Enhancing Semantic Interoperability of Heritage BIM-based Asset Preservation

Introduction

It is of the utmost significance in the field of cultural heritage preservation to guarantee the precise and comprehensive representation of information. The capture of high-quality information and detailed representation allows for the archival documentation necessary to understand an object's original condition and the context of its creation and use. This meticulous approach enables conservators to make informed decisions about restoration and preservation, thus ensuring the object's authenticity. Building Information Modelling (BIM) provides a robust platform for the as-is state documentation and management of heritage assets. However, constraints related to semantic interoperability and the complexity of cultural information often hinder the effectiveness of BIM in a heritage knowledge representation. High uniqueness and detailedness often lead to exclusive descriptive documentation, limiting information consistency across projects. The study aims to answer the question: how can the integration of BIM authoring tools with a data dictionary platform enhance the semantic interoperability of cultural heritage assets?

Methodology

This paper investigates the application of standardised heritage ontology to label heritage assets in the BIM environment and proposes a streamlined approach with the integration of the bSDD (buildignSMART Data Dictionary) platform. The bSDD is a service from buildingSMART International for distributing data dictionaries into BIM applications. The presented workflow is based on the open standard IFC data model of historic tenement house, a predominant way to structure and share BIM information.

About the modelled building: The design of the tenement house on Chopina Street in Tarnów, developed by Franciszek Hackbeil (1879-1921) between 1912 and 1913, is an excellent example of the application of HBIM. The tenement is characterised by an impressive eclectic-secession façade design, reminiscent of the Neo-Baroque, and rich decoration expressed in pilasters, rustication, attics, balustrades and bay windows.

This research employs a proof-of-concept approach to demonstrate the practical use of the MIDAS heritage classification in BIM-authoring software on tenement house mentioned above, thanks to the integration with the bSDD platform. The research methodology consists of four steps: mapping the classification system with bSDD data structure, publishing in bSDD, conducting the case study, and analysing the results. In the project, we use existing classification (MIDAS), software applications (bSDD and BlenderBIM) and the BIM dataset provided by the author. The dataset was obtained through 3D scanning of the monument site, followed by modelling the geometry of elements and semantic enrichment using IFC classes (Figure 1).

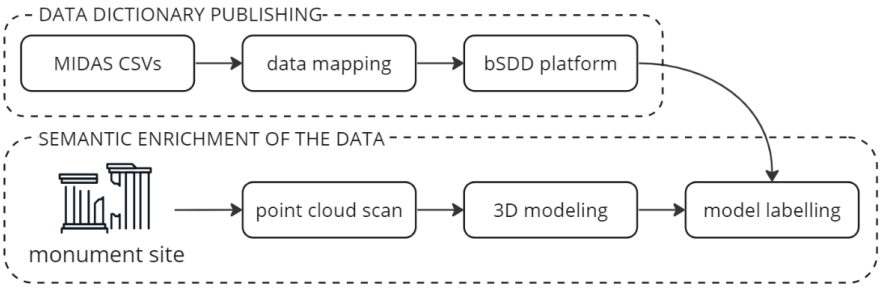

Figure 1. Workflow applied in the study.

The process is applied to a test heritage building model containing detailed geometry and only basic element classification. To increase the depth of information, the model's elements were labelled using the British MIDAS Heritage Dictionary, distributed through the bSDD. Three MIDAS thesauri relevant to the case study were published: *components, materials,* and *monument types*. *Components* include 1397 terms, such as *stoup* or *voussoir,* with their definitions, usually consisting of one sentence. *Materials* include 636 terms, from general to very specific, such as *Baveno Granite* or *Bethersden Marble*. The *monument types* classification describes a whole facility or a place and contains 7897 terms, like Abbey Gatehouse or Anti-Submarine Searchlight Battery. All the published dictionaries can be previewed at https://search.bsd.buildingsmart.org/uri/fish. Due to the abstract's longevity, a further exempliary mapping sequences will be presented in paper.

Further semantic enrichment by assigning appropriate classes from MIDAS is performed using BlenderBIM. BlenderBIM is an open-source application based on the IfcOpenShell library, extending the interface and adding BIM capabilities to Blender, which is a popular free, open-source 3D computer graphics software (BlenderBIM 2024, IfcOpenShell 2024, Blender 2024). BlenderBIM integrates with the bSDD API, an application programming interface that allows interaction with the database.
Using the tool's graphical user interface, we assign MIDAS classes to IFC objects containing general information and geometrical representation.
Result analysis: The final phase involves saving the data to the IFC file and opening it in another software – BIMvision – to preview the information. The performance is evaluated regarding information consistency, accuracy, and usability.

Once published the classification systems instantly become accessible in all integrated software through bSDD API. In this case study, the initial model already contains objects classified using the foundation classes (IFC). For example, the element highlighted (Figure 2) is not a generic object (IfcBuildingElementProxy) but the element of class *IfcBeam* of a predefined IFC type *CORNICE.*

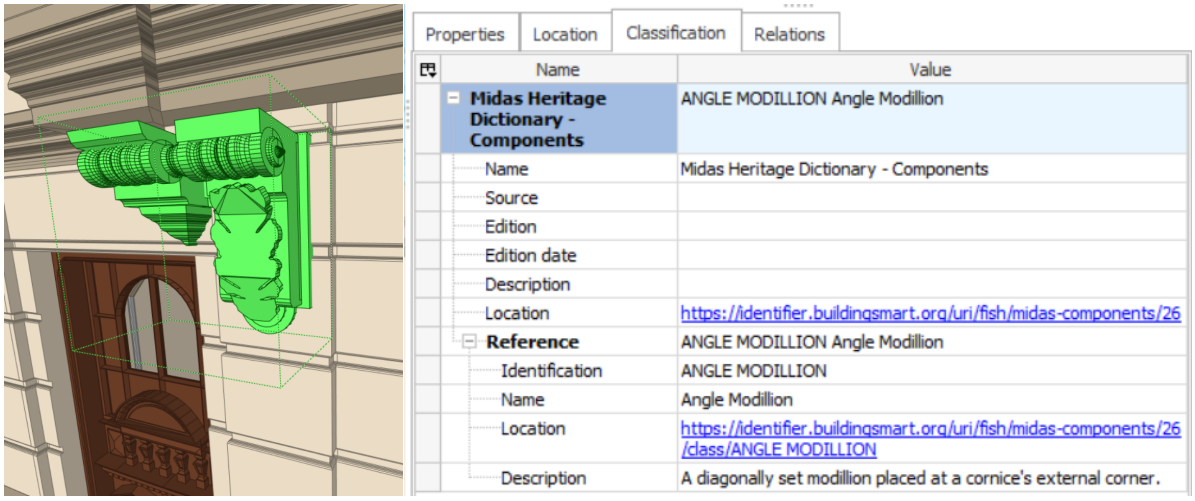

Figure 2. Previewing IFC model with proper references to MIDAS classification and URL identifiers in BIMVision IFC Viewer.

Results and discussion

The detailed semantic layers of MIDAS can be utilised to predict and address preservation challenges. The integration of BIM applications with bSDD support the meticulous documentation of heritage assets, ensuring that every detail, from geometric configurations to cultural attributes, is comprehensively recorded. The use of HBIM extends beyond mere documentation; it enables advanced analysis and management, ensuring that heritage conservation efforts are both precise and

effective. Moreover, comprehensive information representation facilitates interoperability between different technology platforms, increasing the potential for global preservation collaboration.

Furthermore, the proposed method emphasises the significance of information consistency and precision. In the field of heritage preservation, where the integrity of historical data is paramount, maintaining high standards of data quality is critical. Research demonstrates that the integration of bSDD with ontology-based vocabularies such as MIDAS significantly improves the usability of openBIM for documenting historical objects.

This approach not only enhances the documentation and analysis of these assets but also supports their preservation for future generations. The enriched narrative provided by this method ensures that the cultural and historical significance of heritage assets is accurately conveyed and preserved, thereby supporting the integrity and richness of our shared cultural heritage.

Current research is exploring the potential of this framework in developing a predictive model for heritage asset preservation.

Acknowledgements

We want to thank Paul Adams, Data Standards Specialist/Historic England, for their support and for providing MIDAS Heritage FISH standards and permission to utilise them for scientific work.

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