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Enhancing BIM-GIS Integration through InfraWorks: a Comprehensive Application

*E. Genovese, S. Calluso, M. Manti *(Mediterranea University of Reggio Calabria)*

SUMMARY

Building Information Modeling (BIM) and Geographic Information Systems (GIS) are pivotal in modern urban planning, offering digital tools to enhance efficiency. BIM streamlines design, construction, and management via 3D models, while GIS analyzes spatial data for insights. Integrating these systems presents complexities arising from their distinct natures. Challenges encompass data format disparities, intricate BIM model alignment with broader GIS perspectives, and balancing scale and precision. Despite disparities, integration holds promise for sustainable infrastructure practices. Many studies aim to overcome these challenges, integrating BIM and GIS for various applications. This paper proposes an integration method using Autodesk Revit, ArcGIS, and Autodesk InfraWorks, providing a comprehensive visualization in a GIS environment for urban planning professionals. A case study in Reggio Calabria, Italy, demonstrates successful BIM-GIS integration, enhancing energy efficiency interventions.

Keywords: BIM, GIS, land cover mapping, interchage files, laser scanner, infraworks

Introduction

Building Information Modeling (BIM) and Geographic Information Systems (GIS) are two essential technologies in modern urban planning. Both offer advanced digital approaches that enhance efficiency in urban planning. BIM is a collaborative process based on 3D models that integrates the design, construction, and management of buildings and infrastructure. In the context of urban planning, BIM facilitates integrated design, realistic project visualization, detailed analysis (such as energy efficiency), and long-term infrastructure management. On the other hand, GIS are tools that combine geographic data and attributes to analyze spatial information. Moreover, it helps conduct analyses based on demographic, environmental, and infrastructural data, revealing trends and opportunities. They guide land-use planning, enabling the mapping of areas of interest, resource management, and engaging the public through interactive online maps.

The integration of the two system could be very interesting. However, the integration of Building Information Modeling (BIM) and Geographic Information Systems (GIS) in urban planning brings about several challenges. These challenges stem from the differing nature of these technologies and the complexity of harmonizing them effectively. One fundamental issue lies in the distinct data formats used by BIM and GIS. While BIM operates with detailed 3D models (Barrile, Bernardo, & Bilotta, 2022), GIS deals with geospatial data (Barrile, et al., 2020a). Bridging the gap between these formats and ensuring smooth data interchange can be technically intricate. Furthermore, the complexity of BIM models can pose difficulties when trying to align them with the broader scope of GIS. BIM models encompass a wealth of intricate building and infrastructure details that may not always align seamlessly with the holistic perspective of GIS. Finding the right balance between scale and precision presents another problem. BIM focuses on meticulous building-level details, while GIS operates on a larger geographic scale (Barrile, et al., 2020b).

Merging these perspectives without compromising the essence of either can be a delicate task. Accurate data management is essential for successful integration. Maintaining up-to-date and consistent data across both BIM and GIS platforms is crucial to avoid misinformation and skewed decision-making during the planning process. Integrating the two technologies can be highly advantageous for the AEC industry and can contribute significantly to sustainable infrastructure practices.

In the literature, many studies dealt with this issue, trying to overcome the aforementioned problems in different ways. Despite the differences in semantics and domains, BIM and GIS have been integrated for various applications. Some of the areas of application where BIM data is incorporated into GIS encompass urban development, site selection, management of internal and external emergency responses, as well as the planning of walkway networks. Typically, GIS find application in urban management domains, including urban development (Cao, et al., 2023), site selection (Heo, et al., 2021), and fire response management (Atyabi, et al., 2019; Barrile, et al., 2019); nonetheless, these activities necessitate access to both geometric and semantic data, which can be supplied through BIM. A potential method for integrating these two systems is by transferring GIS data into BIM. This type of integration is also realized in many application areas such as environmental analysis and job management (Zhu, et al., 2021). For instance, environmental data like building climatic conditions are usually available in the GIS environment; however, the GIS lacks information about the interior of the building for more detailed climate analysis.

The integration process can be achieved by linking both systems using a new platform. To achieve this goal, we have used the BIM tool Autodesk Revit and the GIS tool ArcGIS, which have been integrated into a new platform, Autodesk Infraworks, to have a complete visualization of the model in a GIS environment in order to help professionals in urban planning. The present study furnishes proof of the successful implementation of BIM-GIS integration through the use of using Infraworks applied for a building situated in the city of Reggio Calabria (Italy) in which energy efficiency interventions have been conducted.

Method

The research study aims to using the software Autodesk Infraworks to merge the 3D model of a building in a GIS environment with the aim to help professionals in efficient urban planning. Typically, in projects where existing buildings are present, capturing their existing conditions is often critical. So, for this reason, laser scanner was used to capture 3D points of the surface (Barrile & Bilotta, 2014). Faro CAM 2 was used for the survey (Barrile, Bilotta, & Nunnari, 2017) that is an instrument equipped with integrated GPS receiver, which represents a reference point for 3D documentation and topographic surveys thanks to the possibility of scanning objects up to 330 meters; it enables fast, accurate and reliable calculation of distances, areas, and volumes as well as analysis, inspection, and documentation.

Planning the survey consists in identifying the points where to place the laser station so that no uncovered areas remain. The highlights are connected to each other through registration of the point cloud, each portion of the cloud is linked to the others through the reciprocal positioning of each survey point. The software "Faro Scene" was used to process the acquired data.

The main steps of this operation are:

- Recording of individual scans (clouds) detected from different positions
- Single Project Cloud Creation
- Project cloud cleaning
- Decimation of points (resolution)
- Cloud Export (E57 format)

The E57 format (the LIDAR Point Cloud Data File) is a neutral file format used for storing and exchanging point clouds, images, and metadata of 3D models scanned by sensing systems such as laser scanners or other similar instrumentation. It is acknowledged by ASTM, a global standards organization, and detailed in the ASTM E2807 standard.

Having obtained the points cloud, Autodesk Recap was used to open this type of file. Prior to linking a point cloud with the Revit model, it's essential to initially index it using Autodesk ReCap point cloud software. In addition to indexing, ReCap can be used to view, edit, and manage point cloud project files. The only operation to be carried out is to isolate the portion of cloud including the building subject to intervention in order to reduce the weight of the file to be exported. Now it is possible to import the points cloud in Autodesk Revit and create the 3D model (Barrile, et al., 2020c).

Not having the points cloud of the interior of the building we proceed importing the DWG file in the project, obtaining a complete representation of the interior and the exterior of the building in question. Once the modeling of the state of affairs has been completed, we proceed with the modeling of the project status, in which all the various energy efficiency and seismic improvement interventions will be added, such as: external coat, photovoltaic system, renovation of the terrace roof, anti-tipping walls, and it is possible to inspect the model using different "display styles". GIS coordinates are used to determine shared coordinates between the various models (architectural, structural, plant engineering). In addition, the same GIS coordinates are used to define the actual location (latitude and longitude) of the Revit model. This location is used to perform an accurate energy analysis of the model.

With the aim to create a dialogue between the BIM model and the GIS environment, Autodesk Infraworks software was used. This software was useful to model and understand the projects in their context, and to allow to visualize the building in his complex in order to plan the maintenance phase, studying the different alternatives of intervention and plan their times and costs. We use Autodesk Connector for ArcGIS to add data layers directly to Autodesk Infraworks models as configured features. This software uses ArcGIS ESRI login information to connect Infraworks to ArcGIS data. The ArcGIS data layer is generated as model objects in Infraworks using the selected feature types. Buildings can be added to the surrounding area with a level of detail that depends on the requirements of the applications.

Further information can be produced using a combination of different packages until you have the GIS map with the desired information and details. This is an extremely useful tool for representing BIM detail information about the GIS asset with accurate geospatial coordinates such as linking geographic and geometric information, integrating terrain and subsurface information, and incorporating detailed city model information. 3D capabilities and the ability to geo-reference digital information provide a unique multi-scale environment that connects BIM and GIS. Geographic Information System (GIS) is useful for solving the complexities of pre-construction planning and supporting the wide range of spatial analysis used in the logistics perspective of design and construction activities. Elements of BIM are recognized as feature layers and can be used as 3D GIS information, allowing operations such as queries or more advanced analysis. Descriptive information in the GIS (e.g., transport network, location of resources, etc.) should be used to model temporary components, locate temporary structures, reduce transport and logistics costs, and many other applications. The model, visually realistic and complete in every detail (Figure 1), was built using all available GIS data: terrain models, orthophotos, survey data, environmental and anthropic data. And if such information is not available, Infraworks allows to draw map data from different cloud services also allowing to create very realistic renderings by introducing a large library related to streetlamps, guardrails, vegetation, with their insertion it is easier and faster modelling.

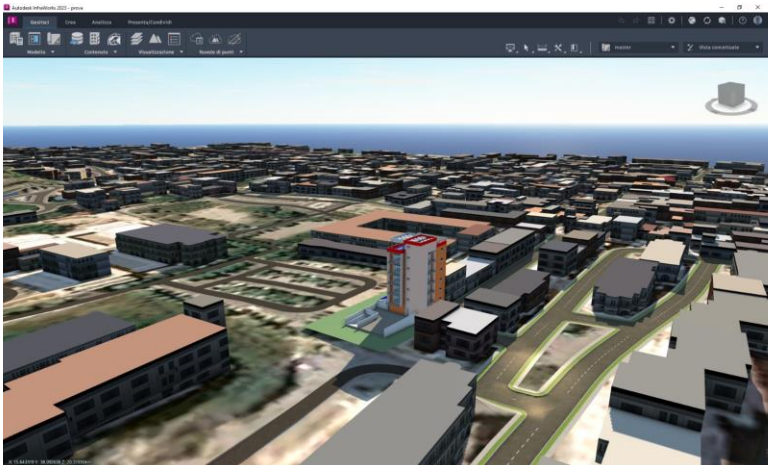

Figure 1. *Autodesk Infraworks environment showing the building situated in Reggio Calabria to which the methodology described was conducted.*

Conclusions

This work provides an application of the software Autodesk Infraworks as a tentative to merge BIM with GIS environment in supporting the city urban planning. The main reason why their integration is necessary is due to the complementary nature of the information provided by each technology. Effective software interoperability is crucial, yet this aspect continues to confront challenges due to the absence of dedicated tools or inflexible procedures and algorithms. Even if the proposed methodology still has some limitations, the future perspectives in this field are huge. Despite the various solutions proposed by other authors, other steps are necessary to completely solve the problem in order to help professionals in urban planning.

Urban planning, in fact, plays a crucial role in shaping the growth and development of cities and urban areas in a sustainable and efficient manner. It serves a multitude of important purposes and benefits that contribute to the well-being of both present and future generations.

One of the primary functions of urban planning is to organize the allocation of land for various purposes. By doing so, it prevents the haphazard expansion of cities and towns, promoting a more organized and controlled approach to development. This helps in avoiding the chaos that can arise from unplanned urban growth. Moreover, urban planning is a key driver of sustainable development. It seeks to strike a balance between economic progress, social equity, and environmental preservation.

This equilibrium ensures that economic activities thrive without compromising the welfare of communities and the health of the environment. This translates to the creation of places where people can live, work, and play comfortably, contributing to their overall quality of life. In this context the integration of the two systems is fundamental.

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