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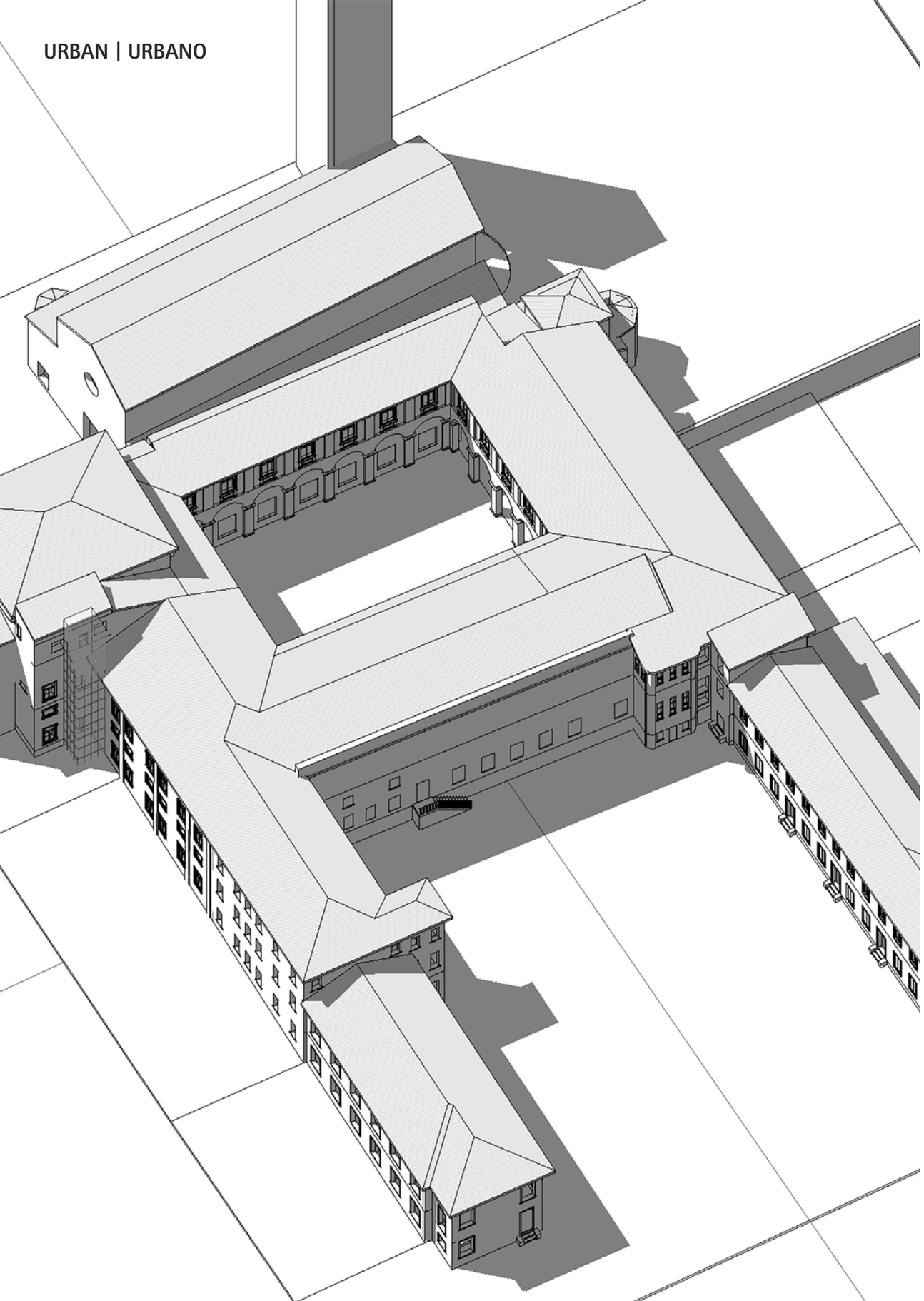

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Santi Felice e Fortunato of Vicenza: historical and architectural evolution from digital survey

Santi Felice e Fortunato a Vicenza: dal rilievo digitale all'evoluzione storico-architettonica

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The case study of Santi Felice e Fortunato is part of the Veneto Region's FSE 2023 project, 'Re-life: accessibility and inclusiveness in scenarios of reuse and enhancement of former monastic buildings', which involved the University of Padova and the Iuav University of Venezia. The building complex located in Vicenza, consists of the former Benedictine monastery, now a High School, and the early Christian basilica. This article provides a comprehensive explanation of the manner in which diverse representation techniques can be integrated for a singular divulgative purpose. The acquisition of spatial data, obtained through direct and indirect surveying methodologies such as photogrammetry (ground and aerial) and laser scanner, enabled the survey of the main volumetries of contemporary building bodies. Concurrently, a comprehensive historical investigation was conducted using archival sources to reconstruct all occurrences related to the monastery. The project also involves the use of

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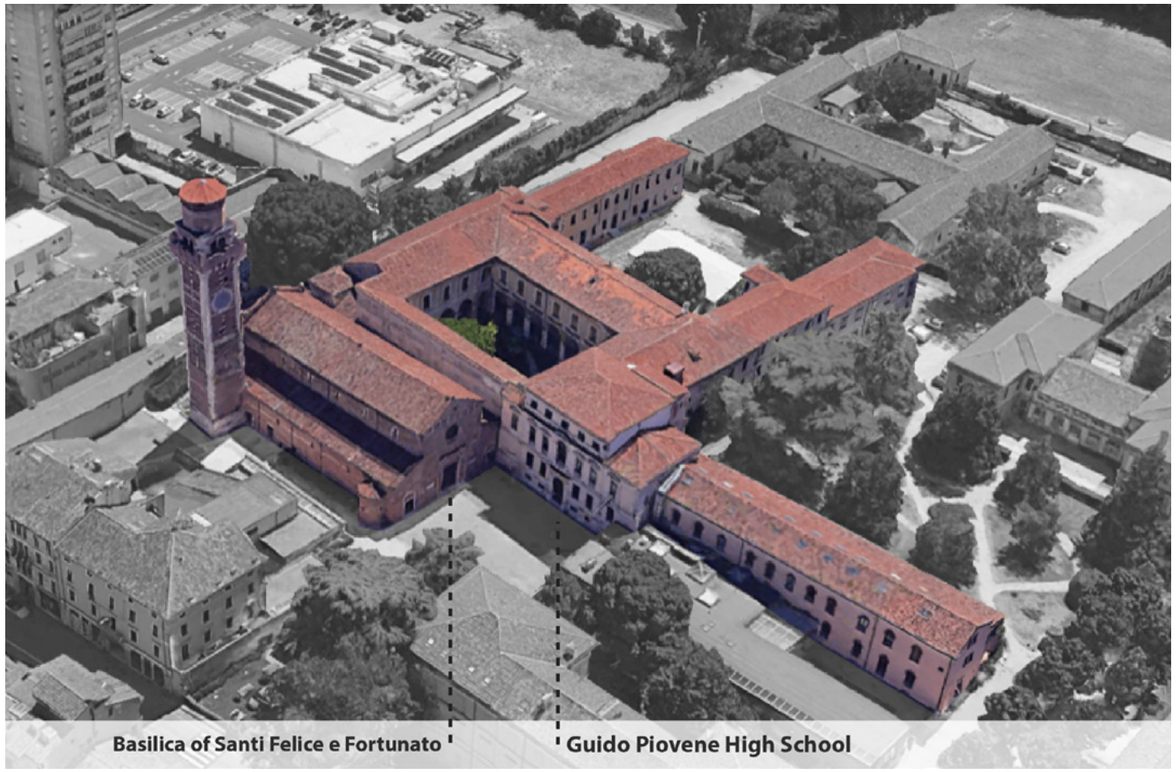
BIM reconstruction of the Santi Felice e Fortunato complex building. Elaboration by the authors.

Building Information Modelling (BIM), accessibility studies and the virtual and augmented reality. This investigation revealed early Christian origins dating back to the fourth century A.D., thereby providing insights into a pivotal aspect of Vicenza's historical, architectural and urban development.

Il caso studio di Santi Felice e Fortunato è parte del progetto FSE 2023: "Re-life: accessibilità e inclusività negli scenari di riuso e valorizzazione degli ex edifici monastici", promosso dalla regione Veneto e che ha coinvolto l'Università di Padova e l'Università Iuav di Venezia. Il complesso di Vicenza è composto dall'ex monastero benedettino (oggi scuola superiore) e dalla basilica Paleocristiana.
Il contributo intende mostrare come diverse tecniche rappresentative possano interagire tra loro per la conoscenza, la fruizione e la divulgazione. L'acquisizione di dati spaziali, ottenuti attraverso metodologie di rilievo diretto e indiretto, sia fotogrammetrico (a terra e aerea) che laser scanner, ha permesso di conoscere i volumi principali dell'intero complesso edilizio. Parallelamente, è stata condotta un'indagine storica attraverso le fonti di archivio, finalizzata a ricostruire le vicende legate al monastero. Il progetto ha inoltre previsto l'utilizzo del Building Information Modelling (BIM), l'analisi sull'accessibilità e l'impiego della realtà virtuale e aumentata. L'indagine ha così rivelato le origini paleocristiane del complesso, risalenti al IV secolo d.C., approfondendo un aspetto cruciale dello sviluppo storico, architettonico e urbano di Vicenza.



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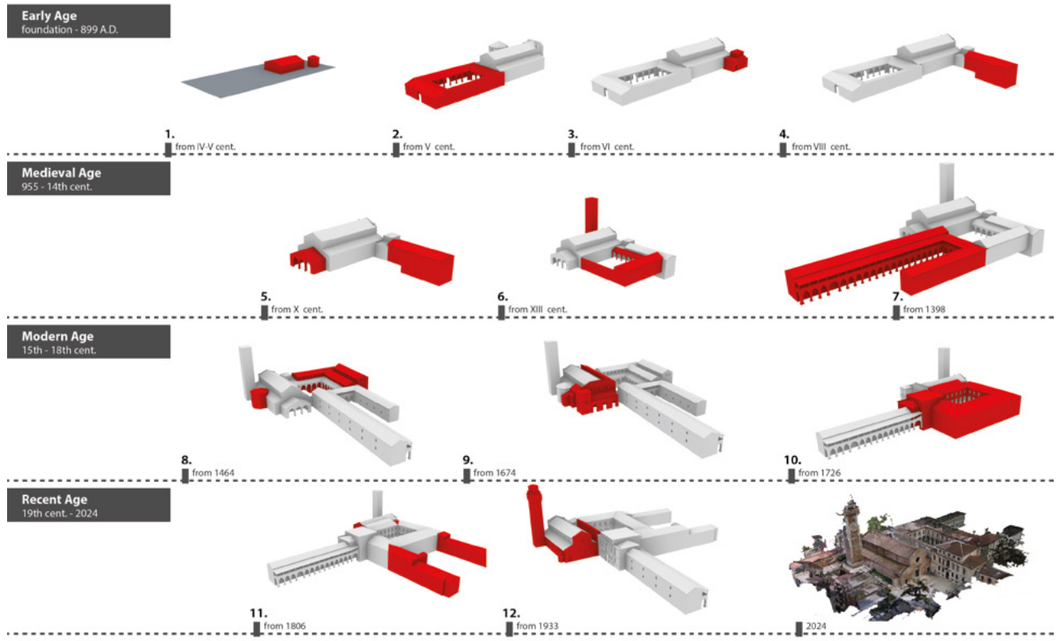
01.

The Santi Felice e Fortunato building complex in 2024, located in Vicenza (Italy). Image by the authors.

02.

Diagram with the architectural evolution (highlighted in red) obtained by the 3d digital reconstruction along the main historical four macrophases, from the foundation to 2024 (obtained by the pointcloud). Elaboration by the authors.

This essay is the result of research conducted within the Veneto Region's FSE 2023 project, code 2105-0067-553-2023 'Re-life: accessibility and inclusiveness in scenarios of reuse and enhancement of former monastic buildings' led by the University of Padova and the Iuav University of Venezia, Principal Investigator Gianmario Guidarelli, Referee Professors Angelo Bertolazzi, Giuseppe D'Acunto, and Andrea Giordano. The case study that the present research focuses on is the Santi Felice e Fortunato building complex, which is located in the northern Italian city of Vicenza (Italy). This complex now comprises the Guido Piovene High School, which is housed in the former Benedictine monastery, and the early Christian basilica of Santi Felice e Fortunato [Fig. 01.].
The paper's aim is to emphasise the pivotal function that archival documentation and digital survey have come to undertake in the graphic and digital reworking of all the historical and architectural phases, thereby enabling a critical reconstruction of the entire building complex's evolution. The acquisition of spatial data, the methodology of which will be explained in more detail below, enabled the research team to survey the main geometries and volumetries of the contemporary building bodies. Concurrently, the research team conducted an extensive historical investigation with the objective of reconstructing all the events related to the complex of Santi Felice e Fortunato, which revealed early Christian origins dating back to the fourth century AD. Archival studies have facilitated the delineation of the compound's overall chronology. This has been achieved by initially identifying four macro-phases [FIG. 02.]: the early age (from the foundation to 899 A.D.), the medieval age (955 to 14th century), the modern age (15th to 18th century), and the recent age (19th century to the present).
The relevant subphases of each macrophase have been identified, and each is described by historical events and related to one or more building bodies, either erected or destroyed. In conclusion,



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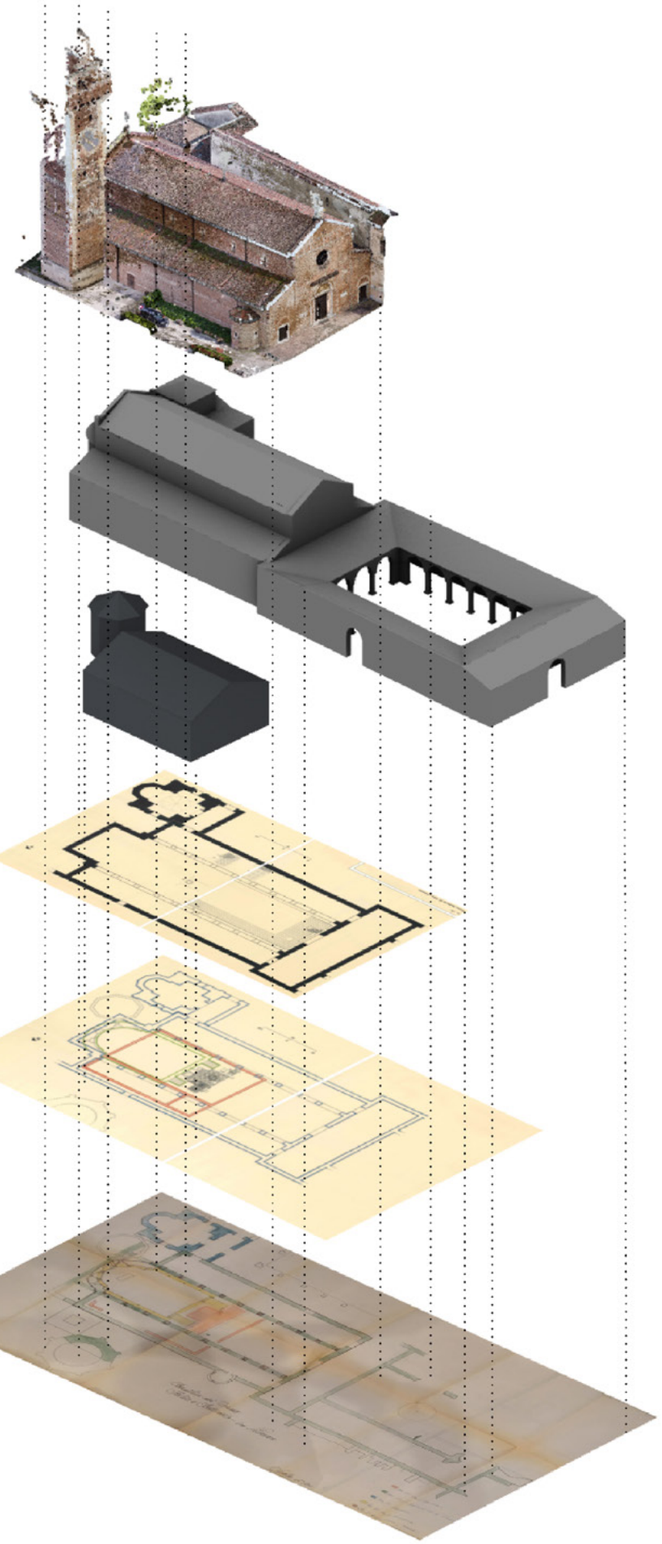
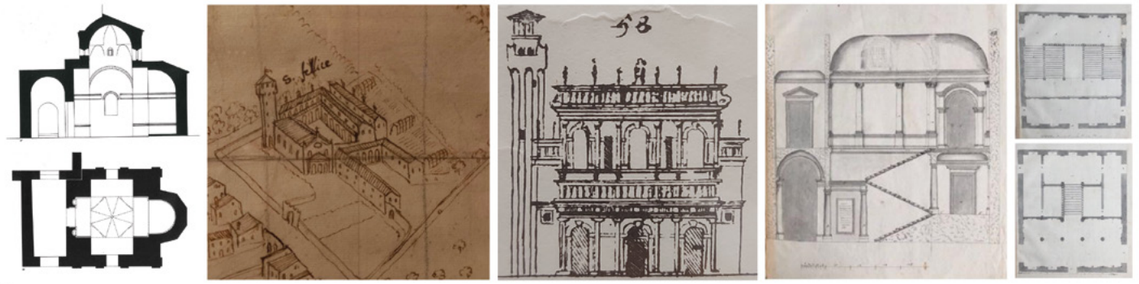
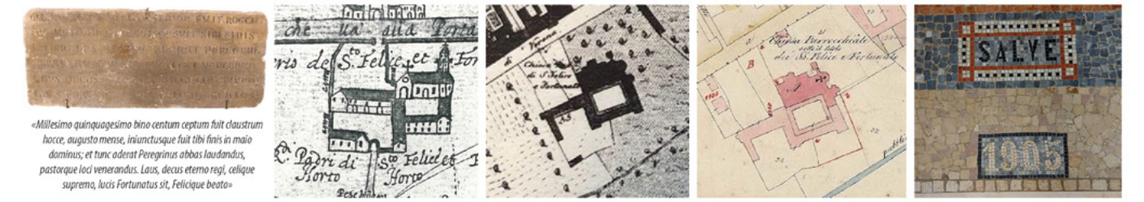



Historical Photos - Soprintendenza of Verona's archives



Graphic representations of plans and elevations - Previtali 1979; Biblioteca Angelica of Rome; Biblioteca Bertoliana of Vicenza; Biblioteca Municipale of Treviso



Other sources - stone inscriptions; Biblioteca Bertoliana of Vicenza; Archivio di Stato of Vicenza

04.

Diagram showing some of the archival documents acquired, analysed and considered during the 3D architectural reconstruction. Elaboration by the authors.

the sources, categorized as primary (archival documents and stone inscriptions) and secondary (drawings and graphic representations), proved to be of significant importance in enhancing the depth of knowledge gained from the case study. The historical and graphic acquisitions allowed the identification of the early Christian basilica as the heart of the architectural complex. The foundation of the structure dates back to the 4th century[01], with subsequent expansions in the 5th century resulting in a tripartite layout and a quadriporticus[02]. In the 6th century, a martyr chapel dedicated to Santa Maria Mater Domini (*Martyrion*) was erected, and in the 8th century, the construction of the Benedictine monastery commenced. Although the architectural survey constituted the foundamental basis for the redesign and automated modelling of the contemporary edifices, the archival sources furnished the requisite support for the definition and configuration of the more antiquated ones [Fig. 03.].
Of particular significance were the records of the archaeological excavations led in the mid-twentieth century by the parish priest Giuseppe Lorenzon (Lorenzon 1934, 1937, 1938, 1969, 1972), and all the relative plans, sections, and technical drawings, found at the Soprintendenza of Verona's archives. The records of Lorenzon are supplemented by historical photographs and additional technical drawings related to some underground rooms, that constitute the foundations of the first Benedictine monastery. The research focused on the earliest known depiction of the monastery[03], which is portrayed in a perspective view of the city of Vicenza dating to around 1580. This view is known as the 'Pianta Angelica' and is preserved in the Biblioteca Angelica in Rome.

03.

Exploded axonometric diagram showing the workflow and the intertwining between different sources, both graphic and from the survey. Elaboration by the authors.

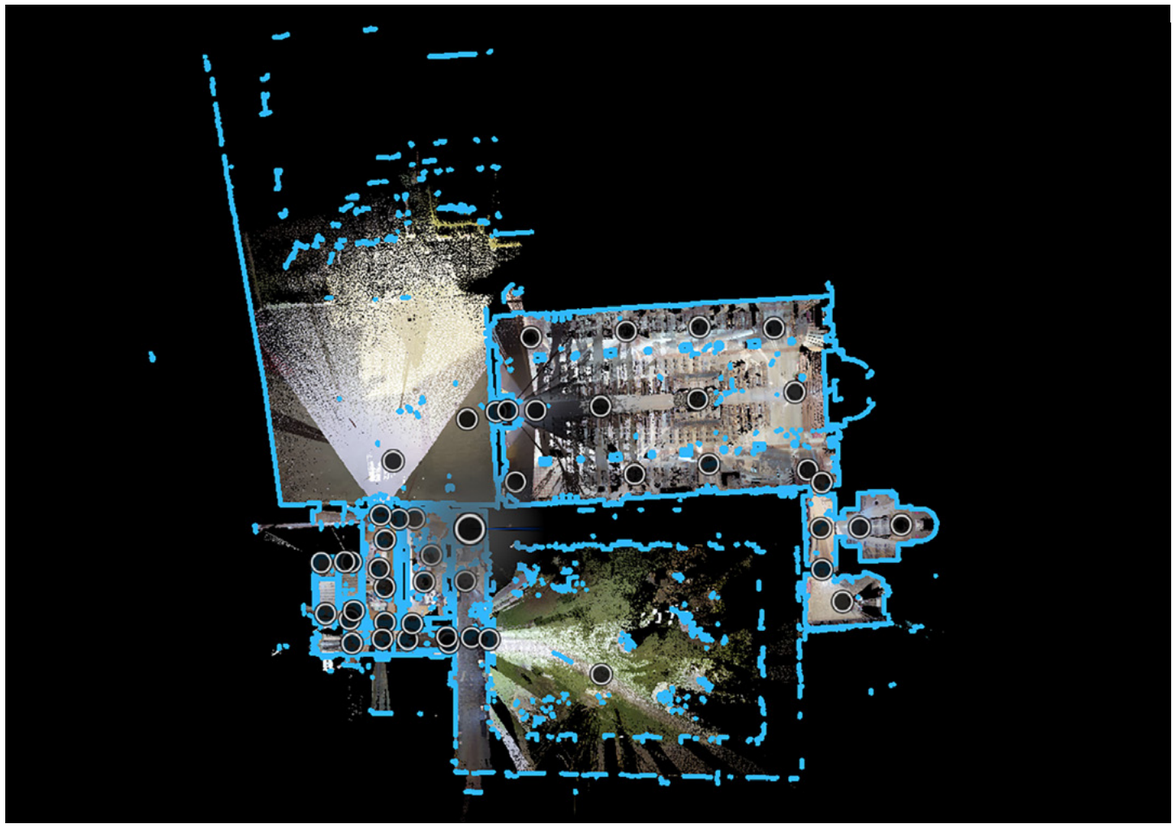
05.

Registration of acquisitions with the Leica BLK360. Elaboration by the authors.

06.

Merging of point clouds derived from range-based and image-based surveys. Elaboration by the authors.

Further iconographical references were identified at the Archivio di Stato of Vicenza, the Biblioteca Bertoliana of Vicenza, and the Biblioteca Municipale of Treviso [Fig. 04.].
The purely historical approach and the critical eye with which the graphic sources were analysed revealed some formal inconsistencies and representational inaccuracies. The purpose of this investigation is to emphasise the synergy between two distinct disciplines: historical research and digital modelling. The crux of this collaboration is the meticulous examination of graphic sources, with the objective of achieving the most coherent and precise historical and architectural reconstruction possible. In the context of the digital survey phase, a range of data acquisition strategies were subjected to testing. Currently, an entirely open-source and low-cost workflow is being developed, aimed at defining an accessible and replicable methodology. The methodology presented in this paper, however, refers to a previously tested approach based on the use of proprietary software and professional instrumentation. In this context, two complementary survey techniques were adopted: an image-based methodology, used for documenting the external surfaces, and a range-based methodology using laser scanning, employed for surveying the interior spaces. The use of the Leica BLK 360 scanner was also essential to align and scale the photogrammetric point cloud accurately. Terrestrial photogrammetry was carried out using a Fujifilm XT50 MILC camera, with particular attention paid to the ground junctions of the building and the surfaces of the façades. In addition to purely metric dimensional data, this approach enabled the acquisition of information on the building's degradation, crack patterns, and was extensively used for texturing the realistic model employed in the virtual reconstruction. For the roof structures, aerial photogrammetry performed with a DJI Mini 2 drone played a crucial role. The integrated survey, processed using Cyclone Register (for the range-based survey) and Metashape (for the image-based survey), produced two dense point clouds which, once merged, were used both for subsequent parametric 3D modeling and for generating detailed mesh models aimed at composing an interactive virtual environment. Integrated surveying, in the absence of absolute georeferencing systems such as GNSS RTK, requires a careful phase of registration and alignment of datasets acquired through different techniques. In particular, photogrammetric data, although internally consistent in terms of proportions and relative geometries due to the nature of the bundle adjustment process, are often unreliable in terms of absolute metrics and global spatial positioning. Conversely, data obtained via laser scanning provide greater metric precision and geometric stability, especially when acquired using professional instruments equipped with inertial compensation and internal calibration. For the integration of the point clouds derived from the two methodologies – image-based and range-based – the open-source software CloudCompare was used. This enabled the unification of datasets through the identification of homologous points (either manually selected or feature-based) present in both acquisitions. The process involved an initial rigid alignment (coarse registration), followed by fine registration using the ICP (Iterative Closest Point) algorithm, with the laser scanner point cloud serving as the metric reference [Figg. 05., 06.].
This approach allowed the generation of a spatially consistent integrated model, with strong geometric and metric correspondence (Bertocci et al., 2024) (Bertocci & Cioli, 2024). The phase following the survey focused on the development of the BIM-based digital model, which constituted the foundation for creating a shared and queryable digital environment. The software used was Revit, which, thanks to its streamlined integration with Recap, allows the use of the point cloud as a reference for modeling. Through Revit, the general 3D model and the families of architectural elements composing it were created. Particular attention was paid to the cloister windows, the various types of openings on the external façades, vaulted surfaces, and the monumental façade of the current entrance to the Guido Piovene High School. The architectural object families were enriched with material, morphological, and technical information, establishing a hierarchical structure consistent with the built environment (Borin & Pedron, 2014) (Bernardello, 2021). The resulting queryable model, a virtual as-built twin of the building, complies with the ISO 16739 standard and ensures semantic, geometric, and relational consistency of the data. The main areas digitally reconstructed include the cloister,



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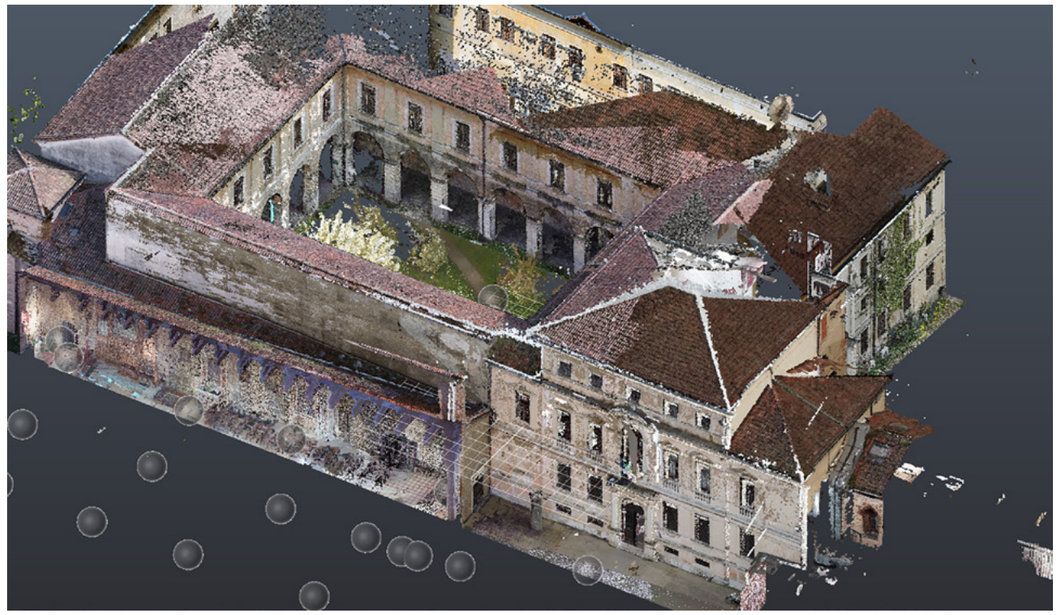

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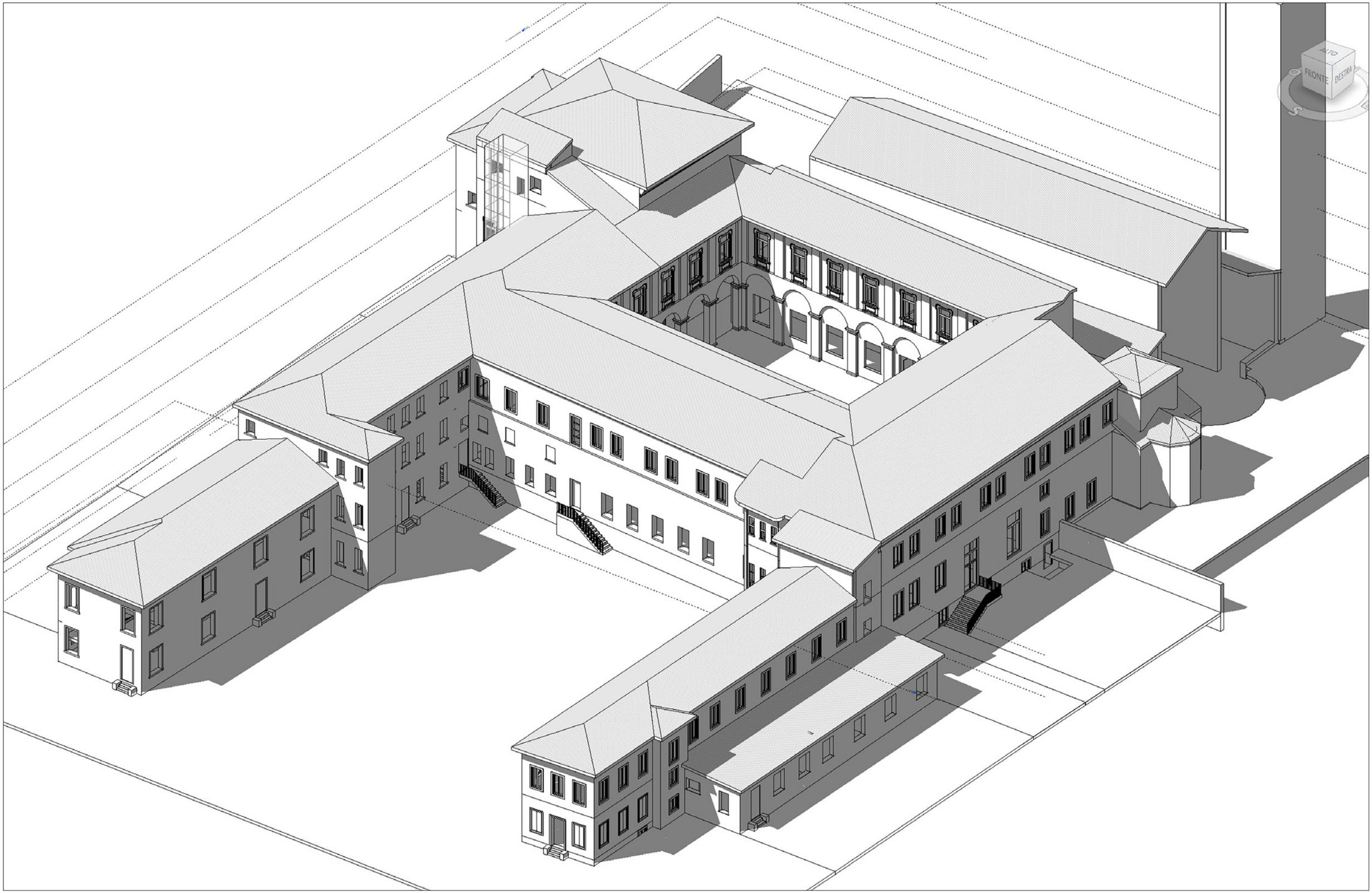
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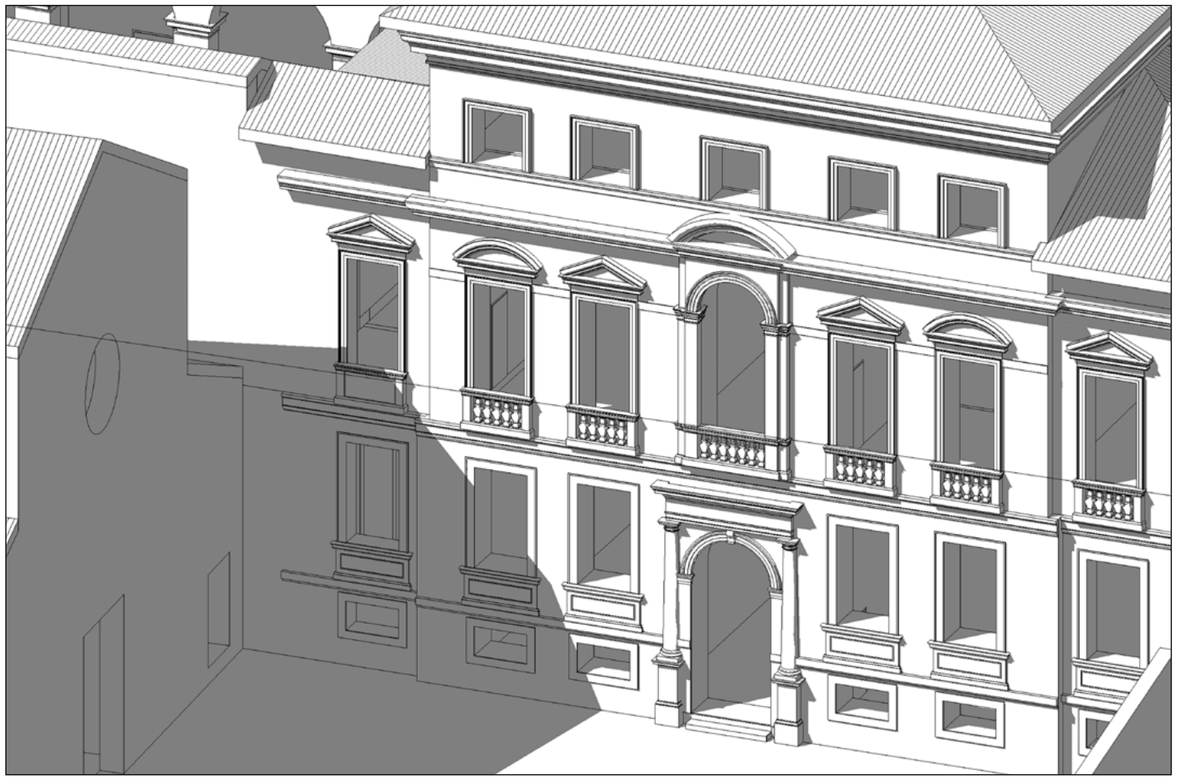

08.

Entrance façade of the current ITC Guido Piovene reconstructed in BIM. Elaboration by the authors.

07.
PP. 48-49

BIM reconstruction of the Monastery of Santi Felice and Fortunato. Elaboration by the authors.

the monumental staircase, the façade and interior of the basilica, the *Martyrion*, and the rooms on the first floor adjacent to the basilica's side nave. The Revit model also incorporates the various construction and demolition phases that have occurred over the centuries, concerning both the basilica and the monastic structures [Figg. 07., 08.].
Once the modeling phase was completed, the model was exported in IFC format to be visualized and queried within a Common Data Environment (CDE), aimed at dissemination, correct visualization, and remote interrogation of the model. The primary objective was to enable centralized collaboration among the various actors involved in the research through a browser-based interface.
The present research seeks to underscore the synergy between disparate disciplines, namely historical investigation and digital modelling, converging in the meticulous examination of graphic sources. The objective was the determination of an effective *modus operandi* for the analysis and reconstruction of historical architectural heritage of the Santi Felice e Fortunato building complex in Vicenza, from its origins to its present form. The historical-architectural reconstruction of the building and the various stages of the digital survey, as previously discussed, represent a preliminary step and an integral part of a larger project: the development of a BIM model and the formulation of new strategies for the virtual utilisation of the complex. That model has to be meant as a comprehensive repository of information, encompassing archival sources and digital reconstructions, which enables individuals to access, explore, retrace and comprehend the historical and architectural evolution of the Santi Felice e Fortunato building complex. In terms of the design of new virtual strategies, a constructive dialogue has been initiated with the educational institution (the Guido Piovene High School) and its student body, both of whom are enthusiastic users. In conclusion, this research, which was developed with methodological, experimental and applicative purposes, has enabled the delineation of an effective *modus operandi* for the analysis and reconstruction of the architectural heritage of the past. This combines historical and archaeological disciplines and advanced surveying techniques with digital modelling tools in a concerted action whose value exceeds the mere sum of its parts.

NOTES

01| During the 4th century, the area in which the basilica is currently located was home to a Roman cemetery situated beyond the city walls, in the proximity of the ancient Via Postumia, a route that connected Vicenza to Aquileia. The remains of the martyrs Felice and Fortunato arrived in Aquileia in 355 A.D., a small community of Christians is believed to have gathered around the relics of the two saints and, towards the end of the 4th century, founded the first church.
02| Excavations in the nineteenth century revealed that the façade was preceded by a narthex, in which a substantial quadriportico was inserted. In the early Christian churches, this structure was utilised for the purpose of welcoming and burying the faithful.
03| The monastery was founded in the early 8th century, in accordance with the establishment of the first Benedictine settlements in Vicenza. The edifice is no longer extant, having been razed to the ground by the Hungarians in 899 A.D.

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