2.2025

paesaggio urbano

URBAN DESIGN

Rivista bimestrale - Anno 2025 - 2.2025 - ISSN for printing 1120-3544 - ISSN for online publishing 2974-5969

MAGGIOLI EDITORE

Paesaggio Urbano - Urban Design

Journal of architecture
and urban planning |
Rivista di architettura e
urbanistica

No 2.2025

ISSN for printing
1120-3544

ISSN for online publishing
2974-5969

paesaggio urbano

URBAN DESIGN

MAGGIOLI
EDITORE

Paesaggio Urbano – Urban Design is a bimonthly magazine on architecture and urban design, founded in 1989 and is published by the Maggioli Group. The magazine has a multidisciplinary approach, ranging from design and survey issues to urban morphology, architectural design and local and international cultural trends.

Paesaggio Urbano – Urban Design è una rivista semestrale di architettura e urbanistica fondata nel 1989 ed edita dal Gruppo Maggioli. La rivista ha un approccio multidisciplinare che spazia dalle tematiche del disegno e rilievo a quelle relative alla morfologia urbana, al progetto di architettura e trend culturali locali e internazionali.

CONTENTS | SOMMARIO

4 — 9
Hybrid intelligence
Intelligenza Ibrida
Luca Rossato

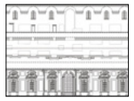
artificial intelligence? | intelligenza artificiale?
10 — 17
From Silence to Voice: Artificial Intelligence as an Interpreter of Architectural Memory
Dal silenzio alla parola: L'Intelligenza Artificiale come interprete della memoria degli edifici
Daniela Antonelli | Matteo Del Giudice | Fabio Manzone

artificial intelligence? | intelligenza artificiale?
18 — 27
The "Intelligence" of surveying: towards a critical epistemology of architectural digitalization
"Intelligenza" del rilievo: verso una epistemologia critica della digitalizzazione architettonica
Simone Lucchetti

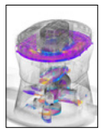
artificial intelligence? | intelligenza artificiale?
28 — 37
Decoding the Past: AI Transcription of Handwritten Historical Text for Built Heritage Conservation
Decodificare il passato: IA, trascrizione di manoscritti e conservazione del patrimonio architettonico
Matilde Ridella | Giulio Lucio Sergio Sacco

artificial intelligence? | intelligenza artificiale?
38 — 47
A Spatial Humanities Framework for the Baroque Urban Landscape of *Terra d'Otranto*
Un modello di indagine Spatial Humanities applicato al paesaggio urbano barocco della Terra d'Otranto
S. Brescia | V. Castagnolo | M. Leserri | G. Rossi

artificial intelligence? | intelligenza artificiale?
48 — 59
IFC to dotBIM. A Vertical Interoperability Workflow for Cultural Heritage
Da IFC a dotBIM. Un flusso di lavoro di interoperabilità verticale per il patrimonio culturale
Andrea Tomalini



artificial intelligence? | intelligenza artificiale?
60 — 67
From digital survey to conservation: integrated approaches for contemporary art documentation
Dal rilievo digitale alla conservazione: approcci integrati per documentare l'arte contemporanea
Giulia Ursino



artificial intelligence? | intelligenza artificiale?
68 — 77
Immersive and Interactive Experiences for the Enhancement of the Cultural Heritage of Inland Areas.
Esperienze immersive e interattive per la valorizzazione del patrimonio culturale delle aree interne
M. Calia | A. Conte | A. Y. Jafari | E. Giaccari

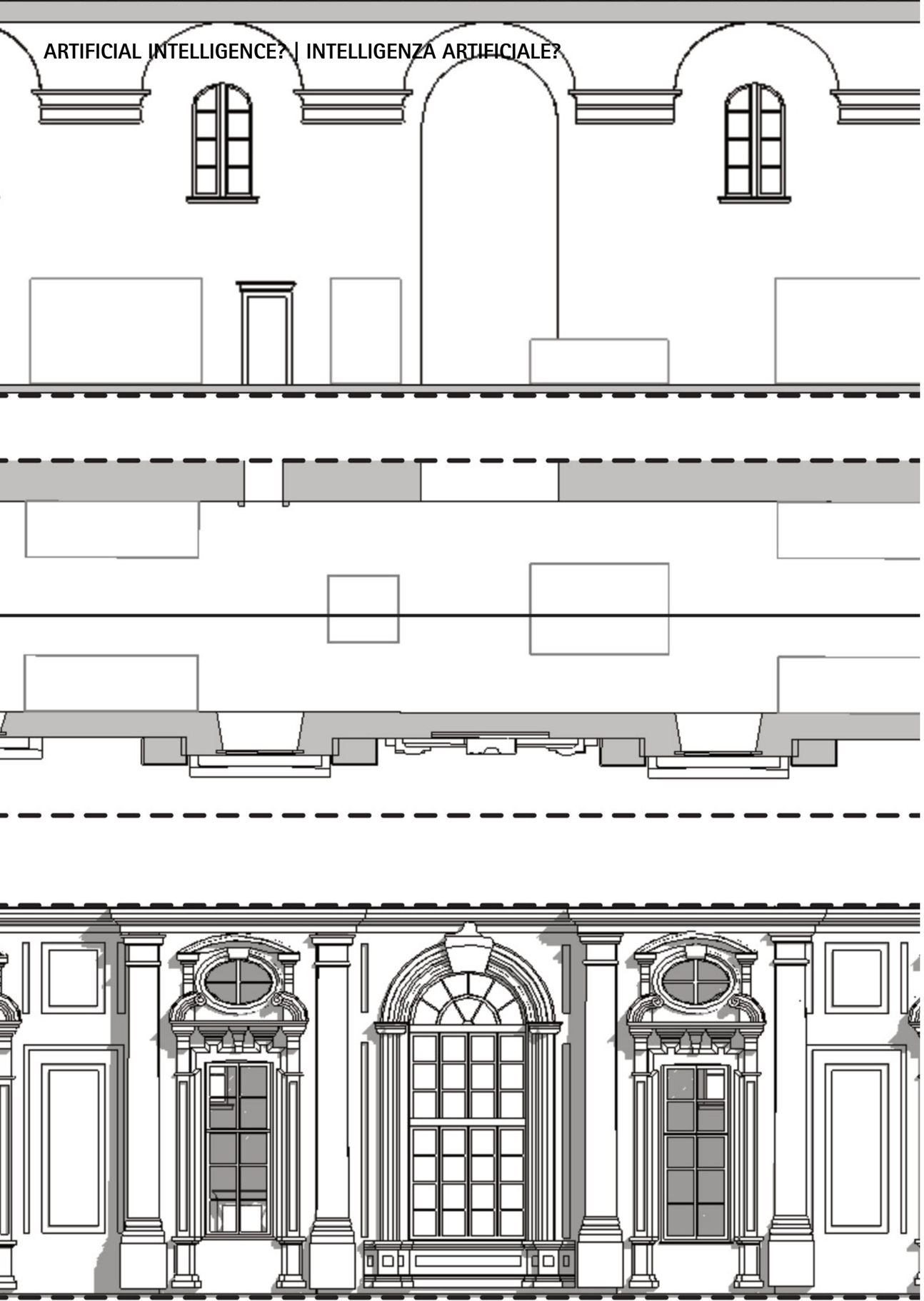
artificial intelligence? | intelligenza artificiale?
78 — 89
From instrumental survey to artificial intelligence: preliminary experiments on the geometric analysis of the ashlars of the Mausoleum of Theodoric
Dal rilievo strumentale all'intelligenza artificiale: prime sperimentazioni sull'analisi geometrica dei conci del Mausoleo di Teodorico
Manuela Incerti | Stefano Costantini

artificial intelligence? | intelligenza artificiale?
90 — 103
Digital Intelligence and Cultural Heritage: Integrated Survey and Perceptual Mapping for Small Historic Centres
Intelligenza digitale e patrimonio culturale: rilievo integrato e mappatura percettiva per piccoli centri storici
Greta Montanari

artificial intelligence? | intelligenza artificiale?
104 — 111
Digitizing Cultural Heritage through Artificial Intelligence: from Painting to Digital Model
Digitalizzare il patrimonio con l'Intelligenza Artificiale: dall'opera pittorica al modello digitale
Ferdinand Rexhaj

artificial intelligence? | intelligenza artificiale?
112 — 121
Connecting fragments. Digital scenarios for the Pavia cover bridge
Frammenti in connessione. Scenari digitali per il ponte coperto di Pavia
Francesca Galasso

artificial intelligence? | intelligenza artificiale?
122 — 133
High Altitude Memory. Enhancement and enjoyment of the Dolomite front during the Great War
Memoria in quota. Valorizzazione e fruizione del fronte dolomitico della Grande Guerra
G. D'Acunto | G. Liva | I. Friso | A. Calandriello | G. Lazzaretto | G. Casarano



00.

IFC to dotBIM. A Vertical Interoperability Workflow for Cultural Heritage

Da IFC a dotBIM. Un flusso di lavoro di interoperabilità verticale per il patrimonio culturale

Andrea Tomalini
Dipartimento di Architettura e Design (DAD) – Politecnico di Torino |
andrea.tomalini@polito.it

Citation: A. Tomalini, IFC to dotBIM. A Vertical Interoperability Workflow for Cultural Heritage, in *Paesaggio Urbano - Urban Design*, 2025, 2, pp. 48–59.
ISSN for printing: 1120-3544
ISSN for online publishing: 2974-5969
Received: October, 2025
Accepted: November, 2025
Published: December 2025
Copyright © 2025 Maggioli Editore.
This is an open access, peer-reviewed article published by *Paesaggio Urbano – Urban Design*, distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

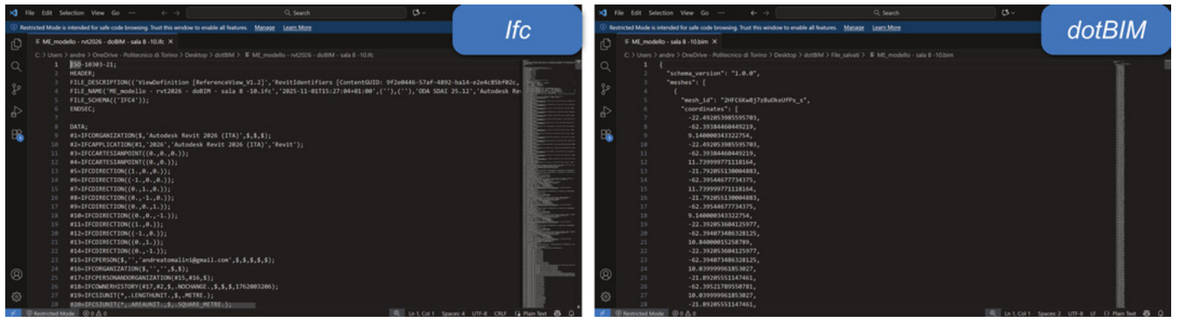
Currently, digitisation processes for architectural heritage are moving towards horizontal interoperability. However, the operational effectiveness of these processes is still limited by the insufficient integration of technological applications, as well as the difficulty of managing the complexity of standard formats in heterogeneous application contexts.
Data standardisation is therefore essential. In the construction sector, the prevailing open standard is Industry Foundation Classes (IFC). However, its complex structure, which is designed to ensure maximum data fidelity, means that integrating it into lightweight or prototypical applications is costly.
This paper therefore proposes defining algorithmic workflows for strategically selecting information contained in IFC files. This approach aims to achieve vertical interoperability by translating data into the lightweight dotBIM format. This JSON-based format is optimised for the web and improves communication efficiency by overcoming current technological rigidities in heterogeneous contexts through the targeted transfer of only essential data.

Attualmente, i processi di digitalizzazione del patrimonio architettonico stanno evolvendo verso l'interoperabilità orizzontale. Tuttavia, l'efficacia operativa di questi processi è ancora limitata dall'insufficiente integrazione delle applicazioni tecnologiche, nonché dalla difficoltà di gestire la complessità dei formati standard

00.
Detail of Fig. 04.

Case study: room no. 8, also known as the "Gallery of Sarcophagi," and room no. 10, known as the "Valley of the Queens". Plan view, section view, and exterior elevation view

in contesti applicativi eterogenei.
La standardizzazione dei dati è quindi essenziale. Nel settore delle costruzioni, lo standard aperto prevalente è Industry Foundation Classes (IFC). Tuttavia, la sua struttura complessa, progettata per garantire la massima fedeltà dei dati, rende costosa la sua integrazione in applicazioni leggere o prototipali.
Questo documento propone quindi di definire flussi di lavoro algoritmici per la selezione strategica delle informazioni contenute nei file IFC. Questo approccio mira a raggiungere l'interoperabilità verticale traducendo i dati nel formato leggero dotBIM. Questo formato basato su JSON è ottimizzato per il web e migliora l'efficienza della comunicazione superando le attuali rigidità tecnologiche in contesti eterogenei attraverso il trasferimento mirato solo dei dati essenziali.



01.

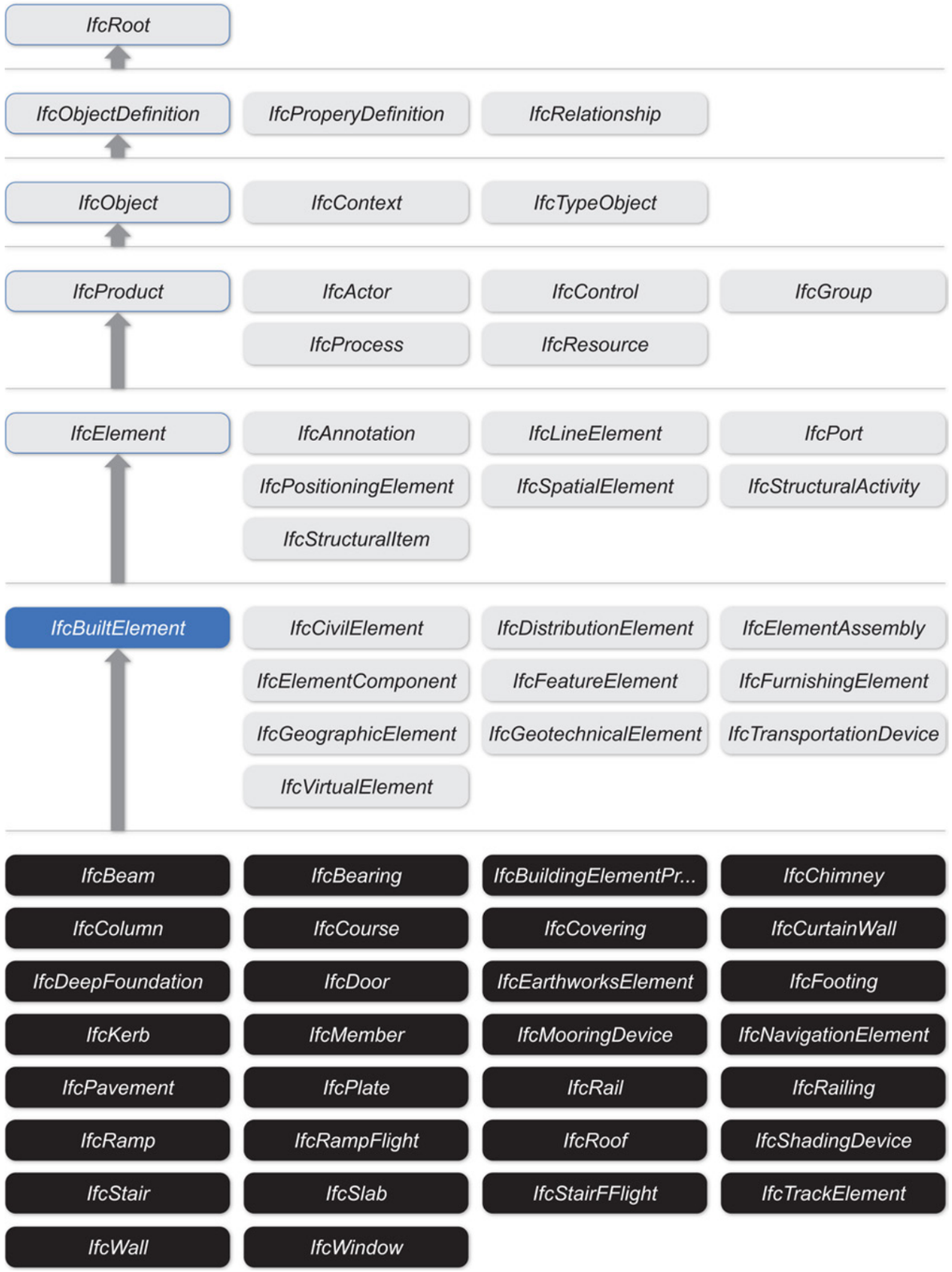
Difference between the two standards IFC on the left and dotBIM on the right opened with a text editor.

INTRODUCTION

The research question focuses on how a vertical interoperability workflow can address the complexity of standard formats, ensuring strategic selection of information useful for specific purposes. The importance of the availability of a standard, and the value of the cultural capital it conveys, leads to an understanding of how these tools should become standard practice (Borin, & Zanchetta, 2020). Indeed, they can be implemented with ease, even and especially in flows characterised by proprietary platforms. The primary obstacle to the implementation of these standards is the challenge of formalising a shared information environment, both in the design and implementation phases. The integration of information from disciplines "tangential" to the Building Information Modelling (BIM) sector into the models themselves requires the use of tools capable of mediating and connecting heterogeneous information systems (Lo Turco, 2015). In this scenario, Visual Programming Languages (VPL), together with traditional syntax-based programming, emerge as the ideal mechanism for prototyping customised workflows (Ernst & Ernst, 2023). This approach overcomes the rigidity of software with "traditional" interfaces and makes data extraction, processing and synchronisation flows transparent and reproducible.

IFC STRUCTURE AND DOTBIM COMPARISON

In order to achieve effective technological integration, it is essential to anchor digitisation to open standards, widely accepted formats and recognised semantic ontologies (Lok et al., 2023). From an epistemological perspective, the adoption of these ontologies transcends technical protocol; it represents a cognitive framework for interpreting architectural space. By structuring data into semantic categories, these digital instruments allow the transition from simple geometric representation to a queryable knowledge graph, where spatial relationships and functional attributes define the very reality of the building model. In this context, Industry Foundation Classes (IFC), the international standard ISO 16739, is the reference format for data exchange in the Building Information Modelling (BIM) sector.
An IFC file can be shared through different encodings (*IFC 4.3.2 Documentation*, n.d.), the most relevant being the *STEP Physical File* (SPF), a widely used text format readable by text editors; XML, which offers a readable tag structure but larger file sizes; and Linked Data-based formats (RDF/TTL) designed to expose IFC data in Semantic Web contexts. Focusing on the SPF format, its structure is classically divided into a *HEADER*, containing metadata such as software version and timestamp, and a *DATA* section. The latter lists all physical and virtual entities described by the *EXPRESS* language, using unique identifiers (e.g., #123) to avoid redundancy and optimize the logical data model [Fig. 01.].
The IFC data model has been designed to facilitate horizontal interoperability. This paradigm aims to transfer data as completely and accurately as possible between software systems operating at the same level of detail or within the same disciplinary domain [Fig. 02.]. In principle, horizontal interoperability is considered advantageous because it maximises the preservation of the model's information capital (Laakso & Kiviniemi, 2012).
However, different needs arise when the information model is to be used in application contexts other than design, such as web visualisation, Facility Management or integration with IoT platforms. In such cases, we enter the domain of vertical interoperability, where data is transferred between systems operating at different levels of abstraction (Tomalini, 2022). This process invariably involves data transformation. While this may appear to be a "loss of information", in this context, it is more accurate to define it as a selection of information that is useful for a specific purpose. The complexity of IFC files can sometimes present challenges in terms of file size and processing time.
This control and 'verticalisation' of data are therefore aimed at drastically improving the efficiency of communicating essential information. Simplifying the data structure facilitates the possibility of linking the BIM model to other information assets (such as maintenance databases, historical documentation or sensors), operations that would be considerably more complex to manage by interacting directly with the complete IFC structure.
The dotBIM format was introduced to address these requirements. It was developed as a lightweight, web-oriented interchange format designed to address the size and processing complexity of traditional BIM files, especially in client-side visualisation contexts.
Although IFC can also be exported to JSON, its original hierarchical structure remains more rigid than the native flexibility of dotBIM, which was designed directly on JSON (JavaScript Object Notation). This choice makes it more lightweight and less "verbose", focusing on the essentials (Radaczynski, 2022; BIM2B EUROPE, 2024) [Fig. 03.].
Its structure is streamlined into essential components: a *Header* for metadata; *Meshes* that store geometry as simple triangles rather than complex boundary representations; *Elements* that link objects to meshes and allow for free-text metadata; and an *Info* section for file-level data. This structural simplification reflects a shift in the ontological approach: strictly defined semantics are replaced by a flexible schema that facilitates the integration of external ontologies. This allows the architectural model to act as an open connector for heterogeneous information assets, from historical documentation to sensor data, enhancing the interpretability of the built environment without the computational burden of a full BIM schema.



02.

IFC hierarchical structure. IfcRoot is the most abstract and root class for all entity definitions that are rooted in the kernel or in subsequent layers of the IFC specification. An IfcObjectDefinition is the generalization of any semantically treated thing or process, either being a type or an occurrence. An IfcObject is the generalization of any semantically treated thing or process. Objects are things as they appear. The IfcProduct is an abstract representation of any object that relates to a geometric or spatial context. An IfcProduct occurs at a specific location in space if it has a geometric representation assigned. An element is a generalization of all components that make up a facility. Elements are physically existent objects. The built element comprises all elements that are primarily part of the construction of a built facility. Built elements are all physically existent and tangible things.

03.

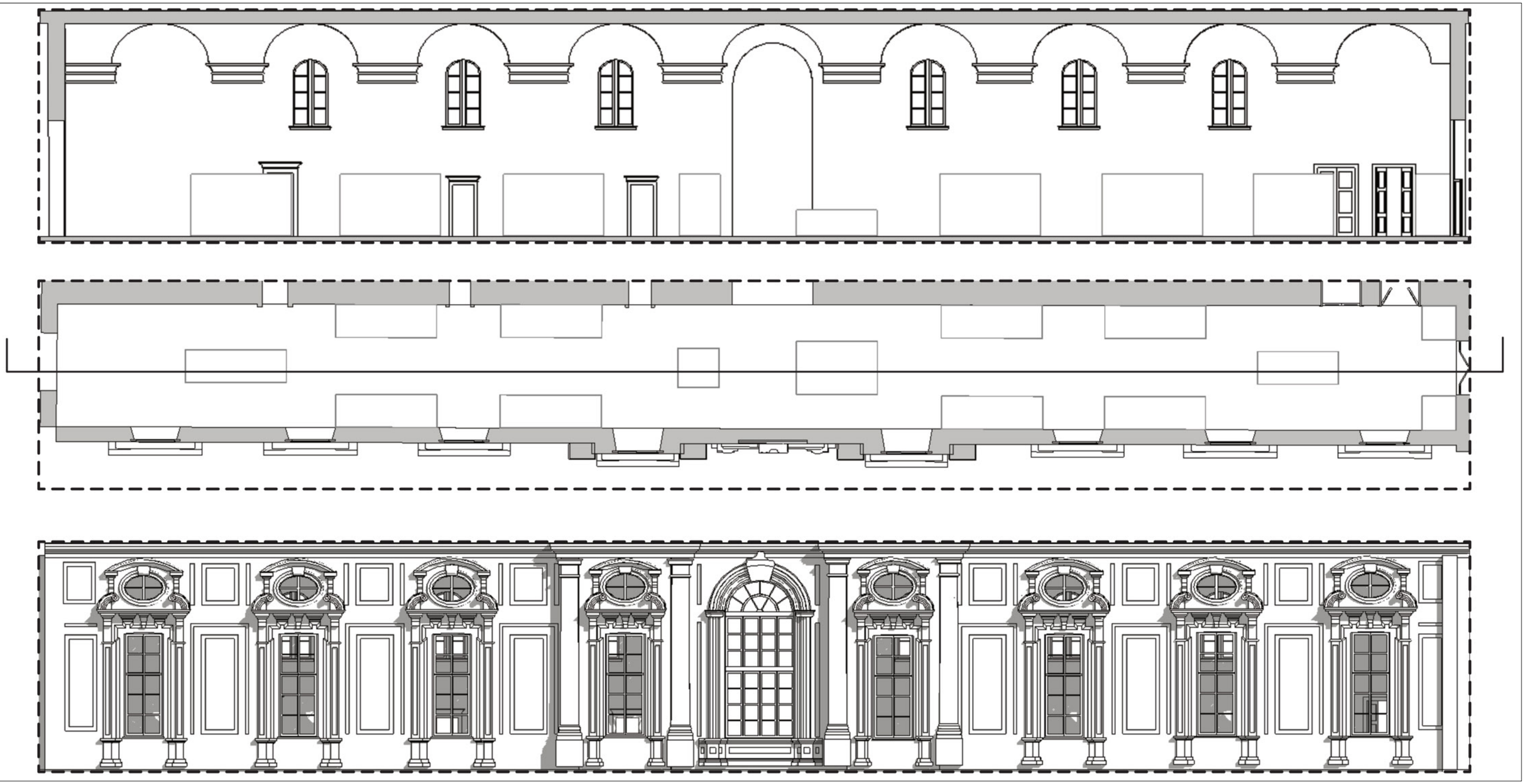
Non-hierarchical structure of the dotBIM format in which I have different classes that do not have dependencies on each other.

CASE STUDY

The selected case study examines the HBIM model of two rooms on the ground floor of the Egyptian Museum in Turin: room no. 8, also known as the "Gallery of Sarcophagi," and room no. 10, known as the "Valley of the Queens". Both rooms were surveyed using TLS instruments, followed by the modelling of architectural components using BIM methodology [Fig. 04.] (Mezzino et al., 2022).

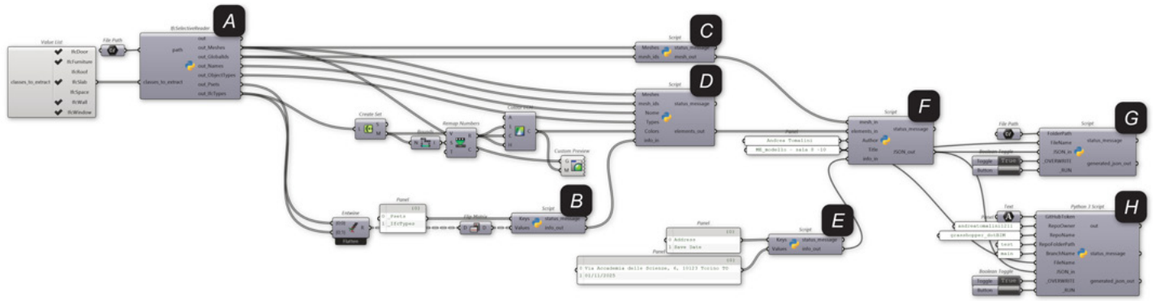
METHODOLOGY

The methodology aims to address the operational rigidity and cost barriers associated with full implementation of complex standards, such as IFC. It proposes a selective and lightweight approach to data extraction and reorganization. The objective is to demonstrate the feasibility of targeted conversion between the IFC standard format and the dotBIM format.
The entire process is formalised through an algorithmic workflow implemented in a Visual Programming environment (Grasshopper/Rhino 8), using the *CPython* interpreter. The choice of *CPython*, unlike I*ronPython* in previous versions, despite being less computationally efficient, allows for the integration of high-performance external libraries [Fig. 05.].
The implemented process commences with access to the IFC file (*STEP Physical File*) provided via the designated *path*. Firstly, the file is validated in the file system. Then it is loaded and subjected to complete parsing by the ifcopenshell library (A).
Subsequently, through targeted queries (executed using the *ifc_file.by_type method*), entities belonging to a predefined list of IFC classes of interest (e.g. I*fcWall, IfcSpace, IfcSlab*) are identified and filtered. At this stage, the focus is not on the model as a whole, but on the selective extraction of subsets of data and geometries.
For each identified entity, the geometric module of *ifcopenshell* (*ifcopenshell.geom.create_shape*) processes complex geometric representations (such as *B-Rep*). The result of this processing is then converted into a *Rhino.Geometry.Mesh* geometry (optimised triangular mesh).
Conversely, if the geometric conversion has produced a valid mesh, the metadata is extracted. Key attributes such as *GlobalId* (used as a unique identifier), *Name*, and *ObjectType* are retrieved. Furthermore, all associated *Property Sets* (PSet) are extracted and serialised into a JSON string



04.

Case study: room no. 8, also known as the "Gallery of Sarcophagi," and room no. 10, known as the "Valley of the Queens". Plan view, section view, and exterior elevation view.



05.

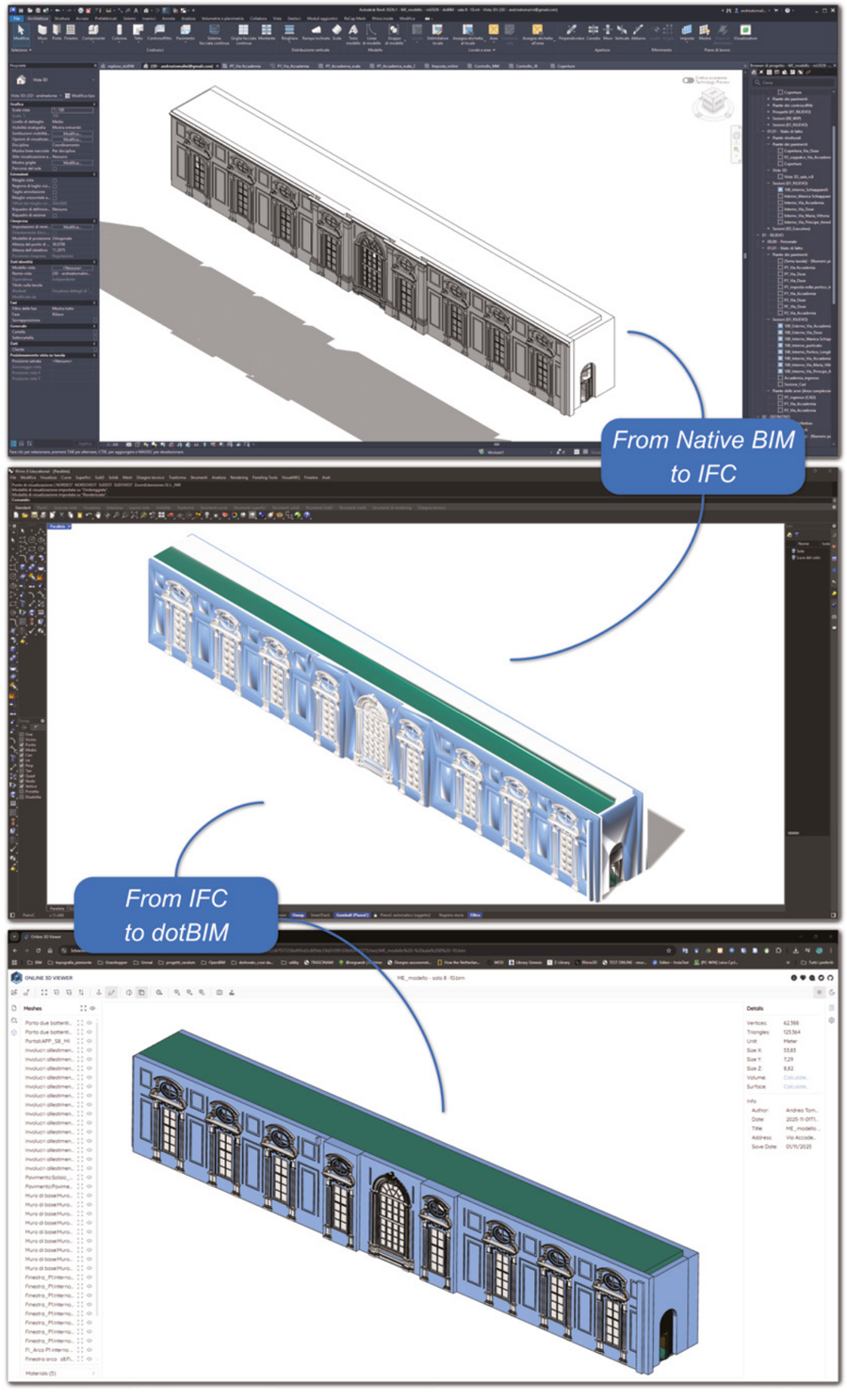
Code developed in a VPL Grasshopper environment. From left to right: the IFC file is imported, the desired classes are selected, these are then converted into meshes and the associated information can be extracted, modified, and rewritten. Finally, the model is exported in dotBIM format.

for the purpose of facilitating structured management.
The strict alignment between the geometry (Mesh) and the information data (*GlobalId* and PSet) is guaranteed by the fact that the information is added to the respective output lists only in a joint manner, ensuring that the index of each mesh corresponds to the index of its metadata. Subsequently, a set of codes builds a "bridge" to convert these meshes and associated information into dotBIM.

Next, the process continues by collecting and formatting the two main types of data: geometries (C) and metadata (D). The script is responsible for translating the geometric part. The *RhinoCommon* library utilises a "disassembly" process for each native Rhino mesh, systematically traversing the Vertices to extract the list of coordinates and the Faces to construct the list of indices that define the triangles. This script is also capable of handling optional data, such as vertex colours, and producing the final mesh block.

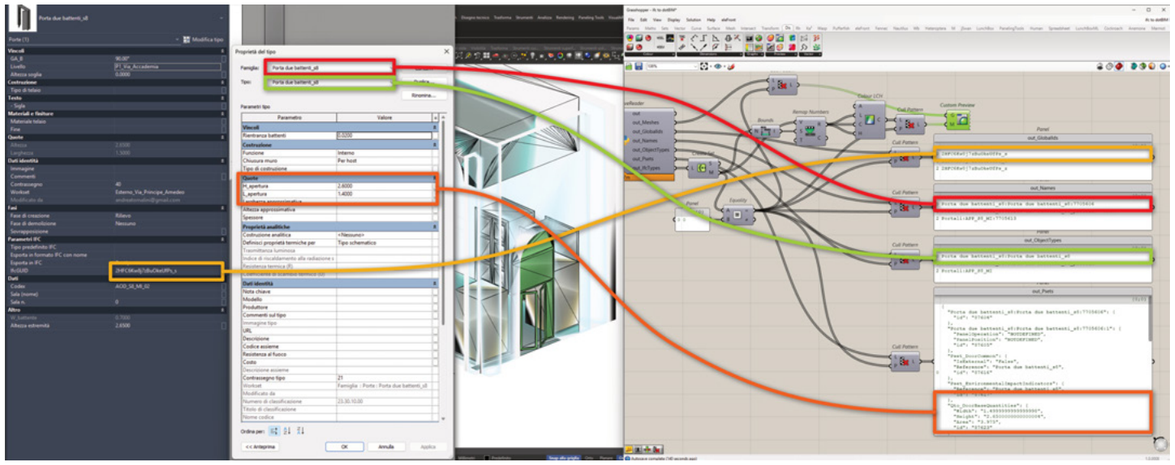
Concurrently, the metadata is prepared by two complementary scripts. The component (D) is responsible for the general metadata of the project, such as the author or title. It uses the standard JSON library to convert simple lists of keys and values into a dictionary and then serialises this into a compact JSON string (B). Its function is based on the use of the ghpythonlib. treehelpers library to correctly interpret *Grasshopper*'s complex Data Tree data structure, ensuring that each set of custom properties is correctly associated with the respective element. Once the data has been prepared, the next script (F) acts as a central assembler. The script ensures that each set of metadata is linked to its specific geometry. Metadata includes both basic elements, such as 'Name' and 'Type', and custom metadata (E) from the script described above (B). The geometry is identified by a *mesh_id*. To ensure the uniqueness of each component, it uses the *.NET System* library to generate a globally unique identifier (Guid) for each element. In addition, *RhinoCommon* is utilised to define spatial positioning data, including vector and rotational information, while *Color4f* is employed to standardise colour using a consistent colour reference.

Finally, the system offers two distinct paths for exporting this JSON string. It should be noted that both export scripts add a timestamp to the data using *System.DateTime*. In order to facilitate local saving (G), the coponent utilises the *System.IO* libraries of *.NET*, leveraging the Path, Directory and



06.

From left to right. BIM model of the case study. Import of the BIM model via IFC format into Rhino. 3dviewer.net web-platform into which the dotBIM file was imported.



07.

From left to right. Information associated with an element in a BIM environment. Information read via VPL codes from IFC files. Information displayed on the 3dviewer.net web-platform.

File classes to create the destination folder and physically write the .json and .bim files to disk. For remote uploading (H), the script is responsible for communicating with the GitHub API. This script relies on the requests library to perform HTTP calls (GET and PUT) and the *base64* library to encode the file content, as required by the GitHub API payload for uploading files.
To ensure a comprehensive process, a script was also developed to perform the reverse process. This process starts from a dotBIM file, analyses the JSON, and then reconstructs the 3D model.

CONCLUSIONS

This paper demonstrates the feasibility of a vertical interoperability workflow, confirming that 'strategic selection of useful information' is a pragmatic solution for data management. The methodology, implemented in a VPL (Grasshopper) environment using *CPython*, uses the *ifcopenshell* library for parsing and querying IFC files, and relies on the *RhinoCommon* API for geometric manipulation. This approach has formalised a transparent algorithmic process for translation from IFC to dotBIM.
The workflow selectively extracts IFC entities, converts complex geometries (*B-Rep*) into optimised *Rhino.Geometry.Mesh* meshes, and associates relevant metadata (PSet), serialised using the *json* library to ensure its integrity. This modular approach facilitates the integration of different ontologies (e.g. BIM and heritage), allowing only the necessary properties to be mapped.
The dotBIM format is a final compilation that integrates export routines for local saving (via *System.IO*) and for versioning platforms such as GitHub (made possible by the *requests* and *base64* libraries). These enable the consultation and 3D visualisation of semantic data on web platforms, making information capital accessible and queryable outside of specialist authoring systems [Fig. 06.].
This can be regarded as a significant step towards more informed management of digitisation processes and the establishment of interoperable methodologies for digital twins [Fig. 07.].

BIBLIOGRAPHICAL REFERENCES

BIM2B EUROPE. (2024, April 5). *BIMPulse 065 — A thousand AI applications.* https://www.linkedin.com/pulse/bimpulse-065-thousand-ai-applications-bim2b-europe-kdivf/?trackingId=CzkecvHH6uJAoB0ClFI56g%3D%3D

Borin, P., & Zanchetta, C. (2020). I*FC: Processi e modelli digitali openBIM per l'ambiente costruito.* Maggioli Editore.

Ernst, L., & Ernst, L. (2023, April 30). Dotbim: Export A 3D Model From Grasshopper As .bim Format – Structural Basics. *Structural Basics - Structural Engineering for everyone.* https://www.structuralbasics.com/dotbim-export-grasshopper/

Radaczynski, W. (2022, May 9). *.bim – a new BIM file format.* Bim Corner. https://bimcorner.com/a-new-bim-file-format/

IFC 4.3.2 documentation. (n.d.). https://ifc43-docs.standards.buildingsmart.org/

Laakso, M., & Kiviniemi, A. (2012). The IFC standard-A review of history, development, and standardization. *Journal of information Technology in Construction.*

Lo Turco, M. (2015). *Il BIM e la rappresentazione infografica nel processo edilizio. Dieci anni di ricerche e applicazioni - BIM and infographic representation in the construction process. A decade of research and applications.* Aracne.

Lok, K. L., Van Der Pool, I., Smith, A. J., Opoku, A., & Cheung, K. L. (2023). Sustainable digitalisation and implementation of ISO standards for facilities management. *Facilities, 41*(5/6), 434–453. https://doi.org/10.1108/f-03-2022-0038

Mezzino, D., Tomalini, A., Bono, J. (2022). Metodologie per lo sviluppo di modelli HBIM per la visualizzazione e la gestione di ambienti museali. *Dn, 10.* 28–44.

Tomalini, A., Lo Turco, M., & Pristeri, E. (2022). IoT and BIM Interoperability: Digital Twins in Museum Collections. In A. Giordano, M. Russo, R. Spallone (Ed.), *Representation Challenges: New Frontieres of AR and AI Research for Cultural Heritage and Innovative Design* (pp. 285–292). Franco Angeli. https://doi.org/10.3280/oa-845-c223

Direttore responsabile | Executive Editor
Paolo Maggioli

Direttore | Editor in Chief
Marcello Balzani

Vicedirettore | Vice Editor in Chief
Nicola Marzot

Comitato editoriale | Editorial committee
Federica Maietti
Fabiana Raco
Luca Rossato
Martina Suppa

Comitato scientifico | Scientific committee
Alessandro Luigini (Libera Università di Bolzano)
Alfred Rütten (Friedrich Alexander Universität Erlangen-Nürnberg, Germania)
Ana Tagliari (UNICAMP, Brasile)
Enrico Cicaló (Università degli Studi di Sassari)
Francesca Fatta (Università Mediterranea di Reggio Calabria)
Franco Purini (Sapienza Università di Roma)
Livio Sacchi (Università degli Studi G. D'Annunzio - Chieti/Pescara)
Manuel Gausa (Università di Genova)
Marco Maretto (Università di Parma)
Marco Trisciuoglio (Politecnico di Torino)
Meghal Arya (CEPT University, India)
Ricky Burdett (London school of economics, UK)
Stefano Brusaporci (Università dell'Aquila)
Thomas Herzog (Technische Universität München, Germania)
Valter Caldana (Universidade Presbiteriana Mackenzie, Brasile)
Wilson Florio (Universidade Presbiteriana Mackenzie, Brasile)
Winy Maas (TU Delft, Paesi Bassi)

Redazione | Editorial board
Gabriele Giau
Greta Montanari
Fabio Planu
Dario Rizzi

Progetto grafico | Graphics
Plam Creative Studio

Impaginazione | Layout
Plam Creative Studio

Collaborazioni | Contributions
Per l'invio di articoli e comunicati si prega di fare riferimento al seguente indirizzo e-mail: bzm@unife.it
For sending articles and press releases, please refer to the following e-mail address: bzm@unife.it

Direzione | Publisher
Maggioli Editore, Via del Carpino, 8
47822 Santarcangelo di Romagna (RN)
tel. 0541 628111 - fax 0541 622100
Maggioli Editore è un marchio Maggioli s.p.a.

Copertina | Cover
Image of human passage in the Calanchi Park of Aliano by colours' inversion (Photography: A. Y. Jafari) |
Immagine del passaggio dell'essere umano nel Parco dei Calacnhi di Agliano a colori invertiti (Fotografia: A. Y. Jafari)

OPEN ACCESS

Le immagini utilizzate nella rivista rispondono alla pratica del fair use (Copyright Act 17 U.S.C. 107) recepita per l'Italia dall'articolo 70 della Legge sul Diritto d'autore che ne consente l'uso a fini di critica, insegnamento e ricerca scientifica a scopi non commerciali.