Architectural Heritage through HBIM and Ontologies: A formal analysis of Sant'Andrea Fortress Portal in Venice

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Abstract

This study outlines a methodological framework for architectural heritage documentation, grounded in integrating HBIM and ontologies. The applied case study is the portal of the *Sant'Andrea* Fortress in Venice, designed by Michele Sanmicheli, where a top-down approach is implemented. The process begins with the typological and lexical interpretation of the components, based on historical sources and architectural treatises, and proceeds to their formalisation into parametric families and digital schedules. The resulting idealised geometries are then compared with digital survey data, enabling a calibrated alignment between the theoretical model and the existing condition.
This approach moves beyond mere geometric recording, transforming the HBIM model into a semantic infrastructure capable of ensuring terminological consistency, interoperability, and opportunities for reuse. The portal of *Sant'Andrea* Fortress stands as an emblematic yet replicable example, particularly in comparison with other portals related to Sanmicheli's oeuvre, validating the construction of a comparative library of cases in support of research, conservation, and the enhancement of fortified heritage.

1. Introduction

This study proposes a conceptual and methodological framework based on parametric modelling and digital ontologies for architectural heritage, interpreting HBIM as a semantic support through which to structure and narrate complex spatial and conceptual relationships. The research forms part of the broader ERC project *Venice's Nissology (VeNiss)*, aimed at documenting and reinterpreting the built heritage of the Venetian lagoon (Galeazzo, 2024). In this broader framework, the study focuses exclusively on the *Sant'Andrea* Fortress, one of Michele Sanmicheli's most significant sixteenth-century military works (Davies & Hemsoll, 2004), examined in depth through its monumental portal. The decision to restrict the investigation to a single architectural element - the monumental portal - stems from the intention to demonstrate, rapidly and effectively, the validity of a methodological approach, defined here as top-down (*from Terminology to Surveyed Reality*), in the processes of documentation, parametric modelling, and semantic structuring of heritage. This choice is also motivated by the portal's rich decorative features, which provide a favourable ground for experimenting with a complex ontological structuring. Its composition, strongly rooted in the classical lexicon yet reinterpreted through Sanmicheli's own style and sensibility, provides a valuable field for testing the potential of parametric modelling to mediate between theoretical idealisation and surveyed reality.
Nor is this an isolated episode: the portal of the *Sant'Andrea* Fortress belongs to a broader corpus of urban and fortified gates designed by the architect, such as the *Porta Terraferma* in Zadar, *Porta Palio* and *Porta Nuova* in Verona, which share analogous compositional principles. It is precisely this typological recurrence that makes it possible to validate the replicability of the methodological system, showing how an approach that proceeds from general, the abstract terminological definition, to particular, the single geometric entity, can be extended to related cases, while at the same time ensuring lexical consistency and adaptability to local specificities. In this context, the BIM model, understood as an information system, is not merely a geometric container but assumes the role of a semantic infrastructure.
The ontology, in turn, becomes a device of mediation between survey data, historical interpretation, and processes of heritage enhancement, establishing itself as a powerful communicative tool capable of facilitating the understanding of complex architectures even for a wider audience. The overarching aim of the research is to formalise, through interoperable tools, a shared methodology capable of interpreting and representing complex phenomena, such as the evolution of historic architectures and their role in landscape construction. From this perspective, space is understood not only as a geometric configuration but as a *semantic construct*, an expression of functional, cultural, and territorial relationships (Goulette, 1999).
The top-down methodological approach highlights the role of terminological consistency, ontological structuring, and typological reasoning as guiding principles in the construction of the HBIM model. In this sense, *top-down* is understood as a process that starts from the idealised definition of architectural components - based on typological repertoires, treatises, and historical grammars - and translates them into parametric families and digital schedules. Only later are these elements verified and adapted against survey data and the point cloud through scan-to-BIM processes, mediating between the theoretical model and the surveyed reality.

2. State of the Art

In the domain of documentation and management of the built heritage, HBIM and digital ontologies represent complementary components of a single process. HBIM provides the environment for modelling and information management, enabling the interpretation of survey data and its structuring into parametric objects validated through Scan-to-BIM processes (Garcia-Gago et al., 2022; Sampaio et al., 2023). Digital ontologies, in turn, make it possible to formalise concepts, relationships, and constraints, establishing terminological consistency and naming rules. The aim is not merely geometric restitution, but the construction of semantically enriched models in which forms, functions, and documentary sources are made explicit according to grammars consistent with the multiple languages of architecture (De Luca et al., 2011; Apollonio et al.,

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2012; Costamagna & Spanò, 2012; De Luca & Lo Buglio, 2014). In historic artefacts, irregularities, deformations, and stratifications require parametric libraries capable of mediating between singularity and class, while preserving the morphological imprint of elements and their transformative processes (Murphy & Dore, 2015; Croce et al., 2021).

The geometric construction in HBIM models, however, presents limitations in the representation and characterisation of reality; such shortcomings can be addressed only if the geometric basis is supported by a solid informational framework capable of integrating historical, functional, and documentary dimensions (Parrinello & Pettineo, 2024). From this perspective, digital schedules and glossaries operate as interpretative interfaces between metric data and semantics, supporting typological recognition, traceability, and knowledge reuse (Quattrini et al., 2017; Parrinello & Dell'Amico, 2020).

At the operational level, knowledge-based approaches and semi-automated procedures enhance the consistency and reproducibility of the model, while nonetheless requiring caution concerning the risks of excessive standardisation and the need for customisation in the case of unique historic elements (Roman et al., 2023; Quattrini et al., 2023; Sommer et al., 2025). The informational dimension requires structured databases and spatial, functional, and compositional relationships that enable interoperability throughout the knowledge and conservation cycle, supported by shared nomenclatures and open ontologies (Sanseverino et al., 2022, Rao & Wang, 2025). Within this framework, consolidated ontologies such as CIDOC CRM, its CRMba extension for the built heritage, the IFC standard, and the Getty AAT thesaurus constitute crucial references for semantic formalisation and interoperability among heterogeneous information models.

The opening of models within cooperative systems and web-based platforms fosters the federation of datasets and access for non-specialist audiences, up to HBIM-HGIS integrations that extend the analysis to territorial dimensions (Palomar et al., 2020; Pettineo et al., 2024).

3. Methodological Framework

The adopted methodological approach proposes a combined vision of HBIM parametric modelling and ontological structuring, which contribute to developing information models capable of representing both the material and the conceptual-terminological dimensions of architectural heritage.

The process aims at translating survey data into geometric entities connected to a shared lexicon, describing architectural components within their territorial, functional, typological, and chronological context (Parrinello & Pettineo, 2025).

Within this framework, the defined *top-down* approach is based on the assumption that the definition of architectural components should not start directly from the surveyed reality, but from a pre-established conceptual and typological framework.

The operational workflow integrates the ontological structuring phase, (i) *terminological and lexical analysis*, with the structuring of geometries in the BIM environment, *(ii) formalisation of geometric components*, and (iii) *model characterisation*. This articulation combines different environments and tools, each with a specific role: *Protégé* for ontology structuring, *Autodesk Revit* for parametric modelling, *Leica Cyclone Core* and *Autodesk Recap Pro* for point cloud management and segmentation, *MeshLab* for the processing of ornamental meshes, and *Dynamo* for automation through visual programming. The combination of these environments constitutes the operational core of the process.

The first phase involves identifying and terminologically defining the architectural elements based on historical sources, treatises, and typological repertoires. In the case of Sanmicheli's fortified portals, such analysis makes it possible to isolate the recurring architectural orders, canonical proportions, and compositional variants.

These data converge into an ontological structure that defines classes, properties, and semantic relationships, formalised within the *Protégé* software and linked to shared thesauri and standards. The definition of the lexicon constitutes the prerequisite for constructing idealised digital components. In *Autodesk Revit*, the geometric profiles are parameterised to generate loadable families and adaptive schedules, aimed at reproducing the main elements of the portal - columns, bases, capitals, entablatures, and cornices.

The objective is the definition of a catalogue of manipulable digital objects, consistent with Sanmicheli's architectural grammar and reusable in further case studies. The parametric families are organised within a structured library that functions as a digital lexicon of elements, enabling hierarchical distinction, the recording of morphological variants, and semantic traceability.

Within this framework, the HBIM model acquires a systematic nature, in which geometry is consistently associated with a term

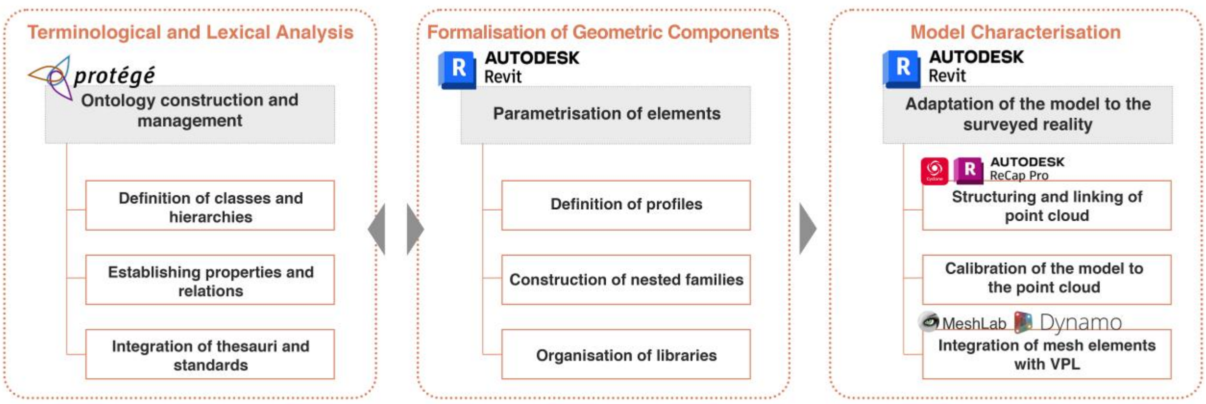

Figure 1. Methodological framework and software environments used. The workflow, constantly supported by external data such as historical documentation and surveys, begins with the ontological formalisation in *Protégé*, where concepts are organised into hierarchical terminological structures functional to operational translation. These structures are then applied in *Revit* to construct a model that makes semantics explicit through the individual architectural components. The characterisation occurs through the calibration of the model against the point cloud and the integration of decorative meshes, optimised in *MeshLab* and managed through *Dynamo*.

and with a defined typological context. In a subsequent phase, the system of families is compared with the metric data derived from digital surveying: the point cloud, produced by laser scanning and photogrammetry, serves as the validation reference in which the idealised elements are adapted to the deformations and irregularities of the surveyed reality. This stage realises the mediation between the theoretical model and the built reality, maintaining semantic consistency and metric accuracy on the one hand.

The peculiarity of the method lies in the direction of the process: not from data to concept, but from concept to data. However, it is an approach that has proven particularly effective in this case, while not representing a univocal or universally valid method. This approach makes it possible to ensure greater terminological consistency, to foster reuse in other contexts, and to structure a digital archive capable of linking the single architectural instance to a broader typological system. Applied to Sanmicheli's portals, it has made it possible to verify the system's replicability and construct a comparative library of cases, within which the portal of *Sant'Andrea* stands as an emblematic episode.

3.1 Terminological and Lexical Analysis

The interpretative phase, conceived in a top-down sense, is based on the typological and lexical reading of architectural elements. The analysis of treatises and repertoires, together with the comparison with other portals designed by Michele Sanmicheli (such as *Porta Terraferma* in Zadar, *Porta Palio* or *Porta Nuova* in Verona), made it possible to identify the main classes and hierarchies, distinguishing principal elements (column, entablature, cornice) and subcomponents (base, shaft, capital, architrave, frieze); as well as to formalise properties and relationships such as canonical proportions, hierarchical connections (the column includes the capital), and functional relationships (the entablature rests upon the column). This interpretation constitutes the conceptual matrix within which each model component is situated, linking the single instance of the portal of *Sant'Andrea* to a broader typological system.

The data thus structured converge into an ontology developed in *Protégé*, where classes, properties, and semantic relationships between architectural objects are defined. The ontology was enriched, where possible, with corresponding references to external sources such as the Getty AAT thesaurus and the bSDD for IFC standards, to ensure terminological traceability and interoperability with other systems, while at the same time highlighting linguistic differences. In this way, the architectural lexicon takes shape as a logical infrastructure that guides modelling processes, facilitates the encoding of elements, and ensures data consistency and coherence.

3.2 Formalisation of Geometric Components

The parameterisation of architectural elements was developed through the analysis of geometric profiles, typological codification, and the definition of compositional rules, integrating the study of Michele Sanmicheli's works and documentary sources (Pompei, 1735; Ronzani et al., 1862) with morphometric information obtained from digital survey activities. This process led to the construction of idealised versions of the elements, organised according to classical modules, Sanmicheli's reinterpretations, and recurring formal logics, translated into digital schedules consistent with HBIM modelling. The definition of profiles was not limited to a simple geometric transposition but constituted the first level of abstraction in constructing a schedule consistent with the compositional rules favoured by Sanmicheli. The comparison of Sanmicheli's architectures, with reference to the monumental portals related to that of the Fortress, revealed significant morphological and stylistic variations, yet always traceable to a common matrix. This coherence made it possible to define a shared formal scheme capable of generating adaptable parametric elements. Particular attention was devoted to defining the architectural orders, which constitute the compositional structure of the analysed portals.

While acknowledging the specificities of each work, the modelling followed a unified logic aimed at representing the formal, structural, and decorative recurrences of Sanmicheli's language.

In all cases, a set of generative objects was defined and organised into nested families, articulated into principal components and subcomponents (e.g. for columns: base, shaft, and capital; for entablatures: architrave, frieze, and cornice). Each part was modelled through the definition of parametric profiles and subsequently integrated into its respective family. The creation of nested families within the BIM environment proved essential for the modelling of articulated objects, enabling precise control of parameters and proportions throughout the entire system.

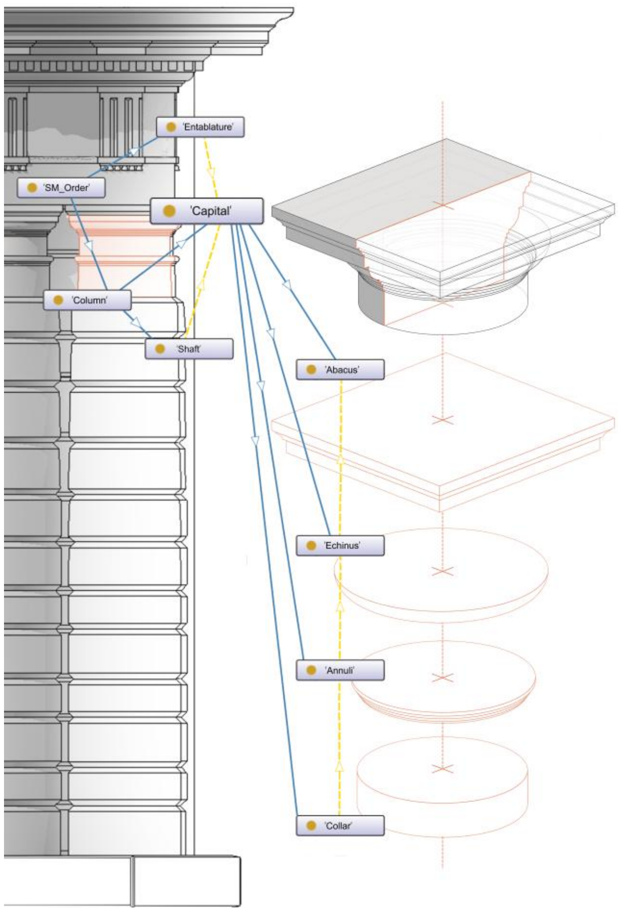

Figure 2. Scheme of ontological and hierarchical relationships in the portal of *Sant'Andrea*. The capital is broken down into subcomponents (abacus, echinus, annulets, collarino) and semantically linked to the column and entablature. The representation highlights the conceptual integration between the ontological structure and the parametric encoding of geometric elements in *Autodesk Revit*, showing how terminological structuring guides modelling and ensures consistency among the different parts of the architectural system.

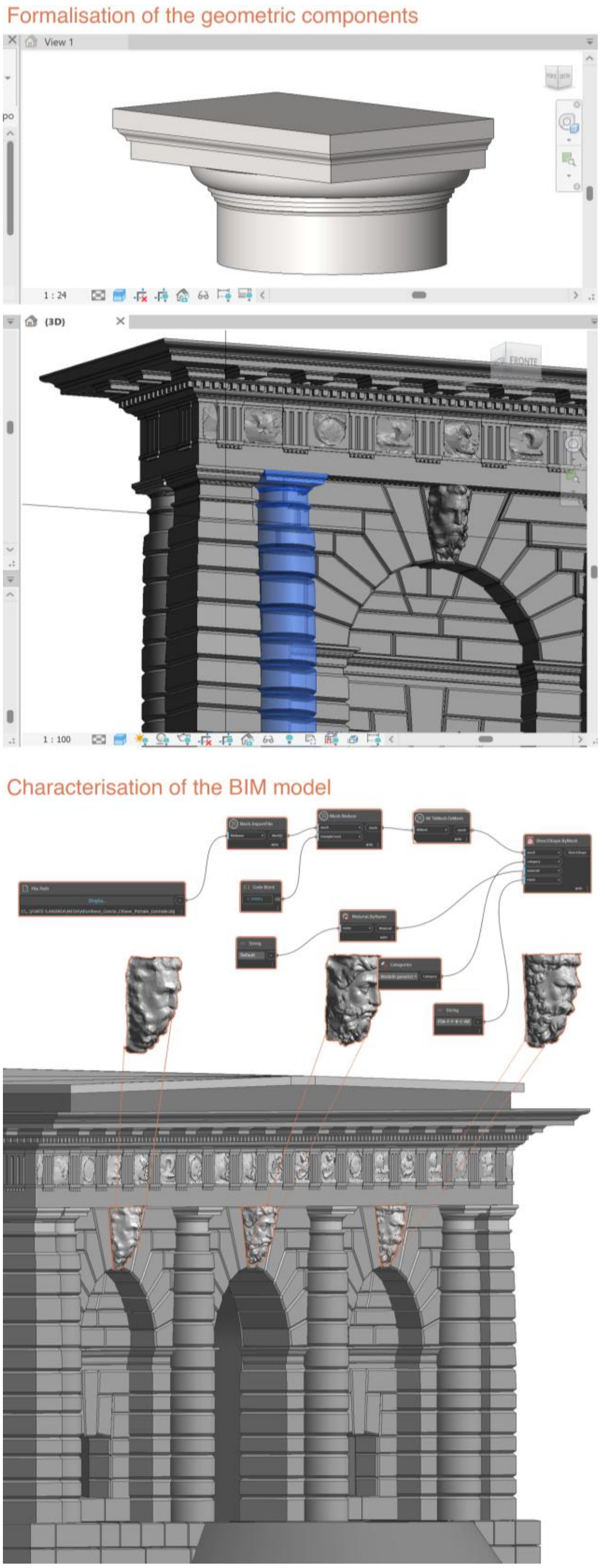

Figure 3. Formalisation and characterisation of the portal of *Sant'Andrea*. The upper part shows the parametric definition of the geometric components in *Revit* and the insertion of modular elements into the model. The lower part illustrates the characterisation phase, with the integration of high-resolution decorative meshes through *Dynamo* and their connection to the HBIM model.

This approach, applied for instance to the engaged semi-columns, made it possible to articulate complex elements through multi-level parametric dimensional relationships, accurately reflecting the compositional logic of the portals. Within the families, parts such as capitals and the individual drums of the shaft were distinguished and hierarchically organised, contributing to the unified definition of the architectural component.

3.3 Model Characterisation

Once the architectural elements were modelled in their “ideal” form within *Autodesk Revit*, they were adapted to the three-dimensional model through direct comparison with the point cloud, obtained from multisource digital surveying (laser scanning and terrestrial photogrammetry). The point cloud of the fortified complex was first structured in *Cyclone Core* and segmented to isolate, in this case, only the area relating to the monumental portal. It was then imported into *Autodesk Recap*, allowing direct connection with the *Revit* modelling environment to accurately correspond with the surveyed reality.

During the structuring of the components, additional deformation parameters were introduced, enabling the calibration of the idealised geometries derived from the theoretical model to the irregularities and specificities observed in the point cloud analysis.

This step allowed for a controlled alignment between ideal and real conditions, avoiding excessive abstraction and reducing the model to a mere digital copy of the survey.

The characterisation phase also concerned integrating decorative and sculptural elements into the information model, which can hardly be managed through conventional parametric families. For these elements, a specific pipeline was devised: the high-resolution meshes, generated from survey data (laser scanning and photogrammetry) and optimised in the open-source software *MeshLab* to preserve their morphological accuracy, were imported as instances within the HBIM model through visual programming techniques using *Dynamo*, directly integrated into *Autodesk Revit*. In particular, the use of scripts made it possible to manage the positioning and orientation of the meshes, ensuring spatial and topological control while maintaining a clear distinction between parametric geometries and non-parametric decorative components. The inclusion of such elements enriched the model with a level of detail consistent with the formal and symbolic complexity of the portal, allowing for a more complete representation of its architectural identity. Characterisation was therefore not limited to geometric adaptation, but entailed the expansion of the model towards a more articulated informational dimension, in which structure, ornament, and decoration coexist within a single digital environment.

4. Critical Reflections and Future Perspectives

Despite its innovative potential, adopting ontologies and HBIM applied to architectural heritage presents limitations and critical issues. First, the availability and reliability of historical sources can affect the quality of the model: partial or hypothetical reconstructions require a constant balance between scientific rigour and interpretation (Apollonio, 2024). Moreover, semantic standardisation at the European level encounters obstacles linked to linguistic and terminological diversity, which may generate ambiguities or flatten local specificities. On the technological level, the complexity of the models risks undermining long-term usability: data maintenance, platform

Figure 4. HBIM model of the portal of *Sant'Andrea* and comparison with the point cloud derived from multisource digital survey. The parametric model reconstructed in Revit is shown on the left and in the centre, while on the right the superimposition with the point cloud verifies the correspondence between the idealised geometry and the surveyed reality, highlighting the qualitative level of detail achieved in the BIM model.

updates, and the need for multidisciplinary expertise represent concrete challenges. It is also necessary to consider the risk of an "over-semantisation" of the data, which may lead to forced interpretations or overlaps that are not always consistent with historical reality.
The operational ambitions of models that are "reliable, reusable, low-cost, and user-friendly" require a delicate balance between modelling costs, semantic accuracy, and the sustainability of update workflows. The scalability from single architectural episodes to complex systems entails risks of data heterogeneity, differences in granularity, and lexical misalignments not always reconcilable within a single glossary (Parrinello et al., 2019; Parrinello & Picchio, 2023). In this respect, the portal of the *Sant'Andrea* Fortress serves as a helpful case study for testing the limits of the framework while at the same time verifying its replicability in other Sanmicheli portals. The proposed framework enhances HBIM's potential as a distributed semantic infrastructure oriented toward representing complex architectural systems. The outcome of this experimentation will be developing an integrated platform, in which the direct connection between the ontology and the geometric model will enable queries, interrogations, and real-time simultaneous visualisations of semantic graphs and HBIM information models. This will foster the synchronous exploration of conceptual and geometric relationships, overcoming the current purely formal and abstract level of connection.
Each modelled element becomes an active node within a knowledge network, where the relationships are not only spatial or temporal but also functional, symbolic, and narrative. The ontological structure may also accommodate immaterial dimensions, such as oral testimonies or local practices, reinforcing the link between architecture and collective identity.

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References

Apollonio, F. I., Gaiani, M., & Sun, Z., 2012. BIM-based modeling and data enrichment of classical architectural buildings. *Scires-It*, 2(2), pp. 41–62.

Apollonio, F.I., 2024. The Three-Dimensional Model as a 'Scientific Fact'. *Heritage* 7(2), 255–273. https://doi.org/10.3390/heritage7100255

Costamagna, E., Spanò, A., 2012. *Semantic models for architectural heritage documentation*. In: Euro-Mediterranean Conference, Berlin, Heidelberg, October 2012, pp. 241–250. Springer Berlin Heidelberg.

Croce, V., Caroti, G., Piemonte, A., Bevilacqua, M.G., 2021. From survey to semantic representation for cultural heritage: The 3D modeling of recurring architectural elements. *Acta IMEKO* 10(4), 98–105. https://doi.org/10.21014/acta_imeko.v10i4.1113

Davies, P. and Hemsoll, D., 2004. Michele Sanmicheli. Electa.

De Luca, L., Véron, P., Florenzano, M., 2011. A semantic-based platform for the digital analysis of architectural heritage. *Comput. Graph.* 35, 227–241.

De Luca, L., Lo Buglio, D., 2014. Geometry vs semantics: open issues on 3D reconstruction of architectural elements. In: *3D Research Challenges in Cultural Heritage: A Roadmap in Digital Heritage Preservation*. Springer, Berlin, Heidelberg, pp. 36–49.

Dore, C., & Murphy, M., 2015. Historic building information modelling (HBIM). In: *Handbook of Research on Emerging Digital Tools for Architectural Surveying, Modeling, and Representation*. IGI Global Scientific Publishing, pp. 233–273.

Galeazzo, L., 2024. Risemantizzare paesaggi perduti: un database per l'arcipelago veneziano. *TRIBELON Journal of Drawing and Representation of Architecture, Landscape and Environment*, 1(2), 64–75. https://doi.org/10.36253/tribelon-2943

Garcia-Gago, J.M., Sánchez-Aparicio, L.J., Soílán, M., González-Aguilera, D., 2022. HBIM for supporting the diagnosis of historical buildings: case study of the Master Gate of San Francisco in Portugal. *Automation in Construction*, 141, 104453. https://doi.org/10.1016/j.autcon.2022.104453

Goulette, J.-P., 1999. Sémantique formelle de l'espace. Application au raisonnement spatial qualitatif en architecture. Intellectica 29(2), 9–34.

Palomar, I.J., García Valldecabres, J.L., Tzortzopoulos, P., Pellicer, E., 2020. An Online Platform to Unify and Synchronise Heritage Architecture Information. *Automation in Construction*, 110, 103008. https://doi.org/10.1016/j.autcon.2019.103008

Parrinello, S., & Dell'Amico, A. (2020). From survey to parametric models: HBIM systems for enrichment of cultural heritage management. In *From Building Information Modelling to Mixed Reality* (pp. 89-107). Cham: Springer International Publishing.

Parrinello, S., Picchio, F., De Marco, R., Dell'Amico, A., 2019. Documenting the cultural heritage routes. The creation of informative models of historical Russian churches on Upper Kama Region. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W15, 887–894. https://doi.org/10.5194/isprs-archives-XLII-2-W15-887-2019

Parrinello, S., Pettineo, A., 2024. Traditional architectures along the cultural route of James I of Aragon in the province of Valencia: Leveraging laser scanning and BIM for heritage management. *Materials Research Proceedings*, 40, 350–357.

Parrinello, S., Pettineo, A., 2025. Databases and Information Models for Semantic and Evolutionary Analysis in Fortified Cultural Heritage. *Heritage*, 8(1), 29. https://doi.org/10.3390/heritage8010029

Parrinello, S.; Picchio, F., 2023. Digital Strategies to Enhance Cultural Heritage Routes: From Integrated Survey to Digital Twins of Different European Architectural Scenarios. *Drones*, 7(9), 576. https://doi.org/10.3390/drones7090576

Pettineo, A., Dell'Amico, A., Picchio, F., Parrinello, S., 2024. H-BIM e GIS per l'analisi e la ricostruzione filologica del castello di Almencir in Spagna. *DN*, 14, 6–16.

Pompei, A., Sanmicheli, M., 1735. Li cinque ordini dell'architettura civile di Michel Sanmicheli rilevati dalle sue Fabriche, e descritti e publicati con quelli di Vitruvio, Alberti, Palladio, Scamozzi, Serlio e Vignola. Jacopo Vallarsi.

Quattrini, R., Pierdicca, R., & Morbidoni, C., 2017. Knowledge-based data enrichment for HBIM: Exploring high-quality models using the semantic-web. *Journal of Cultural Heritage*, 28, pp. 129–139. https://doi.org/10.1016/j.culher.2017.05.004

Quattrini, R., Sacco, G.L.S., De Angelis, G., Battini, C., 2023. Knowledge-based modelling for automatizing HBIM objects. The vaulted ceilings of Palazzo Ducale in Urbino. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 48, 1271–1278. https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-1271-2023

Rao, Z., Wang, G., 2025. S*mart Data-Enabled Conservation and Knowledge Generation for Architectural Heritage System.* Buildings 15, 2122. https://doi.org/10.3390/buildings15122122

Roman, O., Avena, M., Farella, E.M., Remondino, F., Spanò, A., 2023. A semi-automated approach to model architectural elements in Scan-to-BIM processes. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 48, 1345–1352. https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-1345-2023

Ronzani, F., Luciolli, G., Zanotto, F., 1862. Le fabbriche civili, ecclesiastiche e militari di Michele Sanmicheli, disegnate ed incise da Francesco Ronzani e Girolamo Luciolli, con testo illustrativo riveduto da Francesco Zanotto. Torino.

Sampaio, A.Z., Tomé, J., Gomes, A.M., 2023. Heritage building information modelling implementation first steps applied in a castle building: historic evolution identity, data collection and stratigraphic modelling. *Heritage*, 6(10), 6472–6493. https://doi.org/10.3390/heritage6100338

Sanseverino, A., Antinozzi, S., Di Filippo, A., 2022. Sistemi cooperativi informativi in ambiente HBIM per la gestione del patrimonio culturale. Enriched cooperative systems in HBIM platforms for the management of cultural heritage. *DN*, 11, 35–51.

Sommer, E., Koehl, M., Grussenmeyer, P., 2025. Parametric Modelling Techniques for Rhine Castle Models in Blender. *Heritage*. https://doi.org/10.3390/heritage8010031