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ARCHITECTURAL HISTORY AND DIGITAL TECHNOLOGIES: NARRATIVE POTENTIAL AND EPISTEMOLOGICAL CHALLENGES

In recent years, architectural and urban historians have increasingly embraced digital tools, from big data management to Historical Building Information Modeling (HBIM). Initially employed for visualization, digitalization has evolved into an essential research tool. In cases where buildings or sections of cities no longer exist, 3D models have become crucial to the research process, allowing the integration of archival sources with other types of documentation (visual, material, etc.), and enabling the creation and comparison of alternative reconstruction hypotheses within a framework of continuous updating and sharing of data ('open data' and 'open science'). This is an inherently interdisciplinary type of research where languages, heuristic processes, and protocols from different disciplinary fields (e.g., computer science, data visualization, architectural restoration, etc.) must dialogue and operate on a common platform. The use of tools from different disciplines can only be effective under two conditions: the sharing of aligned objectives and the pursuit of research questions that can be answered through methodological experimentation. These principles underpin the 2022 PRIN-funded research project "CoenoBI(u)M. Art and architecture of the Cassinese Benedictine Congregation (XV-XVIII centuries): digital and spatial analysis strategies through BIM models". Here, the need to study the architecture of an entire network of monasteries to identify their shared features has necessitated an interdisciplinary approach and innovative applications of digital modeling.

This paper explores the epistemological and narrative potential of digital technologies for architectural history, examining the different ways in which these tools have been used over the past two decades. Digital technologies have proven particularly effective in both the research phase – especially for reconstructing virtual spaces and managing geo-localized historical data – and in the publication and presentation of findings. Digital and multimedia platforms can now effectively represent even highly complex spaces for audiences that are often non-experts. However, in the case of buildings that no longer exist, virtual reconstructions serve not only to visualize lost structures but are also an integral phase of the research process itself.

By using a digital model as a starting point rather than the final result, researchers can create a network of sources – visual, archival, and bibliographic. In recent years, the adoption of digital technologies such as geographic information systems, geospatial mapping techniques, and data management and modeling platforms has brought about a series of opportunities that have led architectural historians to reflect on the narrative possibilities of their discipline and experiment with their own research protocols. To understand how this approach has influenced historical research in architecture (including the methodologies, findings, and even the very choice of study topics) and to provide an initial assessment, this paper considers several recent case studies (some of which, I duly acknowledge, involve my own work). One of the most important and innovative characteristics of this new approach is its multi-disciplinarity, which requires a collaborative research model. To better understand its evolution, I begin by reviewing the activities of two of the longest-running research centers that have made significant investments in IT tools, tracing how their approach has progressively developed and changed over the years.

The use of digital technologies in architectural history

The field of digital humanities applied to architectural and urban history has become quite vast, making it difficult to provide a comprehensive overview in a short paper. However, it is useful to highlight some foundational projects and ongoing research initiatives in the United States and Europe emblematic of the different methodological approaches.

One of the earliest experimental hubs in this arena was the Media Center for Art History at Columbia University, founded in 1993[1]. One of the center's first research projects, coordinated by Stephen Murray, focused on the cathedral of Amiens. To support his historical research, Murray created an image database, and a multimedia website designed to complement his monograph with drawings and photographs of the cathedral (fig. 2)[2]. Building on this initial experiment, the Media Center launched the "History of Architecture – Real Virtual, Representing Architectural Time and Space" webpage, whose main purpose was to provide digital resources for teaching architectural history to undergraduates. In 2008, this vertical integration of research, teaching, and dissemination of results led Murray and Andrew Tallon to set up the "Mapping Gothic France" webpage, which serves as a database of two hundred Gothic cathedrals in France and England, offering detailed information sheets with plans, elevations, history, and bibliographies for each building.

The digitization of resources and their presentation through GIS-based maps and the related management of big data contributed to the establishment of the Digital Art History & Visual Culture Research Lab (formerly Wired!) at Duke University in 2009, initially coordinated by Caroline Bruzelius[3] and currently by Paul Jaskot. From the start, the activities of this lab – which was founded with the goal of bringing together architectural and art historians with archaeologists and computer scientists – have focused on the diachronic representation of architectural, artistic, and urban phenomena. In the latter half of its first decade, Wired! saw the formation of various collaborative research groups, including "Digital Athens" in 2014. The initial goal of that project was "to produce a comprehensive digital map" – geo-referenced in ArcGIS – "of the archaeological remains of ancient Athens" while simulta-

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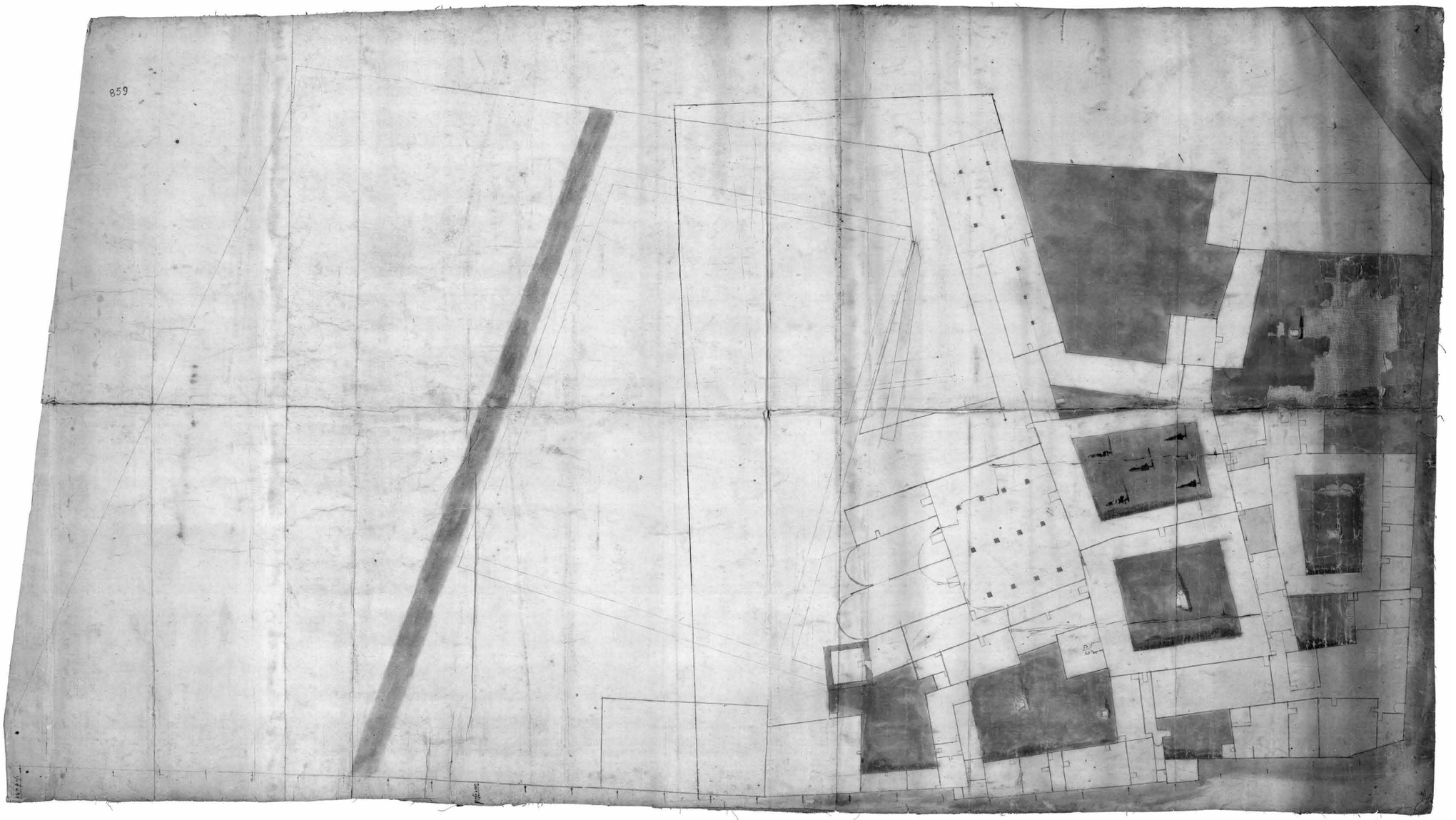
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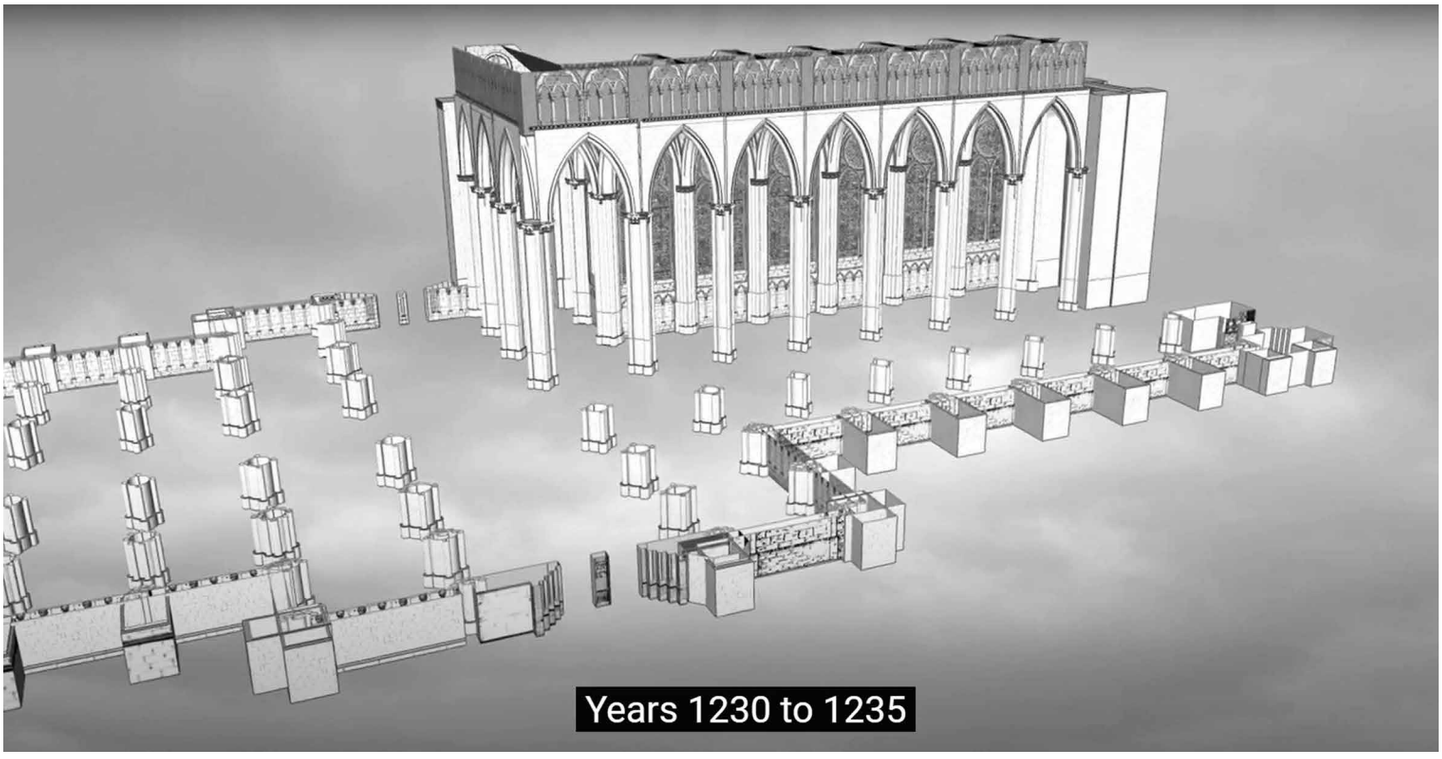

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Fig. 1 *Map of the abbey of San Giorgio Maggiore, Venice, 1490 ca. (Archivio di Stato di Venezia, Miscellanea Mappe, dis. 859).*

Fig. 2 *S. Murray, Visualization of the construction phases of the Amiens Cathedral, video still (https://www.youtube.com/watch?v=b77XFALHNXw; last accessed on 29 October 2025).*

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[1] https://learn.columbia.edu (last accessed 29 October 2025).

[2] https://projects.mcah.columbia.edu/amiens-arthum/ (last accessed 29 October 2025). See also S. Murray, *Notre-Dame, Cathedral of Amiens: The Power of Change in Gothic*, Cambridge 1996; Id., *Notre-Dame of Amiens: Life of the Gothic Cathedral*, New York 2021. Stephen Murray also directed the research project "Mapping Gothic": https://mcid.mcah.columbia.edu/collection/mapping-gothic (last accessed 29 October 2025), on which see Id., *Mapping Gothic*, in *Progetti digitali per la storia dell'arte medievale. Digital projects in medieval art history*, a cura di P. Vitolo, Firenze 2018, pp. 143-153.

[3] https://cmac.duke.edu/labs/digital-art-history-visual-culture-research-lab (last accessed 29 October 2025). W. Broom, *Caroline Bruzelius and an Early Digital Image Study Resource*, in *The Medieval Kingdom of Sicily Image Database: A Tribute to Caroline Bruzelius*, edited by P. Vitolo, Roma 2022, pp. 39-45.

[4] https://dahvc.org/project/digital-athens/ (last accessed 29 October 2025).

neously providing a dynamic visualization of the city's transformation over the centuries[4].

Among the most recent outcomes of the lab at Duke is the project "The Medieval Kingdom of Sicily Image Database", coordinated by Paola Vitolo and Caroline Bruzelius. This initiative has similarly focused on mapping visual and bibliographic resources related to principal monumental buildings constructed in Southern Italy between 1100 and 1450[5]. Once again, a website interface has proven to be the most effective way to organize and present the enormous amount of data. In this case, the platform was developed alongside an edited scholarly volume that outlines its methods and presents the main research results to date[6]. In both cases, the projects at Duke have focused on the mapping of digital resources, but also on the visualization of historical processes related to architecture.

Building on these initial experiments and supported by prestigious institutions such as the Hertziana Library in Rome, digitally oriented research groups in the field of architectural and urban history have multiplied in recent years. One example is the "Naples Digital Archive", directed by Alfredo Buccaro and Tanja Michalsky (fig. 3)[7]. Additionally, the Hertziana Library has been one of the engines behind the CENSUS program[8], as well as an even more ambitious initiative aimed at coordinating major research centers engaged in digitization – the Consortium for Open Research Data in the Humanities, which was established to harmonize data standards and infrastructures and facilitate the interoperability of different databases.

In the broader movement toward collaboration and open-access resource management, digital technologies are radically changing how we narrate the history of architecture and cities. A notable example is the "Paris Past & Present" project at UCLA, which creates "interactive digital 3D digital models of 'great' lost monuments, architectural complexes, and diverse quartiers of medieval Paris"[9]. The ability to visualize these structures has been a key area of study in recent decades, and one that has most urgently required the definition of a rigorous methodology to clearly differentiate the varying degrees of hypothetical reconstruction[10]. This is a challenge that spans multiple dimensional scales – from the spatial organization of interiors, such as sacred spaces, to entire city sections – and extends to the public dissemination of research findings, for instance through exhibitions.

A notable example of such public engagement is a recent series of exhibitions on the city of Carpi, curated by Elena Svalduz, Andrea Giordano, and Manuela Rossi. The 2016 exhibition explored the construction of the cathedral[11], while the 2020 one focused on the church of San

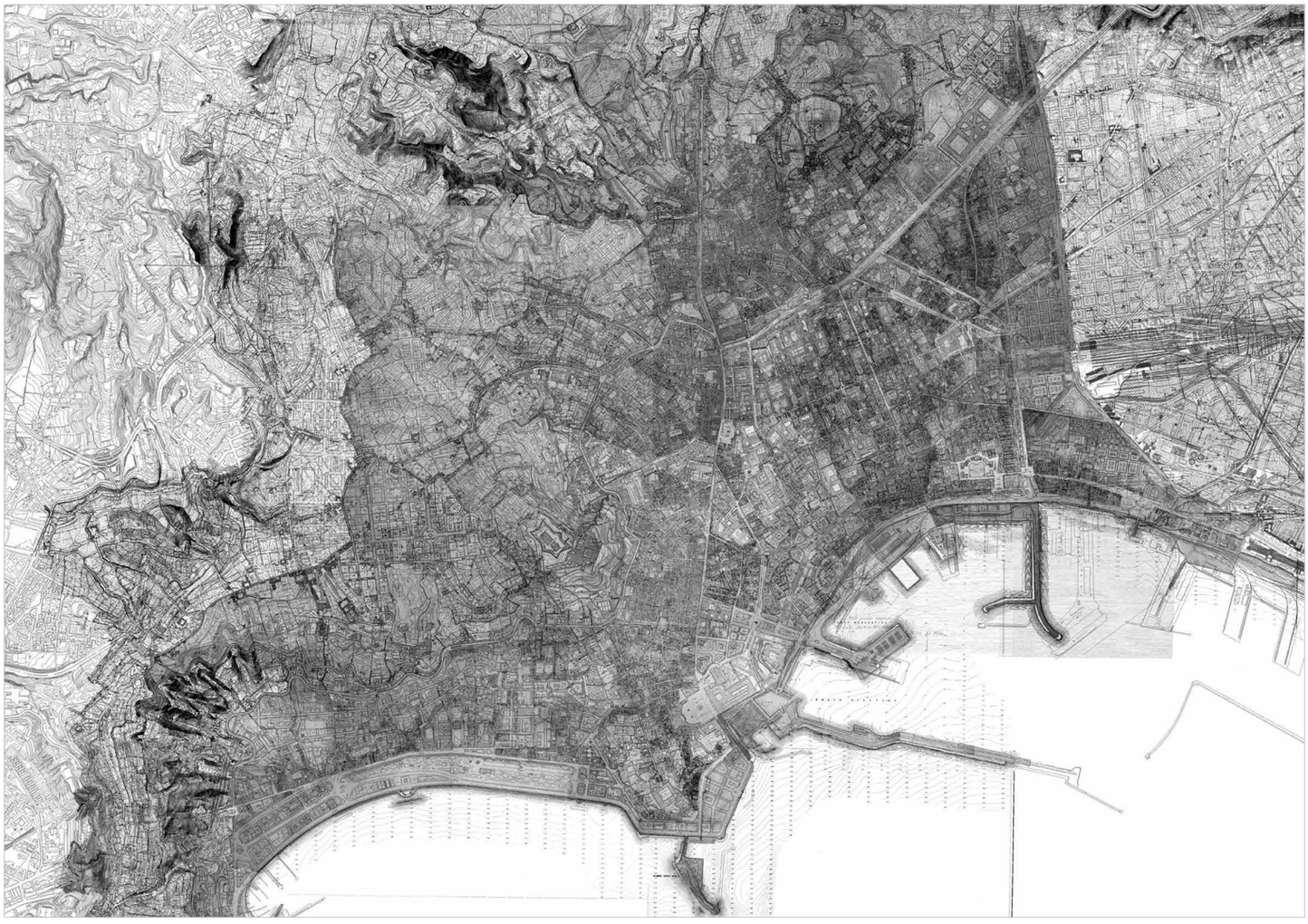

Fig. 3 *Digital cartographic layer showing the "Catasto Storico d'impianto (1895-1905)" on a map of Naples (https://indd.adobe.com/view/d1d7ba9b-b5de-499c-b96e-0f7201b82631; last accessed 29 October 2025).*

Nicolò[12]. In the latter exhibition, a multi-scalar approach – necessary for interpreting the role of the structure withing the urban fabric and its transformations over time – was translated into museum displays, including panels and models, both derived from digital reconstructions (fig. 4). Shifting to a smaller scale, different communication tools have been adopted over time. For example, an interactive 3D model visualizing the geometric genesis of Renaissance architect Baldassarre Peruzzi's distinctive protruding corner pillars was integrated into an app designed to evoke the layout of the original project[13]. By pointing a special tablet at the project plan, visitors could see and explore the 3D model in real time.

The progressive shift from individual research to collaborative, interdisciplinary teams is significantly reshaping the profession of the architectural historian and the training of new generations of specialists. This shift is evident in the "Florence 4D" initiative, where the integration of spatial methodologies (in particular, the mapping and 3D visualization of the city of Florence) is aimed at reinterpreting existing data to develop diachronic narratives for both the scholarly community and the broader public[14]. One of the first significant results of this research group, coordinated by Fabrizio Nevola and Donal Cooper, is the integration of architectural data with fragments of pictorial decoration, now housed in a museum. Here, a laser scanner survey of the building's current state has enabled a virtual reconstruction of the lost structure, allowing researches to hypothesize its original layout, including the placement of the polyptych on the high altar. This modeling process facilitated interoperable visualizations that allowed a virtual recovery of the original spatial layout in front of the painting (currently decontextualized in its museum location), as well as a digital recreation of the lost church in its original urban setting.

These projects demonstrate the remarkable versatility of digital technologies on the narrative level, especially as regards multimedia integration, the interplay between real and virtual environments, and the representation of the tem-

[5] https://koseodiah.org/people.php (last accessed 29 October 2025). See also: C. Bruzelius, P. Vitolo, J. Williams, *Historical Images and the Recovery of the Past. The Medieval Kingdom of Sicily Image Database*, in *Patrimoni culturali nell'era digitale. Memorie, culture umanistiche e tecnologia / Cultural Heritage in the Digital Age. Memory, Humanities and Technologies*, conference paper (Bari, 31 January-2 February 2018), edited by D. Spampinato, Bologna 2018, pp. 135-138.

[6] *The Medieval Kingdom of Sicily*… cit.

[7] https://www.biblhertz.it/it/dept-michalsky/naples-digital-archive (last accessed 29 October 2025). T. Michalsky, *Retorica dell'ordine urbanistico sotto i viceré spagnoli: la veduta di Napoli di Alessandro Baratta (1629/1670) e il suo pendant digitale*, in Ead., *Napoli in scala. Le rappresentazioni della città (XIV-XXI secolo). Saggi scelti su pratiche e media*, a cura di A. Bremenkamp, A. Magnago Lampugnani, E. Scirocco, Milano 2024, pp. 39-57. See also the most recent project "Mapping Sacred Spaces: Forms, Functions, and Aesthetics in Medieval Southern Italy", directed by Manuela Gianandrea, Ruggero Longo, Elisabetta Scirocco, Tanja Michalsky, (Bibliotheca Hertziana, Sapienza Università di Roma, Università degli Studi di Siena).

[8] https://www.census.de/ (last accessed 29 October 2025).

[9] http://paris.cdh.ucla.edu (last accessed 29 October 2025).

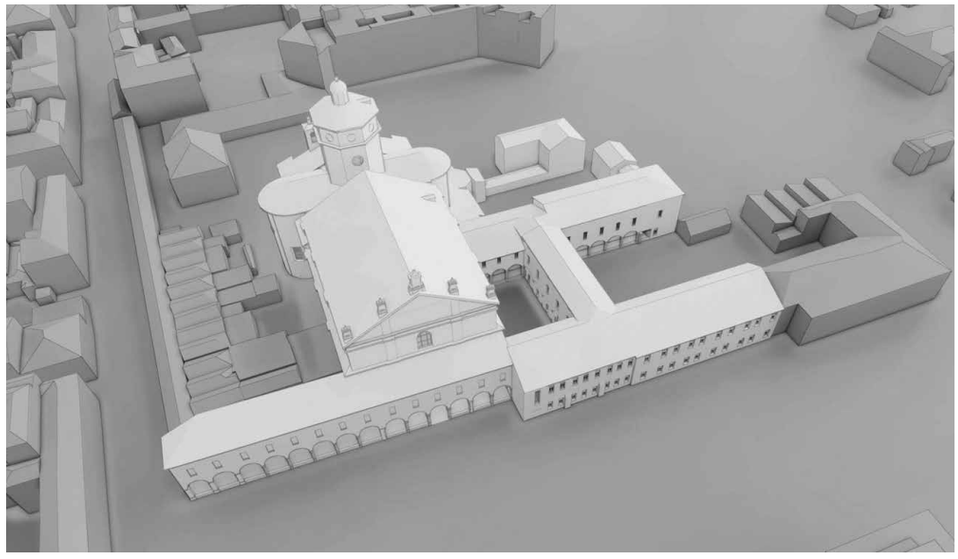

Fig. 4 *Digital reconstruction of San Nicolò, Carpi (R.A. Bernardello).*

poral dimension. When applied during the research phase, these capabilities become even more evident at the urban scale. This has been the case of the "Visualizing Venice" project, active since 2010, which focuses on reconstructing the urban transformations of some of the city's islands[15]. The first case study – the area of SS. Giovanni e Paolo – served as a testing ground for a platform designed to digitize and geo-reference both published and unpublished sources related to the island's urban spaces and buildings[16]. By leveraging GIS technology, researchers were able to project 2D reconstructions of urban transformations (such as the maps published by Wladimiro Dorigo) into three- and four-dimensional representations. In this instance, 3D modeling served as the common platform for both research and the narrative outcome in the various outputs and communication channels that have been adapted from time to time to reach different audiences.

The epistemological potential of digital tools becomes even more pronounced in smaller-scale cases, especially when researchers investigating lost buildings must assess the coherence of their reconstructions and test the different degrees of plausibility of alternative hypotheses[17]. This approach is effective at both at the urban scale and for individual structures. A compelling example is the lost former Venetian cathedral of San Pietro di Castello, where 3D modeling enabled not only the systematic collection of all archival, visual, and archaeological data (such as the geo-radar surveys of the lost crypt), but also facilitated dimensional verification of two alternative reconstructions of the presbytery, an area for which very few sources exist. In fact, the digital model proved even more essential for the study of the church's interiors, for which there is no surviving visual documentation but only a series of heterogeneous and highly specific archival references (fig. 5)[18]. The redrawing of the floor plan and primary cross-sections was the starting point for the development of a 3D model of both the church and the entire patriarchal complex. The coherent interrelation of all the data was made possible through the use of the 3D model as a platform for verifying each hypothesis. This extended study process – greatly enhanced by the possibility of immediate visualization of the object under examination – ultimately led to the discovery of the building's internal and external configurations.

The contributions of archaeology and the history of construction techniques are also becoming increasingly important in this line of research. These digital tools, in fact, allow for the progressively refined and effective integration of data related to the materiality of buildings and construction processes, providing a way to consistently represent different hypotheses regarding construction phases and a basis for further investigation. In this regard, the methods employed by the research team of the Wesleyan-Brown Monastic Archaeology Project (MonArch) have been exemplary. The team conducted a comprehensive investigation of the Abbey of Notre-Dame d'Ourscamp – a building reduced to a state of ruin – by intertwining archaeological analysis of the structure with various historical sources. The outcome is a virtual reconstruction in which varying degrees of certainty, along

[10] *Digital Crossroads: New Directions in 3D Architectural Modeling in the Humanities*, edited by A.R. Flaten, A.A. Gill, "Visual Resources: An International Journal of Documentation", 25, 2009, 4; M. Cohen, *Visualizing the Unknown in the Digital Era of Art History*, "Art Bulletin", 104, 2022, 2, pp. 6-19, D. Peña Pascal, *Modelling Uncertainty in Archaeological Spatial Data*, conference paper, (Santiago de Compostela, September 2015), https://www.researchgate.net/publication/299845868_Modelling_Uncertainty_in_Archaeological_Spatial_Data?channel=doi&linkId=57062d6c08aecbf68ba85982&showFulltext=true (last accessed 29 October 2025); U.U. Schäfer, *Uncertainty Visualization and Digital 3D Modelling in Archaeology. A Brief Introduction*, "International Journal for Digital Art History" 3, 2018, pp. 86-106, https://doi.org/10.11588/dah.2018.3.32703 (last accessed 29 October 2025); *Imagerie numérique et patrimoine culturel: enjeux scientifiques et opérationnels*, edited by P. Liévaux, L. De Luca, "In Situ. Revue des Patrimoines", 39, 2019, https://journals.openedition.org/insitu/21240 (last accessed 29 October 2025). For the case of the reconstruction of the Notre-Dame in Paris, see L. De Luca, *Un ecosistema digitale per lo studio interdisciplinare di Notre-Dame de Paris*, *A digital ecosystem for the interdisciplinary study of Notre-Dame*, "Disegnare. Idee Immagini", XXXIV, 66, 2023, pp. 16-31.

[11] *Costruire il tempio. Alla ricerca del progetto di Baldassarre Peruzzi per il Duomo di Carpi*, catalogo della mostra (Carpi, Musei di Palazzo dei Pio, 18 settembre 2015-6 gennaio 2016), a cura di A. Giordano, M. Rossi, E. Svalduz, Carpi 2015.

[12] *Il principe e la sua chiesa. San Nicolò e il convento dei Frati a Carpi*, catalogo della mostra (Carpi, Musei di Palazzo dei Pio, 9 aprile-26 giugno 2022), a cura di M. Rossi *et al.*, Modena 2022.

[13] A. Giordano, *Guardare/Fruire una mostra: il ruolo delle nuove tecnologie di rappresentazione*, in *Costruire il tempio…* cit., pp. 48-51.

[14] F. Nevola *et al.*, *Bringing Together Geospatial Information, 3D Modeling, Experiential Learning and Research Data. The Ospedale degli Innocenti: A Case Study of the Florence 4D Project*, in *Visualizing Complexities. Practices and Heuristics of Digital Models in Art History*, edited by N. Camerlenghi, T. Michalsky, E. Scirocco, "Hertziana Studies in Art History", 2, 2023, pp. 54-60; Id. *et al.*, *Research-Based 3D Modeling of Santa Maria degli Innocenti: Recovering a Context for the Quattrocento Altarpieces*, in *Lost and Found: Locating Foundlings in the Early Modern World*, edited by N. Terpstra, Firenze-Roma 2023, pp. 109-134.

[15] A collaboration between Duke University, Università IUAV di Venezia, and Università degli Studi di Padova, "Visualizing Venice" has recently expanded into "Visualizing Cities", with the aim of applying the same research methodologies to a broader range of international sites, such as Padua, Paris, Athens, Durham, and Krakow.

[16] *Visualizing Venice: Mapping and Modeling Time and Change in a City*, edited by K.L. Huffman, A. Giordano, C. Bruzelius, London-New York 2018. See also W. Dorigo, *Venezia romanica, la formazione della città medievale fino all'età gotica*, Verona 2003.

with the types of sources informing each assessment, were visualized within a 3D model using non-realistic colors. This is a highly effective method that combines scientific rigor with clear, 'user-friendly' communication of research findings[19].

Another case study where digital technologies have significantly aided in coordinating multidisciplinary research is the monastery of San Giorgio Maggiore in Venice. Best known for Andrea Palladio's design of the church, refectory, and second cloister, the monumental complex of San Giorgio Maggiore is often studied with a narrow focus on Palladio's contributions. In truth, however, his intervention was only one phase of a broader reconstruction of the medieval monastery, which began in the late fifteenth century and continued even after Palladio's death in 1580. Until now, Palladio's project has been examined without adequately considering the physical constraints imposed by the pre-existing monastery, which was gradually demolished as new construction progressed. Reconstructing the earlier building's form will provide a greater understanding of Palladio's design strategy in relation to its context, opening an entirely new avenue of study[20].

Knowledge of the state of the Benedictine complex of San Giorgio Maggiore in Venice before its Renaissance transformation can now benefit from the study of an exceptional dossier of architectural drawings related to the monastery and an impressive documentary corpus, primarily housed in the State Archives of Venice. Through geo-referencing and digital redrawing, we have been able to systematically parse out the different construction phases of the monastery for the first time.

The monastery was founded in the thirteenth century following the donation of the island by Doge Tribuno Memmo to Giovanni Morosini, who established the monastery and later became its first abbot. At the beginning of the thirteenth century, a fire and an earthquake almost certainly prompted the reconstruction of the tenth-century complex. The full reconstruction of the buildings started when the monastery joined the Benedictine "De Unitate" Congregation in 1429. If we compare Jacopo de Barbari's *View of Venice* (which depicts the monastery at the end of the fifteenth century) with the present-day structure, we can clearly see how radical its reconstruction actually was. A map, recently discovered in the State Archives of Venice, shows the monastery before the entire complex was rebuilt at the beginning of the sixteenth century (fig. 1)[21]. The project was analyzed by identifying the main lines and the construction lines. We cataloged the information from the drawing by breaking down and cataloging these indicators. By isolating numerous elements – classified by AutoCAD software and separated into layers that, when superimposed, became visible – we were able to hypothesize the chronological sequence of the graphic execution and trace the successive phases of the drawing's use.

By comparing this two-dimensional image with other three-dimensional views of the same period and a variety of archival sources, we were able to create a digital model of the monastery and the entire island (fig. 6). We discovered that the building's layout later became a base plan for subsequent interventions. In particular, the central portion of the drawing includes a sketch of the plan for a new church, which coincides with the one designed in 1520. The geo-referencing of the map was useful for understanding the geographical context of the historical visual data and for comparing the fifteenth century layout with the present-day situation. As a result, we successfully demonstrated that the plan of the medieval monastery was completely different from its current layout, which dates back to the late Renaissance. This finding will allow us to identify the

[17] G. Guidarelli, *I Predicatori dei Santi Giovanni e Paolo e Venezia. Strategie di insediamento e dinamiche urbane*, in *La città medievale è la città dei frati? Is the medieval town the city of the friars?*, a cura di S. Beltramo, G. Guidarelli, Sesto Fiorentino 2021, pp. 186-205, https://www.insegnadelgiglio.it/wp-content/uploads/2022/03/archimed-1-ebook-CORR.pdf (last accessed 29 October 2025).

[18] G. Guidarelli, *I patriarchi di Venezia e l'architettura. La cattedrale di San Pietro di Castello nel Rinascimento*, Padova 2015, pp. 19-43.

[19] S. Bonde, A. Coir, C. Maines, *Construction-Deconstruction-Reconstruction: The Digital Representation of Architectural Process at the Abbey of Notre-Dame d'Ourscamp*, in *The Digital Middle Ages*, edited by D.J. Birnbaum, S. Bonde, M. Kestemont, "Speculum: A Journal of Medieval Studies", 92, 2017, S1, pp. S288-S320; see also J. Hillson, A. Buchanan, N. Webb, *Tracing the Past: A Digital Analysis of the Choir Vaults at Wells Cathedral and Ottery Saint Mary*, in *The Analysis of Gothic Architecture: Studies in Memory of Robert Mark and Andrew Tallon*, edited by R. Bork, Leiden 2022, pp. 212-237.

[20] G. Guidarelli, G. Liva, S. Musetti, *Il complesso medievale di San Giorgio Maggiore a Venezia. Architettura, scultura, strumenti digitali per l'analisi e l'interpretazione*, "Ateneo Veneto", 3 s., CCVI, 18, 2019, 2, pp. 59-93, https://ateneoveneto.org/wp-content/uploads/2023/06/Guidarelli-1.pdf (last accessed 29 October 20251).

[21] G. Guidarelli, *Una mappa inedita del complesso di San Giorgio Maggiore a Venezia (XV secolo, ante 1494)*, "Ateneo Veneto", 3 s., CCVI, 18, 2019, 1, pp. 181-186, https://ateneoveneto.org/wp-content/uploads/2023/06/AteneoVeneto_CCVI.18.1_Guidarelli.pdf (last accessed 29 October 2025).

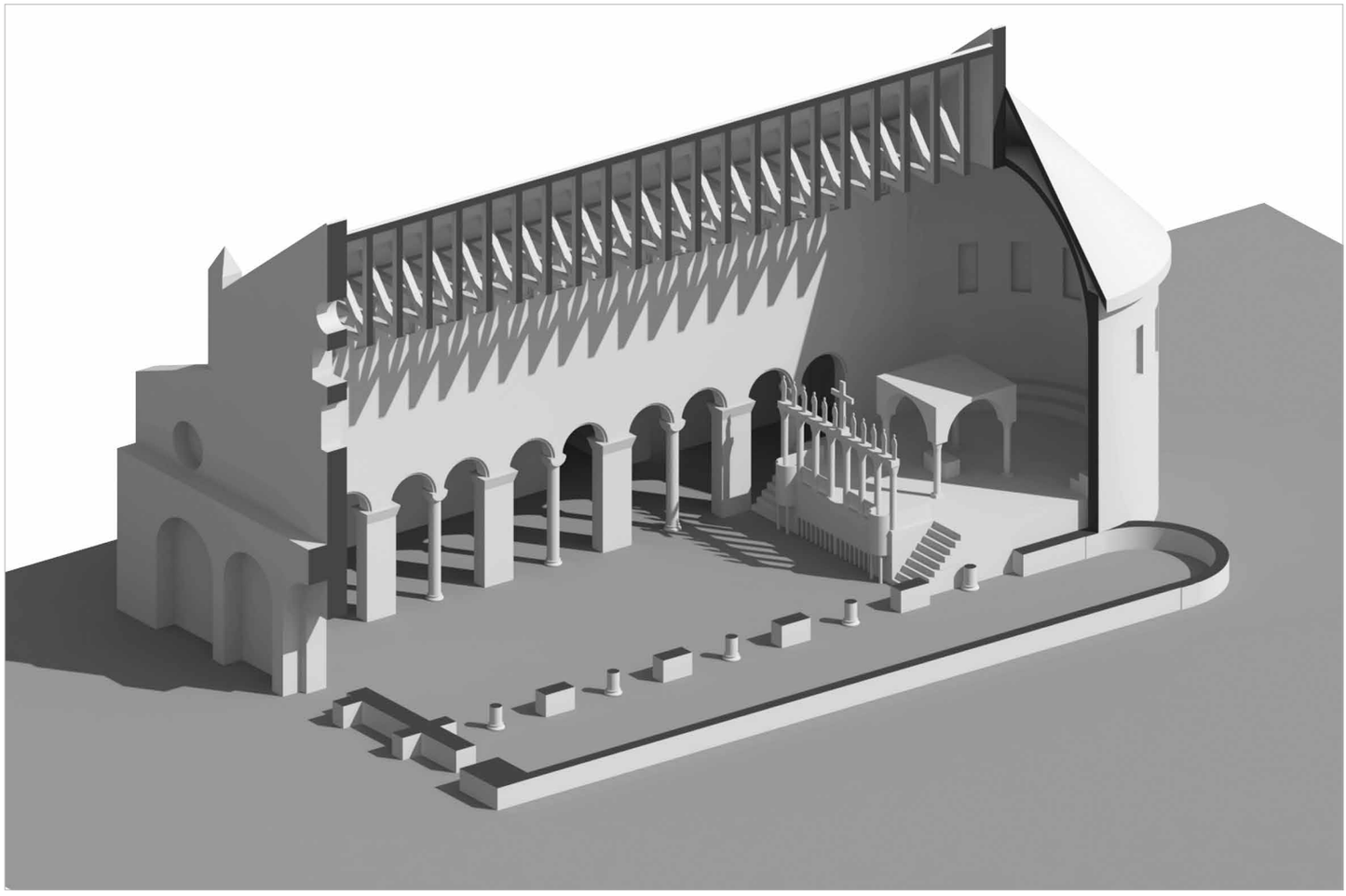

Fig. 5 *Digital reconstruction of the Romanesque church of San Pietro di Castello, Venice (A. Surduleasa, A. Necoloiu, M. Pedron).*

areas of the island most suitable for archaeological excavations by the Superintendency for the Protection of Architectural, Natural, Historic, Artistic, and Ethno-Anthropological Heritages in Venice and its Lagoon, a collaboration that started a few months ago. Additionally, through the analysis of archival data, we were able to accurately reestablish all the phases of reconstruction of the monastery up to the 1564 Palladian project for the church. By having a realistic plan and a workable hypothesis for the 3D shape of the medieval complex, we managed to study and model its intermediate historical phases. Our team also recognized that the designers and craftsmen had to navigate a very particular construction site, as the new interventions had to coexist with the earlier, medieval structures. Throughout this phase of the research, the digital clone of the medieval monastery was progressively refined to account for the gradual transformations that occurred before and after the Palladian renovation.

The most immediate result of this work has been a deeper understanding of a medieval Venetian building of great significance that has remained unknown until now. Furthermore, thanks to the digital analysis of the drawing, we were able to study the techniques of architectural representation in late fifteenth-century Venice. Most importantly, we succeeded in reconstructing, in detail, all the phases of a complex and lengthy construction process, examining how the monks managed to build a structure that remained accessible and inhabited throughout its transformation. In this way, San Giorgio Maggiore provided an opportunity to experiment with the application of digital technologies to study a Renaissance construction site in great detail. This methodology could then be applied to other analogous case studies, particularly to other monasteries of the Congregation of Santa Giustina, built in Italy between the fifteenth and eighteenth centuries and discussed below.

Monastic architecture and digital technologies: the "CoenoBI(u)M" project

The monastery of San Giorgio was part of the reformed Congregation of Santa Giustina. The architecture of the Congregation is the focus of the research project "CoenoBI(u)M. Art and architecture of the Cassinese Benedictine Congre-

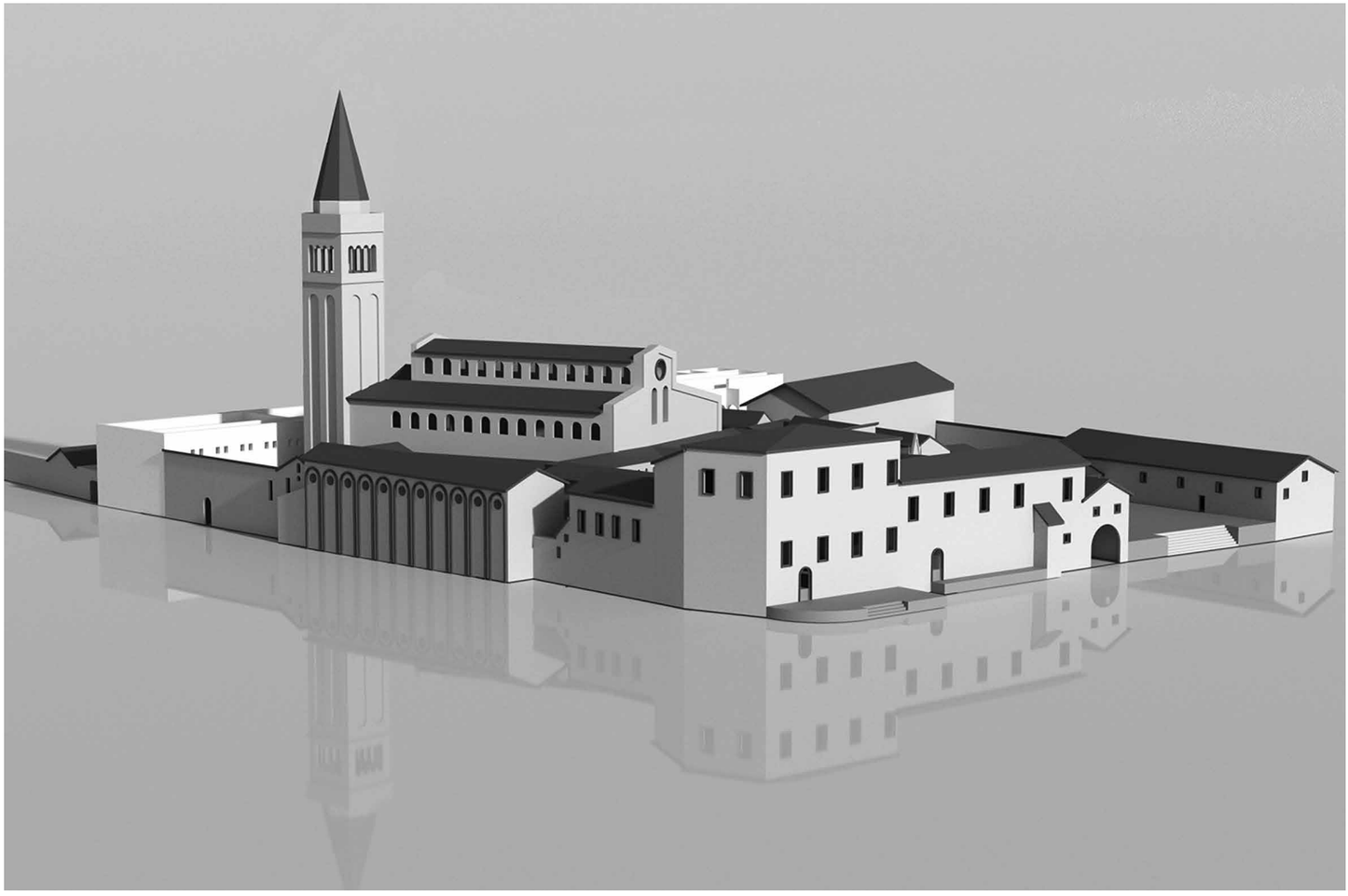

Fig. 6 *Digital model of the appearance of the abbey of San Giorgio Maggiore, Venice, 1490 ca. (G. Liva).*

gation (XV-XVIII centuries): digital and spatial analysis strategies through BIM models"[22]. This highly interdisciplinary project, funded by the Italian Ministry of University and Research, involves the universities of Padua, Bologna, and Brescia, under my direction as Principal Investigator and Sonia Cavicchioli and Paolo Borin as Associated Investigators. A key aspect of the project is the adoption of an innovative digital tool: Building Information Modeling (BIM).

BIM allows us to simultaneously organize data on a three-dimensional model of the building (generated from a survey and point cloud data) and project it in a diachronic dimension by tracing the succession of construction phases. This constitutes, on the one hand, a continuously implementable collaborative and open-access platform and, on the other, a versatile tool for developing verifiable and correctable reconstruction hypotheses. In this way, the research process comes full circle. Thus, the creation of a 3D model is no longer merely the 'final product' but an integral component of the research process with an operational mode that allows the incorporation of archival sources with other types of documentation (visual, material, etc.)[23]. We have chosen to experiment with this versatile and high-performance tool to answer some specific historiographical questions: Was there a distinctive architecture of the Congregation? Can we reconstruct the original decorative schemes of its churches and monasteries? How can we visually retrace the different construction phases of a monastery in 3D?

In 1408, the Benedictine monk Ludovico Barbo became abbot of the monastery of Santa Giustina in Padua. Within a few years, he founded a group of monasteries that revolutionized monastic life, which was in deep crisis at the time. Barbo urged the monks to study, meditate, and dedicate themselves to personal prayer. He also restructured the monastic network: the abbeys were no longer independent but became part of a cohesive system, a 'family' of monasteries that spread throughout Italy in the span of just a few decades. Whenever a monastery joined the Congregation, the number of resident monks increased, necessitating the rebuilding of the complex. From the second half of the fifteenth century, dozens of construction sites opened simul-

[22] https://www.digitalcoenobium.eu/ (last accessed 29 October 2025).

[23] L. Barazzetti et al., *Cloud-to-BIM-to-FEM: Structural simulation with accurate historic BIM from laser scans*, "Simulation Modelling Practice and Theory", 57, 2015, pp. 71-87; P. Borin, R.A. Bernardello, A. Grigoletto, *Connecting Historical Information with BIM Ontologies. HBIM Methods for the Visualization of Harris Matrix for the Torrione in Carpi*, in *Graphical Heritage*, I (*History and Heritage*), conference proceedings (Zaragoza, 24-25 September 2020), edited by L. Agustín-Hernández, A. Vallespín Muniesa, A. Fernández-Morales, Cham 2020, pp. 757-770; S. Bruno, M. De Fino, F. Fatiguso, *Historic Building Information Modelling: performance assessment for diagnosis-aided information modelling and management*, "Automation in Construction", 86, 2018, pp. 256-276; A. Giordano *et al.*, *Time and Space in the History of Cities*, in *Digital Research and Education in Architectural Heritage: 5th Conference, DECH 2017, and First Workshop, UHDL 2017, Dresden, Germany, March 30-31, 2017, Revised selected papers*, edited by S. Münster *et al.*, Berlin-New York 2018, pp. 47-62; L. De Luca, *Methods, formalisms and tools for the semantic-based surveying and representation of architectural heritage*, "Applied Geomatics", 6, 2014, pp. 115-319; M. Murphy, E. McGovern, S. Pavia, *Historic Building Information Modelling - Adding intelligence to laser and image based surveys of European classical architecture*, "ISPRS Journal of Photogrammetry and Remote Sensing", 76, 2013, pp. 89-102; C. Pybus *et al.*, *New Realities For Canada's Parliament: A Workflow for Preparing Heritage BIM for Game Engines and Virtual Reality*, conference paper (Ávila, 1-5 September 2019), "The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences", XLII, 2019, pp. 945-952.

Fig. 7 *Interior of the abbey church of San Pietro Apostolo, Modena (photo S. Cavicchioli).*

taneously, and architects and craftsmen – as well as architectural drawings – began to circulate between the different locations. Decisions regarding individual construction sites required approval from the Chapter General, which met once a year[24]. The most important consequence of this centralization was the formation of a common architectural culture that had a profound impact on the architecture of the Italian Renaissance more broadly. Furthermore, the systematic replacement of common dormitories with individual cells during these reconstructions forced the monks to invent a new monastic layout[25]. The solutions adopted were essentially of two types. The first saw the introduction of a linear dormitory plan with a long central corridor flanked by rows of cells, a model previously tested in the convents of the mendicant orders, where common dormitories had been subdivided by partitions or sheets of fabric into individual spaces for sleeping and study as early as the thirteenth century. The second solution arranged the cells in a ring around a cloister.

This standardization of cloister and church construction, driven by the continuous exchange of architectural and structural solutions between the different sites, can only be studied by gathering a vast amount of data on lots of case studies. To analyze this enormous corpus of buildings, documents, and drawings under a unified research theme requires a coordinated research team working on an integrated digital platform. A simple database is insufficient to manage such diverse and complex information. For this reason, we plan to use Building Information Modeling, which has been increasingly employed in recent years to organize data from archaeological excavations and for research in architectural history. By integrating historical, archival, and bibliographic research with digital representational methods, BIM will provide a multidisciplinary knowledge base of these buildings. Within the "CoenoBI(u)M" project, the platform will connect multiple BIM models of different yet interrelated structures through a device that will allow us to consult the various models in a comparative way. We intend to verify whether similar technological and spatial solutions (including walls, ceiling vaults, roofs, etc.) were consistently adopted in their construction, potentially reflect-

[24] On the Congregation, see J. Leclercq, *Ludovico Barbo e la storia dell'immaginario*, in *Riforma della Chiesa. Cultura e spiritualità nel Quattrocento veneto*, atti del convegno (Padova-Venezia-Treviso, 19-24 settembre 1982), a cura di F.G.B. Trolese, Cesena 1984, pp. 385-400; M. Zaggia, *Mantova e la Sicilia nel Cinquecento*, II (*La congregazione benedettina cassinese nel Cinquecento*), Firenze 2003; *Dalla riforma di S. Giustina alla Congregazione Cassinese: genesi, evoluzione e irradiazione di un modello monastico europeo (sec. XV-XVI)*, atti del convegno (Padova, Abbazia di Santa Giustina, 18-21 settembre 2019), a cura di E. Furlan, F.G.B. Trolese, Cesena 2022.

[25] On the architecture of the Congregation of Santa Giustina, see J. Ackerman, *L'architettura religiosa veneta in rapporto a quella toscana del Rinascimento*, "Bollettino del Centro Internazionale di Studi di Architettura Andrea Palladio", XIX, 1977, pp. 135-164; G. Beltramini, *Architetture di Andrea Moroni per la Congregazione Cassinese: due conventi bresciani e la basilica di Santa Giustina a Padova*, "Annali di Architettura", 7, 1995, pp. 63-94; M.A. Winkelmes, *Form and Reform: Illuminated, Cassinese Reform-style Churches in Renaissance Italy*, "Annali di Architettura", 8, 1996 (1997), pp. 61-84; B. Adorni, *Alessio Tramello*, Milano 1998, pp. 63-67; B. Paul, *Nuns and Reform Art in Early Modern Venice: The Architecture of Santi Cosma e Damiano and its Decoration from Tintoretto to Tiepolo*, Farnham 2012, pp. 121-140; G. Penco, *Funzione e significato dell'architettura monastica nell'età del Rinascimento*, "Benedictina", 59, 2012, pp. 59-76; G. Beltramini, *Modelli antichi e alcuni disegni per i monasteri del-*

Fig. 8 *Chiostro del Capitolo, Abbey of Santa Giustina, Padua (photo G. Guidarelli).*

ing the particular context of the Congregation of Santa Giustina where architectural decisions were made at a centralized level. Through specific queries, we will be able to identify patterns and similarities in the layout of the different environments around the cloister and in their respective spatial relationships (refectory, chapter hall, library, etc.). It will also be possible to verify whether there are common solutions in the dimensioning of community spaces (churches, refectories, etc.) and individual monks' cells. By leveraging BIM, we can test the hypothesis that there was an exchange of solutions between the different building sites. Furthermore, by integrating various relational databases, this methodology will allow us to combine all archival and bibliographic data related to these places. For example, we will be able to trace the circulation of building materials, craftsmen, and architects, focusing initially on three case studies: the abbeys of San Pietro in Modena, Santa Giustina in Padua, and Santa Maria Assunta in Praglia (figs. 7-9). Finally, we plan to conduct a comparative analysis of the construction processes on the different sites, examining how small medieval monasteries evolved into expansive, multi-cloistered complexes. This project aligns with an established field of study that has successfully employed multidisciplinary research and experimented with 4D modeling[26]. In the case of the "CoenoBI(u)M" project, we have applied this methodology to monastic architecture, investigating a network of buildings to uncover shared design principles and construction processes.

Our goal has been to bring together skills, expertise, and findings from different disciplines into a single interpretative framework, where research data is structured to be shared and is always accessible, thus enhancing both the understanding and management of architectural and artistic heritage. By creating a shared virtual environment that integrates heterogeneous visual and non-visual data, this approach enables the definition of historical, architectural, and engineering simulations by coordinating all knowledge related to a single object (e.g., a Benedictine monastery). Consequently, the standardization of information facilitates the generation and comparison of consistent data sets. The process unfolds in four key phases: 1) data acquisition,

la congregazione benedettina di Santa Giustina poi Cassinese nel Quattrocento, in *Renaissance Studies in Honor of Joseph Connors*, I (*Art history*), edited by M. Israëls, L.A. Waldman, Firenze 2013, pp. 253-266; B. Adorni, *L'architettura benedettina cassinese in area padana nel Rinascimento fra* koinè *locale, ritorni al medioevo e disposizioni generali*, in *Cinquecento monastico italiano*, atti del convegno (San Benedetto Po, 18-21 settembre 2008), a cura di G. Spinelli, Cesena 2013, pp. 321-340; J. Gritti, *Echi albertiani. Chiese a navata unica nella cultura architettonica della Lombardia sforzesca*, Venezia-Padova 2014, pp. 233-254; G. Guidarelli, *Vita spirituale, pratica liturgica e architettura: verso un nuovo modello architettonico di monastero benedettino cassinese (XV-XVI secolo)*, in *The Network of Cassinese Arts in Renaissance Italy*, edited by A. Nova, G. Periti, Roma 2021, pp. 81-94; G. Guidarelli, *La formazione di una cultura architettonica comune della congregazione di Santa Giustina nel XV secolo: cantieri, normativa e soluzioni spaziali*, in *Dalla riforma di S. Giustina alla Congregazione Cassinese*… cit., pp. 701-716.

[26] *Visualizing Complexities. Practices and Heuristics*… cit.; S. Münster *et al.*, *Handbook of Digital 3D Reconstruction of Historical Architecture*, Cham 2024.

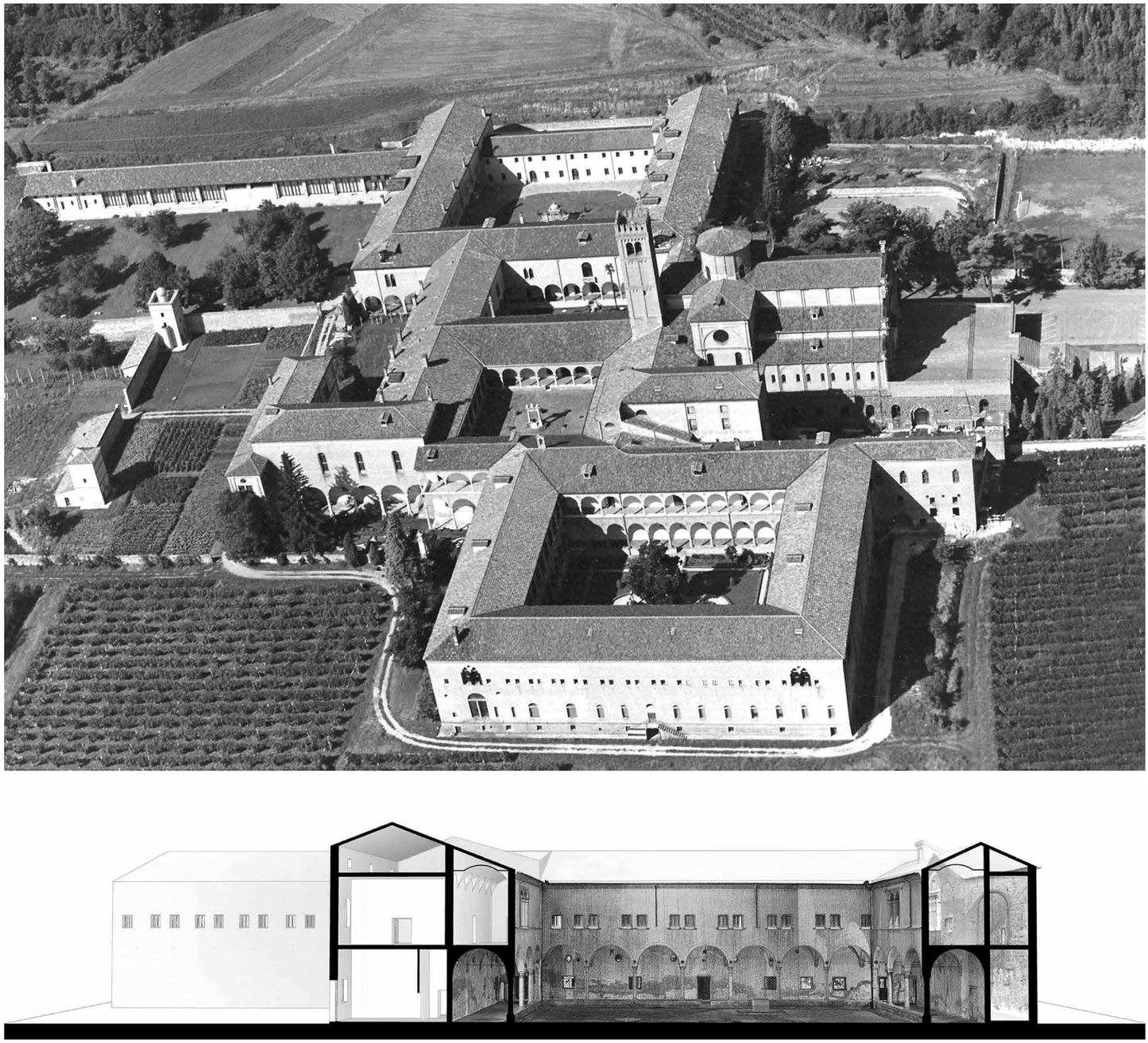

Fig. 9 *Aerial view of the abbey of Santa Maria Assunta di Praglia, Teolo.*

Fig. 10 *Digital model of the monastery of San Nicolò, Lido (V. Merlo).*

gathering all existing information related to the case study; 2) reconstruction, involving the creation of BIM models and the development of hypotheses based on the collected data; 3) conservation, focusing on actions that ensure the long-term usability use of the structure in question; and 4) dissemination, aimed at developing and sharing knowledge with third-party users[27].

The case of the monastery of San Nicolò al Lido illustrates how the BIM methodology combines building surveys, 3D modeling, and the linkage of historical data collected by scholars to specific architectural elements. This approach promotes the creation of a dynamic, continuously expandable 3D database (fig. 10)[28]. This system also allows the visualization of architectural transformations over the centuries, grounding the virtual reconstructions in historical documentation and in the analysis of surviving decorative, architectural, and structural traces. The need to formulate interpretations and hypotheses not only through written text but also via a 3D model implies the localization of spaces and structures. In this way, the BIM model transcends mere replication of reality, serving as an interactive research tool and a shared platform where historical hypotheses can be tested and refined. By associating each monastery with a BIM model

containing both historical records and data on its current condition, it becomes possible to interconnect these models into a networked database that mirrors the organizational structure of the Congregation itself. This framework allows for the systematic comparison of architectural and artistic similarities across monasteries and the study of material, craft, and architectural exchanges, thus progressively reconstructing the architectural and artistic culture of the Congregation. This research model can then be adapted and applied to other fields of study.

Conclusion

From an initial phase in which digitalization was primarily used for the dissemination of research findings, we have gradually moved to an operational use of IT tools that have enabled the creation and comparison of alternative reconstruction hypotheses within a framework of continuous updating and sharing of data ('open data' and 'open science'). In this phase, the work of scholars who engaged in pioneering interdisciplinary research—transferring cognitive processes and investigative tools across disciplinary boundaries—proved essential. Among them, Robert Mark's contribution was particularly significant. Mark experimented with photoelastic analysis (originally developed for the design of nuclear reactor components) and holographic interferometry to formulate a technique that, when combined with digital modeling, could assist in identifying the construction phases of French Gothic cathedrals[29].

The new approach that has developed is an inherently interdisciplinary type of research where languages, heuristic processes, and protocols from different disciplinary fields (e.g., computer science, data visualization, architectural restoration, etc.) must communicate and operate on a common platform and with common objectives. Yet, some important questions remain. For example, do the results obtained through digital methodologies justify the effort, the scale of collaboration, and the increasing complexity of interdisciplinary research groups? Within such groups, how can the architectural historian effectively coordinate heterogeneous disciplinary tools and approaches and meaningfully steer the results toward core historiographical questions? Furthermore, is the digitalization of cognitive processes and narrative protocols merely a trend – one often driven by funding incentives – or does it offer a genuine opportunity to better conceptualize our research and make it more effective? In short, how is our profession evolving in response to the digital tools?

I think that historicizing – that is, retracing the history of this particular approach to architectural history – demonstrates how the process has become increasingly economical, versatile, and productive over the last two decades. It also shows that the transition from simple data mapping to digital narration and, ultimately to complex and interoperable 3D modeling represents, despite all potential misgivings, a significant conceptual advancement. However, this progress must continue to be refined while remaining increasingly attuned to the material reality of the built environment it seeks to understand.

[27] Building Information Modeling (BIM) originated as a digital representation of a building that integrates multiple types of data, enabling interoperability and data sharing across different models and databases. Its most widely accepted definition, as stated in ISO/DIS 6707-2(en), is: "use of shared digital representation to facilitate design, construction, and operation processes to form a reliable basis for decisions". Initially developed as a tool for designing and maintaining new constructions, BIM has since been adapted for use in the context of historic buildings – commonly referred to as Historic Building Information Modeling (HBIM). When applied to heritage sites, BIM facilitates the integration of inherently heterogeneous data, organized according to distinct historical phases. In this way, interdisciplinary collaboration becomes possible, allowing BIM to be used as a research tool. In archaeological contexts, Archaeological BIM (A-BIM) enables the structuring of fragmented and diverse data within a stratigraphic framework, effectively creating a 'digital twin' of the actual excavation. See Borin, Bernardello, Grigoletto, *Connecting Historical Information…* cit., pp. 757-770; L. Sbrogio *et al.*, *Design Criteria and Procedures for Archaeological Shelters: Towards Flexibility Thanks to Algorithmic Modelling*, conference paper (SAHC online, 29 September-1 October 2021), edited by P. Roca, L. Pelà, C. Molins, 2021, https://www.scipedia.com/public/Sbrogio_et_al_2021a (last accessed 29 October 2025).

[28] R.A. Bernardello, V. Merlo, *Nuovi metodi per l'analisi storica. Processi Bim per la catalogazione e lo studio del monastero di San Niccolò del Lido*, "Ateneo Veneto", 3 s., CCVIII, 20, 2021, 2, pp. 51-82.

[29] R. Mark, *Experiments in Gothic Structure*, London 2014; Id., *Structural Archaeology, Photoelastic and Finite-element Modeling of Historic Architecture*, in *Stable-unstable? Structural Consolidation of Ancient Buildings*, edited by R.M. Lemaire, K. Van Balen, Leuven 1988, pp. 79-91.