sources of social and economic development for the European Union, the Horizon 2020 research program has identified two challenges related to the cultural heritage and ICT. These are encompassed in at least two pillars on which the European research and development program is organized. Specifically, significant funds have been allocated for activities in the fields of "Advanced 3D modelling for the understanding of the European cultural heritage" [1] and "Creative industries in the area of digital and multimedia communication" [2]. The specific thread of investigation refers to the opportunities offered by technological innovations aimed at increasing and sharing knowledge in matters of cultural goods. In particular, the research aims to test how the predisposition of specific content, together with the use of identified tools, can significantly modify the relationship between cultural resources, visitors, and curators of the information [3].

2. MAIN OBJECTIVE AND CASE STUDY

With the aim of developing focused intents, the research is inspired by the phenomenon of the wunderkammer developed in Germanic areas and in Italy between the 1500s and the 1700s. The term means 'room of wonders', that is, an environment in which some particular collectors – generally scholars, scientists, and princes – began to collect curious artefacts with the primary scope of provoking amazement. The goal of these collections was to acquire rare and curious objects that were either natural and had some exceptional aspect (naturalia) or were hand created

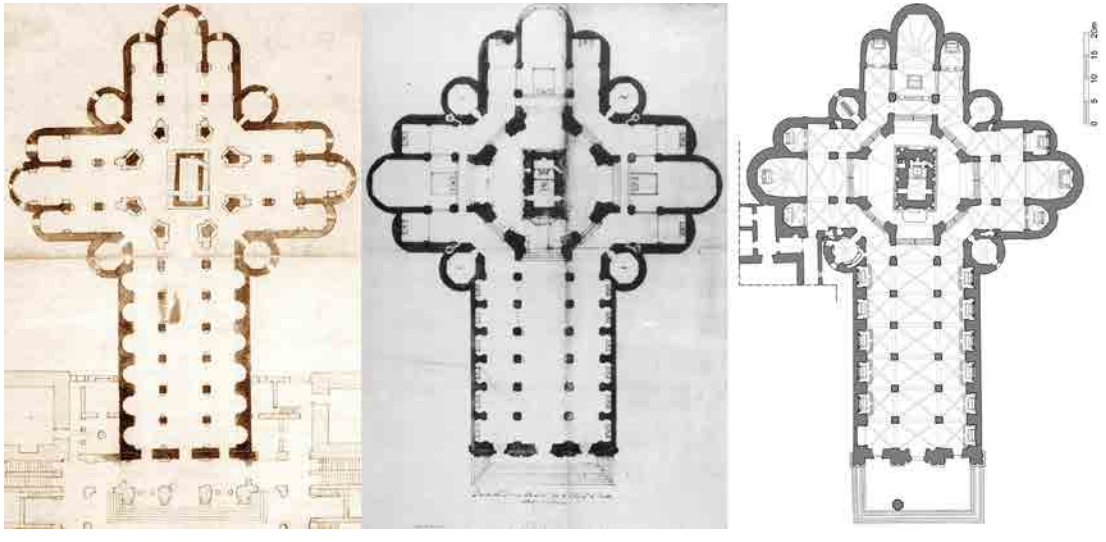

Fig. 1. A Wunderkammer by the Dutchman Vincent Levinus, published by the collector in the catalogue "Wondertooneel der Nature", vol. 2, 1715

Fig. 2. Plans of the Basilica transformations. Left: sixteenth-century plan, attributed to the studio of Antonio da Sangallo the Younger (State Archives of Rome). Middle: seventeenth/eighteenth-century plan before the changes made by Sacconi (Historical Archives of the Holy House). Right: current plan (made by the authors)..

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and considered exclusive or unique for their originality (artificialia). These finds were known collectively as mirabilia, in that they aroused wonder.
The collection of objects, often considered precious in that they were fascinating and bizarre, were usually displayed in a room, but sometimes also on shelves, tables, or in cabinets that were in turn composed of smaller doors and drawers (Fig. 1). Although at the outset the peculiar way of accumulating and bundling the things together was not set according to a methodical, rigorous organization, it can be considered as a prototype, the nascent idea of museum displays.
In fact, towards the end of the 1700s, private wunderkammer owners began to catalogue and order the large amount of material accumulated with the aim of allowing the public to enjoy it. Immediately afterwards, with the advent of the modern area, the characteristic thirst for collecting therefore led to the desire to define a place or a space capable of providing a vision of a complex reality. The many disordered and decontextualized materials were organized according to a coherent scheme and thereby redeveloped as aesthetic products.
Following this suggestion, the research therefore aims to produce a 'cabinet/table of wonders', but reshaping it with a technological/digital interpretation. In other words, the goal is to study and realize a prototype of a multimedia, interactive wunderkammer aimed at using and communicating diverse digital content referring to a specific architectural artefact of particular interest.
The case study is the Basilica of Loreto. It was precisely with the intent both of protecting the wondrous relic of the Holy House [4] and of welcoming the already numerous pilgrims who came to visit that the sanctuary was built. Construction of the new Basilica began in 1469 and finished in 1587. The works saw a succession of the most important architects of the era [5]. In the nineteenth century it suffered a heavy restoration made by G. Sacconi that dramatically transform the original system configuration [6] (Fig. 2).
This architectural complex is particularly adapted to the aims of the experimentation in different ways. Firstly, it is a work of great historical/architectural, artistic, and cultural importance. In addition the sanctuary is one of the places in which the main symbols in the history of Christianity are concentrated. It deals with a particularly representative example of an artefact that 'tells about' itself because it identifies with the sense not only of the entire town, but also of all the pilgrims and visitors coming from every part of the

Fig. 3: A bird's-eye view of the sanctuary complex: view by day and by night.

Fig. 4: The churchyard and the main façade of the Basilica.

Fig. 5: A suggestive snapshot of the nave seen from below looking towards the Holy House.

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world precisely in search of the 'story' imbued with history and symbols (Figg. 3-5).
The goal of the research therefore consists in developing a particular space composed of a multimedia table, at the centre of which is situated a physical scale model of the Basilica produced with a 3D printer. It is intended as a short-lived machine equipped with different applications characterized by different levels of interactiveness and immersion. The setup proposes an approach between amusement and edutainment aimed at communicating and understanding the historical/cultural value of the building.
From a technical point of view, this multimedia wunderkammer is designed as an artefact equipped with a series of technological devices that make the 3D-printed model of the Basilica intelligent. Precisely because it is a physical object, the model acts as an aid to more easily approach the digital applications themselves and therefore to use them better (Fig. 6).

3. METHODOLOGICAL AREAS AND ASPECTS OF THE EXPERIMENTATION

The contemporary view of activities dedicated to exploring cultural goods is now organized into many various experiments. These are concretized in different types of applications in support of visits to museums, archaeological sites, churches, and natural parks.
The applications are necessarily aimed at a heterogeneous public, from simple Sunday consumers of culture to studious lovers of the subject. The logical model regulating the construction of these applications is based essentially on the absorption of information, that is, on one-way communication from the good to the visitor, who should passively absorb a large amount of data. The experience is thus reduced to the simple transmission of ideas, without any involvement.
The wunderkammer prototype proposed here represents an attempt to modify this model, taking advantage of the potential of Augmented Reality/Virtuality, interactive media, and related technologies. These technologies allow users to interact with information related to the cultural good, activating a knowledge-building process based on exploratory techniques modified by the dynamics of some video adventure games. The research is carried out in several phases. First, after careful scientific control of every useful graphic and iconographic document source, the work addressed the construction of different digital content (digitalization of documents, two-dimensional drawings, 3D models of the entire Basilica) in relation to which several particular aspects were then investigated in depth according to the goals of the different applications.
In addition, with specific regard for the response control of the digital reconstruction - two-dimensional and three-dimensional – of the current state of the Basilica, a laser scanner survey was made to make on-site verifications. On the one hand, the surveys were aimed at verifying and improving the precision of the 3D mathematical model. This was done in particular near the octagonal tribune, where most of the changes have occurred over the centuries, also allowing the exact position of the Holy House to be defined within the system. On the other hand, the surveys aimed for precise measurements in order to make a further detailed 3D model of the shrine of the Holy House. The goal was to document an exact measure of the formal geometrical ratio of misalignment between the internal chapel and the external marble surface (thicknesses and conformation), and a detailed rendering of the external decoration (panels of the marble facing) (Figg. 7-8).
Finally and in parallel, the work also concentrated on studying ad hoc systems to create the different levels

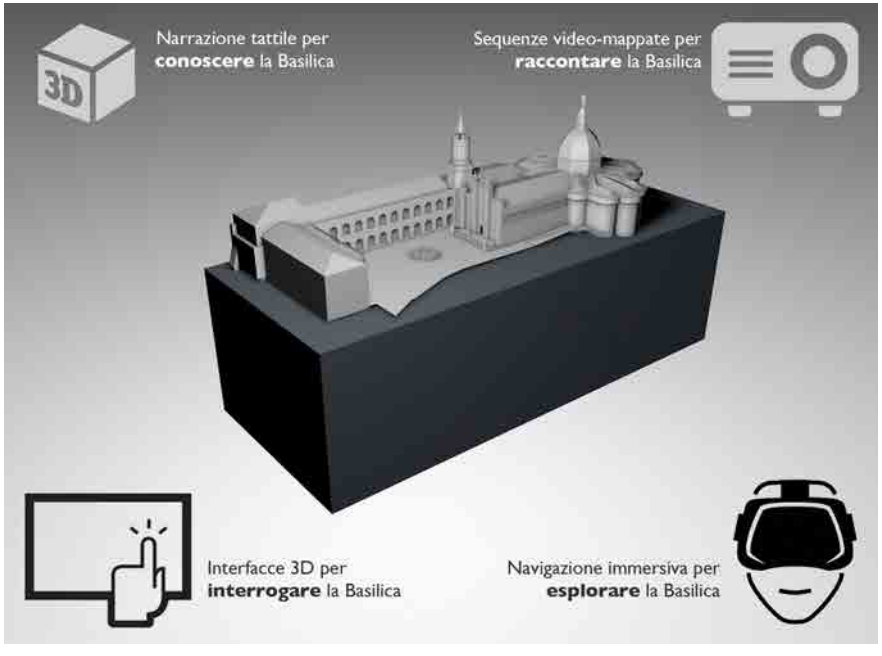

Fig. 6: The design of the multimedia wunderkammer prototype, which exemplifies how the the different interactive/immersive applications are connected to the 3D-printed model of the Basilica.

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of interactiveness/immersion in relation to the devices identified in order to situate them appropriately on the multimedia table designed in the research.
To date, the applications tested that the setup aims to offer the public regard, in particular, realizations pertaining to visual/tactile interactive tools, searchable 3D interfaces, and technological devices for immersive navigation.
Below, a more extensive presentation is given for each of the applications in the wunderkammer prototype, addressing the digital content developed and the means of using the implemented tools, specifying where necessary eventual problems encountered and the choices made to resolve them.

4. DEVELOPING THE 3D MODELS OF THE BASILICA

Reconstruction of three-dimensional models of the sanctuary in the different historical eras was the object of numerous reflections focused on defining the practical phases of the work and the means of progressing, chosen according to the type of historical/architectural documentation available. Since the information available on the current state of the Basilica – deriving from the comparison between the graphical documentation and the data obtained from the laser scanner – were sufficient for a complete, detailed reconstruction, the basic model was used to reconstruct the different historical phases with point-like modifications.

Modelling the sanctuary in its current layout required preliminary work to create vector images of the paper drawings in order to obtain plans and elevations that allowed a geometrical NURBS model of the Basilica to be created. This simplified model was further defined by adding architectural details – mouldings and some particular sculpted elements – reconstructed with data acquired from photographic images and the laser scanner survey (Fig. 9).
At this point, it is good to clarify the criteria of discretization adopted for the three-dimensional representation of a complex organism like the Basilica of Loreto. In describing the geometrical system, the widths of the aisles were normalized – not an important detail on the perceptual level – while the misalignment between the choir and the nave was respected. This is important

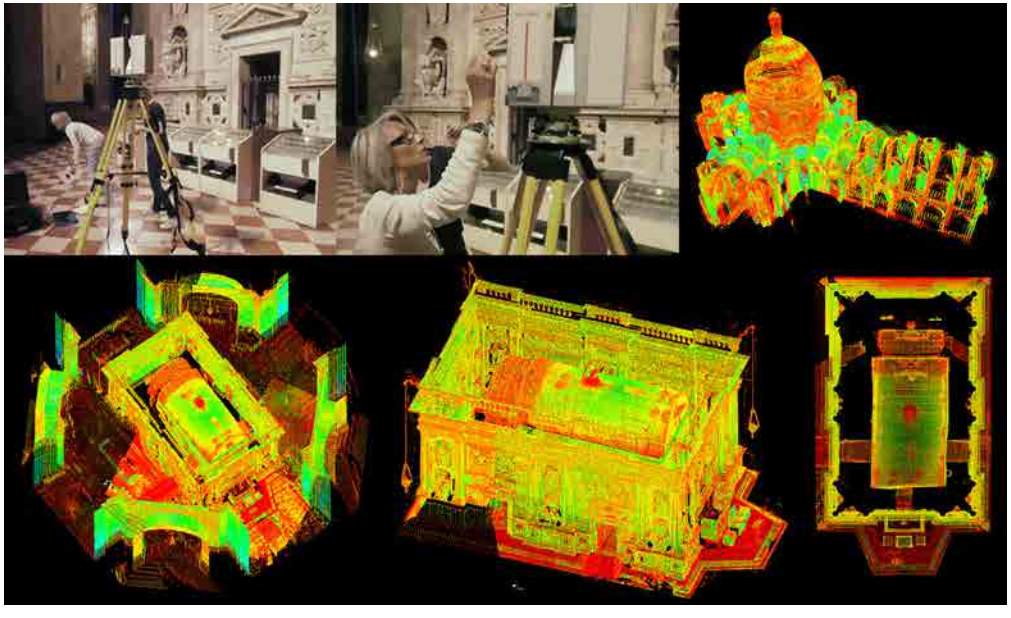

Fig. 7: The instrumental survey carried out by Laser Scanner Leica HDS 7000: snapshot of the campaign and registration of the point clouds.
Fig. 8: The instrumental survey carried out by Scanner 3D Artec Eva: snapshot of the campaign and some processed scans of the Holy House panels.

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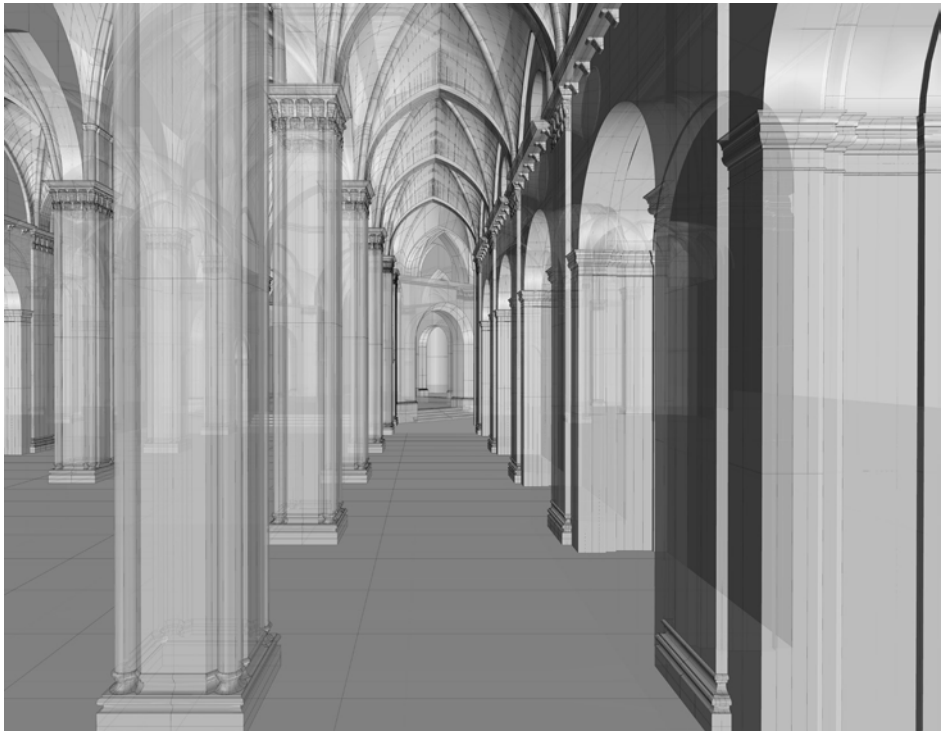
because it produces a distortion of the internal space – in particular the central octagon of the drum – which gives rise to numerous misalignments, both in the layout of the choir and in the position of the Holy House.
The rich decoration in the sanctuary was rendered only partially, favouring elements that were particularly characteristic and overlooking the details. For example, the acanthus leaf motif on the pillars was maintained because the theme is repeated throughout the internal space and is therefore a distinguishing mark. In contrast, the sculptural details of the altars and individual chapels were not rendered since they are less important for the Basilica as a whole. Keeping in mind that one of the established objectives was the virtual navigation of the digital model, particular attention was focused on rendering the moulding, which articulates the elevations and contributes to a more correct perception of the space and the distances involved (Fig. 10).
As mentioned above, historical models of the Basilica were obtained by modifying the basic model just described. First, the areas were identified where the greatest changes were made, primarily the area of the octagonal tribune and the chapels on the side aisles. In this respect, Grimaldi's "Antiche Vedute di Loreto" [Ancient Views of Loreto] provides numerous historical documents, including etchings and project drawings that attest to the state of the Basilica at the beginning of the 1600s. Once vectorized, these documents allowed the previous layout plans to be identified and were fundamental in geometrically reconstructing the arcades and the dome. The sculptural particulars were instead reconstructed thanks to contemporary photographs and some etchings that provided a basis for hypothesizing about the geometries of the coffered vaults – since removed – and the moulding on the pilasters.

5. THE 3D PRINTOUT AS AN INTERFACE TO TELL ABOUT THE BASILICA

The information related to the history of the Basilica is varied, abundant, and diversified. It relates both the sanctuary as a whole and to some of its specific de-



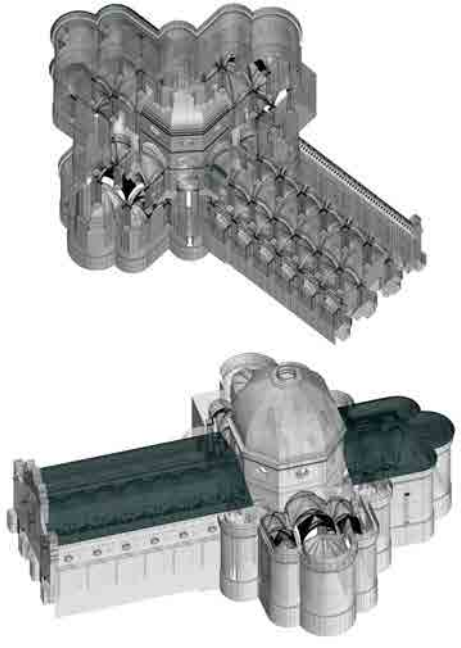


Fig. 9: NURBS model of the Basilica in its current state: perspective view of the side aisle.
Fig. 10: Axonometric views, from above and below, of the whole model.

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tailed elements/parts, and can be used to document content pertaining both to historical/architectural aspects and to questions pertaining to the devotional tradition of the place.
In order to identify a means of communication that is both useful and has a more immediate and direct relationship with the perceptual features of the Basilica – overall and in particular – an application was created that pertains to experimentation in Augmented Reality applied to a physical model. Regarding these intents, therefore, a scaled 3D-printed model of the current state of the Basilica was made 'investigable'. The idea was for it to serve as a real tactile/narrative interface through which the knowledge of some identified content related to the Basilica could be accessed.
In order to create the 3D printout of the Basilica, it was necessary to make some choices concerning not only the material and the printer [7], but also and especially identification of the most appropriate reproduction scale in terms of both the overall size and the level of detail.
This phase therefore dealt with identifying appropriate levels of discretization of the digital model in order to determine the right compromise between the perceptual rendering of the whole and the detail required for the final object, as well as merely technical questions related to creating the 3D printout for which specific tests were made. In addition, but no less importantly, the level of discretization of the digital model was refined until it was optimal both for the aims of the 3D printout and for the virtual immersive navigation application, i.e., according to the criteria specified in the previous section (Figg. 11-12).
The final 3D printout was made in 1:100 scale along a longitudinal section of the Basilica in order to make its internal configuration perceptible, while maintaining the main façade in its entirety. The printout occupies a total space 1 m long, 35 cm wide (maximum halfway along the transept), and 5 cm high (highest point of the roof lantern on the dome).
In order to activate the interactive modes that allow the 3D printed model to become an interface to explore the content, 'proximity sensors' were located in selected areas of the 3D printout of the building. This is an autonomous interaction system based on Arduino

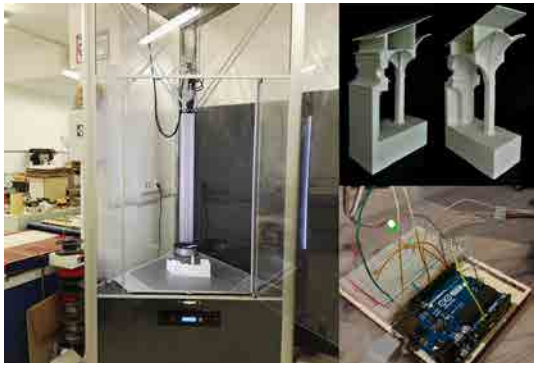

Fig. 11: Operation of the 3D printer and the Arduino-based system that manages the activation of sensors positioned on the model.

Fig. 12: 3D printout of the Basilica façade.

Fig. 13: Tactile experiences using the investigable physical model. The proximity sensors allow multimedia content to be accessed by simply touching the model.

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technology, capable of managing a fixed number of video lights that are activated automatically once the user touches or brushes against the plastic area involved.
Regarding the means of interaction, the application therefore makes possible an extensive multi-sensory approach aimed at rendering the material model 'narrative', creating an experience that is at once fun and provides easy access to information and knowledge related to the building. Specifically, the 3D scale printout of the Basilica at the centre of the multimedia table increases these possibilities thanks to the disposition of both dedicated sensors and connection to specific vision systems, thereby transforming it into an interactive device, a simultaneously tactile and visual exploratory interface.
In effect, the user, by touching the surface of the material model at identified sensitive areas, can access previously organized multimedia content (historical iconographic documents, prints, views, representations, and images of the whole and of details, etc.). That is, users can access basic and in-depth information about the building thanks to the placement of content in audio-video descriptions viewed from a screen connected to the model (Fig. 13).

6. THE VISUAL/TACTILE DEVICE FOR DOCUMENTATION ON THE BASILICA FAÇADE

The façade itself is established as a text containing information related to the complex history of the building and some of its main contributors.
In order to identify a useful interpretational tool to make the information available, a touch-type application was developed, which can be used on a large-format touchscreen such as a standard tablet, for themed knowledge of the historical documentation related to the Basilica façade.
The mode of interaction is visual/tactile, i.e., touch technology. The 3D model of the façade serves as the 3D interface to access 'latent' historical and geometrical information that the touch interaction can make emerge. The result is playful mechanisms of discovery that also facilitate the awareness of the changes in the façade over time by simply touching its two-dimensional representation (Fig. 14).
In particular, the themes considered regard:
- the design of the façade and its interpretations, from the first, never-realized design by Bramante up to the intervention by Lattanzio Ventury, which de-

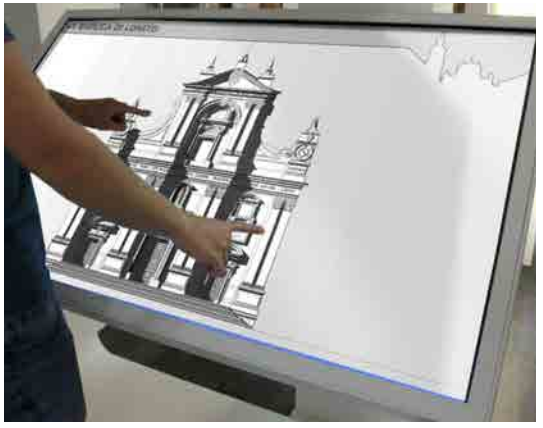
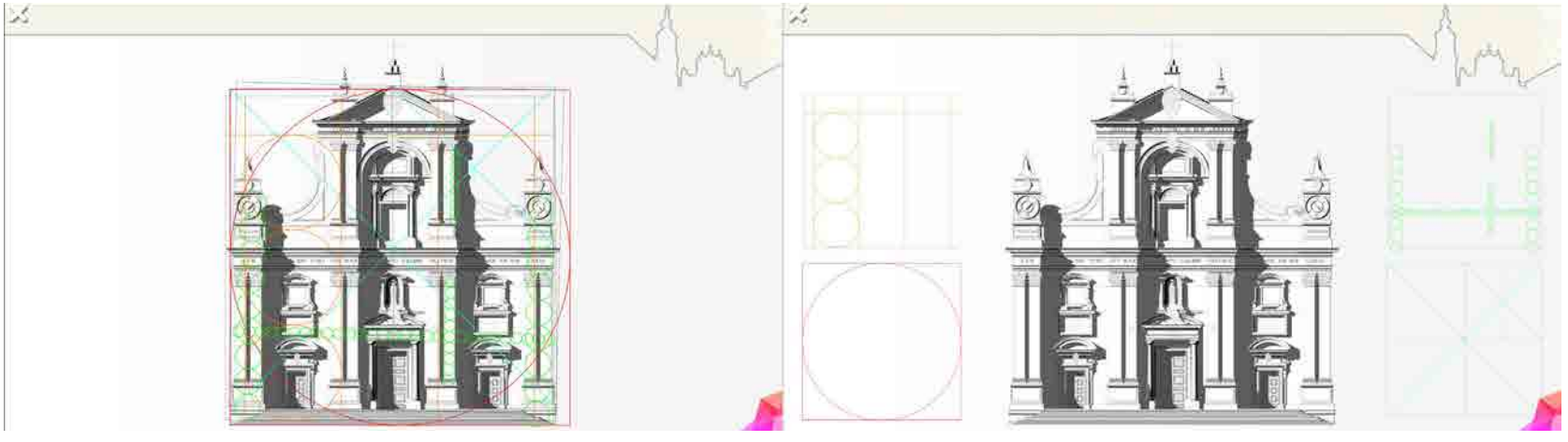


Fig. 14: Touch interface to access information regarding the historical façade of the Basilica of Loreto.

Fig. 15: Study of the geometrical/proportional ratios of the Basilica façade. The two images represent the first interface and, after interaction, with other overlaid levels.



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fined its structure as it appears today. In this section, the type of interaction allows the user to overlay and compare the profile of the current façade with the the project drawings by Bramante, Giovanni Boccalini, and Giovan Battista Ghioldi in order to verify differences and proportions.
With this means of overlaying transparent layers allowed by the interaction with the touchscreen, it is possible to access a section regarding the proportional ratios of the façade in which the user can manipulate up to four different graphical levels. These can the be applied to the 3D model of the façade, appropriately rendered, thereby discovering hidden geometries and metrical correspondences (Fig. 15).

Fig. 16: Virtual immersive navigation of the three-dimensional model of the Basilica with a VR visor.

- the Basilica doors, with a point-like description of the representations of the panels and the bronze ovals portrayed. In this case, the interaction allows for different zoom levels ranging from the general design of the doorway to in-depth photography of each bronze panel with its biblical depiction.
- the emblems and inscriptions that mark the façade. A touch-type tool allows them to be highlighted, transforming the façade itself into a tactile map where some elements of the rich sculpture and iconography present in perspective emerge. For each element, a graphical and textual description is provided, which transforms the façade itself into a consultable hypertext where an alternative and hidden graphical story of the Basilica is activated.

7. THE VISUAL IMMERSIVE NAVIGATIONAL EXPERIENCE WITHIN THE BASILICA

The need to communicate the spaces of the Basilica as they were in the 1600s, before the modifications that led to its current state, was solved by implementing virtual-reality devices, which allow reality to be simulated in a way that tricks visual perception. The immersive perceptual experience created by 3D visors allows for three-dimensional reconstructions of the sanctuary, offering visitors the sensation of really finding themselves in the virtual environment represented (Fig. 16).
Due to the system of binocular projection contained in these devices, it is possible for users to experience a 360° view of the virtual model. Visitors use the space as if they were really there, moving virtually within the visualized 3D scene, approaching, moving away from, or changing the direction of view, i.e., benefitting from a simulated system of possible movements in the space through a natural intuitive interface. If in traditional museums the knowledge of the history of the objects displayed usually occurs through the written word, in virtual museums it is possible to acquire this knowledge through direct experience.
In this case, the 3D interfaces propose a logical and involving means of using the knowledge related to the Basilica, facilitating the awareness of the building's transformations over time (Fig. 17). As part of the setup, this specific application therefore identifies the main focus of the study in the 3D digital models appropriately optimized for visual use. Once the modelling phase was complete, the virtually navigable immersive environment was set up. For this purpose, a system composed of the graphical engine Unreal Engine and the HTC Vive virtual reality headset was used as the hardware/software platform. The number of polygons in the 3D model was therefore optimized in order to lighten the model and guarantee fluid navigation higher than 60 fps. The setup was then finished with natural volumetric lighting with a dominant light yellow colour to accentuate the realism, while point and jump dynamics developed specifically for this type of visor was used for the displacement and internal navigation.

8. RESULTS AND FURTHER DEVELOPMENTS

The innovative aspect of this multimedia table resides in the structured set of applications, which offer the possibility for an in-depth approach to the knowledge experienced in means of amplified, multi-sensory use.
Based on a scientifically correct standard of content and information and using different languages, the experience allows cognitive models to be constructed and calibrated according to different needs. That is, they are capable of communicating to both occasional and more qualified users. The 'box of wonders' prototype therefore proposes intelligent dissemination of the cultural heritage, renewing the 'traditional' concept of museum in that it maintains the principle of 'correlation' with the real place, but proposes a dynamic, complementary story integrated with the experience of visiting the Basilica. It is a pilot experience that can also be applied to other contexts.
Today, the theme of accessing the knowledge of cultural goods represents a great occasion for technology, so it is definitively marked by the concept of use extended exclusively to maintaining and managing the good. The challenge is therefore to overturn the one-way relationship between cultural heritage and visitor, instead offering new cognitive processes based mainly on active experience rather than passively 'absorbing' the work of art without any empathetic involvement.
The research is still underway; so further developments will be aimed at:

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Fig. 17: Comparison of three-dimensional models. Left: a reconstruction of the current state. Right: a model of the Basilica before the nineteenth-century restorations.

- cataloguing all the documentation accessed in an appropriate database;
- a detailed digital reconstruction and 3D printout of the Holy House that defines the formal geometrical ratio of misalignment between the internal chapel and the external surface, as well as a detailed rendering of the decoration of the marble facing;
- an extension of the content usable through the touchscreen, which also allows the different 3D reconstructions of the Basilica to be visualized.

NOTES

[1] Third pillar: Societal Challenges: Inclusive, innovative and reflective societies.

[2] Second pillar: Industrial leadership.

[3] This article grew out of the success of a University Research Project entitled SMART-HERITAGE_ Digital tools for the SMART enhancement of the cultural HERITAGE of Marche region conducted at the School of Architecture and Design in Ascoli Piceno and funded by the University of Camerino.

[4] The historical events of the place began well before the architectural events of the Basilica. According to legend, the angels carried the house where the Virgin had received the announcement of the miraculous birth of Jesus from Nazareth to the peak of Mount Prodo. The worship of Holy House was recognized in 1458.

[5] Among the architects called to work at the Basilica during slightly more than a century, can be cited: Marino di Marco Cedrino (plan of Basilica), Giuliano da Maiano, (corbels runners in the apses, octagonal tribune), Giuliano da Sangallo (dome), Francesco di Giorgio and Antonio da Sangallo the Younger (reconfiguration and consolidation of the tribune), Bramante (tribune, side aisles and façade project later reworked in a late Renaissance style by Francesco Boccalini, Giovan Battista Ghioldi and Lattanzio Ventura).

[6] The major changes made by Sacconi to the original plant configuration were concentrated in the area of the dome and the octagonal pillared tribune where the four triple-aisled halls of the Basilica come together. The rounded vaults were substituted with Gothic arches, the openings on the drum were changed from rectangles to circles, and interventions were made to modify the pillars supporting the dome. As well, the dome was repainted, forever losing the previous seventeenth-century frescoes by Pomarancio.

[7] The 3D reproductions were made using fused filament fabrication (FFF) technology, with about 10 kg of material (polylactic acid) and a DeltaWasp 40 70 printer.

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