

A computational approach to 'drawn' architecture: a Drawing Encoding Initiative (DEI)

Original

A computational approach to 'drawn' architecture: a Drawing Encoding Initiative (DEI) / Giovannini, E.C.. -
ELETTRONICO. - (2025), pp. 104-113. (3D Modeling & BIM 2025 - Desarrollos Futuros Cordoba (AR) 9 maggio 2025).

Availability:

This version is available at: 11583/3006324 since: 2026-01-07T22:43:43Z

Publisher:

PVBLICA Sharing Knowledge

Published

DOI:

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

COLLANA

3D MODELING & BIM

DESARROLLOS FUTUROS

a cura di Tommaso Empler, Adriana Caldarone,
Javier Nuñez, Stefania Tuzi, Bernardo Pèrgamo

PUBLICA

ISBN 9788899586591

PIANO NAZIONALE RIPRESA E RESILIENZA (PNRR), INIZIATIVE EDUCATIVE TRANSNAZIONALI (TNE), PREVISTE DALLA SOTTOMISURA T4 “INIZIATIVE TRANSNAZIONALI IN MATERIA DI ISTRUZIONE”, INVESTIMENTO 3.4 “DIDATTICA UNIVERSITARIA E COMPETENZE AVANZATE” DEL PIANO NAZIONALE DI RIPRESA E RESILIENZA, MISSIONE 4 “ISTRUZIONE E RICERCA” – COMPONENTE 1 “POTENZIAMENTO DELL’OFFERTA DEI SERVIZI ALL’ISTRUZIONE: DAGLI ASILI NIDO ALL’UNIVERSITÀ”

Titolo del progetto

TNE AdvancedSkills

Comunicazione e Valorizzazione del Patrimonio
Culturale

Finanziamento

Finanziato dall’Unione europea- Next Generation EU,
Missione 4 Componente 1

TNE23-00080 CUP F31I24000320006

Soggetto attuatore

Dipartimento di Storia Disegno e Restauro
dell’Architettura
SAPIENZA UNIVERSITA’ DI ROMA
Piazza Borghese, 9
CAP 00186

Tommaso Empler, Adriana Caldarone, Javier Nuñez, Stefania Tuzi, Bernardo Pèrgamo (a cura di)
3D Modeling & BIM 2025 - Desarollos Futuros

© PUBLICA, Alghero, 2025

ISBN 9788899586591

Pubblicazione Dicembre 2025

Questa pubblicazione è distribuita in modalità Open Access.

Dipartimento di Storia, Disegno e Restauro dell'Architettura
Sapienza Università di Roma

DIPARTIMENTO DI STORIA
DISEGNO E RESTAURO
DELL'ARCHITETTURA



SAPIENZA
UNIVERSITÀ DI ROMA

Progetto grafico: Francesco Cocchi

PUBLICA

Dipartimenti di Architettura, Design e Urbanistica

Università degli Studi di Sassari



A cura di:
Tommaso Emler, Adriana Caldarone,
Javier Nuñez, Stefania Tuzi, Bernardo
Pérgamo

3D MODELING & BIM

DESAROLLOS FUTUROS

I volume raccoglie i contributi, dei relatori e degli studiosi, pervenuti in occasione del *Workshop 3DModeling&BIM. Desarrollos futuros*, che si è svolto a Cordoba (Argentina) in data 9 maggio 2025.

La valutazione dei contributi pubblicati è avvenuta con la modalità del double blind review.

This book collects contributions, of speakers and scholars, received during the *Workshop 3Dmodeling & BIM. Desarrollos Futuros*, which took place in Cordoba (Argentina) on May 9th 2025.

Contributions are printed under double blind review mode.

Organizing Commitee

Eng. Salvatore Barba (*Scientific Attaché of the Italian Embassy in Buenos Aires*)

Arc. Adriana Caldarone (*DSDRA – Sapienza*)

Arc. Tommaso Emler (*DSDRA – Sapienza*)

Arc. Javier Nuñez (*BIM – FADU*)

Arc. Stefania Tuzi (*DSDRA – Sapienza*)

Arc. Bernardo Pégamo (*FAUD – UNC*)

Scientific Committee

- Arc. Ing. Jimena Alvarez (*UNR*)
- Eng. Salvatore Barba (*Scientific Attaché of the Italian Embassy in Buenos Aires*)
- Arc. Santiago Becerra (*FAUD-UNC*)
- Arc. Adriana Caldarone (*DSDRA – Sapienza*)
- Arc. Rita Comando (*SCA*)
- Arc. Victoria Ferraris (*FAUD – UNC*)
- Arc. Carla Ferreyra (*UNISA*)
- Arc. Tommaso Emler (*DSDRA – Sapienza*)
- Eng. Luciano Gorosito (*UTN*)
- Arc. Alejandro Moreira (*UNL*)
- Arc. Javier Nuñez (*BIM – FADU – UBA*)
- Eng. Joel Oggero (*UTN*)
- Arc. Bernardo Pégamo (*UNC*)
- Arc. Stefania Tuzi (*DSDRA – Sapienza*)
- Arc. Lucrecia Real (*Autodesk Expert Elite*)
- Arc. José María Saleme (*UNT*)
- Arc. Ana Licia Sanchez (*UNSJ*)
- Arc. Silvia Szuchman (*FADU*)

Editorial Manager

- Francesco Cocchi

INDICE

Summary

PRESENTAZIONE

14

Foreword

Tommaso Empler

FROM HBIM 0 TO HBIM 3: INTRODUCING HERITAGE BIM AT THE ROMAN CAPITOL OF OUDHNA, TUNISIA

18

Wiem Alimi

DAL GIARDINO ZOOLOGICO ALL'ECOPARQUE. METODOLOGIE DI ANALISI E STRATEGIE DI CONSERVAZIONE DEL PATRIMONIO BUENOS AIRES

24

From the Zoological Garden to the Ecopark: Methods of Analysis and Conservation Strategies for the Heritage of Buenos Aires

Adriana Caldarone, Tommaso Empler, Enrique Javier Nunez, Stefania Tuzi

DAL "CASTELLO ELETTRICO" ALL'USINA DEL ARTE: ARCHITETTURE INDUSTRIALI DELLA CIAE A BUENOS AIRES

36

From the "Electric Castle" to the Usina del Arte: Industrial Architectures of the CIAE in Buenos Aires

Adriana Caldarone, Tommaso Empler, Stefania Tuzi

VERSO UN ECOSISTEMA DIGITALE PER LA MODELLAZIONE 3D NELL'AMBITO MUSEALE

48

Towards a digital ecosystem for 3D modeling in the museum field

Michele Calvano, Alessandra Meschini, Jessica Romor, Marta Salvatore, Graziano Mario Valenti

**MUSE. UN ECOSISTEMA MUSEALE PER LA “MISURA”
DELL’ESPERIENZA UTENTE** 58

MUSE. A Museum Ecosystem for “Measuring” the User Experience
Flavia Camagni, Andrea Casale, Elena Ippoliti, Luca J. Senatore, Noemi Tomasella

MÚLTIPLES VERSIONES DE UNA COSA SINGULARIDADES, INVARIANTES E INNOVACIONES EN LOS SISTEMAS DE REPRESENTACIÓN DE LA ARQUITECTURA EN EL POST-HUMANISMO 70

Multiple versions of one thing Singularities, invariants, and innovations in Representational systems in post-human Architecture
Carlos Campos

LO XYSTUS NORD DI VILLA DEI QUINTILI: STUDIO ANALITICO E PROPOSTA PER LA CONSERVAZIONE 78

The North Xystus of Villa dei Quintili: Analytical Study and Conservation Proposal
Alessandra Capuano

INNOVACIÓN Y CONSERVACIÓN: IMPLEMENTANDO HBIM EN LA FORMACIÓN UNIVERSITARIA 86

Innovation and conservation: Implementing HBIM in university education
Agustín A. Clavero, Francisco Somoza, Jan Heinrich

RICOSTRUIRE IL MEDIOEVO: TRE CASI STUDIO 94

Reconstructing the Middle Ages: Three Case Studies
Rinaldo D’Alessandro

A COMPUTATIONAL APPROACH TO ‘DRAWN’ ARCHITECTURE: A DRAWING ENCODING INITIATIVE (DEI) 104

Elisabetta Caterina Giovannini

**MÁS ALLÁ DEL MODELO
TRES IDEAS PARA PENSAR EL HBIM COMO
LENGUAJE, TRADUCCIÓN E INTERPRETACIÓN.** 114

Beyond the Model. Three Ideas to Reframe HBIM as Language, Translation, and Interpretation

Aldo Guzmán

**DIGITAL TWIN MUSEALE: MONITORAGGIO IN TEMPO
REALE PER GARANTIRE UNA GESTIONE PROATTIVA** 124

Museum Digital Twin: Real-Time monitoring for enabling proactive management

Marco Limongiello, Caterina Gabriella Guida, Javier Nuñez

**METHODOLOGIES AND PRACTICES IN SURVEYING
ANTIQUITY: ANTONIO DA SANGALLO THE YOUNGER,
RAPHAEL, AND THE MAP OF ANCIENT ROME** 134

Simone Lucchetti, Alessandro Viscogliosi

**MODELLI INFORMATI INTERATTIVI PER LA GESTIONE
E VALORIZZAZIONE DEL MANN DI NAPOLI** 146

Interactive Information Models for the Management and Enhancement of the National Archaeological Museum of Naples (MANN)

Alessia Mazzei

**INTEROPERABILITÀ SEMANTICA E GOVERNANCE
DIGITALE: IL PARADIGMA INFORMATIVO DEL BIM
CONTEMPORANEO** 154

Semantic Interoperability and Digital Governance: The Informational Paradigm of Contemporary BIM

Michela Meschini, Matilde Cozzali, Chiara Mommi, Laura Suvieri

**GLI HORTI LAMIANI: MODELLAZIONE 3D PER LO SVILUPPO
DI MODELLI PER LA COMUNICAZIONE E L'ACCESSIBILITÀ** 162

Horti Lamiani: 3D Modeling for the Development of Models for
Communication and Accessibility

Pasquale Micelli

**IMAGE-TO-BIM. AI PER L'INTEGRAZIONE DELL'APPARATO
DECORATIVO NEI MODELLI INFORMATIVI** 172

Image-to-BIM. AI for the Integration of Decorative Apparatus in
Informative Models

Andrea Migliosi, Claudia Cerbai, Simona Ceccaroni, Filippo Cornacchini

**EL IMPACTO DE LAS TECNOLOGÍAS DIGITALES EN LA GESTIÓN
MUSEAL: PLAZA ESPAÑA Y EL MUSEO METROPOLITANO DE
ARTE URBANO, CÓRDOBA, ARGENTINA.** 182

The Impact of Digital Technologies on Museum Management: Plaza
España and the Metropolitan Museum of Urban Art, Córdoba, Argentina.

María Belén Moll, Victoria Ferraris, Carla Ferreyra, Nicolás Ruscelli, Anna Sanseverino

SCAN TO BIM - DEL ESCANEEO AL MODELO DIGITAL 192

Scan to BIM - From Laser Scanning to Digital Modeling

Natalia Pirazzini, Andres Jerez, German Mata

**UNA NUOVA LETTURA DELL'ORDINE DORICO DI
PALAZZO BARBERINI: IL BIM PER L'ESPLORAZIONE
DELLE VARIAZIONI PROGETTUALI** 200

A new perspective on the Doric order of Palazzo Barberini: BIM
for investigating design variations

Esterletizia Pompeo

**DEL RITO AL DATO: UNA PROPUESTA
METODOLÓGICA PARA LA MUTACIÓN DIGITAL DEL
PATRIMONIO SACRO**

208

From the Rite to the Data: A methodological proposal for Digital mutation of the sacred heritage

Juan Cruz Reyes

**MODELLARE IL TEMPO: AMBIENTI BIM PER L'ANALISI
DIACRONICA DELL'ARCHITETTURA STORICA**

218

Modeling Time: BIM-Based Environments for the Diachronic Study of Historical Architecture

Rebecca Rossi

**HBIM PER IL RESTAURO E LA VALORIZZAZIONE:
STUDIO SUL MAUSOLEO DI ROMOLO A ROMA**

228

HBIM FOR RESTORATION AND ENHANCEMENT:
a study of the Mausoleum of Romulus in Rome

Lorenza Ruggiero

**MODELIZACIÓN INFOGRÁFICA PARA LA GESTIÓN DE
DATOS HISTÓRICO-ARQUITECTÓNICOS. EL COLEGIO
NACIONAL DE MONSERRAT**

238

Infographic Modeling for Managing Historical Architectural Data. The Case of the Colegio Nacional de Monserrat

Constanza Valencia, M. Clara Amoedo Fiore, Carla Ferreyra

A COMPUTATIONAL APPROACH TO 'DRAWN' ARCHITECTURE: A DRAWING ENCODING INITIATIVE (DEI)

Authors

Elisabetta Caterina Giovannini

Department of Architecture and Design - DAD, Politecnico di Torino

Email

elisabettacaterina.giovannini@polito.it

Keywords

ANDREA PALLADIO
'DRAWN' ARCHITECTURE
SEMANTICS
VPL
HBIM

Abstract

Archives preserve thousands of architectural drawings that embody unbuilt visions and design reasoning. These documents represent a valuable but fragile category of heritage, drawn architecture, that exists only in representation, not in material form. This research introduces the Drawing Encoding Initiative (DEI), a methodology that employs Visual Programming Languages (VPL) and Heritage Building Information Modelling (HBIM) to encode the semantics of drawn architecture.

Introduction

Architectural archives and libraries safeguard vast collections of drawings, sketches, and plans that represent an overlooked form of heritage: projects conceived and designed but never built. This category, often referred to as unbuilt heritage, includes competition entries, visionary projects, utopian plans, and treatise illustrations. These works are more than visual documents. They embody the intellectual and cultural intentions of their authors and preserve fragments of design reasoning that never materialised in stone, brick, or mortar [Hollander, 1977].

Unlike built heritage, which endures as tangible artefacts, unbuilt heritage survives mainly through its representations. Plans, elevations, sections, and annotations provide evidence of stylistic experimentation and theoretical exploration. As scholarship increasingly acknowledges, the study of such documents reveals otherwise invisible processes of innovation.

The concept of drawn architecture emphasises the epistemological role of drawing. A drawing is not only an image; it is a codified language with its own grammar of proportions, conventions, and symbols that communicates complex ideas beyond the reach of words [Ching, 2023]. In architectural culture, the act of drawing has historically represented both an intellectual and a technical operation. Drawings combine multiple layers of representation: textual notes, orthographic projections, three-dimensional models, and, potentially, higher-order systems of structured knowledge [Giovannini, 2022].

Historically, treatises and competition entries preserved in archives constitute an extraordinary source of drawn architecture. From Renaissance codices and Baroque utopias to modernist projects that remained unbuilt due to political, economic, or technical constraints, these documents bear witness to the evolution of architectural thinking across the centuries. Vitruvian descriptions, Renaissance manuscripts, and Palladian treatises all exemplify how the medium of drawing structured architectural discourse. Each era introduced new modes of representation, shaping not only design practice but also the way knowledge was transmitted and interpreted.

The late twentieth century marked a decisive turning point in digital design. Computer-Aided Design (CAD) introduced precision and reproducibility to architectural practice, parametric design enabled flexibility and relational logics [Stiny & Gibbs, 1978], and Building Information Modelling (BIM) incorporated semantics and structured knowledge into three-dimensional models [Carpo, 2012; Caetano & Leitão, 2020]. These technological shifts profoundly transformed the way architects represent, analyse, and communicate

spatial ideas, moving from static drawings to dynamic and data-rich models. Since 2009 BIM approach was also used for documenting and representing historic buildings (HBIM) offering new perspectives for cultural heritage management and conservation [Murphy *et al.*, 2009; Lovell *et al.*, 2023].

A similar trajectory can be observed in the field of digital humanities, although with a different emphasis. Here, information technology has been primarily used to analyse documentary heritage through encoding systems, digital editions, and large-scale text or image corpora. Initiatives such as the Text Encoding Initiative (TEI) demonstrate how transcriptions and annotations can be structured into machine-readable resources that preserve and interpret cultural texts¹.

Architecture and the digital humanities thus share the same fundamental challenge—how to represent, organise, and interpret knowledge—but apply technological systems in different directions. While the humanities are primarily concerned with encoding and interpreting texts and images, with a focus on art history [Impett, 2024], architecture utilises computational frameworks to reconstruct and represent three-dimensional complexity.

Proposed solution

The Drawing Encoding Initiative (DEI) positions itself precisely at the intersection of these traditions. It extends the encoding logic of the digital humanities to architectural drawings, but simultaneously adopts architectural tools capable of representing spatial relationships and design grammars in 3D. In this way, DEI demonstrates how methodologies from distinct domains can converge to produce digital critical editions of architecture, combining the interpretive rigour of the humanities with the representational capacity of architectural practice.

By combining Visual Programming Languages and HBIM, DEI translates drawings into semantically enriched 3D models. Its novelty lies in its insistence on evidence-based encoding. Unlike artificial intelligence approaches, which may generate plausible but unverifiable forms, DEI builds reconstructions that are grounded in archival rules and proportions. This guarantees transparency, reproducibility, and accountability. Translating 'drawn' architecture into tangible and digitally accessible heritage offers new opportunities for the preservation and valorisation of documentary heritage and drawings.

In the digital age, digitising this fragile heritage poses unique challenges. Contemporary strategies for built heritage, such as laser scanning and photogrammetry, are effective in recording existing

1_ Text Encoding Initiative (TEI). Available at <https://tei-c.org/>

buildings but cannot capture projects that were never realised. In such cases, the building exists only on paper, requiring source-based methods that can extract and encode information directly from documentary evidence.

The Drawing Encoding Initiative (DEI) responds to this challenge. The method can be compared to the Text Encoding Initiative (TEI) in the humanities [Ciotti, 2018], which transforms manuscripts into digital critical editions. DEI extends this logic to architecture by linking graphic elements to semantic categories, thus ensuring that drawings are not only visualised but also interpreted and structured as data. In doing so, the initiative contributes to a broader vision of FAIR-compliant heritage digitisation [Wilkinson *et al.*, 2016], creating resources that are findable, accessible, interoperable, and reusable.

Finally, the DEI distinguishes itself from emerging AI-based generative imaging approaches, which can produce plausible but unverifiable reconstructions of unfinished architecture [Merino-Gómez *et al.*, 2023]. While AI tools generate statistical approximations and unverified errors, the DEI encodes architectural rules and archival evidence, delivering reconstructions that are

transparent, reproducible, and critically accountable. In this regard, it signifies a methodological advancement in digital heritage: one that not only visualises the past but reconstitutes architectural thinking into structured, reusable knowledge.

The comparison in Fig. 1 highlights the unique contributions of the DEI methodology within the broader landscape of digital heritage modelling. Traditional 3D modelling, though valuable for visualisation, depends on manual interpretation and offers limited semantic enrichment, making it less reproducible and only partially FAIR-compliant. AI generative tools, such as GANs and diffusion models, have recently been explored for architectural applications, yet their outputs remain speculative, visually plausible, but methodologically unverifiable. Conversely, the DEI integrates VPL and HBIM to develop algorithmic, rule-based workflows that are transparent, reproducible, and semantically enriched. In this way, it represents not only a methodological improvement over existing practices but also an epistemological shift: from image-based visualisations to digital critical editions of architecture, ensuring the FAIR management of 'drawn' architecture and documentary heritage.

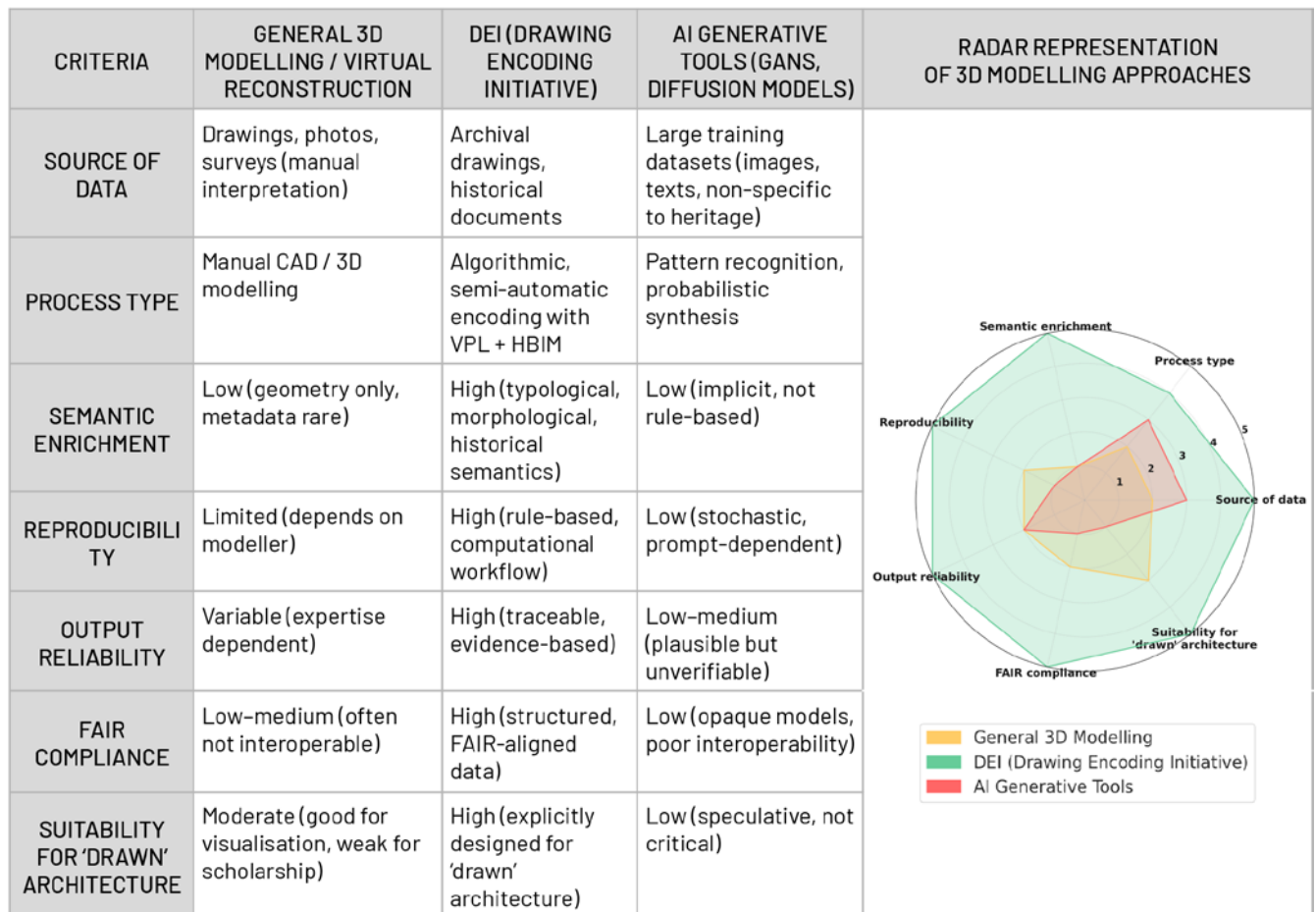


Fig. 1: Comparison of 3D Modelling Approaches

An integrated approach

Computational design tools such as Grasshopper (for Rhinoceros) and Dynamo (for Revit) have introduced new possibilities for algorithmic modelling. Within HBIM, these VPL environments allow architects and researchers to organise diverse data into structured workflows that can encode both geometry and semantics.

The DEI workflow integrates geometric modelling with semantic modelling. In the first phase, points, curves, and surfaces are extracted from digitised drawings through algorithms capable of reconstructing proportions and alignments. Once the geometric base is defined, it is enriched with meaning by classifying the elements into typological, constructive, and stylistic categories, thereby turning them into HBIM objects.

Archival drawings pose specific difficulties. Unlike modern technical plans, they often lack precise scales, may contain hand-written annotations, or suffer from distortions due to reproduction and ageing. Converting them directly from two dimensions to three, as in CAD workflows, risks introducing errors and inaccuracies [Feist *et al.*, 2024]. DEI addresses these issues through pre-processing techniques such as noise removal, rescaling based on historical units of measure, and proportion rectification. This ensures that both the graphical and textual content of the drawings are preserved and accurately reflected in the digital model.

The methodology also anticipates future integration with computer vision. Automated recognition of text and graphic components, coupled with semantic segmentation (Ahmed *et al.* 2011), could accelerate annotation and dimension checking. Such tools would not replace scholarly interpretation but rather provide support in verifying accuracy and consistency.

Experimental results

Andrea Palladio's Villa Sarego was chosen as a test case precisely because it exemplifies the challenges of unbuilt heritage. Designed in 1562, the project was only partially realised before construction was abandoned, and the remaining structures were later demolished.

Today, Palladio's drawings are the only evidence. His corpus has long served as a reference in computational research (Fig. 2), from Stiny and Mitchell's P*alladian Grammar* [1978] to Sass's experiments with digital fabrication [2007], facade's semantic analysis [Buthayna, 2008] and recent explorations of GANs for plan generation [Uzun *et al.*, 2020].

DEI builds on this tradition but shifts attention from generative approaches to the critical recovery of Palladio's design reasoning. Figures 3 and 4

illustrate the overall workflow of the Drawing Encoding Initiative (DEI) applied to Palladio's Villa Sarego (1562). The process begins with the digitisation and pre-processing of archival drawings, followed by image colour analysis, pixel-to-point conversion, and semantic labelling of architectural components. These data are then vectorised and anchored to HBIM elements, integrating plan and elevation information within a structured library of parametric entities. The outcome is a semantically enriched three-dimensional model, a 3D Digital Critical Edition, that transforms 'drawn' architecture into machine-readable, interoperable heritage knowledge.

Plan analysis

The initial stage focused on analysing the plan. The digitised image was cropped, resized, and normalised to ensure uniformity. Colour processing then converted it into a binary image, which facilitated the isolation of architectural lines and reduced background noise. From here, a pixel-to-point translation created a grid in which black pixels became active points representing architectural elements, while white spaces defined voids. These clusters of points were automatically grouped and interpreted according to their architectural role, such as walls, columns, or openings.

Vectorisation and anchoring

Once the drawing was cleaned and structured at the pixel level, the process advanced to vectorisation. The clusters were transformed into vector geometries that traced the centrelines of walls and the axes of columns. These geometries were then anchored to HBIM components drawn from a dedicated library. The transition to three dimensions was made possible by this step, which connected abstract vectors to parametric entities.

Elevation analysis

The workflow also relied on elevation drawings. These provided vertical references that were aligned with the plan data, ensuring that the three-dimensional reconstruction remained coherent across different representational systems. The integration of plan and elevation produced a model faithful not only to proportions but also to Palladio's compositional logic.

HBIM library of elements

Central to the methodology was the creation of an HBIM library (Fig. 5) tailored for Palladian architecture [Giovannini, 2023a, 2023b]. While generic components, such as walls and floors, exist in standard HBIM frameworks, features like classical columns, entablatures, and vaulted systems require custom, adaptive families. Their inclusion ensured that the resulting model captured the stylistic grammar specific

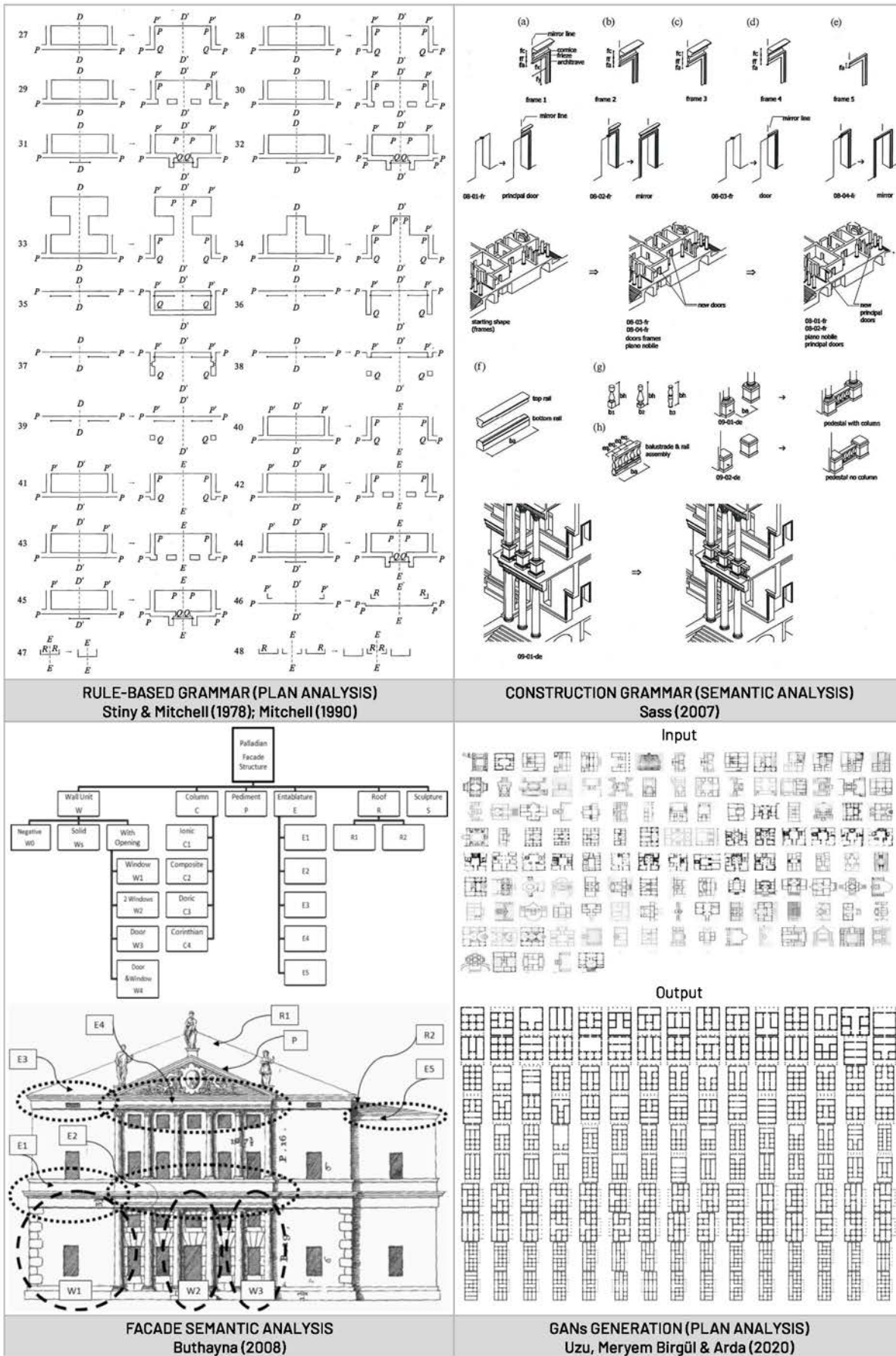


Fig. 2: Different computational approaches to Palladio's design

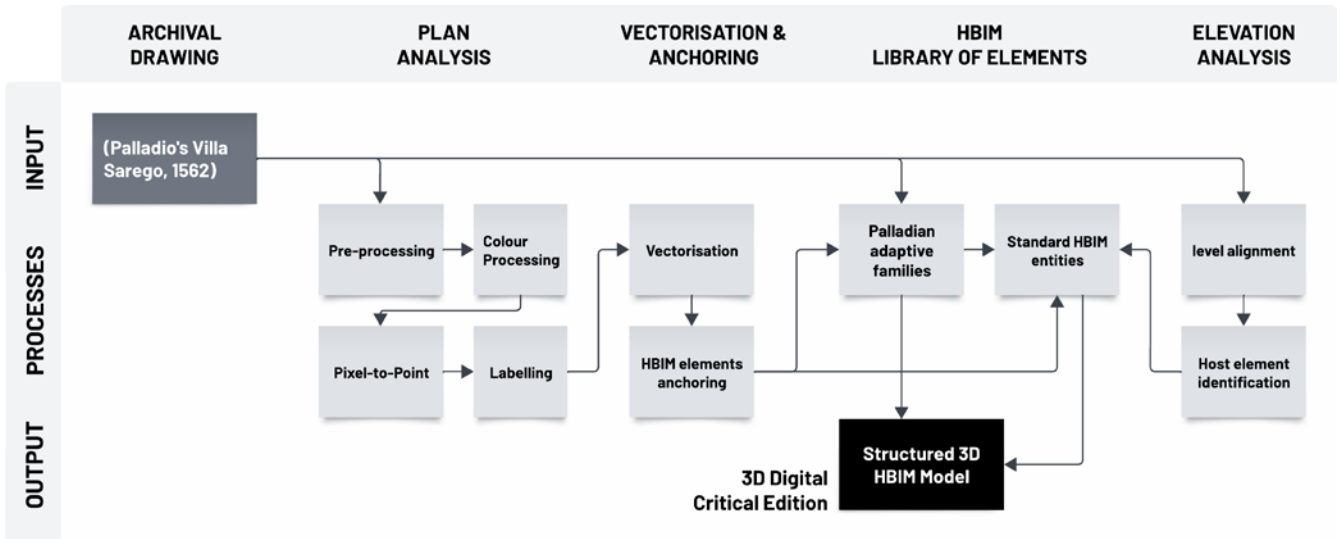


Fig. 3: Flowchart of the DEI workflow

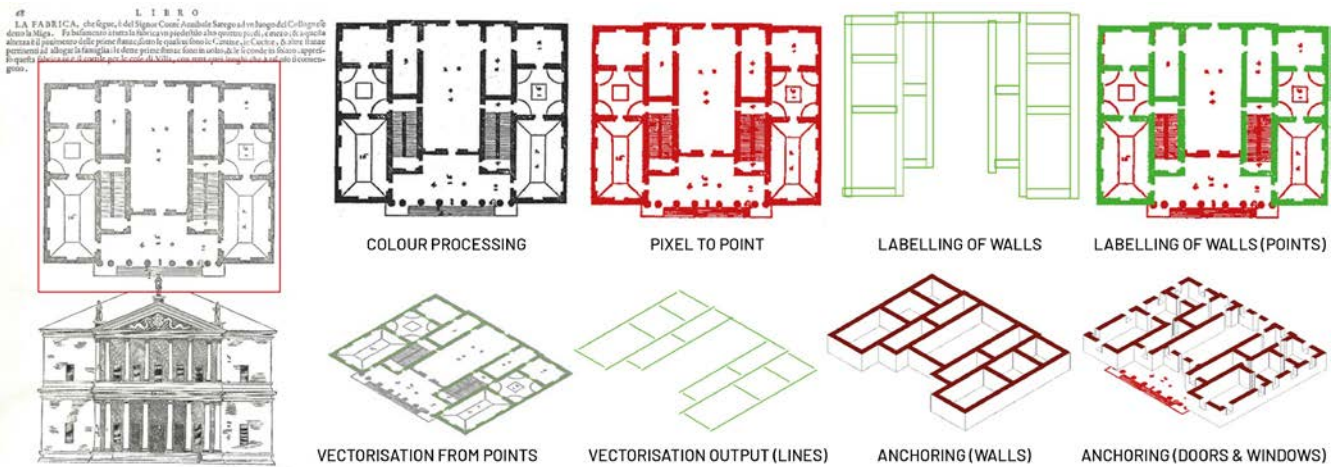


Fig. 4: DEI Workflow applied to Villa Sarego.

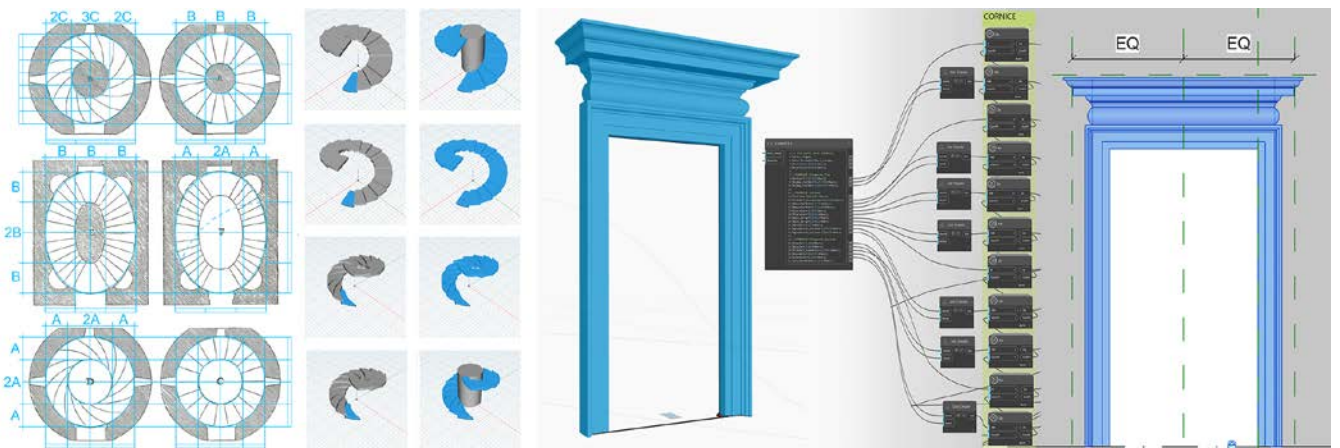


Fig. 5: A portion of HBIM library for Palladian Architecture. [Giovannini, 2023a,b]

to Palladio, extending beyond mere geometry to encode the cultural and formal essence of his design.

The outcome was a model that preserved both form and meaning. Rather than a static reproduction, it functioned as a digital critical edition: a structured artefact that both human scholars and computational tools could interrogate to reveal the underlying architectural grammar.

An HBIM open visualisation using dotbim format

At the beginning of 2022, a new file format was released for the BIM industry. It's called dotbim (extension: .bim), the project is 100% free and open². This is a minimalist, simple, JSON-based file format for BIM developed by MIT in response to the perceived complexity of other OpenBIM initiatives, such as those of buildingSMART International (bSI)³. It supports only one representation (triangularization) and associates key-value pairs of data with it [Böhms *et al.*, 2023].

While Industry Foundation Classes (IFC), developed by bSI⁴, remains the gold standard for contemporary construction workflows, its complexity and industry-specific semantics make it less suitable for the digitisation of unbuilt or documentary heritage (Fig. 6). In contrast, dotbim provides a lightweight, flexible, and FAIR-compliant format that is better aligned with the objectives of the DEI methodology, where the priority is not facility management but the encoding of architectural knowledge extracted from historical drawings into structured and reusable 3D digital critical editions (Fig. 7).

In this regard, semantic interoperability of complex cultural data could be integrated with the buildingSMART Data Dictionary (bSDD) platform⁵ to enhance semantic interoperability for heritage assets [Argasiński & Tomczak, 2025].

By connecting bSDD shared definitions to virtual HBIM models, the DEI methodology ensures consistent, accurate, and interoperable 3D data across different software, supporting research and virtual reconstruction management by creating a more transparent and repeatable scientific process for unbuilt heritage.

2_ .bim - a new BIM file format, Bim Corner, 4 may 2022. Available at <https://bimcorner.com/a-new-bim-file-format/>

3_ buildingSMART International (bSI). Available at <https://www.buildingsmart.org/>

4_ Industry Foundation Classes (IFC). Available at <https://www.buildingsmart.org/standards/bsi-standards/industry-foundation-classes/>

5_ buildingSMART Data Dictionary (bSDD). Available at <https://www.buildingsmart.org/users/services/buildingsmart-data-dictionary/>

Conclusions

The Drawing Encoding Initiative illustrates how archival drawings can be reinterpreted and transformed into structured, semantically enriched digital models. By combining HBIM with algorithmic modelling, it establishes a workflow that is transparent, reproducible, and critically grounded in evidence.

The approach combines building typological shape grammars [Mamoli, 2020] with an encoded representation of architectural elements [De Luca *et al.*, 2007] using a semi-automatic algorithmic approach.

The Villa Sarego case study demonstrates the potential of this methodology. The process went beyond reproducing spatial configurations: it enabled the recovery of Palladio's design logic and reasoning. In this respect, DEI differs fundamentally from AI generative methods. While such tools may create visually convincing images, their speculative nature prevents them from serving as reliable resources for heritage research. DEI, on the other hand, emphasises accountability, ensuring that every step of the reconstruction can be traced back to archival evidence.

The initiative contributes to heritage studies by proposing a source-based framework for the digitisation of unbuilt architecture. It integrates geometry with semantics, produces resources that operate as critical digital editions, and adheres to the FAIR principles that guarantee reusability and interoperability.

The current limitations of the method lie in its semi-automatic character and the need for specialised HBIM libraries.

Currently, significant scholarly intervention remains necessary, and scalability to extensive archival collections remains challenging. However, the workflow points towards promising directions. Integration with computer vision may automate routine operations, while collaborations across disciplines could expand the semantic depth of HBIM libraries. Beyond academia, DEI also opens opportunities for museums, archives, and educational institutions, which could present unbuilt heritage through interactive and immersive visualisations.

Ultimately, DEI envisions a future in which drawings are not treated as static relics but as living digital resources. Through their transformation into structured models, they contribute to a renewed cultural memory, offering scholars, practitioners, and the public new insights into projects that were imagined but never realised.

6_ The Online 3D Viewer, allows visualisation of diverse types of 3D file formats, including .bim and IFC. Available at <https://3dviewer.net/>

CRITERIA	INDUSTRY FOUNDATION CLASSES (IFC)	DOTBIM (.BIM)
PURPOSE	Industry standard for construction and facility management	Lightweight format for exchanging 3D BIM-like models
COMPLEXITY	Very high (tens of thousands of entities)	Low (JSON-based, simple structure)
SEMANTIC STRUCTURE	Rigid, technical, oriented to contemporary construction	Minimal semantics, extensible with custom fields
FLEXIBILITY	Limited, requires strict classification	High, allows tailored metadata from historical sources
ACCESSIBILITY	Heavy viewers and libraries required	Lightweight, human- and machine-readable, browser-friendly
FAIR COMPLIANCE	Good, but complex to integrate with LOD/Linked Data	High, easy JSON integration with databases and FAIR workflows
SUITABILITY FOR 'DRAWN' ARCHITECTURE	Low: assumes complete, standardised building information	High: suitable for partial, interpretive data from archival drawings

Fig. 6: IFC vs dotBIM comparison

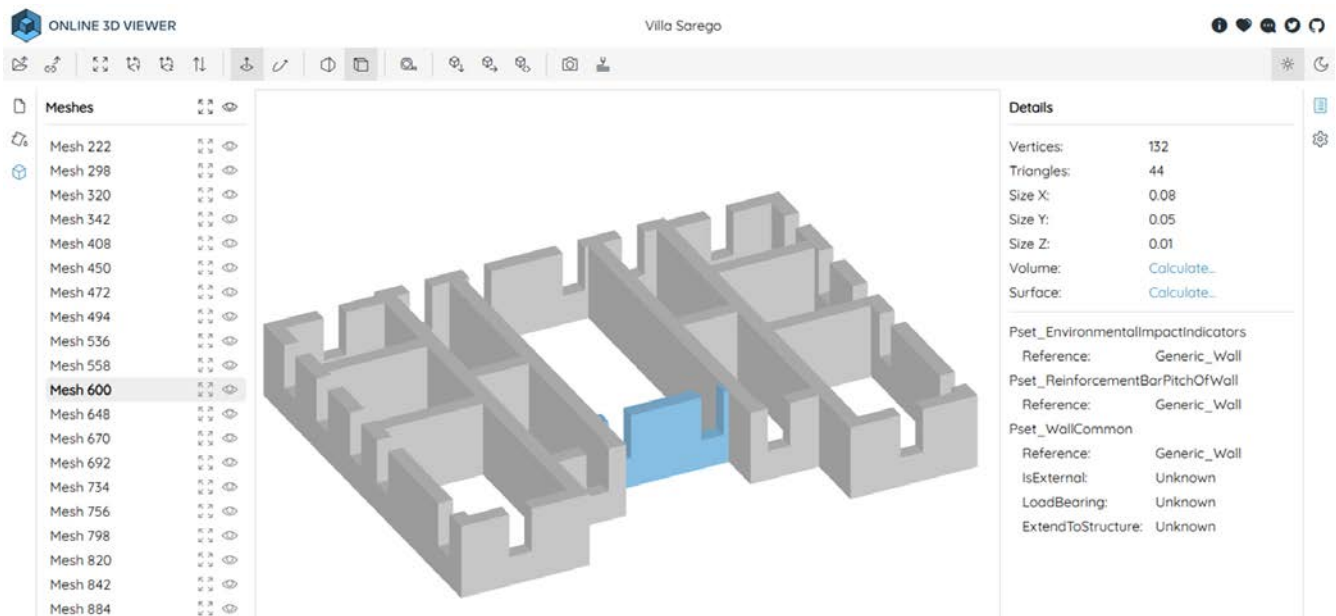


Fig.7: Web-based dotbim visualisation using Online 3D Viewer⁶

Acknowledgement

The author would like to thank PhD. Arch. Andrea Tomalini, research fellow at the Department of Architecture and Design (DAD) of Politecnico di Torino, for his valuable advices on the visual programming language (Grasshopper GH) and its application in the development of the dotbim file format.

Bibliography

Ahmed, S., Liwicki, M., Weber, M., & Dengel, A. (2011). Improved automatic analysis of architectural floor plans. In *2011 International Conference on Document Analysis and Recognition - ICDAR 2011* (pp. 864–869).

Argasiński, K., & Tomczak, A. (2025). Enhancing semantic interoperability of heritage BIM-based asset preservation. *Heritage*, 8(10), 410.

Caetano, I., & Leitão, A. (2020). Architecture meets computation: An overview of the evolution of computational design approaches in architecture. *Architectural Science Review*, 63, 165–174.

Carmo, M. (Ed.). (2012). *AD Magazine: The digital turn in architecture 1992–2012*. John Wiley & Sons Ltd.

Ching, F. D. K. (2023). *Architectural graphics*. John Wiley & Sons.

Ciotti, F. (2018). A formal ontology for the text encoding initiative. *Umanistica Digitale*, 3, 137–153.

De Luca, L., Véron, P., & Florenzano, M. (2007). A generic formalism for the semantic modeling and representation of architectural elements. *Visual Computer*, 23, 181–205.

Feist, S., Jacques De Sousa, L., Sanhudo, L., & Poças Martins, J. (2024). Automatic reconstruction of 3D models from 2D drawings: A state-of-the-art review. *Engineering*, 5, 784–800.

Giovannini, E. C. (2022). *Knowledge representation in architecture: Data modelling between digital humanities and H-BIM*. Aracne.

Giovannini, E. C. (2023a). Making Palladio digital: Geometrical parameters in door's ornaments. *Nexus Network Journal*, 25(3), 773–794.

Giovannini, E. C. (2023b). An algorithmic approach to Palladio's design of stairs. *Nexus Network Journal*, 25(Suppl. 1), 293–301.

Hollander, M. (1977). *Unbuilt America: Forgotten architecture in the United States from Thomas Jefferson to the Space Age*.

Impett, L. (2024). Digital art history as critical AI. *The Art Bulletin*, 106(2), 11–14.

Lovell, L. J., Davies, R. J., & Hunt, D. V. L. (2023). The application of historic building information modelling (HBIM) to cultural heritage: A review. *Heritage*, 6, 6691–6717.

Merino-Gómez, E., Reviriego, P., & Moral, F. (2023). Arquitecturas inconclusas: Una perspectiva desde la inteligencia artificial. *EGA Expresión Gráfica Arquitectónica*, 28(48), 254–267.

Mamoli, M. (2020). A shape grammar for the building-type definition of the ancient Greek and Roman library and the evaluation of library plans. *AI EDAM*, 34(2), 191–206.

Mitchell, W. J. (1990). *The logic of architecture: Design, computation, and cognition*. MIT Press.

Murphy, M., McGovern, E., & Pavia, S. (2009). Historic building information modelling (HBIM). *Structural Survey*, 27, 311–327.

Sass, L. (2007). A Palladian construction grammar—Design reasoning with shape grammars and rapid prototyping. *Environment and Planning B: Planning and Design*, 34(1), 87–106.

Stiny, G., & Gips, J. (1978). *Algorithmic aesthetics: Computer models for criticism and design in the arts*. University of California Press.

Stiny, G., & Mitchell, W. J. (1978). The Palladian grammar. *Environment and Planning B: Planning and Design*, 5(1), 5–18.

Uzun, C., Meryem Birgül Ç., & Arda, İ. (2020). GAN as a generative architectural plan layout tool: A case study for training DCGAN with Palladian plans and evaluation of DCGAN outputs. *AJ Z ITU Journal of Faculty of Architecture*, 17, 185–198.

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J. W., Da Silva Santos, L. B., Bourne, P. E., & Bouwman, J. (2016). The FAIR guiding principles for scientific data management and stewardship. *Scientific Data*, 3(1), 1–9.