Development of software solutions for advancing GeoBIM integration in digital twins

Hakim, Amir; El Yamani, Siham

Publication date
2024

Document Version
Final published version

Published in
Digitalisation of the Built Environment: 3rd 4TU-14UAS Research Day

Digitalisation of the Built Environment

3rd 4TU-14UAS Research Day

Extended abstracts

25 April 2024

Delft

Edited by

Giorgio Agugiaro, Perica Savanović and Rizal Sebastian

Colophon

Digitalisation of the Built Environment
3rd 4TU-14UAS Research Day

Editors:
Giorgio Agugiaro[1], Perica Savanović[2], Rizal Sebastian[3]
[1] 3D Geoinformation group, Department of Urbanism, Faculty of Architecture and Built Environment, Delft University of Technology – g.agugiaro@tudelft.nl https://orcid.org/0000-0002-2611-4650
[2] Research and Innovation Centre Engineering, Design and Computing, Inholland University of Applied Sciences – perica.savanovic@inholland.nl https://orcid.org/0000-0003-3232-1362
[3] Future Urban Systems Research Group, The Hague University of Applied Sciences – r.sebastian@hhs.nl https://orcid.org/0000-0003-1714-8418

Keywords:
Built Environment, Artificial Intelligence, Robotics, Augmented/Virtual/Mixed Reality, Digital Twins

Published by:
TU Delft OPEN Publishing | Delft University of Technology, The Netherlands

DOI: https://doi.org/10.59490/mg.112

ISBN: 978-94-6366-912-2

Use of AI:
During the preparation of this work, the author(s) used Paperpal in order to language editing. After using this tool/service, the author(s) reviewed, edited and made the content their own as needed and take(s) full responsibility for the content of the publication.

To cite this publication:
Agugiaro, G., Savanović, P., Sebastian, R. (2024) *Digitalisation of the Built Environment: 3rd 4TU/14UAS Research Day*. TU Delft OPEN Publishing, Delft University of Technology, The Netherlands.

Development of software solutions for advancing GeoBIM integration in digital twins

Amir Hakim, Siham El Yamani

Delft University of Technology, Faculty of Architecture and Built Environment, Department of Urbanism, 3D Geoinformation Group, Delft, The Netherlands – {s.hakim, s.e.elyamani}@tudelft.nl

Keywords: Digital Twinning, GeoBIM Interoperability, Georeferencing, Geospatial integration, BIM.

Extended Abstract

The digitalisation of the built environment is a key challenge and opportunity for the construction industry. One of the emerging trends in this field is the development and use of digital twins, which are virtual representations of physical assets that can be used for simulation, analysis, and optimisation. However, creating and maintaining digital twins require interoperable and geospatially accurate data from different sources and formats. During the presentation, we introduce two software tools that have been developed by our team to facilitate the integration of geospatial and Building Information Modeling (BIM) data for digital twin applications.
The first tool is the CityJSON importer for Autodesk Revit, which allows users to import and visualise 3D city models in CityJSON format. By creating individual geometries for each city object and their associated attributes as parameters, the plugin empowers users to assess the environmental impact of the BIM during the design phase. This method promotes a unified workflow, simplifies the management of GeoBIM information within an integrated environment, and improves the interoperability between the geospatial and BIM data. The direct integration of CityJSON data into Autodesk Revit streamlines processes, preserves attributes, enhances analysis capabilities, fosters GeoBIM interoperability, and offers a specialised Revit solution, surpassing the need to convert CityJSON to IFC for Revit importation. Another distinction of this tool is its ability to generate individual objects separately. This is unlike existing tools, which primarily generate each file as a shell without separating each city object. During development, numerous challenges have been addressed, including georeferencing, data format importation, handling of different geometry representations, attribute hierarchies, code optimisations, user-friendliness, and improved visualisation.

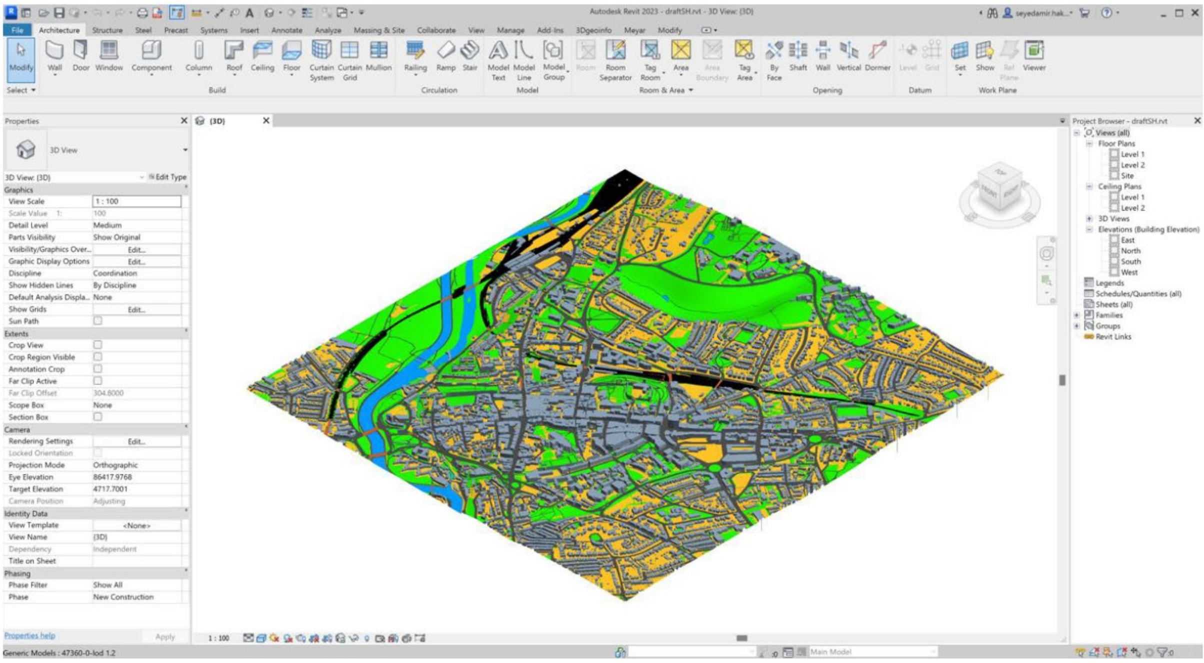

Figure 1. 3D City Model of Southampton, England created via CityJSON importer plugin.

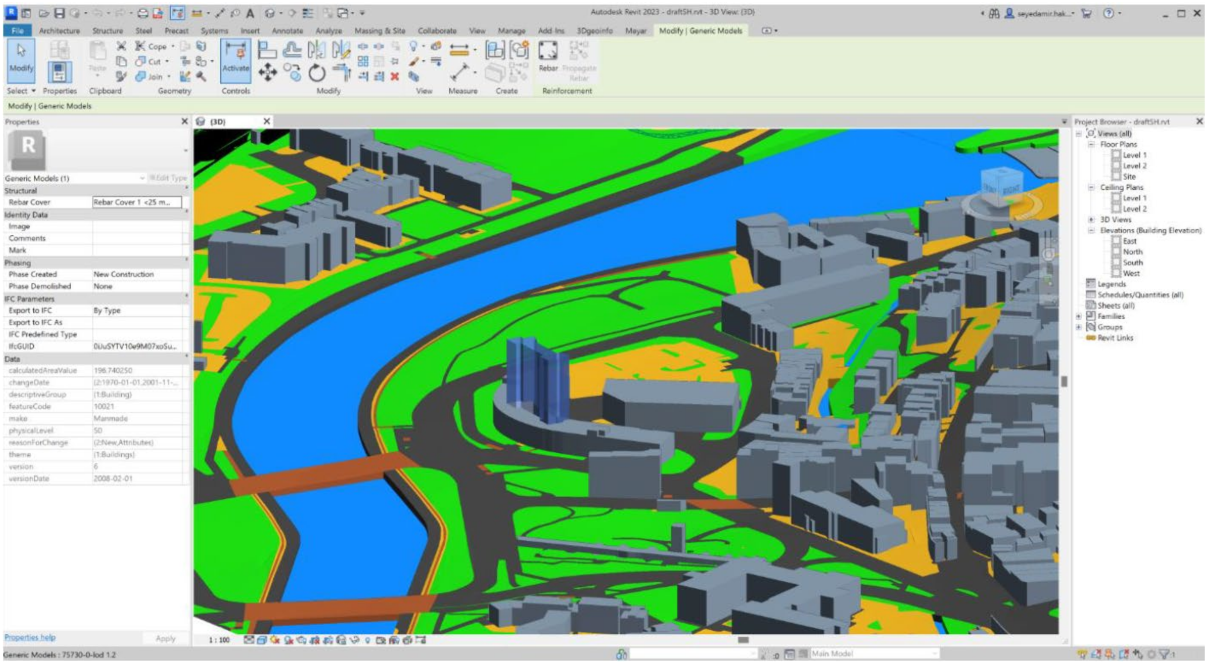

Figure 2. Visualisation and selected geometry information from Southampton City Model in Autodesk Revit Software.

This application primarily focuses on creating generic models within a BIM environment by using CityJSON geometries. Looking ahead, it would be greatly advantageous to generate geometries incorporating semantic attributes tailored to Autodesk Revit for future advancements. The application conducts a re-projection of CityJSON points to the EPSG 4326 coordinate reference system (CRS) as the fundamental reference point.

The second tool is a web app for georeferencing, named IfcGref, which enables users to control, assign, or modify georeferencing information in IFC models, a standard format for exchanging

BIM data, and visualise the roof outlines of the IFC models on the target CRS map. In the context of integrating Building Information Models (BIM) and city models, a critical challenge arises in ensuring consistency between the localised, three-dimensional, Cartesian coordinate system of BIM models and the projected coordinate system of city models. Georeferencing has become a fundamental task, requiring the transformation of coordinate systems to facilitate integration and decision making in GeoBIM projects. To address the georeferencing challenge, an IfcGref Web-Based Application was developed. This lask-based tool[1] provides a comprehensive solution for designers, engineers, and software developers. IfcGref supports georeferencing operations starting from IFC4, thereby ensuring backward compatibility with earlier versions. The tool utilises IfcMapConversion, incorporating attributes such as SourceCRS, TargetCRS, and other key parameters to enable precise coordinate transformation. The workflow of IfcGref involves a user-friendly interface for file uploading and verification. Georeferenced files are promptly confirmed, whereas non-georeferenced files undergo a guided process, including EPSG code selection, optional surveyed point input, and visualisation. The tool employs scientific computing libraries to ensure optimal solutions for coordinated operational values. A visualisation feature allows users to observe the real-world impact of georeferencing on the geometry of the IFC model and its location on the map.

Figure 3. 3D view of a georeferenced BIM model (left) and its visualisation on the map (right).

These tools serve distinct purposes in GeoBIM. The CityJSON importer facilitates the import of geospatial information for a widely used commercial BIM platform, whereas IfcGref aids in integrating open BIM formats into the geospatial domain. However, the georeferencing methodology employed by IfcGref can potentially be adapted for future developments aimed at implementing precise coordinate reference systems from city models in Autodesk Revit.

Demonstrating with a real-world example:

In showcasing the functionalities and benefits of integrating Building Information Modeling (BIM) and geospatial data, real-world projects such as the CHEK project serve as exemplars. The 'Change toolkit for DBP' (CHEK) project[2], a European initiative, illustrates the development of digital tools and methodologies for performing Development-Based Planning (DBP) checks. Central to this initiative is the seamless integration of buildings and 3D city data.

[1] https://ifcgref.bk.tudelft.nl

[2] https://chekdbp.eu

Georeferencing tools play an important role in ensuring accuracy, particularly in terms of regulatory compliance. For instance, consider the computation of regulations, such as the maximum building height. Accurate georeferencing enables precise measurements such as determining the distances between buildings or computing building heights from the ground level to the roof. Without accurate georeferencing, these computations can yield erroneous results. An illustrative case study involved four municipalities with distinct regulatory frameworks. For example, in Prague, the regulated building height is defined as the distance from the lowest point of the adjacent terrain to the main cornice level. As presented in Figure 1, to assess the maximum building height in this context, workflows include the following steps.

1) IFC Modeling and Georeferencing: Utilising tools, such as the IFC Georeferencing solution, the initial step involves georeferencing the IFC model.
2) Visualisation and Verification: Following georeferencing, visualisation tools were employed to verify the outcomes, ensuring accuracy and compliance.
3) Storage of Georeferencing Data: Georeferencing data, crucial for subsequent computations, are stored in CityJSON files based on the IFC building envelope extractor during the conversion process.
4) Building Height Computation: Utilising a voxelisation approach, such as the extraction-based highest point roof method, building height computations are performed, adhering to regulatory data requirements.

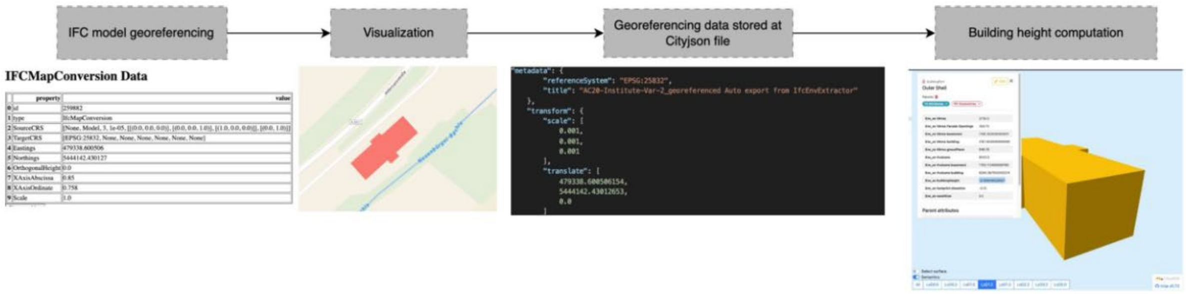

Figure 4. IFC georeferencing in maximum building height showcase (CHEKDBP project).

Improvements have been made to this example, particularly in enhancing interoperability and georeferencing. One notable improvement is optimising the process of storing georeferencing data in the process of conversion from IFC to CityJSON. This transition is facilitated by solutions such as the IFC Georeferencing tool and the IFC EnvelopeExtractor envelope solution, demonstrating progress towards resolving this challenge.