Management and Dissemination for Dismissed Religious Architecture. An Approach Fusing HBIM and Gamification

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Abstract. Theories, techniques, and technologies from the field of gaming and edutainment are now gradually pervading AEC (Architecture, Engineering and Construction) industry. This contribution highlights the potential within the integration between BIM models and real-time game engines, for the management and dissemination of the historical architectural heritage. This is the purpose behind the experimentation carried out on the Complex of Santa della Pace, located in the historical center of Castellammare di Stabia (in the province of Naples, Italy), detailed in this paper. It was aimed to the construction of a HBIM model based on an integrated digital survey, exploring its possible interactions in a VR-enjoyable, serious game-based informative communication: the main requirement of the model was to fulfill the need for transmission of interdisciplinary information, structured in various interactive routes and representation scales, in order to share the historical memory of a complex scenario to different typologies of users, from professionals to common virtual tourists.

Keywords: Cultural heritage · Parametric modeling · Virtual reality · Cultural game design

1 Introduction

The digital world demands a continuous technological evolution to the field of technical knowledge, as well as to other sectors. This pushes forward testing new possibilities of interaction with the so-called digital clone of buildings and architectural works: in particular, after understanding the potential that BIM-oriented modeling offers to conservation and knowledge of the cultural heritage [6, 9], it seems necessary to participate in the elaboration of more suitable modalities of informative communication, modifying both information structure, and the relationships between information and the geometric-formal component, within the boundaries of BIM philosophy. For this purpose, the usefulness – or even the necessity – of the recognition of limits and opportunities concerning the mutual support and necessity between information and geometry. In addition to that, the recent updates produced by changes in legislation [10] require the possibility to verify if modelling approaches designed for new constructions can be suitable for the management of the existing building stock as well. Moreover, one of the examined

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topics involves the possibility to use new digital infrastructures to diversify the fruition of information: that is, to introduce interactions with the object of virtualization – especially if it is characterized by architectural and historical value – with other purposes in addition to technical knowledge.

2 Methodological and Operational Notes for Augmented Fruition

On this basis, the contribution aims to highlight original possibilities of information management offered by object-oriented modeling, aimed to the multi-dimensional and multi-disciplinary description that characterizes existing historical buildings.

The main characteristic of the proposal is represented by the focus on structuring and populating a Common Data Environment (CDE), and on managing its information access. As it represents the vital core of a BIM collaborative system, it seems natural to investigate how it could also be meant for the interaction with the part of the model that would allow extrapolating information for non-technical users, who can enjoy the interaction with some of its information for purely cultural and touristic uses.

Moreover, considering uses and functions beyond the field of pure technical applications would help understanding if and how qualitative data harvesting and feedback from non-technical knowledge represent a further information input in the iterative system that is typical of BIM [1]. This is particularly relevant in cases, such as the one presented here, where technical knowledge takes advantage from sensitivity and focus on the context. On the other hand, because of their present rigidity toward data interpretation, several digital tools show problems in the integration of specific qualitative aspects in the firmly structured procedure offered by national and international standards. Hence, the purpose is to describe how information structure, while allowing different typology of users, can prevent potential ambiguity and non-unicity of information access, without undermining at the same time the essential principle of duality, and integrating it in a cloud-based parametric infrastructure, possibly usable in user-friendly interactive modalities, generating specific contents that keep their autonomy in the organization of information.

The chance to test and verify this premise was offered by the possibility to interact with the religious complex of Santa Maria della Pace, located in the city of Castellammare di Stabia, in the province of Naples (Italy), which includes a church within a courtyard building which changed several intended uses since the 16th century [4] (see Fig. 1). In its current state, the complex still has a rectangular floor plan, with a large courtyard in the style of the 16th century, with tuff walls. The complex is surrounded by three streets (south-west Largo Pace, south-east Via Viviani, north-east S. Bartolomeo alley) and is adjacent to other religious structures, abandoned as well, at north-west. The structure of the monastery appears to be unchanged, if compared to its state at the foundation of the Carmelite Monastery of Santa Maria della Pace in 1525, at the behest of the Stabian *Universitas* (the ancient city), in the place marked with the toponym *in capite portus.*

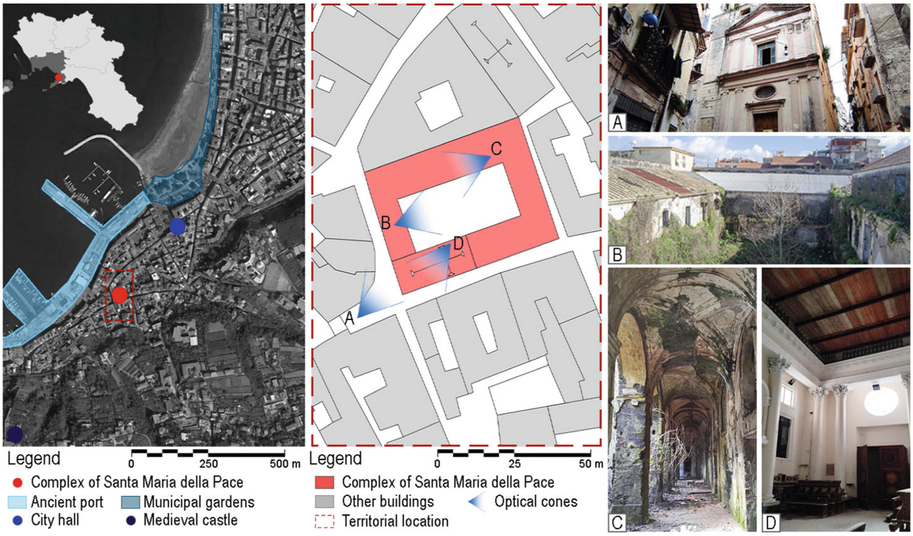

Fig. 1. Framing of the area and site of the Gaming-HBIM experimentation: the Church and Monastery of Santa Maria della Pace in the historic center of Castellammare di Stabia.

After the completion in 1561, the complex was compounded by the adjacent church, built in 1587; unlike the monastery, it has been subjected to several transformations and its current state derives from refurbishment works in 1820, which led to its reopening in 1900. According to documentary sources, the entrance to the complex was located in Largo Pace and consisted in a piperno portal, now walled up yet still visible, which led to a vast covered atrium with a vaulted peristyle, sustained by columns and archs leading to the garden, where a small pool of water. Several spaces opened along the corridors, among them were the kitchen and the refectory: wide stairs on vault buttresses, with landings sustained by diminished Catalan archs, were located in the corners and led to the upper floors, used as dormitories. The first floor overlooked – and overlooks – the covering of the porch, while on the second floor there was a balcony with a continuous railing on the four sides.

The succession of intended uses, started with the suppression of religious orders, included the use as a school in 1877, as demonstrated by the project for a kindergarten that involved part of the internal courtyard and the closure of some of its archs; then, it was designated for institutional use in 1881, first as a local magistrate's court and then as an office of Public Safety Guards; finally, it became a primary school in the 20th century. In the postwar period, the site was eventually occupied by homeless people. This condition has determined a progressive decay of the complex, despite several attempts of restoration over the whole 20th century, stimulated by the key role of the site as a gathering place for the community of the historical center [7]. However, the social value of the site progressively decreased over time until 2009, when the beams of the roof truss were smuggled in an act of vandalism. The whole building has been condemned since then, and in 2018 this state of abandonment led to the collapse of part of a slab of the church. These characteristics, together with the huge information base showing both the value and the historical and social relevance, as well as the compositional and constructional of the building, led to consider this case study as emblematic for the development of knowledge and modelling phases, as paradigmatic for cloud-based information organization in a multi-user logic. The digital clone produced a multi-scalar and multi-disciplinary database from the four main phases – data gathering, processing, output and model sharing – constituting a support for the description of the building, aimed to both synchronous and asynchronous augmented knowledge. The former is meant for technical knowledge, to regulate and organize information in order to realize design action; the latter is considered as an information base made available for non-technical users as well.

3 Gaming-HBIM Multi-scalar Model for Knowledge, Management and Virtual Fruition

The historical and architectural value of the complex of Santa Maria della Pace, covered by the transformations it received over time, motivated the construction of a Gaming-HBIM multi-scalar model of knowledge, management and virtual fruition, in order to share the historical memory of a complex scenario to different typologies of users, ranging from professionals to common virtual tourism users.

Based on new modalities of digital storage provided by the paradigm of object-oriented parametric modelling, and on new possibilities for the virtual representation of the building, the proposed model of organization and communication of its associated information (metadata) allows an interaction with the digital twin characterized by a wide conformational and typological variety, which cannot be easily standardized.

The starting point for the structure of a virtual model that included the different evolutionary phases of the historical building was represented by a consolidated methodology of digital survey and integrated representation of information (see Fig. 1). The main sources for the latter have been obtained from an in-depth research and critical analysis of existing technical documents, and archival and iconographic records. In particular, the digital survey has been performed by integrating different reality-based approaches. Image-based techniques, specifically terrestrial and aerial photogrammetry, were used for the survey of elevations and roofs.

The investigated complex is located in the historical center, so the small dimensions of the adjacent spaces do not allow an optimal terrestrial photographic coverage of the external fronts. In order to overcome this problem, photographic sets were acquired with a Reflex Nikon D7000 camera; its optical axis is perpendicular on the horizontal plane and slanted on the vertical plane, and this characteristic leads to disadvantageous angles of incidence when surveying particularly tall buildings. Spatial data gathering has been integrated by photographic acquisitions performed through a RPA, making use of a DJI Spark drone. This tool can take both nadir shots, aimed to obtain detailed images of the roofs, and shots in a longitudinal and/or circular direction with camera axis by 30° approx., meant for the survey of the main surfaces of the cloister, or of elements and floors located at greater heights, such as the bell tower (Fig. 2).

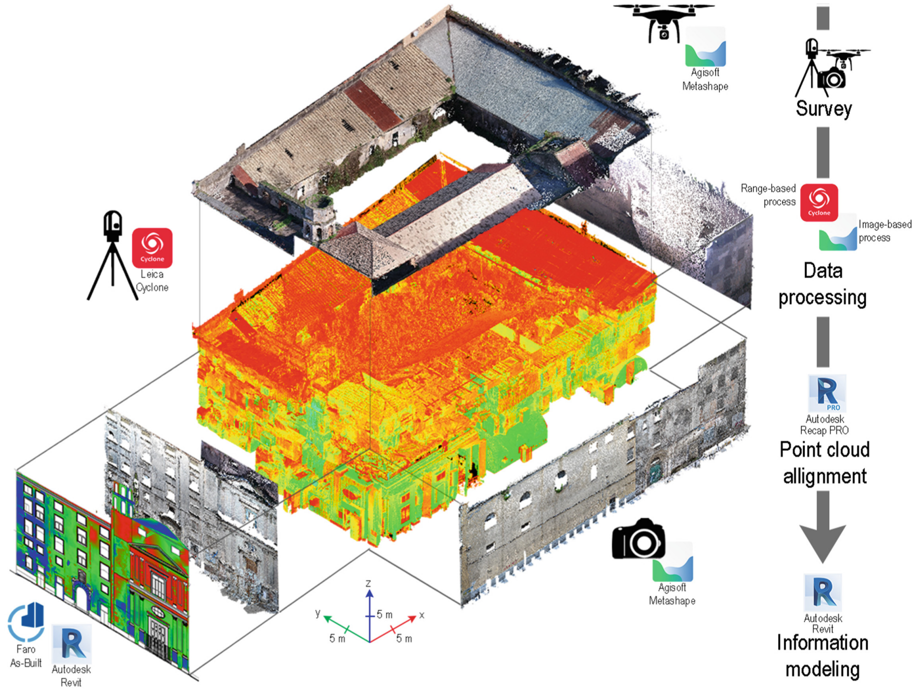

Fig. 2. Description of the integrated digital survey techniques for the reconstruction of the experimentation site.

Finally, in order to achieve a more in-depth knowledge of the internal spaces of the Complex, the output from photogrammetry has been integrated with a range-based acquisition from TLS systems, using a 3D Leica BLK360 laser scanner, in order to provide metric accuracy and overcome photogrammetric difficulties deriving from lighting conditions. Spatial data acquisition phases represented the first steps of the methodological process, adopted to generate an As-Is parametric model of the Complex (see Fig. 1) and originated from the integration of CAD to BIM approach – which supports the preliminary definition of the geometry of the parametric components of the model – with Capture/Lidar data to BIM [3], which allowed achieving the Level of Accuracy (LOA) of the BIM model and integrating information gaps related to the level of detail needed for a virtual travel through the construction phases of the building. In particular, historical records allowed individuating functions related to two main historical periods, that is the 16th and 19th century, and modelling alternative configurations of the site, overlapping them to its current state. Elements whose age is unknown have been graphically edited, and parameters have been integrated with comments and hypertext links that enrich the model with additional information units. These information units seem useful for the description of the native functions and evolutions of the building and of its conservation state, detailing its decay conditions by characterizing an adaptive metric model from discretized textures within the photomaps obtained from photogrammetric survey (Fig. 3).

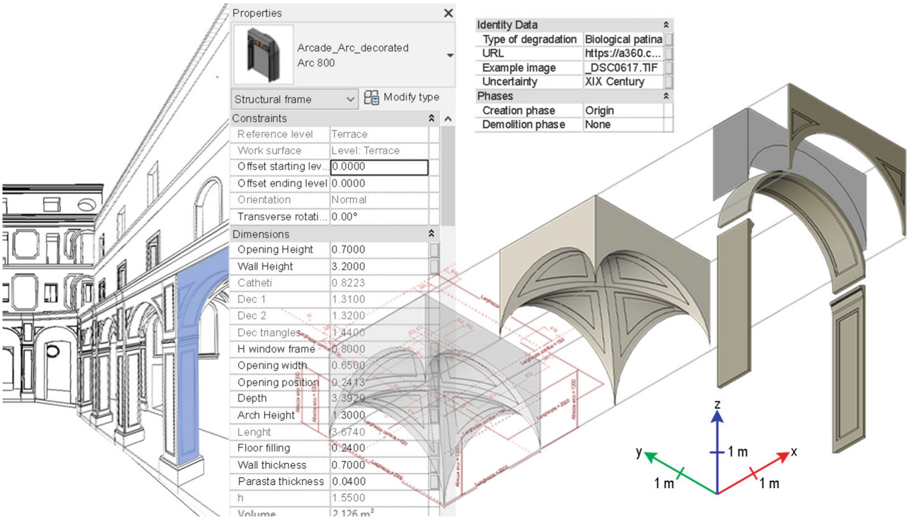

Fig. 3. Synthesis framework of the parametric-digital reconstruction process and characterization of the instance and type parameters for architectural elements of the trial site.

A greater focus has been given to the Porch area, representing the most distinctive and functional element in the complex; above all, it is particularly relevant in relation to the lines of reasoning developed in the modelling and in the integration of data deriving from the digitization of the project for the transformation of part of the Complex into a kindergarten, in 1877.

This structure of the geometric-informative component of the model is particularly suitable to fulfill the increasing demand for accessibility and interaction with information, coming from the different typologies of users. This requires experimenting new forms of visualization, and integration between game engines with BIM systems, in order to make use of contents in a virtual and immersive modality [11].

Several platforms have been tested for this purpose, and finally an optimized solution has been structured for this case study, adopting an integration between Autodesk A360 platform and the interactive game engine named Unreal Engine. The digital environment has been set on the first-person view template, in order to adapt to the VR [2] visualization of models related to the different construction phases of the building, characterized by different information levels (see Fig. 4). Technical-descriptive data have been recalled in Unreal through widget design, specifying Interaction distance and Interaction source, set on Center screen. Two different types of widgets have been programmed – pop-up and interactive – structured in blueprint visual scripting by Unreal Engine, by sectoring information as amusement, edutainment [5], or as data for the management of the building by professionals. This facilitates the interaction with the platform by allowing graphical customization, adding images, texts or 'buttons', setting performable actions through programming codes. Specifically, widgets related to information panels belong to the static type and contain general data on the complex and the functional diagrams of each area.

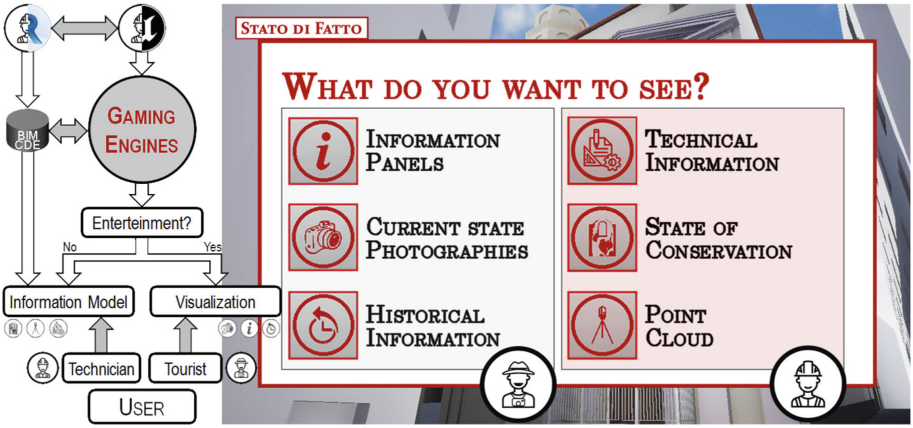

Fig. 4. Descriptive methodological scheme of the separation of information associated with the Game-H-Bim model to different types of users, from professionals to ordinary virtual tourists.

On the other hand, widgets related to historical data have been programmed to view the phases represented in the BIM model, allowing the exploration of different periods of the building, supported by the photographic and documentary archive, which surrogates details non included in the model. Finally, technical data can be consulted thanks to the direct 'queribility' of the elements provided by the integration of Autodesk A360 (see Fig. 5).

Fig. 5. Summary picture of the parametric-digital reconstruction process and virtual use of the complex using widgets structured in visual scripting blueprints.

The possibility to navigate freely in an immersive virtual tour through nested windows, and to interact with Cloud-BIM historical-informative parametric elements within the principle of duality, allows understanding the spatiality and the nature of the various parts of the architectural work, in order to preserve its historical record and achieve an optimal management and valorization of the building [8].

4 Conclusions and Future Developments

The contribution highlights the experimentation of an integration of BIM models with game engines, addressing both specialized professionals and common users, outlining new virtual reality – and, hopefully, augmented reality – fruitions. In this way, entertainment functions are added to technical data: the result is an immersive virtual experience that can lead to the direct involvement of the whole community, restoring value and 'accessibility' for the dismissed and/or decayed cultural heritage. Some topics have not been discussed in this article, such as the implementation of interoperability with social network platforms will be object of future developments. The results achieved to this point open the way for the creation of specialized figures, such as the BIM Gamer, who might support the BIM Specialist by working on data optimization and validation within game engines, in direct connection with BIM digital models.

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