A Dynamo workflow for the recognition of an HBIM model's architectural period

Konstantina SIOUNTRI, University of Piraeus, Greece
Elias SAKELLARIS, University of Piraeus, Greece
Christos- Nikolaos ANAGNOSTOPOULOS, University of the Aegean, Greece

Keywords: *Dynamo — HBIM — Semantic — Aware 3D Database*

CHNT Reference: Siountri, K., Sakellaris, E., Anagnostopoulos, C.-N., (2022). 'A Dynamo workflow for the recognition of an HBIM model's architectural period', *Proceedings of the 27th International Conference on Cultural Heritage and New Technologies, November 2022.* Heidelberg: Propylaeum. DOI:

Introduction

Urban environment in historical cities very often is characterized by typological and structural inhomogeneity as it consists of buildings that have been built with different materials and styles in different periods of time. Nevertheless, the "type" of such buildings is perceived as part of a class of repetitive objects characterized by their common morphological features. Until nowadays, the recognition of the "type" was the result of collective mental mechanisms, which the professionals of the field processed through their academic training and experience.

This paper focuses on a workflow that has been created to recognise the architectural typology of cultural heritage Athenian house buildings (1830-1940) through the evaluation of their façade's elements that can defined and translated in logical commands that are possible to be calculated. In this process of multi criteria analysis the façade's elements are rated based on multiple factors, like their morphology or materiality. The total result of this rating corresponds to one of the three main architectural periods of modern Athens (neoclassical, eclecticism or interwar period).

This process is based on logic evaluations and therefore it has perfect application in the Heritage Building Information Modelling (HBIM). In an HBIM environment the model can be subdivided and inspected in all its components, and it is possible to extract the necessary information to create a database that can also be used by another software. The identity of each of the façade's elements is processed with Dynamo, a visual programming software, which can lead to the rating and the categorization of each building's facade to the corresponding architectural period. (Fig.1)

The results were tested on a database of over 1000 buildings that was created for the purpose of this research, until an acceptable error of 5% of the evaluations had been reached. With the novel procedure established for the automatic verification of the architectural period, the semantic relations of the HBIM elements are expanded and new ways of enriching HBIM libraries are explored.

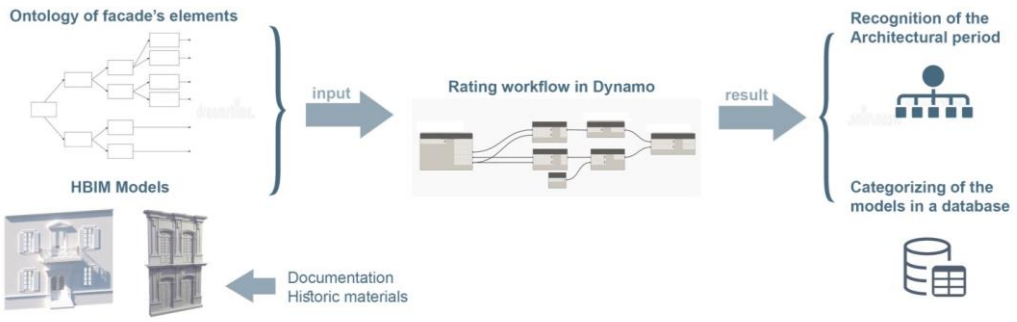


Fig. 1. Diagram regarding the methodology

Ontology of façade elements

The research has focused on creating an ontology on the external characteristics of the cultural heritage (CH) Athenian houses as this method of recognition and classification of structural elements was considered more efficient due to the abundance and availability of the information. The ontology created was expected to be semantically aware and to encapsulate the rules of each architectural period. (Quattrini 2018).

The buildings which were studied, dated to Neoclassical, Eclectic, and Interwar period. The Neoclassicism as a style was applied in the Athenian buildings after 1834 when the city was chosen as the capital of the newly established Greek State. Its main characteristics were the plasticity, the elaborate decoration, the pilasters, the friezes, etc. (Biris & Kardamitsi-Adami, 2001). Eclecticism appeared at the late 19th century and the early beginning of the 20th century. This style combined elements of different periods in one building like the Art Nouveau and the Beaux Arts with new, modern materials such as iron and glass. From 1920 to 1940, the construction of the facades of the Interwar houses are characterized by “simplicity” and consist of elements that refer directly to the Architecture of Bauhaus and they, in contrast to the impressive classicist elements and the exterior decorations of the previous years.

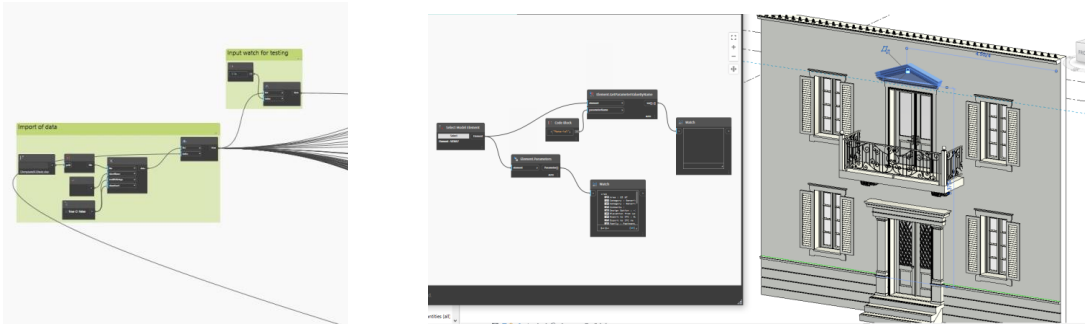
The information was extracted through the relevant literature and the in-situ research and was divided according to the size of the houses, the masonry, the openings, the roof ending, the balconies, and the decoration. These six categories consisted of 40 possible different elements that may be found on an CH building. Each element corresponds to a specific rating and the total sum to in a price range for each typology.

Methodology of the workflow

In this study the process of evaluating the elements has two types of inputs. The attributes of the elements can either be selected from the HBIM model and imported in the Dynamo routine (Fig. 2a), or they may be inserted from an external table database (Fig. 2b), which is an excel sheet with a row for each building and columns with the attributes for each element.

To guarantee the correspondence between model properties in text and the layout of a Building Information Modelling (BIM) project, the structure of the database requires high clarity in the definition of each attribute and the text must be formulated in the same way as in BIM environment (Giovannini 2017). The attribute can contain either numeric data, dimensions, geometric properties, the

true or false condition and in various cases a keyword like “elaborate” or “simple”, “stone” or “metallic” etc.



a *b*

Fig. 2. Input of building’s element attributes a) from a text table b) from an HBIM model

This information will be processed in the software plugin called Dynamo, which is an open-source visual programming environment that allows composing custom algorithms using nodes and relationships (Quattrini 2018). Each node has a function, which varies from the definition of parameters to the design of geometries. While not being its main use, Dynamo provides multiple nodes capable of managing data and interacting with the system parameters. These nodes were used as logic commands or mathematical formulas to recognise the values of the façade elements. The type of the element can be further secured by setting a numerical value as its identity (Element ID). This numerical value can be kept separately in a list as a reference.

After the numerical processing which leads to the sum rating of the building elements, this result is further evaluated in order to recognize in which of the three architectural periods it belongs. After a lot of testing, three result areas has been recognized and set as the default for the routine.

Overall, the user can have the modelling software running simultaneously with the Dynamo script and watch the result, or manually set the attributes in the excel table and get the result from the Dynamo standalone software. The corresponding knowledge regarding the building’s architectural period is finally displayed in the “watch” window at the end of the Dynamo script. (Fig. 3)

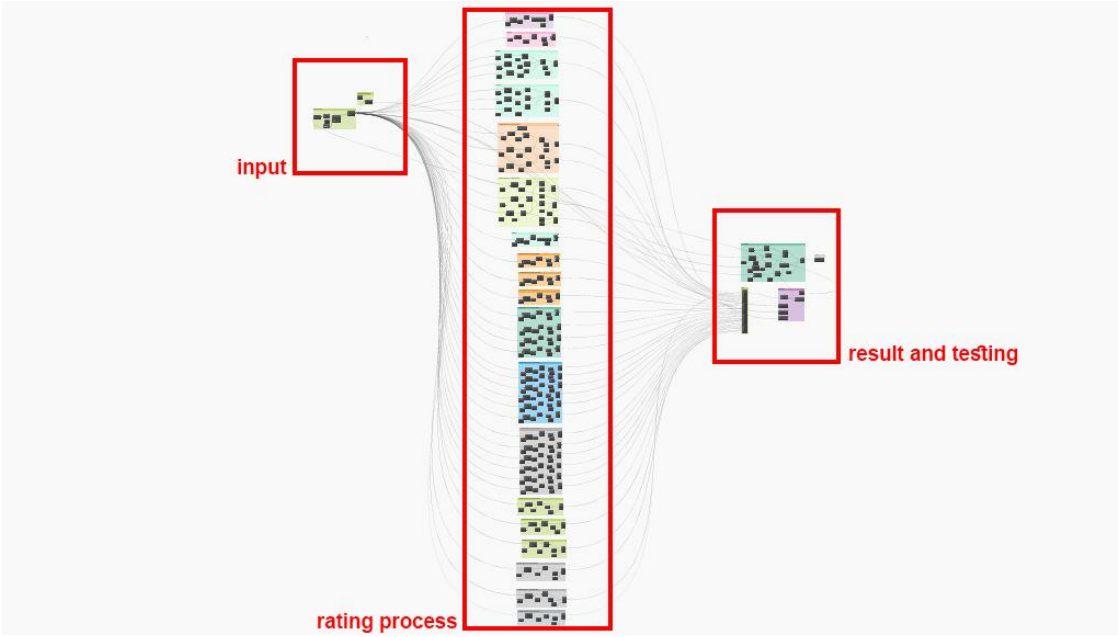


Fig. 3. The full Dynamo routine.

Testing the database

The database that was used to ensure that the workflow works consisted of more than 1000 Greek listed historic buildings. The results of the evaluations needed to be tested many times, until an acceptable error of 5% of the evaluations had been reached. This was done by introducing a “watch” node in each index to quickly identify the part of the analysis that made the certain building each time that gave result in the wrong architectural period (Villaschi 2022). By easily identifying the mistake during the data extraction phase, actions were taken more decisively to improve the routine.

The output of the process is a table which categorizes the buildings in their architectural period as intended. The result can be added as a new attribute in the properties of each element in the HBIM model. In this way the data are enriched, and the elements can be included in a library referring to each architectural period.

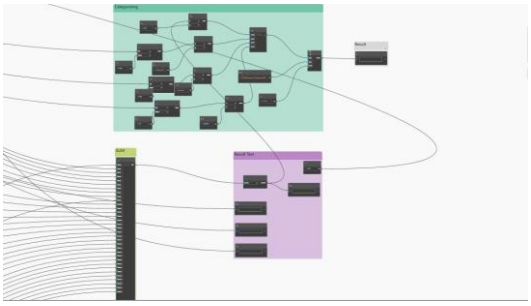


Fig. 3. The full Dynamo routine.

Conclusion

This research contributes to the semantic management of 3D data relating to the structural analysis of historical buildings and to the development of an innovative application in the CH field. By automating the process of documentation in digital environment like HBIM, the barriers to heterogeneous semantic data sharing and integration about cultural heritage can be overcome.

Acknowledgements

The publication of this paper has been partly supported by the University of Piraeus Research Center (UPRC).

References

Biris, M & Kardamitsi-Adami, M (2001) Neoclassical architecture in Greece. Melissa, Athens

Quattrini R., Battini C. and Mammoli R. (2018). 'HBIM To VR. Semantic Awareness And Data Enrichment Interoperability For Parametric Libraries Of Historical Architecture', The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2, pp. 937-943. DOI:10.5194/isprs-archives-XLII-2-937-2018

Yang, X., Lu, Y.-C., Murtiyoso, A., Koehl, M. and Grussenmeyer, P. (2019) 'HBIM Modeling from the Surface Mesh and Its Extended Capability of Knowledge Representation'. ISPRS Int. J. Geo-Inf. 8, 301. https://doi.org/10.3390/ijgi8070301

Villaschi, F.S.; Carvalho, J.P.; Bragança, L. (2022) BIM-Based Method for the Verification of Building Code Compliance. Appl. Syst. Innov. 5, 64. https://doi.org/10.3390/asi5040064

Giovannini, E. (2017). 'VRIM workflow: semantic H-BIM objects using parametric geometries.', Conference: 3D Modeling & BIM. Progettazione, design, proposte per la ricostruzione, At: Roma, Faculty of Architecture - Sapienza University, Volume: ISBN 978 88 49645019