AR&AI classification and 3D analysis

Immersive Technologies for the Museum of the Charterhouse of Calci

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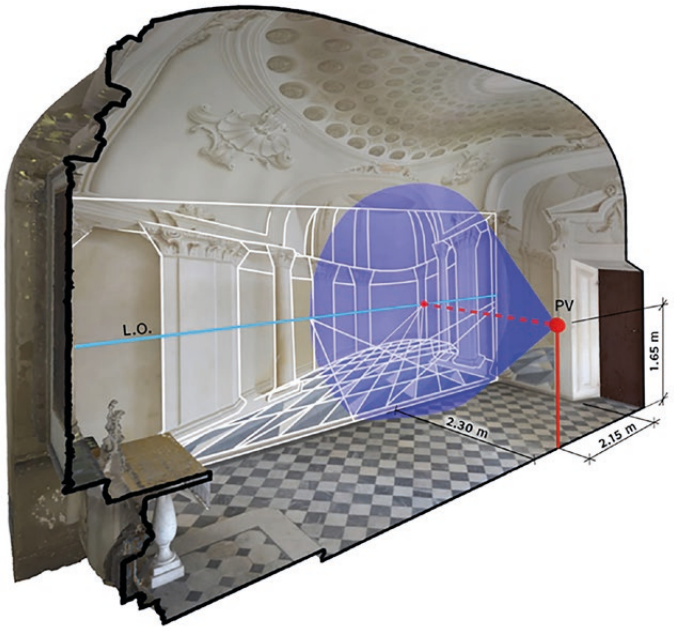
Abstract

The Charterhouse of Pisa in Calci, one of the most important monasteries in Tuscany, now houses two important museums: the Natural History Museum of the University of Pisa and the National Museum of the Monumental Charterhouse of Calci. While the Natural History Museum has recently enriched its collection by offering structured and differentiated visits based on user type, the offerings of the Museum of the Monumental Charterhouse are not sufficiently adequate to meet the great historical value of the complex. This contribution therefore presents the first results of a project aimed at enhancing visits to the National Museum of the Charterhouse using immersive technologies. The project envisages the definition of a new visit path, modifying the current path and integrating it with immersive experiences of video mapping, VR/AR, sound immersion, informative totems, audio–visual supports, and multisensory activities.

Keywords
Charterhouse of Calci, VR/AR, video mapping, 3D modeling, immersive experience.



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Introduction

Recent studies demonstrate how immersive technologies based on augmented, real, and mixed reality are currently and widely used in the fruition of cultural heritage (Bekele et al. 2018). In the field of fruition of monuments and museal spaces, these technologies provide solutions enabling patrons to view 3D digital models of cultural artifacts and to interact with them in a variety of ways, enhancing their involvement (Trunfio et al. 2021). Most of these applications enjoy continuous evolution in the fields of 3D digital survey, modeling, and graphics. AR applications, virtual reconstructions, video mapping, etc. are, in fact, widely used to enhance visiting experiences, as well as serving as tools for promotion and enhancement of cultural heritage. In Italy, there are several noteworthy cases, such as those of the Virtual Archaeological Museum of Herculaneum, the Egyptian Museum of Turin, and the National Archaeological Museum of Naples, the AR/VR applications at the Baths of Caracalla and the Ara Pacis in Rome, and the video mappings in the Imperial Forums in Rome, to name but a few.
This contribution intends to present the first results of a project aimed at enhancing the tour of the National Museum of the Monumental Charterhouse of Calci using immersive technologies. The project envisaged the definition of a new visit path, modifying the current one and integrating it with immersive experiences of video mapping, VR/AR, sound immersion, information totems, audio–visual supports, and multisensory activities.

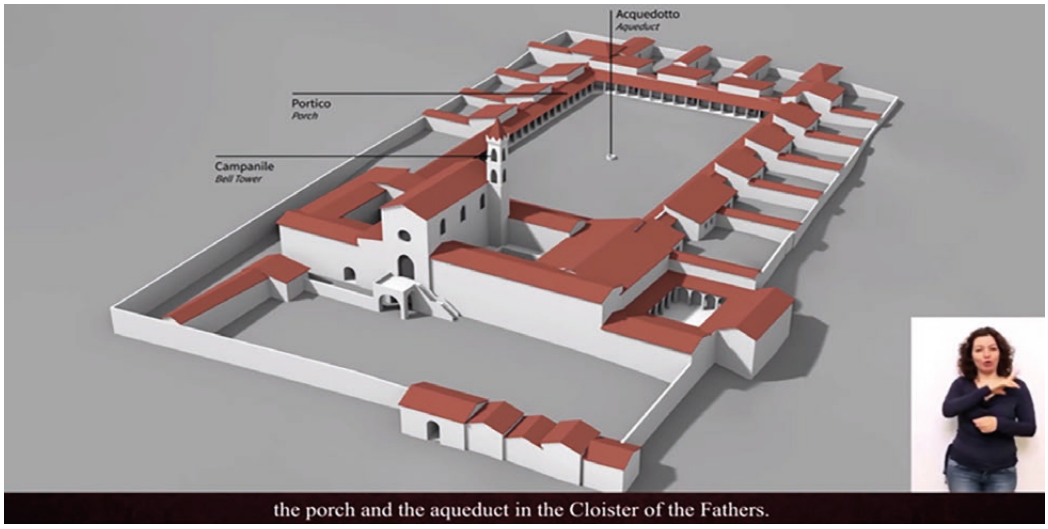

Fig. 1. Frame of the introductive video projected in the Chapel of San Sebastiano (elaborations by A. Fedeli).

The Case Study: the Museum of the Monumental Charterhouse of Calci

Founded in 1360 on the slopes of Monte Pisano, the Charterhouse of Pisa in Calci represents one of the most significant monasteries in Tuscany. The charterhouse is the result of several modifications and extensions documented from its founding to the end of the 18th century and reflects the strict rules of the Carthusian Order [Piombanti 1884; Manghi 1911, Giusti & Lazzarini 1993]. It represents an ideal semi–urban 'village' in which hermit and cenobitic life are harmoniously blended. The *correria*, the *coenobium*, and the *desertum* are distributed following the idea of a gradual separation of the fathers from the common life. The large Courtyard of Honor separates the entrance and the *correria* from the *coenobium* and the church; this is placed in a central position emphasizing the compositional axis of the entire complex. On the southern side of the church, there are spaces dedicated to the life of the religious community (minor cloisters, refectory, *colloquium*, and chapter room), the noble guesthouse, and the grand ducal apartments. The northern side boasts several buildings originally used for agricultural activities. The Great Cloister with the cells of Fathers completes the system on the eastern side.
In 1962 the religious community left the Charterhouse of Calci. Since 1972, the complex has hosted the National Museum of the Monumental Charterhouse of Calci, under the control of

the Ministry of Culture and, since 1978, the Natural History Museum of the University of Pisa. The National Museum of the Monumental Charterhouse offers visits to the monumental spaces of the monastery: the church, the refectory, the chapter room, the noble guesthouse, the grand ducal apartments, the pharmacy, and one of the fathers' cells. The Natural History Museum occupies most of the service buildings on the northern side of the complex.
The Natural History Museum has recently enriched its collection and provides customized visits based on user type; meanwhile, the current offerings of the Museum of the Monumental Charterhouse aren't sufficiently adequate to the great historical value of the complex, presenting critical issues: some of the most important spaces are not visitable, visits are organized in staggered guided tours, and contents are oversimplified.
In 2018, the University of Pisa funded an interdisciplinary research project aimed at the conservation and enhancement of the Charterhouse [1]. More than 15 research units participated in the project, developing research in several fields, from historical analysis to specialized studies, such as those relating to fire prevention and accessibility.
As part of the project, in addition to a campaign of digital surveys and an in–depth historical study, the work we present here was developed, aimed at enhancing visits to the National Museum of the Charterhouse through immersive experiences of augmented and virtual reality.

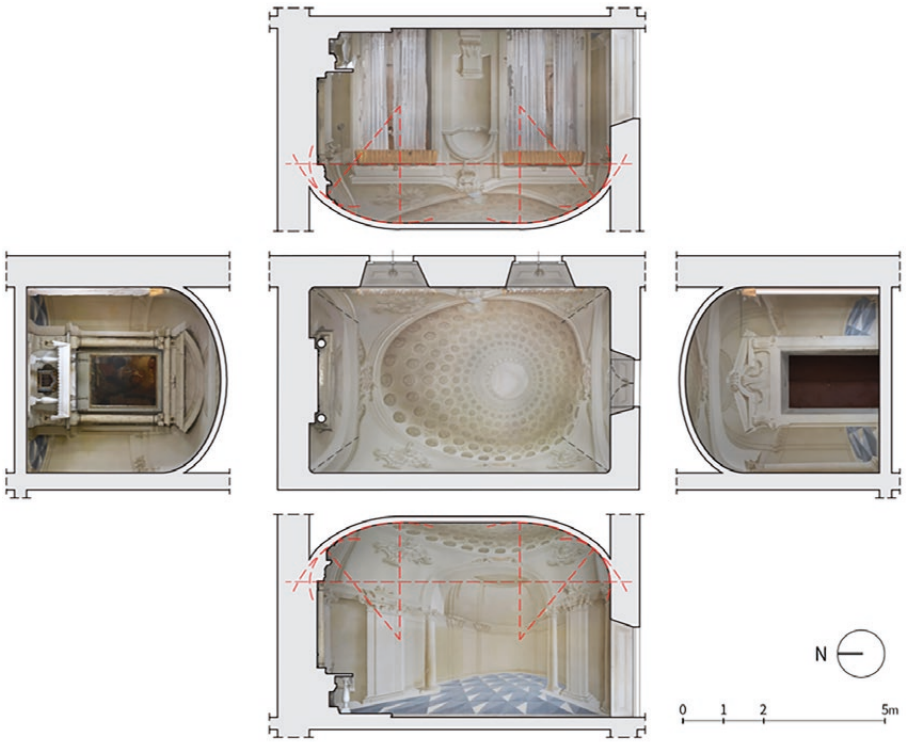

Fig. 2. Orthophotos of the frescoes in the Chapel of St. Anthony (elaborations by A. Fedeli).

The Project for a New Guided Tour of the Museum of the Charterhouse of Calci

The project was structured in two phases. The first concerned preliminary analysis for the development of the project. In addition to a study of the state of the art in the field of VR/AR use in museum environments, the tour path currently active in the museum was analyzed to highlight its problems and potential. The results of the in–depth historical research on the Charterhouse, developed under the coordination of Ewa Karwacka within the project funded by the University of Pisa, provided the definition of objectives and contents of the new visit tour. Specifically, it was decided to focus the tour on the monastery's evolutionary phases, on its most valuable decorative and architectural elements, and on the figures who, over time, had a prominent role in the history of the Charterhouse.
The second phase concerned the development of the project. The new guided tour is based on the current one but modifies its route, expanding the number of spaces that can be visited

and increasing the immersive involvement of visitors, who are left free to move along the path using an audio–video guide. The guide can be downloaded on tablets or smartphones and provides information on the spaces and their locations. Each space features an informative totem, and sound atmospheres are envisaged to amplify the sense of interaction.
Access is scheduled at set times for groups of people who, once their entrance tickets have been paid, can wait for their turn in the nearby San Sebastiano Chapel, appropriately rearranged for the projection of an introductory video on the history of the Charterhouse and the life of the monastic community.
All the spaces are classified into three categories based on the information that will be provided: art and architecture, monastic life, and mixed information. In some spaces, experiences of virtual and augmented reality, video mapping, or multisensorial experiences are provided. All the applications are accessible for deaf people as well, through a guide in Italian sign language.
Once the general visit program was defined, some of the augmented reality applications were developed: the introductory video projected in the Chapel of San Sebastiano, the virtual reality experience in the Chapel of Sant'Antonio, and that in the Cloister of the Chapter [2].
For the development of the applications, realistic 3D models were created on the basis of the results of the surveys carried out with LIDAR and 3D photogrammetric methodology by the ASTRO Laboratory within the activities of the project funded by the University of Pisa. Models were developed with the open–source software Blender. The informative texts, based on the original results of the historical research, were processed with Audacity, a software for editing and audio recording. The final processing was developed in graphic animation software including Adobe After Effects for the introductory video in the Chapel of San Sebastiano, and Unreal Engine for the immersive experiences in the Chapel of Sant'Antonio and in the Cloister of the Chapter.

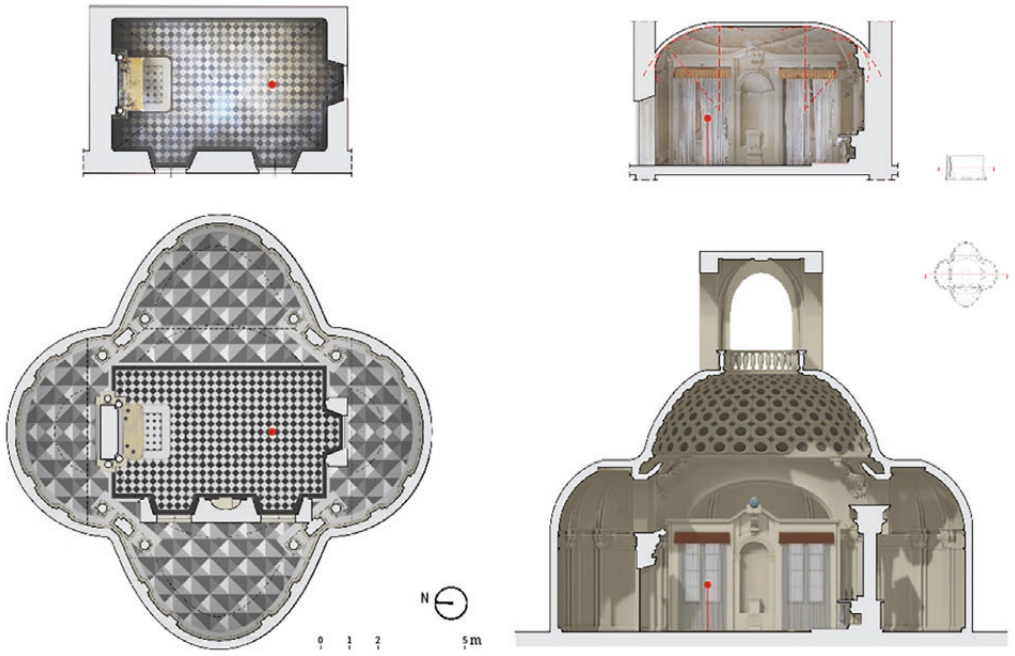

Fig. 3. Comparison between real space – on the top – and illusory one – on the bottom – in the Chapel of Sant'Antonio. Plan and longitudinal section (elaborations by A. Fedeli).

Immersive Experiences at the Museum of the Charterhouse of Calci

The first digital application developed was the introductory video projected in the Chapel of San Sebastiano for visitors waiting for entry. The historical research developed in the project of the University of Pisa identified, in chronological order, the most significant events that affected the Charterhouse from the day of its founding to today. The video presents a graphic animation of 3D models that reproduce an external view of the various construction phases of the complex. Information pop–ups superimposed on the video help to point out the buildings as they are being described in Italian by the narrator voice. Subtitles scroll

for the translation of the text into various languages; a small panel in the lower corner of the screen is dedicated to the video guide in Italian Sign Language for deaf visitors (fig. 1).
The second application concerns the experience of virtual reality in the chapel of Sant'Antonio, characterized by the quadraturist frescoes by Pasquale Cioffo, a Neapolitan painter very active in Pisa in the second half of the 18th century. The experience focuses on quadraturist painting techniques, explaining the geometric principles underlying the representation and providing a 3D reconstruction of the illusory space depicted (fig. in cover page), inside which the visitor is immersed thanks to the use of a VR headset. Wearing the headset, visitors find themselves inside a high–resolution 3D reconstruction of the real environment, created thanks to 3D photogrammetry techniques (fig. 2); the narrator voice explains what is being observed. Subsequently, the real environment changes and the reconstruction of the illusory space imagined by Cioffo appears (fig. 3). The story then focuses on the optical phenomenon of anamorphosis, found on one of the sides of the chapel.
The last application is the virtual reality of the Cloister of the Chapter, also to be experienced with a VR headset. In this case, the viewer is immersed in virtual spaces that depict the layout of the cloister in the most important historical phases; a narrator voice accompanies the visitor during the experience. The development of the application required a preliminary reconstruction of the 3D models that describe the various evolutionary phases.

Conclusions

The project aimed to investigate the potential in the application of new AR/VR technologies to the specific case of the Charterhouse of Pisa in Calci. This work was also an opportunity to study a communication strategy for the results of the research project funded by the University of Pisa with particular reference to that of the historical/critical study. The first results obtained in this phase are functional to the search for funding for the realization of the project as a whole and of the specific applications.

Notes

[1] The research is part of the biannual research project "Studi conoscitivi e ricerche per la conservazione e la valorizzazione del Complesso della Certosa di Calci e dei suoi Poli Museali" financed by the University of Pisa in 2018 and 2019, coordinated by M.G. Bevilacqua. The authors wish to thank Ewa Karwacka, Elisabetta Pozzobon and Stefano Aiello, director of the National Museum of the Charterhouse of Calci, for their support and collaboration.

[2] Video demonstrations of the applications are available at the following links: https://www.youtube.com/watch?v=haLQXXsLZ_k (Chapel of San Sebastiano), https://www.youtube.com/watch?v=pPZuzoBbaRQ (Chapel of Sant'Antonio), https://www.youtube.com/watch?v=f4vtJ0BrqMw (Cloister of the Chapter).

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