

Hidden Monuments Revealed: 3D Digitization of the Benedictine Monastery of Catania and its Stratified Spaces

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Abstract – This work presents the digitization of the Levante Cloister and other hidden spaces within the Benedictine Monastery of Catania (Italy) using the Matterport Pro3 scanner. The project supports interdisciplinary research into stratigraphy in architectural contexts by creating accurate 3D digitizations of complex architectural environments. The methodology involves systematic Light Detection and Ranging (LiDAR)-based scanning, data processing, and integration with stratigraphic information, enabling detailed spatial and historical analysis and virtual exploration. The resulting models facilitate heritage documentation, conservation, and studies into the historical layering of the site. This approach demonstrates the potential of advanced 3D scanning technologies in bridging computational methods and cultural heritage studies.

I. INTRODUCTION

The Benedictine Monastery "San Nicolò L'Arena" of Catania (Italy) presents itself today as a late Sicilian Baroque masterpiece, but its origins date back to the XVI century. Its history is not linear: the current monument is the product of successive phases of transformations and reconstruction that took place over various historical periods, prompted by natural disasters such as eruptions (1669) and earthquakes (1693), structural damages, or changes in the functional use of its spaces [1, 2]. With its rich architectural and historical complexity, the Monastery contains hidden spaces that are critical for understanding landscape stratigraphy. Today, a building as architecturally complex and multi-layered as the Monastery requires very precise and interdisciplinary methodologies, starting from a careful digital geometric survey of the spaces. This introduction outlines the significance of the Monastery's heritage, the research gap in digital stratigraphic documentation, and the collaborative framework required for its study.

II. MOTIVATIONS AND OBJECTIVES

Context and Importance of the Site

The primary objective of CHANGES Spoke 6, to which this research belongs, is to design and implement comprehensive methodologies, strategies, and approaches aimed at facilitating historical interpretation, preservation, restoration, monitoring, and inclusive, sustainable planning within complex cultural heritage settings.

Within this context, the Benedictine Monastery in Catania has been chosen as the initial case study. This research addresses the need for precise digital documentation to support interdisciplinary research involving diagnostics and computer scientists. By leveraging 3D scanning technology, we aim to create comprehensive digital replicas that accurately represent the site and serve as a foundation and support for detailed studies on its evolution.

Objectives of the digitization

- Creating accurate and navigable 3D models that preserve the spatial and aesthetic qualities of the sites.
- Enabling remote access for researchers, educators, and the general public.
- Supporting the development of immersive and interactive experiences.
- Providing a reliable metrological dataset for future studies.
- Supporting stratigraphic analysis of walls and material diagnostics for restoration purposes.

The selected areas for digitization include both outdoor and indoor spaces: the Levante Cloister with its "Cafeaos" (Fig. 1, 2 and 3), the sixteenth-century hall preserving the Roman Domus ruins (Fig. 4, 5 and 6) and rooms behind the library's storage area identified as the 16th-century refectory (Fig. 7, 8, 9 and 10).



Fig. 1. High-resolution image of the Cafeaos area, acquired with Matterport Pro3.



Fig. 2. High-resolution image of the Cloister, processed via Matterport Cloud.



Fig. 3. Dollhouse view of the Cloister, acquired with Matterport Pro3.



Fig. 4. High-resolution image showing the mosaics of the Roman Domus, acquired with Matterport Pro3.

This project stands out due to the scarcity of comparable 3D digitization initiatives at the regional and national level, filling a significant gap in the stratigraphic documentation of historic architectural complexes. The absence of similar models in Italy highlights the originality and pioneering value of this work, which can serve as a methodological reference for future efforts in digital conservation and heritage enhancement.

III. METHODOLOGY

Instrumentation

The Matterport Pro3 scanner, equipped with LiDAR technology, was selected for its capacity to capture high-resolution 3D data with millimeter-level accuracy in both interior and exterior environments. Scanning was performed from multiple positions to ensure full coverage and optimal overlap for model alignment. The system's ability to automatically align scans and generate real-time previews facilitated efficient data acquisition in complex environments with limited access and lighting [5]. Its portability also proved fundamental in accessing narrow or obstructed spaces, such as those within the refectory and behind the library storage.

The method enables material-based stratigraphic stud-

ies for research purposes, providing access to scholars and professionals who are unable to visit the site in person. Moreover, it supports a strategy that balances preservation with public engagement: the site can be explored virtually, minimizing the risks associated with physical visits, particularly in fragile areas with restricted access and confined spaces.

Functioning of the Matterport System

The Matterport Pro3 scanner operates by combining LiDAR technology with high-resolution RGB imaging. During each scan, the device emits laser pulses to measure distances to surrounding surfaces with millimetric precision, capturing both geometric and visual data simultaneously.

The scanner is mounted on a tripod and rotated 360° at each station. As it scans, it generates a detailed point cloud representing the spatial structure of the environment. The internal software stitches together multiple scans by detecting common features and aligning them within a unified 3D coordinate system.

The generated point clouds serve as the foundational dataset for further geometric analysis and can be exported for integration into Building Information Modeling (BIM) environments. This enables a semantic enrichment of the



Fig. 5. High-resolution image showing the frescoes of the Roman Domus, acquired with Matterport Pro3.



Fig. 7. High-resolution image of a small altar on the hidden floor, acquired with Matterport Pro3.

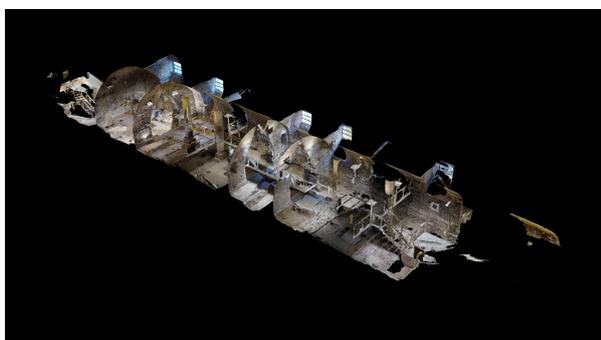


Fig. 6. Dollhouse view of the Roman Domus, acquired with Matterport Pro3.



Fig. 8. High-resolution image of column remains, acquired with Matterport Pro3.

3D models and supports advanced heritage management processes. Furthermore, the digital models represent an initial step towards the creation of Digital Twins—dynamic, data-enriched replicas that can be updated over time to monitor changes, support diagnostic analyses, and inform conservation strategies [5, 8, 9].

The collected data is then uploaded to the Matterport Cloud, where it is processed into textured mesh models and immersive digital environments. These outputs support both metric analysis and realistic visualization, facilitating remote navigation and integration with additional metadata. This dual utility aligns with the principles of experiential media, where immersive environments foster deeper engagement and presence in cultural storytelling contexts. Notably, this approach supports semi-interactive experiences that fall between game design and documentary film production, enhancing the user’s sense of agency [6].

Data Acquisition and Processing

A systematic scanning plan was implemented to cover the Levante Cloister, the refectory, and the Domus, maintaining 8-12 meters between scanning positions in open spaces and 2-3 meters indoors. Particular attention was paid to transitions between levels and tight corridors to

ensure alignment accuracy and continuity of spatial data. Specifically, 30 scanning points were executed for the Domus, 49 for the Levante Cloister, and 24 for the refectory.

The supports behind the red architectural reconstruction of the refectory, designed by Giancarlo De Carlo, were also digitally captured alongside the actual refectory spaces (Fig. 9). This digitization preserves De Carlo’s interpretative restoration work as an integral part of the site’s stratified architectural narrative, allowing detailed comparison and analysis within the overall 3D model.

Raw data were processed using Matterport Cloud services to generate point clouds, textured meshes, and navigable 3D spaces. The cloud-based system allowed rapid visualization of captured environments and supported tagging and annotation workflows. These functionalities align with methodologies in immersive media design that advocate for the strategic placement of interaction elements, spatial consistency, and nonlinear navigation. Furthermore, this structured workflow echoes the importance of narrative design and the integration of consistent Points of Interest (POIs) for immersive cultural storytelling experiences [6].

In parallel with the scanning process, the following activities were carried out to complement the digital survey:



Fig. 9. High-resolution image of the Refectory highlighting Giancarlo De Carlo’s architectural structure, acquired with Matterport Pro3.

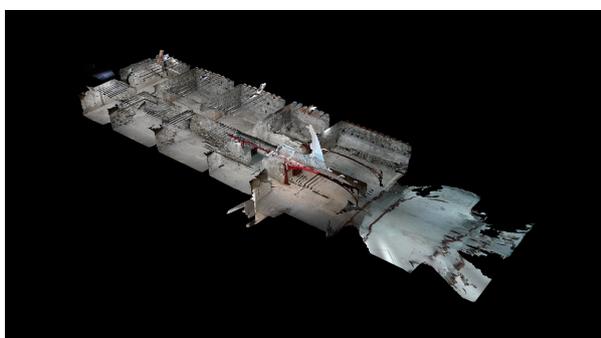


Fig. 10. Dollhouse view of the Refectory, processed via Matterport Cloud.

- Architectural archaeology studies, especially stratigraphic analysis of walls, were conducted to expand knowledge on spatial evolution.
- Targeted sampling of mortars and plasters was carried out to support material analysis for future restoration.

All approaches and data will be progressively integrated, as the Matterport platform enables the enrichment of 3D models with tags, annotations, and multimedia content, linking spatial elements to stratigraphic data, diagnostic analyses, and historical narratives. The direct analysis of walls identified stratigraphic units and studied their mutual relationships to highlight construction phases, transformations, or coeval developments. These observations were particularly significant in the sixteenth-century hall and refectory, where overlapping construction techniques and reused elements were observed. This refined understanding informs both historical interpretation and restoration planning.

A. Virtual Experience Integration

The digital replicas were optimized for interactive virtual tours via web browsers and XR devices. These envi-

ronments feature embedded multimedia content and digital tags, enhancing educational and curatorial potential. Within the Levante Cloister, for example, hotspots can be used to highlight the construction details and visible alterations in the *Cafeaos* area. In the Roman Domus hall, virtual access can help contextualize the preserved mosaics, while in the refectory area, interpretative layers can help visualize now-inaccessible elements and hypothesized historical layouts.

This structure aligns with immersive virtual tour strategies that emphasize branching narratives, non-linear exploration, and user-driven interaction [6]. Additionally, these experiences represent an accessible and inclusive mode of cultural engagement, consistent with hybrid physical-digital approaches that employ 360° imagery and storytelling to adapt to users’ contexts and preferences. Such systems may further benefit from integration with context-aware recommendation engines that personalize narrative flow and POI visibility based on real-time conditions and user profiles [7].

IV. RESULTS AND DISCUSSION

The project has produced detailed 3D models and virtual tours of the Monastery’s selected environments, enabling remote access and immersive exploration for historical and stratigraphic study, as well as potential restoration monitoring. Digitization supports metric analyses relevant to stratigraphic interpretation and heritage conservation. The integration of 3D data with stratigraphic information has revealed new analytical perspectives on site evolution. Digitization enabled more effective examination of masonry details, providing higher visual quality and facilitating study in confined spaces. Without digital support, the analysis would need to be conducted entirely on-site, which, given the limitations of visibility, accessibility, and narrow spaces, might be insufficient.

Digitalization allows off-site documentation to complement on-site surveys and recording. For the masonry analysis, stratigraphic unit sheets were compiled and integrated off-site, eliminating the need for frequent returns to the site. Furthermore, having digital resources proved invaluable for interdisciplinary discussions of the results, enabling collaborative analysis directly in front of the scans.

Challenges with complex geometries and lighting were overcome with strategic scanning placement. The stratigraphic data will be useful both to improve and extend the survey and, conversely, the survey will support the analysis of the building. The virtual environment will be enriched with additional interpretive data and material analysis, including information related to the current knowledge of the monument, its history, and the materials used.

Moreover, this technology overcomes accessibility limits: in the sixteenth-century hall, the Roman Domus mosaics prevent direct passage between rooms, while the re-

factory has low ceilings, poor lighting, and obstructive walls.

Although the current work focuses primarily on the technical aspects of digitization, future developments should also address user experience, even at a qualitative level, to better evaluate accessibility and engagement. Incorporating considerations of user interaction and perception would not only strengthen the educational and curatorial potential of the virtual models but also align the project with best practices in digital heritage design.

V. CONCLUSIONS

The digital models of the monument represent a significant outcome of the research, enhancing understanding of its historical development, stratigraphy, and constituent materials. These models aid archaeometric analysis and restoration planning. Matterport-based digitization facilitates conservation and visibility where physical access is restricted. Moreover, it encourages public engagement, cultural tourism, and awareness through virtual access to otherwise inaccessible areas and detailed technical features of the monument. Ultimately, this form of digital interaction fosters a broader social participation in the preservation of cultural heritage. This work also contributes to the broader field of Archeomatica¹, a multidisciplinary research area combining archaeology and computer science. Within this framework, digital technologies are applied to the documentation, interpretation, and conservation of cultural heritage. At the University of Catania, these methodologies are being actively developed and implemented through collaborations between departments and research groups involved in digitization of cultural heritage. Future work will focus on enriching the digital models with additional interpretive data and user-centered evaluations, ensuring their continued relevance for both research and public engagement. These developments are expected to expand the methodological framework and provide a foundation for broader applications of 3D digitization in heritage conservation and education.

VI. ACKNOWLEDGEMENT

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¹<https://www.archeomatica.unict.it/>