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The scan-to-BIM process for the enhancement of architectural heritage. The church of San Giovannello in Gerace.

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Abstract

The study we present is related to a scan-to-BIM process carried out on the Romanesque-Byzantine church of San Giovannello, located in the historic center of Gerace (Reggio Calabria, Italy). The work is part of a broader research project, called GENESIS (acronym for Seismic risk management for the tourist enhancement of the historic centers of Southern Italy), promoted by various research groups from numerous Italian universities and aimed at managing seismic risk for the tourist enhancement of the historic centers of Southern Italy. The scan to BIM process constitutes the central phase of a flow of actions that begins with the study of historical sources, proceeds with the analysis of the current conditions of the buildings and concludes with a series of design proposals aimed both at mitigating the consequences of any actions seismic, and the implementation of innovative systems for remote and in-person use (VR, AR). The proposed valorization strategy embraces different fields: it develops starting from the historical knowledge of the building, rests on the solid scientific foundations of the instrumental survey, and it exploits the information coordination potential offered by BIM-based methodology and tools. Finally, the communicative aspect involves both the morphology, identifying the underlying geometric structure, and the iconological and iconographic aspects.

Keywords

Scan to BIM, Church of San Giovannello in Gerace, Church of San Francesco in Gerace, HBIM, Seismic risk management, Heritage enhancement.

1. Introduction

The presented study describes a scan-to-BIM process relating to the Romanesque-Byzantine church of San Giovannello, located in the historic center of Gerace (Reggio Calabria). The work is part of a larger research project (GENESIS - GEstioNE del rischio SISmico per la valorizzazione turistico dei centri storico del Mezzogiorno), whose objective is to offer support for the safe and aware use of cultural heritage, starting from the knowledge of its history and characteristics, and to improve the methods of use through innovative forms of management. In this project, the studies carried out in different fields are inserted into an IT platform capable of collecting the investigations carried out at different levels of accuracy (from the territorial and urban scale to that of individual artefacts), of simulating

damage scenarios useful for managing emergencies, of making access to information available by promoting new ways of use based on the renewal of the offer and the valorization of new tourist destinations.

The research group of the Mediterranean University of Reggio Calabria, is investigating on an urban scale the historic center of Gerace, a medieval village in the province of Reggio Calabria and, more specifically, the monumental complex of S. Francesco and the small church of S. Giovannello, located in the so-called "square of the three churches" (Figure 1). The structural safety conditions are the basis of a stable and sustainable development based on the tourist use of the Calabrian territory, unfortunately characterized by a high seismic risk. The project, therefore, represents an opportunity to aim at the conservation, enhancement, and use of the heritage of Gerace and to experiment with a good practice to export to other similar contexts.

The objectives, in detail, are:

- verify the static safety and vulnerability of the two monuments.
- identify suitable systems to improve their behaviour in the event of an earthquake.
- define new methodologies for the protection, safeguard, and conservation, developing technologies useful for the correct management/conservation of the historical-cultural heritage;
- provide a reference to companies operating in the sector of restoration and safety of historic-monumental buildings;
- enable multi-level access to information: guided tours, thematic insights, direct access to sources, development of innovative systems for remote and face-to-face use (VR, AR).

This last point, in particular, will be able to promote the attractiveness and competitiveness of tourism and culture according to the objectives indicated by the Strategic Plan for Tourism 2017-2022 of the Ministry of Cultural Heritage and Activities, as it promotes new ways of enjoying the area based on the renewal and expansion of the offer.

In this scenario, as we will see later, the scan to BIM process represents the crucial phase of a path that allows the digital model to be associated with a multilevel system of information that can be used for the purposes indicated above. The modeling, based on the semantic decomposition of the architectural organism, facilitated the coding and transmission of information through the IFC format, also thanks to the small size and recognizability of the typological elements that characterize the church of San Giovannello.

2. On the restoration of S. Giovannello

In September 1961, a restoration and consolidation project for the Church of S. Giovannello in Gerace was financed by the Cassa per il Mezzogiorno within the implementation program for the 1960-1961 financial year for a project amount of £ 3,000,000. At that time, the place of worship, hypothetical and without flooring, had evident vertical structural lesions in the surrounding walls. The project included consolidation of the walls that were damaged in several places with consequent repainting of the plaster, restoration of the roof of the hall, excavation of an embankment in front of the entrance portal, reopening of the single-lancet windows and portals, as well as specific interventions for drainage and protection of the walls from rising damp. The execution of the works, to be completed within eight months from the approval of the project, is directed by the Superintendent Architect Paolo Paolini of the Superintendence of Monuments and Galleries for Calabria. A subsequent variant project is approved during the works following some important on-site checks. During the excavation works in the church hall, at a depth of 1.50 m, some burials on the ground are found, while close to the south wall, a deep cistern is located, which was later emptied. Traces of frescoes emerge during the plastering, leading to their consequent restoration. The identification of precise traces of the original roof level leads the designer to modify the project to reach the height necessary for the positioning of the trusses, reconstructing the surrounding masonry with the same traditional stone construction technique without creating the previously planned reinforced concrete curb (Paolini, 1969).

A subsequent restoration project was carried out in October 1997 by the Orthodox Archdiocese of Italy, which was the concessionaire of the building for its worship. The intervention consisted of the removal of a wall made of inconsistent stone masonry that blocked the opening located on the western façade, while at the same time, through

a “stitch and unstitch” operation, restoring the structural functionality of a stone arch above the reopened space. On the internal façade of the same wall, an isolated non-passing lesion is expected to be repaired (Minuto, 1993).

In November 2011, as part of the 2010-2013 Ordinary Programming of the Ministry of Cultural Heritage and Activities, the Superintendency for Architectural and Landscape Heritage for the Provinces of Reggio Calabria and Vibo Valentia financed further restoration work on the church following the widespread deterioration of the materials constituting the mortar for setting the masonry and the external finish due to the significant presence of nitrates in the lime-based mortar which promotes crumbling and subsequent detachment. Before starting work, a seismic safety assessment was carried out in accordance with OPCM 12.12.07. To eliminate the humidity present in the environment, the main cause of the deterioration, an aerated crawl space was created on which the existing flooring was relocated, and constant thermo-hygrometric monitoring was programmed. Finally, an electrical system was created to enhance the value of the architectural work (Naymo, 1998).

3. Scan-to-BIM process: general principles and applications to the case studies

The BIM methodology applied to historical heritage requires a different workflow compared to the one used for design. The process began with the documentation and survey phase and the subsequent encoding of the data in distinct formats, analog and digital. The information acquisition, in the dual qualitative and quantitative components, was carried out through different methods and techniques. The modeling approach was based on a semantic decomposition of the architectural organism (Attenni, Rossi, 2022), a key step, essential to associate and transmit data while minimizing ambiguities. It also facilitated the information encoding and transmission through the IFC format. In the case of San Giovannello, the small scale of the structure and the recognizable typological elements simplified the semantic breakdown phase.

Thus, the representation *as-is* involved the application of *reverse engineering* techniques (Lumini, 2023). The Scan-to-BIM process included these phases: (i) acquisition of point clouds, (ii) interpretation of the raw data, (iii) modeling, and (iv) semantic enrichment. The last step, in particular, represents a critical and strategic moment for the enhancement of cultural heritage, as it enables the association of information useful for preservation and management. This is because BIM is based on the construction of a language (the model). The models are made up of parametric components, self-aware of their architectural identity and their mutual semantic interactions (Bolognesi, Garagnani, 2018) (Figure 2).

The software Autodesk Revit was used for the three-dimensional reconstruction, and the coding was affected by its standard. From a geometric point of view, a "tracing" operation was used based on the point cloud guide; the result of this is the control of the coherence between what was detected and what is modelled. However, challenges were encountered in managing the geometric complexity and irregular surfaces, which required an interpretative effort. The information exchange is obtained through the use of the open format (IFC - Industry Foundation Classes). Since a scientific gap is recognized in the immaturity and lack of exhaustiveness of the IFC standards (Della Torre, Pili, 2020). In order to optimize the results and the movement of knowledge, we focused on key issues.

The first is the level of detail, consistent with the objectives. They are the generation of an archiving document intended for the exchange of information between the actors involved in the Genesis project and the insertion into its platform, where the model data supports the content of the survey sheets.

The second was the structuring of an adequate semantic dictionary in which each element was recognizable starting from appropriate nomenclature and functional and relational attributes. It was fundamental for the control and organization of the information process.

Another important element was the information content. It was structured on three orders of semantic classification to manage and share information on different levels of granularity:

- Building: the work in its entirety;
- Objects: the individual technological components;
- Point elements: parts for which a higher modeling detail was expected (e.g., materials).

The integration of data related to the states of conservation and interventions carried out during time was essential for improving knowledge and developing coherent and targeted strategies for heritage protection. These data are valuable for companies specialized in restoration and structural safety, as they provide direct access to technical documentation, conservation status, materials used, and potential structural weaknesses.

4. Enhancement of heritage with video projection techniques

The church of San Giovannello is practically invisible in the context in which it stands. The city of Gerace is full of architectural works of great value and impact, while San Giovannello, as the name indicates, is a small, bare, and austere church, located in a square where all the attention is for the magnificent medieval portal of the church of San Francesco (Figure 1 on the left).

However, the small church is a historically central testimony for the understanding of Italo-Gracian architecture in Calabria (Placanica, 2001; Minuto, 1985; Venditti, 1967). For this reason, it was analyzed and detected with digital techniques. The instrumental survey was conducted in September 2023 with the Faro Focus 3D X330 laser scanner. 5 internal and 12 external scans were performed. The precision of the instrument for each single scan is equal to UcRanging = 0.496 m, the point cloud that describes the church is formed by the alignment of the individual scans, therefore the precision of the land survey is lower than that of the instrument; nevertheless, the average value of the tensions reported in the alignment, given the nature of the walls and the irregularity of the path, is negligible. Furthermore, the terrestrial survey was integrated with a photogrammetric survey that used drone images. The two point clouds were aligned using the ReCap management software.

The complete restitution of the building, the creation of a real digital twin, allow for the experimentation and graphic verification of some communication strategies.

First of all, it was imagined to project, even if partially, the iconographic apparatus that covers the interior of the sacred architecture of Italo-Greek origin. The Byzantine decorative canon is strongly codified and represents a true and proper story that guided the faithful in the ascent towards the divine. The iconographic representation of the saints was widespread, and the faithful recognized the name of the saints from small codified details: the length of the beard, the color, or the receding hairline. The iconographic apparatus told the story of the saint by indicating the main moments and connecting, without the use of the written word, the human to the divine. The restitution could occur by reporting effigies of the saints that were supposed to be present inside the church, with video projection systems activated by a motion sensor.

The video projection system could be extended, for example, also to the representation of abstract elements, difficult to perceive during the use of the sacred space. One could imagine representing the complex system of tracing and proportioning of San Giovannello (Zanetto, 2017). To do this, a luminous grid could divide the space in the unit of measurement of the time, the Byzantine foot, and represent the modules used to proportion the width and depth of the church. The system could therefore show the visitor the founding traces, demonstrating the correspondence between the golden rectangle and the currently existing wall structures. (Figure 3)

5. Conclusions

In conclusion, the hypotheses put forward can certainly foresee further improvements related to the processing of IFCs and the management and design of APPs. In this project, in fact, it is assumed to use the data produced by instrumental and photogrammetric surveys through completely different procedures and software. In the case of BIM, the implementation of the data is aimed at technicians and scholars. The performance of the software is guaranteed by the expertise of the users. As regards the valorization and communication of cultural elements, sometimes neglected, invisible, and immaterial, such as regulatory routes, ancient units of measurement, and proportional relationships, the design of Video Mapping and 3D Mapping is imagined that illustrate the compositional and decorative motifs of the architecture in question. Even if one were to imagine reproducing the construction geometry on the point cloud, the latter, freed from the need for precision and detail related to documentation, could be decimated and adapted to use on a mobile App.

There are also some platforms for semantic enrichment, such as Aïoli. With the latter, we are trying to create a link between users and scholars for the ontological definition of architectural elements. The process is still in its infancy and has numerous elements of difficulty, such as the clear definition of the intellectual property of the data, the complexity of interoperability operations, and the dissemination and advertising of the platforms. The digital documentation obtained from the instrumental survey, and even more so from photogrammetry, was essential for the reconstruction, after the disastrous fire of 2019, of the Notre Dame Cathedral, rebuilt using Aïoli (Abergel, 2023).

Figure 1 Gerace (RC), three churches square. Axonometric view of the point cloud (top), of the TIN mesh (center), of the textured mesh (bottom) (Graphic elaboration by Lorella Pizzonia).

Figure 2: Internal views of the San Giovannello. Form left to right: a view of the model (Autodesk Revit) and a photograph of the inside of the church (Graphic elaboration by Serena Buglisi).

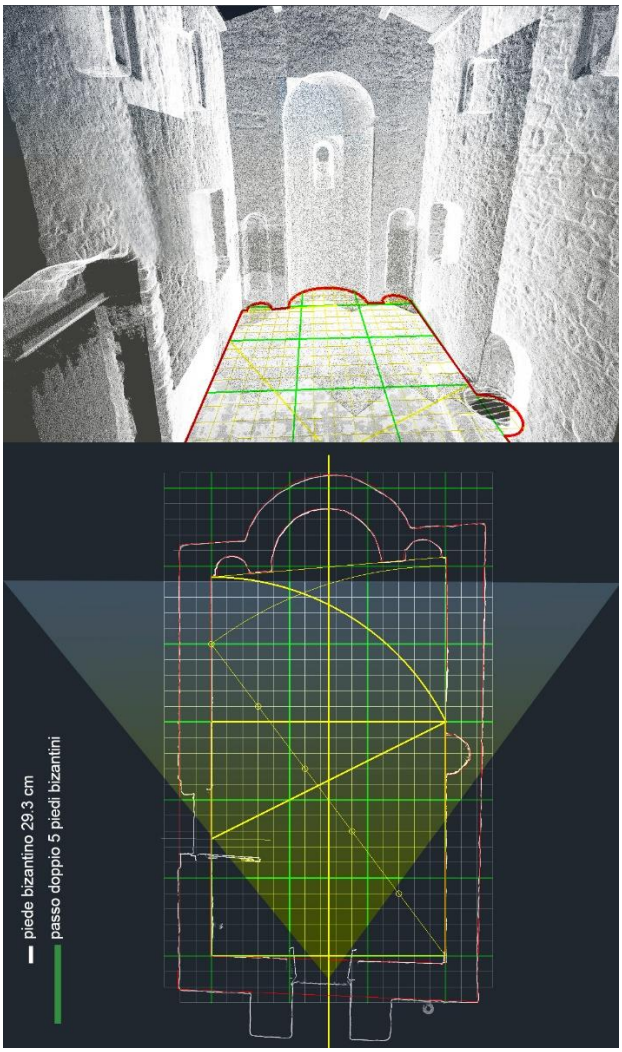

Figure 3 Simulation of the video projection of the geometric regulatory paths inside the Church of San Giovannello (Graphic elaboration by Marinella Arena).

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