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FROM SURVEY DATA TO VIRTUAL ENVIRONMENT. TWO CASE STUDIES

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Abstract

In this paper we present the latest experiences carried out by our research group in the field of multimedia communication. Starting from the construction of virtual models, interactive and non-interactive, we pursued the aim to introduce edutainment paths in some museum contexts, both increasing the value of cultural assets and creating an attractive pole for the visitors. The current trends are gradually transforming museums from static places of conservation into active and engaging spaces to deliver accessible culture to the masses, using digital technologies for creating new paradigms of interaction and enhance the experience of the visitor. Here we present two case studies, whose purpose is to bring together the different competences by various experts to test the potential of digital products as non-formal teaching tools to allow a satisfying learning experience. The case explored are those of the Civic Museum of Schifanoia (Ferrara) and the octagonal cloister of the Carracci in San Michele in Bosco (Bologna). The multimedia products discussed here relate to these two research themes, and up to now 3 out of 5 planned products have been made (in final mode, or in prototype form). The experimentation led to concrete results that introduced a reflection on what investigative methodologies and protocols are more suitable to be adopted in these cases, in compliance to the aim identified by the project.

Keywords

Multimedia communication, Digital models, Virtual Museum, Edutainment, Survey, Palace of Schifanoia, San Michele in Bosco, Carracci Cloister.

1. *Introduction*

The present contribution concerns experiences conducted by the research group on new multimedia communication modes (interactive and non-interactive), based on virtual models using *edutainment*[1] to benefit cultural heritage sites. The current trends have primarily focused on scientific structures, such as the Science Museum of London, the Victoria & Albert Museum in London[2] or the more recent MUSE Science Museum of Trento, gradually transforming museums from places of conservation of tangible or intangible heritage into active and engaging spaces to deliver accessible culture to the masses. This has been made possible by the extensive use of technology, creating new paradigms of interaction. Furthermore, the various forms of interactivity and immersion in use today not only increasingly focus on education and research, but also cater to the enjoyment and enhancement of the experience of the visitor.

The purpose of the case studies presented was to bring together the researchers, historians and experts in communication media to test the potential of digital products as non-formal teaching tools to allow a more engaging, effective, intuitive and customizable use of content. The case studies explored are those of the Civic Museum of Schifanoia (Ferrara) and the octagonal cloister of the Carracci in San Michele in Bosco (Bologna). They refer to two different experiences, still in progress, having in common a previous research based on scientific survey and advanced and critical analysis of the architectures

[1] Neologism born from the fusion of the words educational and entertainment, means enjoying education and educating. A reference glossary containing the terms used in this contribution can be found at: https://www.v-must.net/virtual-museums/glossary, site network *MusT* (last consultation December 2014). *V-MusT.net* is a Network of Excellence. The research leading to these results has received funding from the European Community's Seventh framework Programme (FP7 2007/2013) under the Grant Agreement 270404.

[2] See for example the videogame *Strawberry Thief*, realized for the Victoria & Albert Museum: a playful celebration of the Victorian artist William Morris and his popular repeating designs for textiles.

of interest. Starting from the acquired knowledge, we planned a multi-year research program in phases: it involves the construction and development of different and coordinated multimedia products, aimed to build an *edutainment* path based on scientifically reliable contents. In both cases the first products (two phases for Palazzo Schifanoia and a sample interactive model for the cloister of the Carracci), have already been made: the phases and their state of progress will be widely described in the following sections.

2. *The Este's "Delizia" of Schifanoia in Ferrara between past and future*

The earthquake that struck the territories of Emilia and the city of Ferrara in 2012 has left many unresolved problems in the field. Immediately after the first operations and safety measures, the start of a process of investigation was required, which used survey as the central pivot around which recovery, consolidation, restoration and revitalization operations developed.

Palazzo Schifanoia, Estense "delight" founded around 1385 by Alberto d'Este, is among the largest historic buildings damaged. For this reason the building has long been closed to the public, only the Hall of Months is actually usable. In synergy with the operations of consolidation, restoration and renovation, a development project was undertaken, aiming to create a digital representation of the building to act as an essential tool for the communication of heterogeneous content (scientific, iconographic etc...).

The information apparatus dedicated to the visitors of the Schifanoia Museum, a prestigious structure in the Civic Museum sector of Ancient Art in Ferrara, has long been committed to a series of panels of historical contextualization and to a video accessible from a source located near the exit. The experience of visiting the rooms and the works on display in the building has always been a critical problem recognized and reported even by the museum management personnel. The building has undergone heavy transformations over the centuries, which have completely altered the nature of the Estes town "delight", nestled in an elegant Renaissance garden. In the Hall of Months, both the controlled lighting of the surviving frescoes (for reasons of protection) and the height of the painted scenes (6 meters) constitute a limit to the use of the famous cycle that covers the walls. Furthermore, given the low lighting of the room, the consultation of traditional paper guides is uncomfortable. Some rooms of great interest have always been inaccessible and unknown to the public for reasons of expediency (for example rooms converted to provide storage of artifacts) or security. Such is the case of the attic, which has recognizable ancient crowning battlement paintings on the walls, or even the Marble Hall, where traces of the ancient exterior decoration of the fifteenth century building are still visible.

For these reasons, a research project supported by an agreement with the body of Civic Museum of Ancient Art was developed. The aim of the project is the creation of a **4-stage**[3] program starting from the survey produced and recently integrated,[4] the execution of digital models of the building, virtual reconstructions to provide information on the history and architecture system thanks to high-definition reproductions of images of pictorial cycles. The models, highly detailed, initially non-interactive, will in future also be navigable on tablet device screens or via network during the tour route, and may be used as the basis of projects of augmented reality which are key to a revival of the museum reality of Ferrara.

[3] The four steps of the program, described in the next sections, are respectively: the chronological development of the Palace (step 1), a historical study on the Hall of Months (step 2), the iconological program of the Hall (step 3) and its perceptive reconstruction (step 4). The realisation of the program has started from step 1, which has been completed and presented to the public (21st of december 2014). To test a different type of multimedia product, on exact request of the Musei Civici di Arte Antica, it was decided to work directly on the third step, leaving the second step to be completed later. For this reason we also present here the first results produced for Step 3 (under construction). The Steps 2 and 4 will be developed in the near future: in this sense a declaration of interest of the managing body has already been expressed.

[4] The scale of representation used for the survey is 1:50. The topographical support and the survey of the hall counts 528 points measured by Total Station. The following architects collaborated and took part in this phase: G. Galvani e M. Cecchinato (instrumental survey), C. Villani, G. Tammiso, E. Minghini (direct survey). Some students of the Corso di Rilievo dell'Architettura 1, A.A. 2005-06 also contributed to the direct survey of external spaces and the ground floor. Recently new measurements have been taken in the Hall of Months with the Disto laser 3d Leica. We would like to thank the Musei civici di Arte Antica di Ferrara to have allowed access and the surveying of spaces and the DIAPREM of Ferrara.

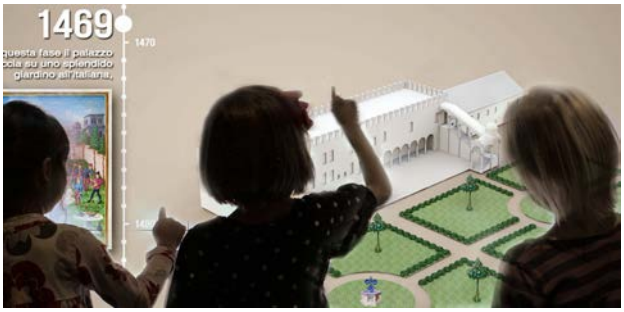

Fig. 1: Palazzo Schifanoia, Ferrara. Interactivity project for a diachronic model describing the development of the building.

In the definition of the communication format, particular attention has been paid to the needs of young audiences to facilitate their approach to cultural issues that often do not collect interest. Speed, immediacy and multitasking characterize the cognitive approach of youths: the communicative success, even in the case of layered content, is for this reason always subordinate to the quality of involvement obtained.

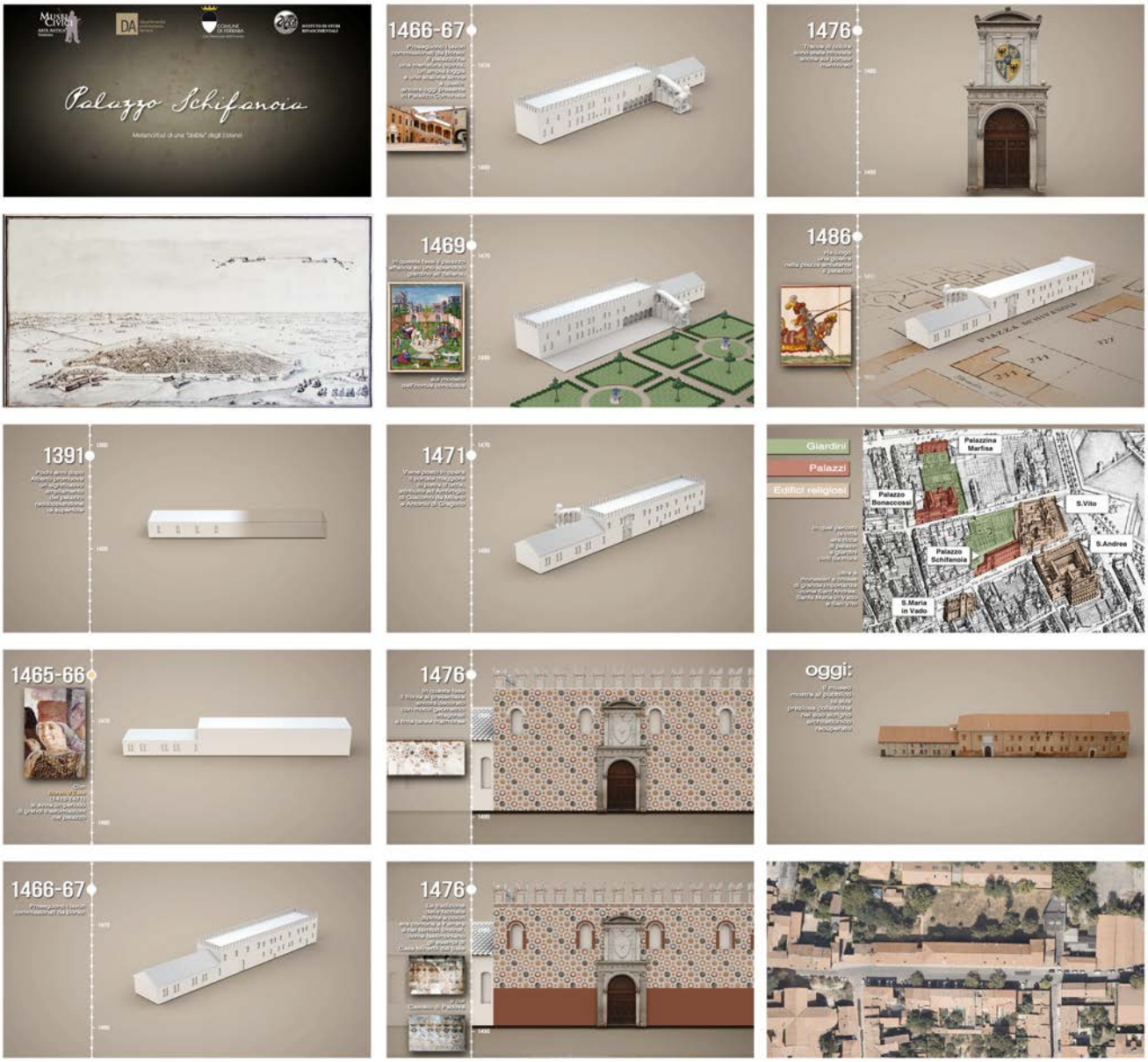

Fig. 2: Palazzo Schifanoia (Ferrara). Some frames taken from the first informative-educational video made for the multimedia program of the museum.

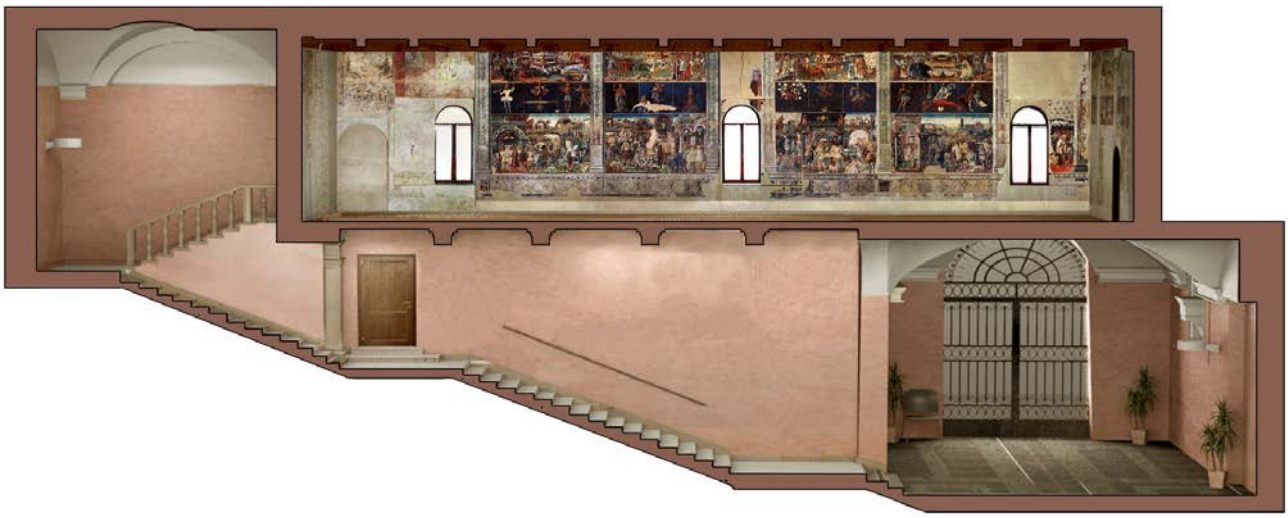

Fig. 3: Perspective section of the partial model of Schifanoia Palace, passing through the staircase and the Hall of Months. Image developed in the integrated course of *Tecniche della Rappresentazione II*, A.A. 2013/2014 (Proff. M. Incerti, S. Iurilli), students: C. Solis Bonini, C. Troisi e S. Venturini.

2.1 Step 1. The different ages of Schifanoia Palace, the narration

The Este's family "delight", Schifanoia Palace, was built around 1385 by order of Alberto d'Este. The current building is the result of numerous expansions and renovations:

Around 1450 the initial works are wanted by the Marquis Leonello. The adjustments of the square and the raising of the palace of Borso date to 1465. Between 1469 and 1470, the famous cycle of frescoes of the Hall of Months was painted. Between 1483 and 1498, more changes were carried out, cutting down the battlements and expanding under the direction of Biagio Rossetti and the Duchy of Ercole.[5]

The building was located in the East of the city, adjacent to the complex of San Vito, near St. Andrew of the Augustinians and Santa Maria in Vado. A grand staircase, destroyed in 1700, allowed access to the large Renaissance garden from the main floor. Among the interior rooms, all sumptuously decorated, the Hall of the months stood out for its richness and vivacity, synthesis of the thought of the astronomical and astrological Renaissance in Ferrara.

The multimedia product realized for the first step of the program,[6] an animated sequence of almost eight minutes, shows the chronological phases of the development of the building through the evolution of its shape, supported by historical documents. In the layout, a scrolling vertical time-line splits the screen into two different areas, occupied respectively by the *moving model* and *historical documentary sources*. The images play an important role in creating an engaging narrative and simultaneously providing an element of rigorous scientific support to the story. The narrative dimension[7] pursued includes

[5] For an essential bibliography see: Varese, R. (1989). *Atlante di Schifanoia*. Modena: Panini; Settis, S., Bentini, J., Ghiraldini, A., & Cupperi, W. (2007). *Il Palazzo Schifanoia a Ferrara*. Modena: F.C. Panini; Bertozzi, M., & Hübner, W. (1999). *La tirannia degli astri: gli affreschi astrologici di Palazzo Schifanoia*. Livorno: Sillabe; Bertozzi, M. (2002). *Aby Warburg e le metamorfosi degli antichi dei. Modena: F.C. Panini*; *Schifanoia* (2013) *Rivista dell'Istituto di Studi Rinascimentali di Ferrara, Atti della Settimana di Alti Studi*, Febbraio 2012, Vol. 42-43, 2013; Visser Travagli, A. (1991). *Palazzo Schifanoia e Palazzina Marfisa a Ferrara*. Milano: Electa.

[6] The multimedia product was presented in a press conference at Palazzo Schifanoia on 21st of December, 2014 and put into operation on the same date. Scientific coordination of the project: Manuela Incerti. Research group: Angelo Andreotti (*Director of Musei Civici di Arte Antica di Ferrara*), Marco Bertozzi (*Director of Istituto di Studi Rinascimentali di Ferrara*), Manuela Incerti (*Department of Architecture of Ferrara*), Stefania Iurilli (*Department of Architecture of Ferrara*), Giovanni Sassu (*Curator of Musei Civici di Arte Antica di Ferrara*). Models and animation: Dario Arnone e Stefania Iurilli. Video editing: Paolo Marchetti.

[7] «A narration is a symbolic presentation of a sequence of events connected by subject matter and related by time. Without temporal relation, we have only a list. Without continuity of subject matter we have another type of list. A

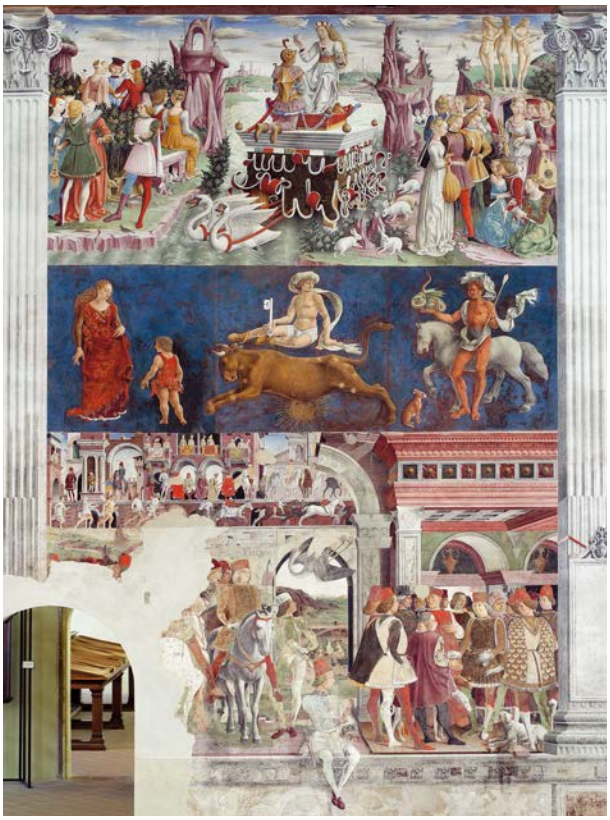

Fig. 4: Palazzo Schifanoia (Ferrara): frame dedicated to the month of April (author: Francesco del Cossa, 1469-70).

Fig. 5: Palazzo Schifanoia (Ferrara): frame dedicated to the month of March (author: Francesco del Cossa, 1469-70).

the description and interpretation of spaces, objects and events, but also the development of logical connections and space with the purpose of contextualizing Palazzo Schifanoia in the history of the Estense family and the city of Ferrara.

The different 3D models (*reconstructed models*) created for this phase (corresponding to the stages of development of the building and its garden) were modelled on the basis of the shape and appearance of the real building thanks to survey data previously collected and historical document sources. The final products have adequate attention to the replication of the "thickness" of architecture (walls, openings, cornices and details) avoiding processing models that are excessively rough and imprecise, which we often encounter in museums and websites:

"boxes" consisting of elementary-sheet walls devoid of depth on which textures materials are simply resting on.

To convey the *morphological aspects*, a palette of neutral colours was selected, as it was considered most effective with the ability to not overwhelm with the weight of its visual content. On the other hand, the quality of fifteenth century colours (prior to rossettian intervention) is preferred to characterize the photo-textured surfaces reconstructed based on the existing fragments. The outer eastern wall (now incorporated in the Marble Hall) in fact still has a painted patterned polychrome decoration on an octagonal base, very similar to that recently rediscovered in the castle of Padua[8]. It is probably a decorative theme spread around the middle of the fifteenth century, as attested by Michele Savonarola (Padua 1384 - Ferrara 1468) doctor of

telephone directory is a list, but we can give it a strong push in the direction of narrative by adding the word 'begat' between the first and secod entries of the words 'who begat' after each successive entry until the end.» Scholes, R. (1981). *Language, Narrative*, and Anti-Narrative. In W.J.T. Mitchell (Ed.), *On narrative* (pp. 200-8). Chicago: University of Chicago Press.

[8] In the castle of Padua the motif is on a hexagonal base. We thank the *Comitato Mura di Padova* for the kind concession of study-aimed images.

Niccolò III d'Este, Ferrara University professor and tutor of the most famous grandson Michele.[9]

The digital model shows a new hypothetical reconstruction of the outer shell,[10] aiming to involve the viewer in a perceptual experience of strong and ringing colors that, in the last years of the fifteenth century, still characterized the geometric designs and the grotesques of the fresco facade.

With the same intention, the crest of Borso d'Este was revived, located on the monumental entrance portal, in its original two-tone gold-blue received on May 5 1452 with the investiture by Emperor Frederick III. The operation was made possible thanks to the discovery of ancient traces of colors documented during the recent restoration.

2.2 Step 2. The Hall of the Months, location, history and organization

The second multimedia product uses the same format and layout of the previous one and aims to deepen the historical and descriptive knowledge of the main space of the Estes: the Hall of Months, synthesis of astronomical and astrological thought of Renaissance Ferrara. At the heart of the program is the client, Borso d'Este, born August 24th, Thursday, 1413 *hora XXII* under the Virgo sign, the third son of a pair of lovers: Stella de' Tolomei and Nicolò III d'Este.

The letter of Francesco del Cossa in Borso d'Este, dated March 25 1470, remains the most important document for the authorship of the pictorial program of the Hall of Months and its dating. Among the various authors, Prisciani Pellegrino is mentioned, a man of great influence in Ferrara in the late fifteenth century. The letter allows you to attribute the execution of the three compartments of the east wall to the Ferrarese painter. Historians have instead only been able to formulate hypotheses about the authorship of the other surviving sectors (June, July, August, September), based on technical and stylistic criteria. June and July are attributed to the *Master with wide open eyes* (active in the second half of the fifteenth century), August to *Andrea Fiorini Gherardo da Vicenza* (documented between 1424 and 1485-86), September to *Ercole de' Roberti* (Ferrara, c. 1450 -1496)[11].

The model shows the original space characterized by a different access on the north-west, a wide staircase that has now disappeared. A large fireplace and a system of internal obscuration were also present; frescoes that met the need for visual continuity of the cycle were reproduced on the wooden panels mounted over the windows.

The organization of the geometric decorative painting,[12] based on rectangles with sides of proportional relationship,[13] is the backbone of composition of the three narrative bands: the stories of the Duke Borso (12 frames), the 12 zodiac signs and 36 deans (12 frames) and, above, the triumph of the gods (12 frames). The goal is to recreate a unified vision of the project for the observer, an image currently lost due to the deterioration suffered by the paintings and the transformations that occurred.

2.3 Step 3. The Hall of Months and its iconographic reading[14]

The complexity and layered nature of the information contained in the painting program have always made the narration of the cultural, geographic and iconographic route of the images difficult, synthesis of the Arab-Persian, Indian and greek-Ptolemaic knowledge of the astronomical and astrological matter.

Astronomy and astrology, during the government of Lionello, Borso and Ercole I, played an outstanding role at the court of Ferrara, as well as in other Italian Renaissance courts[15].

[9] Savonarola, M., & Segarizzi, A. (1902). 24.15: *Libellus de magnificis ornamentis regie civitatis Padue Michaelis Savonarole,* 50-51. Citta di Castello: S. Lapi. Written around 1446.

[10] Some reconstructive hypotheses used in the multimedial product have been drawn from: Ghironi, S., & Baroni, F. (1975), *Note storiche su palazzo Schifanoia*, in *Atti e memorie della Deputazone Ferrarese di Storia Patria*, S. III, XXI, 1975. R. Varese hypothesised on the distribution of the external decoration in 1978. See R. Varese, *Atlante di Schifanoia* (1978), p. 145.

[11] Sassu, G. (2010). *Guida a Palazzo Schifanoia*, Ferrara: Musei Civici di Arte Antica 2010.

[12] The photographic images have been supplied by Musei Civici di Arte Antica, thank you for the courtesy.

[13] On this matter see Incerti, M. (2013), *Misura del cielo e misura dello spazio nella sala dei mesi di Schifanoia*, in *Schifanoia Rivista dell'Istituto di Studi Rinascimentali di Ferrara,* Atti della Settimana di Alti Studi, 42-43. Pisa-Roma: Serra editore.

[14] The realization of this product is in progress, herein we present the first partial results.

[15] Milano, E., & Bini, D. (1996). *Astrologia: arte e cultura in età rinascimentale, art and culture in the Renaissance* (pp. 38-42). Modena: Il bulino. Catalogue of the exhibition held in Modena

The development of knowledge of these cultural aspects of Ferrara have largely contributed investigations, especially in the field of iconography, conducted on the famous cycle. Starting from the innovative and fruitful studies of Aby Warburg[16] has proved the presence of a specific strand of the history of astrology in the pictorial program: they belong to the *Astronomicon* of Manilio[17], the *Introductorium in astronomiam* of Albumasar and the tradition of medieval magic and renaissance *Picatrix.*[18] In this strand, great importance is given to the constellations, their mythical images, the visual representation and the fantastic suggestions from which they are born.

The project, currently under construction, uses a high detail photo-textured model, from which extracting informations using a simple input device or a touchscreen. The deepening possibilities are inevitably different depending on the state of preservation: the frescoes preserved with colors (March, April, May, June, July, August, September) and the paintings lost and subject to hypothetical reconstructions (in black and white and color) by artist Maurizio Bonora.[19]

In addition to the general description of the 36 main panels, arranged on three horizontal bands, you can interrogate individual or homogeneous groups to identify the meaning and characteristics. The individual visitor can choose the level of information desired, based on his personal curiosity and the time available for the visit. This so allows immediate access to the iconographic sources (such as the Bianchini's *Tabula Planisphaerium*) and to their deeper meaning.

A query by subjectwill also be possible, which will be able to trace back to the specific *representation* from the *name* through tags. The name of Leon Battista Alberti (whose image was identified by Ranieri Varese) will thus be connected to the panel governed by Pallas Athena (Minerva), goddess of wisdom, war, the sciences and the arts. To the left of the scene, amongst the doctors, artists, poets and jurists (sons and disciples of the goddess) Alberti would in fact appear. Alberti arrived in Ferrara in 1438 with the opening of the Ecumenical Council in the wake of the papal court, but previously already linked to the Este as testified by the dedication of *Philodoxeos fabula* in 1437 to Lionello, elder brother of Borso.[20]

2.4 Step 4. The Hall of Months and perceptive reconstruction

The last phase regards the reconstruction of immersive perceptual space and its original elements (garden access, fireplace, lost and reconstructed frescoes). A wide and spectacular marble staircase connected the vast Renaissance garden with the impressive show. From the top of the staircase, it was definitely possible to see the Bonaccossi palace and its grounds (wanted by Borso around 1469) and, later, the sixteenth-century Palazzina Marfisa. To formulate a reconstructive hypothesis (on which historians do not agree) we made use of the survey of the staircase of honour in the Town Hall, designed by ducal architect Pietro di Benvenuto dagli Ordini, part of the complex of works of transformation of the building court made since 1471 according to the will of Ercole I d'Este.[21] The communicative and expressive value of digital models is rendered very effective in relation to this aspect because

in 1996-97. Vasoli, C. (1980). *La cultura delle corti* (pp. 129-158). Bologna: Cappelli.

[16] Warburg, A. (1912). *Arte italiana e astrologia internazionale nel Palazzo di Schifanoia a Ferrara.* In Bertozzi, M., & Hübner, W. (1999). *La tirannia degli astri: gli affreschi astrologici di Palazzo Schifanoia*. Livorno: Sillabe. Bertozzi, M. (2002). *Aby Warburg e le metamorfosi degli antichi dei.* Modena: F.C. Panini.

[17] Poetic work in five books constitutes the first complete work to reach us regarding astrology. There is no information on the author, who probably lived at the time of Augustus and Tiberio and died around 22 d.C. The work is published in the critical edition: Manilius, M., Flores, E., Scarcia, R., & Feraboli, S. (2011). *Il poema degli astri.* Milano: Fondazione Lorenzo Valla.

[18] The Arab manuscript, written around the middle of the XI century in Spain, was translated to Castilian in 1256 by Alfonso X (work attributed to: al-Magriti Maslamah ibn Ahmad). It diffused in Europe through its Latin translation al-Maǧrīṭī, M. Rossi, P. (1999). *Picatrix: dalla versione latina del Ghāyat al-hakīm.* Milano: Mimesis.

[19] The reconstructions were published in Bonora, M. (1992). *Lo zodiaco del principe: i decani di Schifanoia di Maurizio Bonora.* Ferrara: M. Tosi.

[20] A second draft of a pseudo antique comedy composed by Battista in 1924, still a student in Bologna. His relationship with the Este household was long lasting: the dedications date back to 1441 (still to Lionello) the treatise of moral consolation *Theogenius* and the *De equo animante* (1444-45), while the *Ludi Matematici*, dating to the period between 1450 and 1452 are dedicated to Meliaduso, brother of Lionello. Again by direct sollicitation of Lionello in 1447, finally, the draft of Alberti's most important work begins, the *De re aedificatoria*.

[21] Incerti, M., & Cecchinato, M. (2007). *Lo Scalone d'onore di Palazzo Comunale: regole e geometrie costruttive*, in *Bollettino della Ferrariae Decus*, 24, Ferrara.

manages to make explicit and real what was previously described in documents and ancient maps.

The model at this stage will also evoke the movement of unusual lighting effects that, in some significant dates (for example, the celebration of the election of Borso, Duke of Modena and Reggio) would illuminate the frescoes. It will simulate the natural light and artificial light of ancient torches at a salon furnished with contemporary furnishings.

Through animated reconstructions, it will also be possible to communicate the strict geometric constructions that underlie the perspectives painted by Francesco del Cossa in the band dedicated to Borso in the months of March and April in an immediate and accessible way.

Room after room, the museum path introduces the history of the building starting from the observation of its current appearance and it gradually fascinates its visitors. For this fascination to turn into real involvement, the visitor is required a creative effort in visualizing a remote time, elements and an atmosphere that do not exist anymore. However, these are all abilities that the average visitor rarely uses, even the most motivated and interested.

The design of the virtual apparatus for the museum, as described in the previous paragraphs, aims to fill this gap, making the visit more stimulating and culturally constructive; the proposed contents derive from the combination of different scientific matters, and are communicated with different methods depending on the target group and on the level of interest

Fig. 6: Palazzo Schifanoia (Ferrara). Layout of the database record dedicated to iconographic and textual sources of the first Decan of Aries (March): the *vir niger*.

3. *Designing interactivity in a "symbolic" environment. Palazzo Schifanoia and its Hall of Months*

From the point of view of a visitor, Palazzo Schifanoia today impresses more for evocation than for appearance: the big spaces of its rooms, clear of furniture, calls to mind a magnificence in part disappeared, although still detectable through architectural masses and remains of the wonderful decorations.

expressed.

The literature on the topic of virtual museums is wide although recent, and among the examples already realized all over the world, it is possible to individuate the traits that allow a typological classification. The effectiveness of the final project is conditioned by the model on which the virtual museum will be built, as well as by the levels and modes of sharing knowledge.[22]

[22] For a possible classification see Caraceni, S. (2012). *Musei virtuali-Augmented heritage. Evoluzioni e classificazione delle tipologie di virtualità in alcuni case histories.* Rimini:

The multimedia project designed for the Este family Palace does not substitute, but complements the visit to the museum. Therefore it does not belong to that category of museum-replica (mostly based on quick time VR technology, with panoramic 360 degrees from a unique viewpoint), which allow the viewer to virtually visit the exhibition areas through a client provided by a web-browser and accessible from any place in the world. The museum-replica is useful to plan a path inside the physical museum, bookmark points of interest, or to "return" on the site for further study; neverthless it does not replace or recreate the atmosphere of the place, nor the journey feeling, which the visitor often perceives during a visit to the museum. Concisely, the museum-replica does not create a real emotion and it does not generate an event to be told once that experience is over. Exploration is conditioned by the rules dictated by the available technologies and software used, as well as by the choices of the programmer of the user interface; the feeling of freedom of movement and selection is always subject to rules imposed from above about explorability, databases consultability and model illumination.[23]

At the current state of the media and technologies, this condition can be mitigated but not canceled, thanks to the different levels of interactivity, which can now be implemented into a VR artwork. The perspective changes if the virtual reconstruction becomes a complement to the physical visit experience, a sort of enhanced guide that uses different multimedia products on different matters and complexity levels. This content can be displayed on different devices (touchscreen, tablet, stereoscopic viewers, HMD[24] devices like *oculus 3D*), in an articulated perceptual path, that stimulates the senses and increases user involvement. In this way the inertia of the acquisition of information through the reading of panels along the exhibition is cancelled; at the same time a simple visit is enriched with reconstructions, captivating images, motion sequences, auditory stimuli.

The experience is enhanced by the possibility of comparing past and present, what is visible with what has disappeared, and to discover symbolic meanings and hidden paths, as in the case of the painted perspectives.

If we look at its implementation, the project includes a first stage – corresponding to Steps 1 and 2, currently almost completed – during which two different animated sequences will be introduced in the museum. The videos will be projected on screens strategically placed along the museum path, and they will be accompanied by a narrating voice available in multiple languages[25] that provides information about the history of the building and the people who influenced its development. At this stage, the animated clips are focused on two main themes of general interest (exterior development of the building with chronological phases, Step 1, a historical study on the Hall of Months, Step 2). They will be limited to a one-way, non-interactive communication: we choose therefore to opt for a very didactic and simple message, addressed to an audience of any age and at level of education.

For step 1 we needed a set of versatile, extremely concise models, describing the volumetric qualities of the building with the metric accuracy of a urban scale maquette. The 12 models used, one for each chronological stage, were made starting from the survey data, through a synthesis and discretization process, using a direct modeling application coming from the entertainment industry[26]. Starting from the essential measures we built continuous, low-poly mesh models, made of quadrilateral (quad) polygons[27]. This choice was made to ensure the processability of the model in animation and, in a second time, in interactive apps, when the same models are used to calculate real time interaction. The same software was used to set the essential

Guaraldi, and Bandelli, A. (1999), *Virtual Spaces and Museums. In The Journal of Museum Education,* Vol. 24, No. 1/2, pp. 20-22. Boston: Maney Publishing.

[23] Maldonado, T. (1992). *Reale e virtuale* (p.150). Milano: Feltrinelli.

[24] Head-Mounted Displays. An HMD is a display device, worn on the head or as part of a helmet, with a small display optic in front of one or each eye. It has the capability of reflecting projected images as well as allowing the user to see through it.

[25] The actual product is underlined by a background music, a renaissance instrumental composition; the narrating voice will be recorded and mounted in a second time.

[26] 3d modeling and animation application (for the whole project): Luxology Modo; video editing and post production application; Adobe Premiere, Adobe After Effects.

[27] In this way the material transformations of the model between a chronological stage and the other are easily manageable. The changes are based on the use of morph maps (vertex maps allowing to define, store and animate user-defined deformations for any mesh), as well as on simple transitions that make appear or disappear elements between stages.

camera movements and calculate the video sequence in HD, compatibly with the screens present in the museum.

In a subsequent phase, there is provided a upgrading of the materials realized for the first two steps: it consists of arranging the same content in a explorable graphical interface. Touchscreens will be placed on especially designed holders and positioned at eye level, with the possibility for the user to take action, skip forward or backward on the timeline, select an event or a document, open the dedicated database record and access data (multi-resolution images, scientific references, videos, audio guides, historical data). In this direction a first experimental sample (not yet released) has already been made, using the game engine Unity 3D. It allows to visualize, orbit and manage a real-time textured model, even with multiple sets of textures and lights. It is also possible to connect the different states (ages of the Palace) with clickable buttons on the timeline.

The media dedicated to the Salone dei Mesi are to be placed preferably inside the hall itself.[28] The visitor will be given the chance to turn a detailed model of the environment of 360 degrees, select one wall or one of the frescoes just by touching it, zoom on the details and access to the related metadata.

The next phases of the project will focus exclusively on the Salone dei Mesi, and include the creation of more advanced multimedia contents, featuring more complex informations, different degrees of detail and a more advanced type of interactivity (applications on tablets, switching to immersive virtual environments). Even in this case we realized a first test, an immersive exploration of the Salone with Unity. Through the use of Prefabs (special parametric items supported by the software) it's possible to generate a virtual exploration of a selected model, already compatible with the chosen output device (in our case the HMD oculus 3d).

The general proposal stresses the programmatic intent to propose a communication which is initially simple, dedicated to everyone, then passing to a more stratified and complex information, where a single model can be enquired in different ways. It enables the user to choose how much time to dedicate to the learning experience and what information to listen or watch, by selecting the content according to his own profile.

In this way both the casual user, moved by curiosity, and the scholar seeking specific insights, can be motivated by a kind of information which is different from the one that can be read in a guide book or listened from a simple audio guide. The multimedia guide thus facilitates an accelerated and selective synthesis, allowing the user to operate all those mental connections (between information and source, between perception and data) that are not always obvious if one lacks deep knowledge of the places of interest and the related works of art.

As stressed in the previous paragraph, the technologies used to develop the multimedia contents comes from the field of entertainment and videogames; the construction of models and databases uses instead the data coming from the survey, processed through modeling and programming techniques, based on the synthesis of geometric data and the optimization of models and textures for real time rendering.

3.1. Content analysis, multidisciplinarity and construction of visual databases

The construction of virtual contents and guides on the model described above often clashes, in a first phase of research, with the difficulty of coordinating the different contributions and useful skills, as well as the large amount of data needed to effectively describe a fine architectural complex.[29]

In the case of Palazzo Schifanoia our research unit has availed itself of first-hand basic geometric information from the integrated architectural survey of the building, in addition to literature and other basic sources, as well as unpublished data from the historical, geometrical and metrological study. The study has produced a summary of the state of the art that has been the subject of several discussions and exchanges with specialists with different skills (historians from Ente Musei Civici di Arte Antica and from the Istituto di Studi Rinascimentali). The results of surveys and investigations by other research

[28] The screen is actually located into the adjacent Sala delle Virtù, while awaiting the recovered total practicability of the hall after the earthquake of 2012.

[29] Gaiani, M. (2012). *Sistemi informativi per studiare, conservare, gestire e comunicare sistemi architettonici e archeologici complessi.* In Disegnarecon, nov. 2012. pp. 9-20.

groups will be implemented at a later time,[30] so that they can be made known to visitors. The objective, already partially achieved, is the development of a database of information which is ever updatable, and upon which the models and their interactivity are built – and will keep on being built in the following phases.

The images database (photos, orthophotos, maps, archival footage, and historical photos) is particularly interesting and useful, as it is the core for thematic research about color and of the elaboration of structural textures, needed for recreating painted surfaces, both the existing ones and the lost ones.

3.2. Digital models and multimedia products

Already at this early state of the project, different models for different uses and products have been built.

The first is a set of low detail models[31], used as a basis for the video on the diachronic development of the building (choice conditioned by the lack of information on the oldest iconographic and descriptive chronological phases). The second one is a highly LOD model of the current status, based on the data coming from the survey and from high-resolution models of salient architectural details, such as marble portals. In some cases, the general surveys of the buliding have been complemented by further analysis aimed at acquiring details through digital photogrammetry and photomodeling techniques.

Due to optimization needs, it has been necessary to shape low-poly models, based on data fetched through specific decimation algorythms.

The process of production of the models, limited to what was achieved up to now, can be summarized as follows:

- Semantic study and identification of the appropriate communication features of the different models in each phase.
- Storyboarding and design of the different layouts, GUI[32] , and of the functionalities of the single multimedia objects.
- Extraction of the essential measures and production of synthetic models for Step 1, including the reconstruction of missing elements on the basis of existing documents (as in the example of the staircase).
- Production of more detailed models, even textured, in support of some specific phases of the narration (patterned façade, portal). The same detailed models were then incorporated into the general model of the current state of the Palace.
- Production of the general "perceptual" model of the current state (interior and exterior). At this stage the perceptual quality is essentially entrusted to the textures. The aim was to keep the model low-poly, already thinking to use it for a real time exploration.
- Creation of the animated clip for the Step 1
- Introduction of interactivity in the multimedia product of the Step 1 (timeline navigation)
- Test of interactive exploration with oculus 3d interior of the Hall of Months.

In the later stages the general models will be complemented by thematic textured models focused on specific environments, such as the interior of the Salone dei Mesi, both as it is now and how it was in the sixteenth century setting. In this case, the need to produce a data, which is easily processable and manageable – and thus a low-polygon model – collides with the attempt of not affecting the perceptual quality of the final product. The successful result is guaranteed by the use of texture mapping techniques based on the use of color maps and normal maps, but also thanks to multi-resolution images that are loaded progressively from the rendering engine[33], especially when it comes to yield coloured pictorial surfaces, existing or missing. The loading is done in a directly proportional measure to the zoom level on the paintings.

[30] We mainly refer to the multimedia content dedicated to the iconographic program of Salone dei Mesi (Step 3).

[31] The set of 3D models is the one described in the previous paragraph.

[32] Graphic User Interface. The Unity UI system allows to create custom User Interfaces (UIs) fast and intuitively.

[33] Unity automatically supports this function, through a texture prefiltering algorithm (mipmap) useful to process the image and storing it in smaller sizes down to a single pixel. As the textured surface moves farther away, the texture being applied switches to the prefiltered smaller size. Different sizes of the mipmap are referred to as 'levels', with Level 0 being the largest size (closest to the viewer), and increasing levels used at increasing distances. Moreover the PRO version of Unity allows to use LOD (Level of Detail) for selected objects, so that it is possible to define how far away an object has to be before the texture level falls.

3.3. Time, perception, interactivity: the virtual model as a detector of hidden meanings

In implementing the virtual informational program for Schifanoia special attention has been paid to the sensory and perceptual setting, both static and dynamic, that involves the visitor and the object in a mutual relationship, not always unidirectional. In this sense, the media apparatus supports and amplifies the real object, and becomes itself the object of perception by the user: to achieve full effectiveness, it must be designed taking into account the dynamics of perception involving the senses of the audience.

Thinking to the structure of the layout and graphical user interfaces, for example, we conducted a specific study aimed at the choice of the colors. We mainly choose dominant samples reminding the image of Ferrara (the colors of earth and bricks, for example, in different shades of red and brown), as a base for a reference palette to be used for the whole graphic project, in line with the previous choices made by the Museum.

The perceptual aspect plays an important role even in the reconstruction of the spaces and their former functions; in the immersive virtual visit of the Hall of Months, which will be explorable through tablet devices or through HMD, the original access from the ancient garden staircase (today disappeared), will be virtually restored. In this way the visitor will experience the vision of the salon at the time of Borso d'Este, being involved in a different observation perspective. The visiting experience opens to an immediate and "live" comparison, in which the spectacular visual impact to the salon offers multiple solutions of exploration: the original access, angular, is opposed to the current (of nineteenth-century conception) where the access from the short side includes monumentally the room in a symmetrical field, framed by a central point of view.

The linked themes of iconologic reading of the paintings and geometric reading of the perspectives assume great relevance, especially for the contents dedicated to the Hall of Months. The knowledge and comprehension of these aspects profoundly influences the emotional impact of the visit: if they do not emerge, the whole experience may result disappointing (the beauty of the place is evident, but its true value is tied to its hidden meaning).

The construction of the contents in this phase is very complex, and it is critical that content and container are uniformly designed by the same people within the working group. A prime example is that of perspectives. Despite all the technological means available today the only way to decode a painted perspective is to retrace, in reverse, the construction operations carried out by the artist, using the rules of linear perspective. It is a laborious process, but it produces very interesting results and attractive for the audience (it's exciting to see a painting that is transformed into the corresponding three-dimensional space, animated by its characters). Communicate simply and synthetically, and with an attractive graphic look, the results of these studies is something that, in our opinion, can be effectively pursued only by those who brought them; in this sense, scientific research and production of informational content must indissolubly bind.

4. The San Michele in Bosco complex and the octagonal Carracci cloister

The second research experience concerns the prestigious church of San Michele in Bosco, a former monastery converted to an orthopedic hospital at the end of the 1800. The prime, scenic location and the luck of the olivetan religious community first and then of the clinic, are probably among the main reasons that favored the constant presence of this extraordinary complex in the history of the city.

The building stands out not only because of its historical, architectural and artistic value, but also for its impressive dimensions: the hallway of the dormitory is the longest space in Bologna (427 *piedi bolognesi*, 162 m) and opens with a wide serlian window on the vast panorama looking onto the Asinelli tower.

The last surveys carried out in a systematic way throughout the complex date back to the 800, prior to the structural changes that enabled the conversion of an old and run down monastery into the most modern orthopedic hospital of the time[34] to occur. The works found in the archives are solely related to planimetric graphics,[35] the

[34] The works are documented in: Bacchelli, G. (1895). *L'Istituto ortopedico Rizzoli a S. Michele in Bosco: relazione della Deputazione al Consiglio provinciale di Bologna*. Bologna: Regia tipografia.

[35] Graphic documents have been found in the Communal Library of Bologna (BCB, cartella Antolini), in the Archivio Storico della Provincia di Bologna (ASPB), in the State

more complex and difficult drawing sections (due to the size of the building) are completely absent.

The impressive complex has a maximum size of about 180x80 meters[36] and is spread over three main floors. Among the most significant nineteenth-century spaces surviving transformations is the monumental church, the refectory decorated by Vasari, the prestigious Scientific Library and three cloisters amongst which one with an octagonal plan. A survey campaign on the Complex of San Michele in Bosco is in act since 2011.[37]

4.1. The architect Pietro Fiorini and the invention of the octagonal cloiste

The work of Pietro S. Fiorini at Michele in Bosco is documented from 1587 to 1616. In 1588 he worked at the grand staircase and the middle or the Pine cloister, in 1602 work began on the construction of the octagonal cloister. The cloister of the stables is from 1606-07, while the extension of the dormitory dates back to 1616. The octagonal cloister of San Michele in Bosco is situated in the existing Renaissance cloister built in early 1447[38]; Fiorini documents its quadrangular shape in a graph[39] (1539-1529): the architect, in 1588, received 10 crowns for drawing the plan of the monastery[40]. The drawing is of great interest because of the overlap of survey data and project data, traced with different colors on the sheets glued together laterally, which can also be opened.

Among the papers of the architect, preserved in the Archbishop Archives of Bologna, is his diary[41], collecting both personal information and reflections on the theory of architecture developed through the major treatises known to him. The notes constitute a sort of "index by subject" on issues of design and construction, accompanied by brief notes and references (with specified book title and page number) to the texts of Vitruvius, Alberti, Daniele Barbaro, Palladio, Cesare Cesariano, Serlio and others. The paper, whose purpose is to collect things *alcune cose necessarie di sapere nelle occoretie* (needed to know in occoretie) (c. 49r), opens with the definition Architecture, *scienza di molte discipline* e *amaestrameti* (science of many disciplines and teachings) that, to paraphrase Vitruvius, Fiorini lists and comments on one by one: letters, drawing, geometry and arithmetic. The frequent reference to the importance of the ancient monuments, the different units then in use, the geometry and concept of proportion have guided research into geometric reasons for the architectural form of this innovative *claustro a otto faze* (cloister with eight faces) (c. 44v), research published in a recent contribution.[42]

Archive of Bologna (ASB, Fondo demaniale) and in the Diocesano Archive (ADB, Fondo Breventani).

[36] The extension of the monumental wing is about 19.000 mq.

[37] The survey campaigns began in 2011 with the survey seminar *Misurare il sacro* of the course of *Rilievo dell'Architettura 1*, Department of Architecture of Ferrara (A.A. 2011-12, 2012-13_ Prof. M. Incerti, Prof. U. Velo; 2013-14_Prof. M. Incerti, Prof. G. Lavoratti). The direct survey was integrated with profile survey of significant points with *leica disto 3d* (interiors mostly done by M. Incerti, while A. Ballarin prevalently did the exteriors). In San Michele in Bosco, 146 scansions were carried out with a *Faro focus3d* scanner (survey M. Incerti e P. Lusuardi, data elaboration by M. Incerti, we thank the Compagnia delle Misure for the use of the instrument). We thank: Don Lino Tamanini Parroco San Michele in Bosco di Bologna, the Fondazione Carisbo, the Istituto Ortopedico Rizzoli, the Biblioteca Scientifica, the Centro Studi per l'architettura sacra e la città, the Istituto Veritatis Splendor.

[38] 4 June 1447. *Libro Fabbrica* 1, c. 112r (ms. ASB), v. Malaguzzi Valeri, F. (1895). *La Chiesa e il Convento di San Michele in Bosco* (p. 20). Bologna: Tip. Fava e Garagnani, 1895. For a synthesis on the authors and the different development, steps of the church and main spaces see: Incerti, M. (2013). *Il disegno della chiesa di San Michele in Bosco a Bologna: composizioni e sovrapposizioni*. In Bertocci, S. *Architettura eremitica Sistemi progettuali e paesaggi culturali* (pp. 150-155). Firenze: Edifir-Edizioni.

[39] Pietro Fiorini, *plant of the Monastero di San Michele in Bosco* (Archivio Arcivescovile, Fondo Breventani G (I) VIII, n 5.

[40] See ms. Malvezzi 51 (BCB), c. 6. The manuscript is most probably an eighteenth century copy of some of the books owned by the convent, including the *Libri delle uscite* and the *Libro delle riparazioni.* Rediscovered by Zucchini reproposed in the essay of 1943, it is rich of unpublished news but the papers have large gaps and are not always in order. Zucchini, G. (1943). *San Michele in Bosco di Bologna*. In *L'Archiginnasio,* XXXVIII, 18-70.

[41] Pietro Fiorini, *Diario*, Fondo Breventani G (I) VIII, n 1.

[42] The octagon probably finds its *raison d'etre* in the necessity to carve a space for the chapel of San Carlo Borromeo, built in 1614. The octagonal shape left four small triangular courtyards free, one of which was occupied by the very chapel, possibly built for both economic and religious reasons. For the analysis of compositional aspects see: Incerti M., Foschi P., Iurilli S., & Velo U. (2014). *Rilievo, conoscenza e comunicazione: il complesso di san Michele in Bosco e il Chiostro ottagonale dei Carracci. Survey, insight and communication: the complex of San Michele in Bosco and the Octagonal Cloister by Carracci.* In P. Giandebiaggi & C. Vernizzi (Ed.), *Italian survey & international experience: 36°*

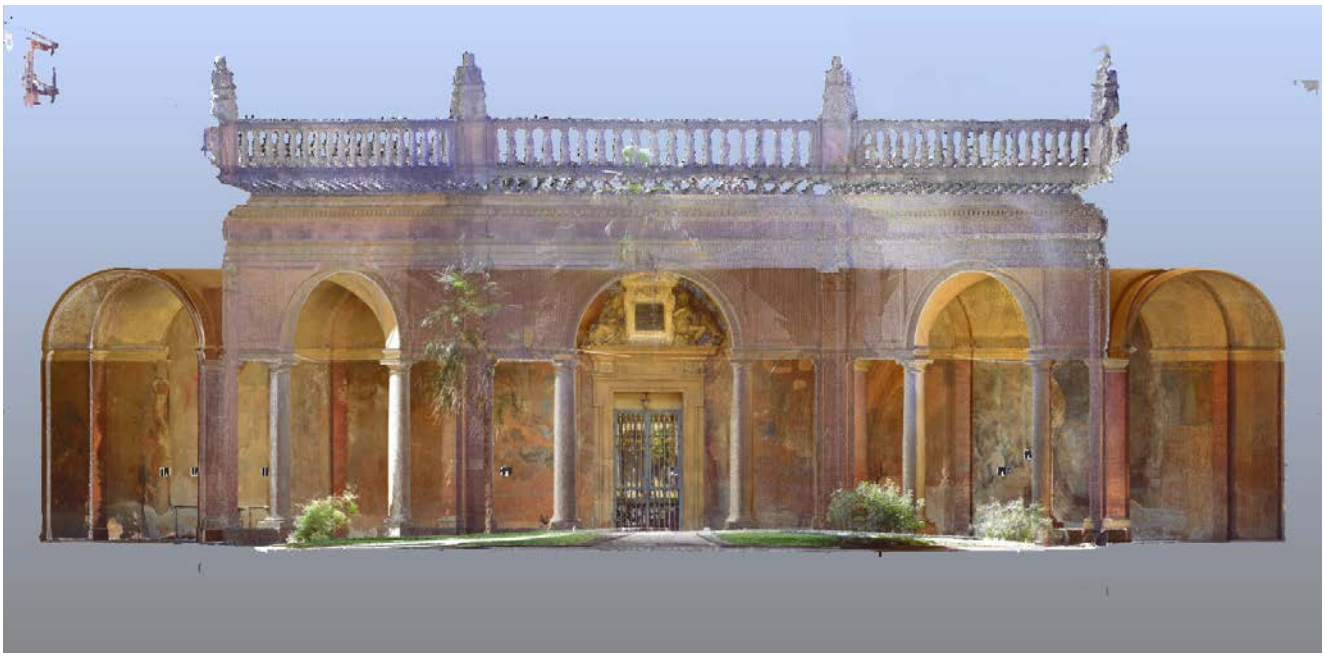

Fig. 7: San Michele in Bosco (Bologna), point cloud of the Carracci cloister.
146 scans have been done with a scanner Faro focus 3d for the survey of the whole complex.
Software for data management Scene 5.2 (Survey M. Incerti and P. Lusuardi, data processing M. Incerti).

4.2. Form and perspective: the place of the sublime

In the Fiorini design, the "bizarre"[43] but reasoned form of the cloister[44] is closely related to the famous painting program created by Ludovico Carracci (assisted by artists of his school) and Guido Reni.

The story is explained in 37 sections divided in two cycles of St. Benedetto (21 episodes) and Santa Cecilia (16 episodes). In the organization of the decoration, the five areas into which the eight walls are divided derive from the projection of the serlian of the minor octagon on the larger octagon. The most important scenes from the life of St. Benedetto are placed in the central space (larger and higher up given the presence of the cross vault) in all areas except those occupied by monumental portals that lead to the upper church, the cloister del Pino and the refectory. The five scenes and the three major portals are always flanked by two minor episodes from the life of St. Benedetto, whose height is lower because it is limited by the frame the barrel vault. Finally, in the eight corners are the stories of Santa Cecilia, side by side, two by two. The compositional rhythm is thus: *cecilia, benedetto, BENEDETTO, benedetto, cecilia*[45], according to a spatial distribution that requires station points and different paths for the viewer to follow the narrative of each cycle.

Because of the humidity of the walls and the construction technique used (oil on plaster), the stories immediately suffered a sharp decline that quickly led to their progressive disappearance. To preserve this treasure of artistic tradition from oblivion, Carlo Cesare Malvasia promoted the reproduction of 15 episodes of the life of St. Benedetto, with engravings printed in a volume in 1694.[46] In the next century, both cycles were

Convegno internazionale dei docenti della rappresentazione, Undicesimo congresso UID. Roma: Gangemi.

[43] The definition is by Malvasia, C.C. (1686). *Le pitture di Bologna* (p. 348). Bologna: Monti. Cited in Campanini, M.S. (1994). *Il Chiostro dei Carracci a San Michele in Bosco* (p. 219). Bologna: Nuova alfa editoriale.

[44] The direct survey of the cloister was carried out by B. Moretti, M. Neri, G. Marchetti, A. Zattoni. The instrumental survey (scansion and significant points) was carried out with the total station TOPCON IS-3 Imaging Station (dott.ssa S. Zaia), Disto Leica 3D (survey seminar, prof. M. Incerti, prof. U. Velo, A.A. 2012-2013) and laser scanner Faro focus3d (survey M. Incerti and P. Lusuardi, data elaboration M. Incerti).

[45] Campanini, M.S. (1996). *Il Chiostro ottagonale con i ciclo delle Storie di San Benedetto e Santa Cecilia*, in A. Cioni & A. M. Barsotti (Ed.), *L'Istituto Rizzoli in San Michele in Bosco* (p. 186), *Bologna:* IOR.

[46] Malvasia, C., Giovannini, G., & Carracci, L. (1694). *Il claustro di S. Michele in Bosco di Bologna dipinto dal famoso Lodovico Carracci, e da altri eccellenti maestri usciti dalla sua scola descritto dal sig. co. Carlo Cesare Malvasia e ravvivato*

subject of a broad new iconographic survey campaign published by Zanotti in a remarkable volume of significant dimensions.[47]

From the engravings, one can only begin to guess the importance of perspective construction, expertly used to expand and visually break through the real and closed space of the *claustrum*. The columns of the serlian, viewed from the center of the cloister, find a compositional match in the Telamoni on base (similar to the order in the foreground), constituting a second perspective point able to frame the depth of the additional narrative spaces.

The research experience has therefore wanted to experience the potential of virtual reconstruction to recall, at least in part, the perception of the original space, syncretically defined by architectural form and perspective painting. The chosen approach follows the philosophy of *restoration of completion*, where the addition of accessories is implemented according to the *criterion of recognizability*.

The deepening of thematic analysis and knowledge occurs on the model with interactive mode[48] structured according to different reading levels, ranging from the general to the particular. The general approach to the two cycles of paintings is bipartite between the two hagiographic subjects from the beginning, St. Benedetto and St. Cecilia, with the identification of the different points of the station for the correct view of the respective scene. The items focused on in this phase are subject, artists, dates of creation, technique, condition and source of the reproductions.

By clicking directly on the representations of the model, equipped with a tag, one can then access a second level of interpretation, a card currently structured with texts and images, which contains

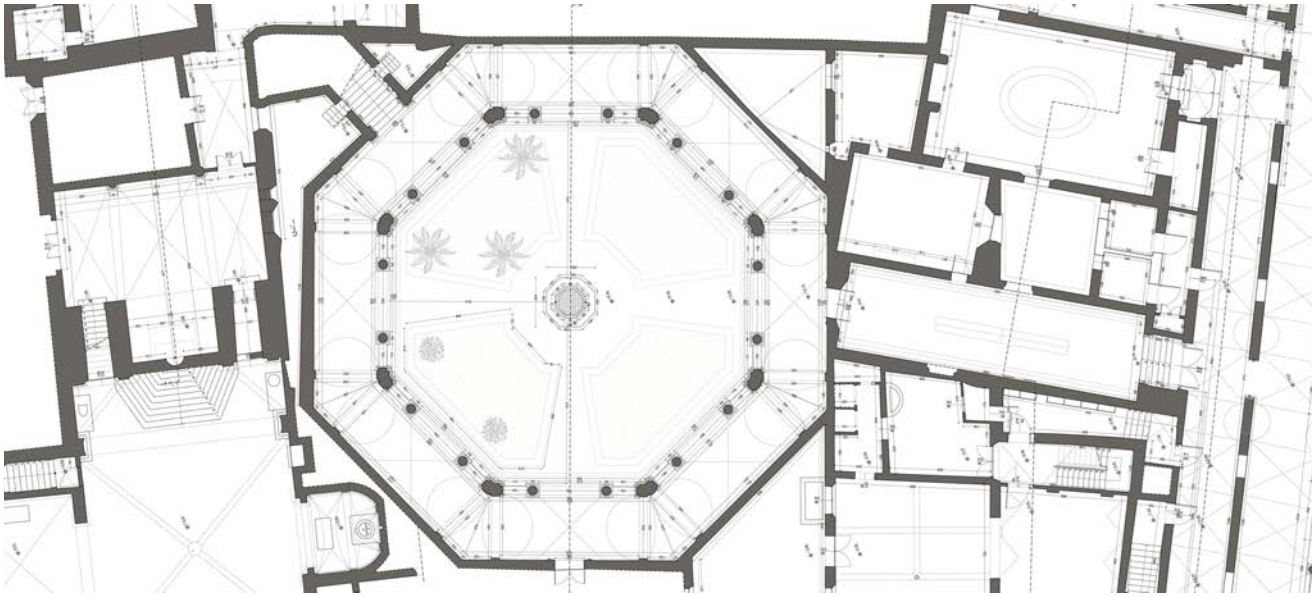

Fig. 8: Complex of San Michele in Bosco (Bologna), plan of the ground floor (1:50).
The survey campaign (still in progress) began in 2011 with a workshop called "Misurare il sacro", *Corso Integrato di Rilievo dell'Architettura I*, Department of Architecture, University of Ferrara (A.A. 2011-12, 2012-13_Prof. M. Incerti, Prof. U. Velo; 2013-14_Prof. M. Incerti, Prof. G. Lavoratti).

all'originale con l'esatto disegno, ed intaglio del sig. Giacopo Giovannini pittore bolognese... In Bologna per gli eredi d'Antonio Pisarri.

[47] Zanotti, G., Panfili, P., Carracci, L., Fabbri, G., & Fratta, D. (1776). *Il claustro di San Michele in Bosco di Bologna de' monaci Olivetani dipinto dal famoso Lodovico Carracci e da altri eccellenti maestri usciti dalla sua scuola descritto ed illustrato da Giampietro Cavazzoni Zanotti con la compiuta serie delle dipinture diligentemente disegnate, ed incise in rame,* In Bologna impresso nelle Stampe dalla Volpe.

[48] By interactive we mean "the development of the relationship between person and computer, and with other via the computer."

information on the subject, episode, artist, date of creation, source textual, technical, conservation status, source of the reproductions and iconographic comparisons. It is furthermore possible to use the next levels for more information on the author or the other items on the card.

mind, in fact, the digital models should not arise only as replicas, virtual copies of the object providing information about its history and its architectural layout: the critic reading of the spatial values to get across becomes the engine for the creation of the virtual environment.

In this sense the spatial value of the cloister is closely tied, in the conception of its creators, to

Fig. 9: The Carracci cloister (Bologna), navigation devices for multimedia contents.
The digital model was used in the first few perceptive simulations on the ancient claustrum by adding images of the frescoes surveyed by Zanotti before they disappeared. 3D model by S. Iurilli.

5. *Designing interactivity through restoring lost elements and ideal viewpoints*

The operations of critic survey and historical research on the cloister highlighted some essential points to consider in a graphic synthesis operation and virtual "storytelling". The visit to the cloister today, yet striking, hides the eye of the visitor some aspects that were rather essential in its conception and realization. Its original spatial qualities are still evident, but the pictorial treatment of the surfaces is just enough perceivable, invalidating an effective and satisfying reading of the whole space.

These perceptual aspects have to be seriously considered when designing a virtual reconstruction of the cloister: therefore, in a first phase of the research, we paid a specific attention to the concept design of the model. With this in

some ideal points of view and privileged paths. These, by binding to specific views of the cycles of paintings on the porch walls, amplify their meaning in fact transforming a simple *promenade* in a narrative experience, not devoid of religious and symbolic implications. Our goal is to bring out these issues through the virtual reconstruction, and then to offer the visitor the opportunity to choose from different deepening approaches.

5.1. The model and the organization of informations

In the attempt to effectively describe the space of the cloister we choose to start with a "study model", a mathematical surface model aimed to describe the ideal geometry of the object (a perfect, regular octagon) leaving out the constructive irregularities evidenced by the survey. Using this synthetic model as a basis, only

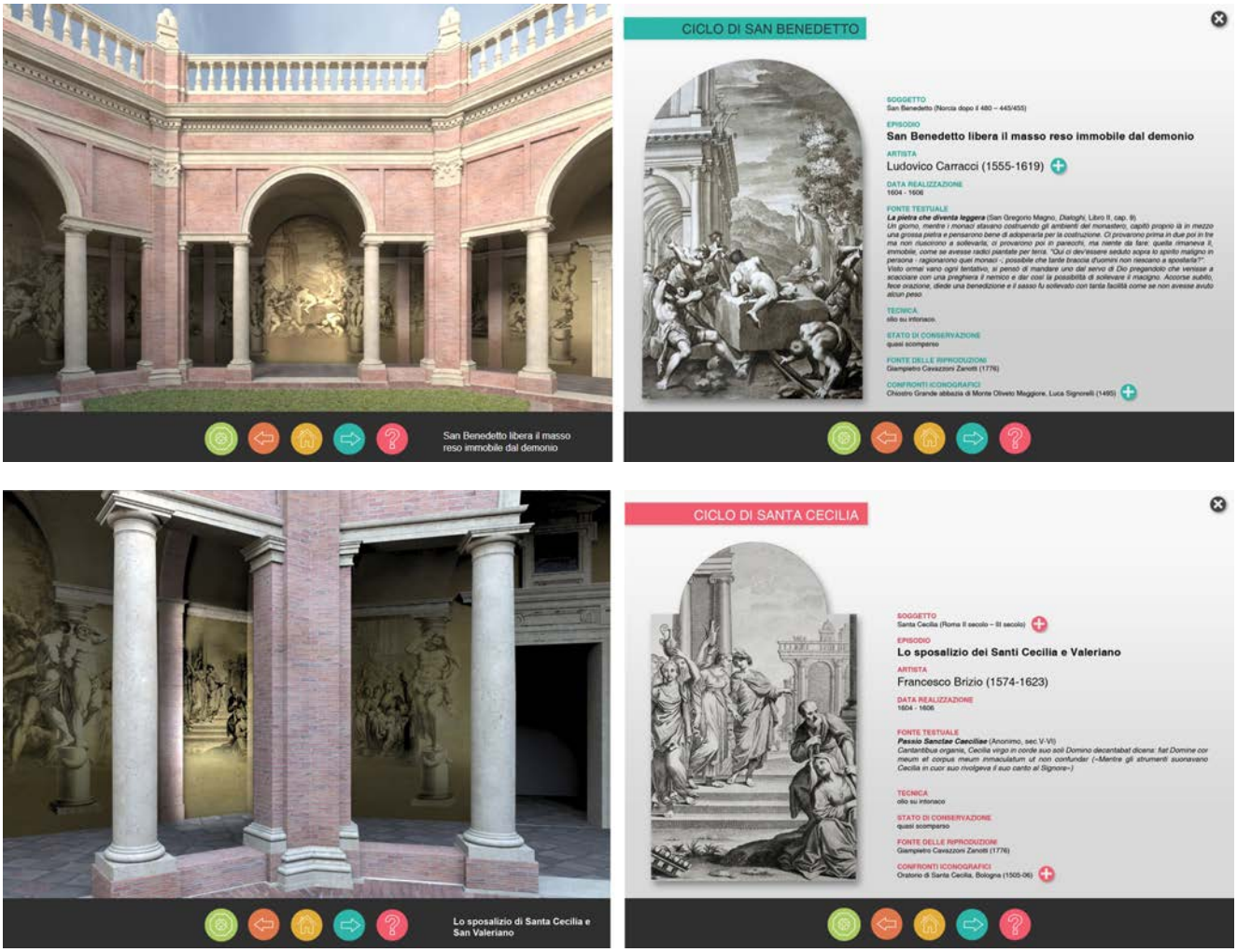

Fig. 10: The Carracci cloister (Bologna). Views of the explorable model and layout of the database records dedicated to the iconographic and textual sources: Cycle of St. Benedict (top) and Stories of Santa Cecilia (bottom).

comprising the essential architectural elements, we built up a numerical mesh model charachterized by a higher level of detail. This detail was obtained both with the addition of modeled geometries (on separate layers, to be used exclusively on pre-rendered sequences), both with the use of photographic textures derived from orthophotos and applied using baking techniques (low-poly model optimized for real-time rendering). On this basis, a first exploratory promenade through the porch ring was set up, to give back the spatial perception of the object, as it should appear at the time of its creation. The digital model was used for the first simulations on the ancient cloister, through a mapping process based on a reintegration of the paintings; this operation has been possible using some reproduction of the original paintings, patiently copied by Zanotti before their disappearance[49].

The cloister has not undergone substantial changes in the morphology over time, so it was possible to use the same model as a basis for the different chronological phases. The substantial changes occurred concerned, as already pointed out, the painted surfaces and the degradation of materials; the representation of the chronological evolution, therefore, has been entrusted to different sets of texture associated to the same basic model. In this framework we used a double register of images, the first obtained from the photographic textures of the current state, which include the degradation of the surfaces, the second coming from a cleanup and reconstruction

[49] Zanotti, G., Panfili, P., Carracci, L., Fabbri, G., & Fratta, D. (1776). *Op. cit.*

of the same, in order to credibly restore the perception of the cloister at the time of its creation.

An essential aspect concerns the construction of the critic informational database, which necessarily affects the structure of the VR model to achieve. The research data, not always homogeneous, have to merge into a complete artifact, free from "information gaps", in which the presence of multiple data in a single point of interest is seen as a benefit, and not as a lack.

One notable example concerns, once again, the representation of pictorial cycles, which state of preservation is currently not homogeneous, as some areas are better preserved than others. The drawings by Zanotti however provide a full documentation of the subjects and their location in the cloister, but without the color data. Furthermore we have some color reconstructions, unfortunately only available for a few episodes of the cycle of St. Benedict.

encourage a rapid and easy assimilation of the information transmitted; in this way, each user can choose how much time to devote to the visit, in relation to the level of interest.

5.2. Building, reconstruction, restoring. Actual spaces and lost perceptions

The project provides, in a second phase, the development of interactive applications which allow to virtually explore the cloister and extract further content from the model in a direct and intuitive way, through the use of immersive devices. In this regard, a sample VR was made, where the simple exploratory path is associated to a first interactive experience, with the ability for the user to virtually visit the cloister, view the paintings in their original location and access, in the logic previously expressed, in-depth multi-level contents.

In this first phase the explorability of the

Fig. 11: The Carracci cloister (Bologna), Cross section by B. Moretti, M. Neri, A. Zattoni (*Tecniche della Rappresentazione II*, A.A. 2013-14, Prof. S. Iurilli, Prof. M. Incerti).

Our choice, however, was to employ this data, even if the information is only locally available: the color input, though partial, is indeed very powerful in influencing the imagination of the visitor, who may well derive from the virtual tour a general idea of the original vision of the cloister. For each painting frame, corresponding to an episode, a synthetic database record was set up. It can be activated by clicking on the associated painting: each record also contains additional levels of detail, related to the news about the authors, for example, or comparative analysis with different but thematically related artworks. The records are extremely synthetic, designed to

model is limited to two fixed paths, corresponding to the two cycles of paintings and their ideal viewpoints. The client also called for maximum compatibility and flexibility of the prototype [50], which is why we chose a multiplatform, hybrid output in HTML5.

The actual product is introduced by a short animated intro that, in a gradual fade-in effect, shows the walls of the porch enriched by the lost painted surfaces; in this way, there is already in

[50] Compatibility was required with both output devices (PCs, tablets, smartphones, with every browser installed), and platforms (mainly Apple iOS and Google Android).

the user before a suggestion, and it stimulates their curiosity to continue exploration. After the intro, we are introduced to the user interface, designed in a simple and intuitive way, this time with strong colors and a contemporary layout, in contrast to the traditional image of the subject. The virtual visiting path is based on two alternative itineraries, the first focused on the the cycle of St. Benedict, the second instead dedicated to the cycle of St. Cecilia; the choice of the topic takes place in the home screen, by clicking on the dedicated icon. The cycle of Saint Benedict is thought to be viewed from the center of the cloister according viewpoints placed frontally to the eight *serliane* that frame the paintings; the choice, therefore, has been to provide a VR point of view bound, a 360 degrees exploration of the cloister from its center that effectively reproduces this ideal point of view.

The cycle of Santa Cecilia, however, must be ideally viewed from a ring path with eight "staging points" on the corners of the octagon from which you can sight the small quadrants that contain the stories. We decided, therefore, to create a route with multiple viewpoints, explorable by clicking on a schematic map of the cloister marked by corresponding points, or moving in order from one point to another with the arrow keys.

The map-navigator of the cloister with the points of view is always present on the screen, and since each cycle is distinguished by its own color, so we always know, in exploration, where we are standing and what subject we are observing.

For the product assemblation we used Hype, a graphical editor able to trigger custom animations, scene transitions, sounds, or JavaScript functions in response to actions like mouse clicks, touch events, specific times, or document events, all inside of a completely self-built GUI. One of the most interesting features is the possibility to obtain a product with a responsive interface, able to adapt the size of the graphic elements to the display of the output device. Where necessary you can intervene in the generated code for fine-tuning adjustments. The animated sequences were precalculated in Modo, and saved as a sequence of frames with a fixed resolution (1280x1024); in Hype, it was possible to associate the frames to a timeline, navigable forward and backward, thus turning them into explorable paths that you can "run" by clicking on the corresponding buttons.

At a later stage the model, already prepared and optimized for real-time, will be processed in Unity 3d to build a higher level of interactivity, with free exploration paths inside the cloister.

Fig. 12: The Carracci cloister (Bologna). Photo by F. Cappelli

6. Conclusions

In the cases presented above, the Schifanoia Museum and the Carracci Cloister digital tools can really innovate modes of representation, communication and dissemination of layered complex content, which is often difficult to convey. The model's quality plays a central role in the communication of the architectural, historical and cultural content. The narrative, conducted on philologically based tracks, can therefore return not only the architectural form but also its decorative details too as in the minds of the authors of the project.

In Ferrara, in anticipation of the full reopening of the Schifanoia Museum, after the forced closure due to the earthquake, the organisational body Civic Museums of Ancient Art wanted to take the opportunity to enhance the experience of visitors with new communication strategies and support that made the museum experience more complete and satisfactory. On the other hand, in Bologna, the octagonal cloister still awaits to be included in the new tourist routes (Red City bus) that lead dozens of tourists on the panoramic square on a daily basis.

Tab. 1

	Schifanoia_*step 1*	Schifanoia_*step 2*	Schifanoia_*step 3*	Schifanoia_*step 4*	Carracci cloister
Content	Historical VM	Art Vm	Art Vm	Art Vm	Art Vm
Duration	Permanent Vm	Permanent Vm	Permanent Vm	Permanent Vm	Permanent Vm
Communication	Narration	Narration	Exposition	Exposition	Exposition
Interaction technology:	Non Interactive Vm (future desktop device interaction)	Desktop device interaction Vm	Desktop device interaction Vm	Desktop device interaction Vm	Desktop device interaction Vm
Level of immersion	Non-Immersive Vm[1]	Non-Immersive Vm	Non Immersive Vm	Future immersive Vm	Non Immersive Vm (future immersive)
Format	Non distributed Vm	Non distributed Vm	Non distributed Vm	Non distributed Vm	Non distributed Vm
Scope	Enhancement of visitor experience	Enhancement of visitor experience t	Enhancement of visitor experience Research	Enhancement of visitor experience	Enhancement of visitor experience Research
Sustainability	Re-Usable Vm	Re-Usable Vm	Re-Usable Vm	Re-Usable Vm	Re-Usable Vm
See more at: http://www.v-must.net/virtual-museums					

Finally, it is possible to point out that a correct and far-sighted planning of multimedia products, through appropriate references (Tab.1),[51] can create relevant links with other monuments, inviting tourists to visit other places, within and beyond the borders of the town. You can foreground, in this regard, the museum of the Marfisa building and other buildings widely quoted in the movie about the historic Palazzo Schifanoia, such as the oratory of Santa Cecilia in Bologna where there is an extraordinary cycle of frescoes on the stories of the saint, by Francesco Francia, Lorenzo Costa, Amico Aspertini and other artists.

It is necessary for each individual entity, all tourist and non-tourist sectors, to identify synergies that can reactivate virtuous economic circuits: the development of innovative museum systems is capable of benefitting cities (and regions) by re-launching tourist attractions that widen the chances of the individual structures and the entire museum system. [52]

[51] For Interactive VM the following definition is commonly accepted :"A Virtual Museum communicating the content by means of immersive technology, making the user feeling to be immersed in a surrounding environment, shutting out sensations from the 'real world'. From user perspective, as it emerged from Archeovirtual 2011 evaluation [see Deliverable 7.2], level of immersion is connected not only with the *technology used*, but also with the type of *communication used* which contributes to create an experience [narrative virtual museum] and [dramatization-based virtual museum]. It includes [high-immersion Virtual Museum] and [low-immersion Virtual Museum] (http://www.v-must.net/virtual-museums/glossary).
According to this definition, therefore, the products we presented (Tab.1) do not have the characteristics to be defined "immersive" in the network V-MURST. In our opinion, however, the products (in particular the third, fourth and fifth) stimulate perceptual aspects that are attributable, at least partially, to the interactive dimension, even if not yet immersive.

[52] Manuela Incerti is the author of paragraphs: 1, 2, 2.1, 2.2, 2.3, 2.4, 4, 4.1, 4.2: Stefania Iurilli is the author of paragraphs: 3, 3.1, 3.2, 3.3, 5, 5.1, 5.2. The conclusions have been written by both authors.

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