Data interoperability between element classifications and semantics of historic buildings. Case study of the Duomo of Molfetta (Italy)

Enrique Nieto-Julián[a], Juan Moyano[a], Alessandra Pili[b] Silvana Bruno[c]

a University of Seville, Department of Graphical Expression and Building Engineering, Universidad de Sevilla, Spain

b Department of Architecture, Built environment and Construction Engineering, Politecnico di Milano, Milano, Italy

c Department of Civil, Environmental, Land, Construction and Chemistry Engineering, Politecnico di Bari, Italy.

Abstract

The research deals with the study and implementation of new solutions for the preservation of the Architectural Heritage, covering the phases of auscultation, intervention, and maintenance. A sustainable technological process is applied, based on the collaborative BIM methodology, which constitutes a bulwark for the efficient management of the historic building as it is effective in the interoperability of data from the Heritage-BIM (HBIM) project. In the study and conservation of Heritage, there are many disciplines that are part of the investigation or intervention and that require extracting, sharing and contributing data linked to the historic building. The use of a new collaborative construction process management technology involves implementing design, modeling, planning and maintenance improvement processes. These logistic production benefits will now be transferred to a historical-constructive context.

On the other hand, reinforcing the interoperability of the data is decisive for a BIM system to function with full capacity. Classifying allows standardizing and organizing elements based on an established criterion. Assigning classifications to historical elements and systems in an HBIM project, including detected problems or deterioration, is also essential for proper interoperability between architects, archaeologists, historians, engineers. Currently, the BIM environment has classification systems, based on the correct identification of the most common systems in construction. But the context of the historic building is very complex as it is affected by the temporal-evolutionary component and by the great diversity of types within an architectural style. To solve it, the ontology provides us with a computable knowledge base, a representation system through which it is possible to model a domain of knowledge.

In this work, a semantic segmentation of the point cloud obtained by TLS is carried out using the Cyclone 3DR point cloud processing software. In the second phase of work, the elements are structured in an HBIM project. From these data, a classification of the elements is executed using the ontology base developed by (Pili, 2023). Element classification covers an export process in IFC format. This workflow will allow the creation of a future universal classification related to Cultural Heritage. For the procedure to be properly implemented, the Duomo di Molfetta (Bari, Italy) has been taken as a case study.

Keywords

HBIM, Scan-to-BIM, Segmentation, Ontology, Heritage, Preservation

References

1. Acierno, M., Cursi, S., Simeone, D., & Fiorani, D. (2017). Architectural heritage knowledge modelling: An ontology-based framework for conservation process. Journal of Cultural Heritage, 24, 124–133. https://doi.org/10.1016/j.culher.2016.09.010
2. Afsari, K., & Eastman, C. M. (2016). A Comparison of Construction Classification Systems Used for Classifying Building Product Models. 52nd ASC Annual International Conference Proceedings, 2001, 1–8.
3. Alshawabkeh, Y., & Baik, A. (2023). Integration of photogrammetry and laser scanning for enhancing scan-to-HBIM modeling of Al Ula heritage site. Heritage Science 2023 11:1, 11(1), 1–17. https://doi.org/10.1186/S40494-023-00997-2
4. Castán, M. Q., & Hernández, L. A. (2022). Metodología de captura y procesado para el desarrollo de una base de datos gráfica 3D del patrimonio arquitectónico. Ge-Conservacion, 21(1), 72–84. https://doi.org/10.37558/GEC.V21I1.1048
5. Croce, V., Caroti, G., Luca, L. De, Jacquot, K., Piemonte, A., & Véron, P. (2021). From the Semantic Point Cloud to

Heritage-Building Information Modeling: A Semiautomatic Approach Exploiting Machine Learning. Remote Sensing 2021, Vol. 13, Page 461, 13(3), 461. https://doi.org/10.3390/RS13030461

6. De Fino, M., Galantucci, R. A., & Fatiguso, F. (2019). Remote diagnosis and control of heritage architecture by photorealistic digital environments and models. SCIRES-IT, 9(2), 1–16. https://doi.org/10.2423/i22394303v9n2p1
7. Grilli, E., & Remondino, F. (2019). Classification of 3D Digital Heritage. Remote Sensing 2019, Vol. 11, Page 847, 11(7), 847. https://doi.org/10.3390/RS11070847
8. Leica Geosystems AG-Part of Hexagon. (2023). Leica Cyclone 3DR. https://leica-geosystems.com/es-es/products/laser-scanners/software/leica-cyclone/leica-cyclone-3dr
9. Li, W., He, C., Fang, J., Zheng, J., Fu, H., & Yu, L. (2019). Semantic Segmentation-Based Building Footprint Extraction Using Very High-Resolution Satellite Images and Multi-Source GIS Data. Remote Sensing 2019, Vol. 11, Page 403, 11(4), 403. https://doi.org/10.3390/RS11040403
10. Miceli, A., Morandotti, M., & Parrinello, S. (2020). 3D survey and semantic analysis for the documentation of built heritage. The case study of Palazzo Centrale of Pavia university. Vitruvio, 5(1), 65–80. https://doi.org/10.4995/vitruvio-ijats.2020.13634
11. Moyano Campos, J. J. (2022). Desde la forma al modelo digital: teoría de la morfogénesis en el ejercicio de la forma natural (U. de Sevilla (ed.)). Universidad de Sevilla. https://dialnet.unirioja.es/servlet/libro?codigo=873511
12. Moyano, J., Fernández-Alconchel, M., Nieto-Julián, J. E., Marín-García, D., & Bruno, S. (2023). Integration of dynamic information on energy parameters in HBIM models. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLVIII-M–2, 1089–1096. https://doi.org/10.5194/ISPRS-ARCHIVES-XLVIII-M-2-2023-1089-2023
13. Moyano, Juan, León, J., Nieto-Julián, J. E., & Bruno, S. (2021). Semantic interpretation of architectural and archaeological geometries: Point cloud segmentation for HBIM parameterisation. Automation in Construction, 130, 103856. https://doi.org/10.1016/J.AUTCON.2021.103856
14. Moyano, Juan, Nieto-Julián, J. E., Lenin, L. M., & Bruno, S. (2021). Operability of Point Cloud Data in an Architectural Heritage Information Model. International Journal of Architectural Heritage, 1–20. https://doi.org/10.1080/15583058.2021.1900951
15. Nieto-Julián, J. E., Lara, L., & Moyano, J. (2021). Implementation of a TeamWork-HBIM for the Management and Sustainability of Architectural Heritage. Sustainability, 13(4), 2161. https://doi.org/10.3390/su13042161
16. Pierdicca, R., Paolanti, M., Matrone, F., Martini, M., Morbidoni, C., Malinverni, E. S., Frontoni, E., & Lingua, A. M. (2020). Point Cloud Semantic Segmentation Using a Deep Learning Framework for Cultural Heritage. Remote Sensing, 12(6), 1005. https://doi.org/10.3390/rs12061005
17. Pili, A. (2023). Integrated BIM process for cultural heritage : ontologies and interoperability for information interchange. https://www.politesi.polimi.it/handle/10589/196392
18. Robert McNeel & Associates. (2019). Rhinoceros. https://www.rhino3d.com/
19. Spina, S., Debattista, K., Bugeja, K., & Chalmers, A. (2011). Point Cloud Segmentation for Cultural Heritage Sites. VAST: International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage, 41–48. https://doi.org/10.2312/VAST/VAST11/041-048
20. Stanford University. (2023). Protégé. https://protege.stanford.edu/
21. Troitiño Vinuesa, M. Á. (1998). Turismo y desarrollo sostenible en las ciudades históricas con patrimonio arquitectónico-monumental. Estudios Turísticos, ISSN 0423-5037, No. 137, 1998, Págs. 5-53, 137, 5–53. https://dialnet.unirioja.es/servlet/articulo?codigo=2197398&info=resumen&idioma=SPA
22. Zou, Y., Weinacker, H., & Koch, B. (2021). Towards Urban Scene Semantic Segmentation with Deep Learning from LiDAR Point Clouds: A Case Study in Baden-Württemberg, Germany. Remote Sensing 2021, Vol. 13, Page 3220, 13(16), 3220. https://doi.org/10.3390/RS13163220