Research on Conversion and Integration Framework from BIM Data to 3DGIS Scene

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Abstract. There are large differences between BIM and 3DGIS in model scale, data standards, information expression, etc., which brings great challenges to the conversion and integration between them. Through in-depth analysis of the current status, problems and difficulties about the integration of BIM models in 3DGIS scenes, aiming to the optimization of graphic information conversion, extraction and integration of attribute information, model light-weighting, shared scheduling, and integrated management of the entire life cycle, combined with IFC and CityGML, a framework for the transformation and integration of BIM models to 3DGIS scenes is proposed. Taking the management information system of the Changjiang Water Resources Committee as an example, after forming a preliminary three-dimensional terrain scene and building appearance model, the process of transforming and integrating a BIM building model into 3DGIS scene is discussed. The results show that the framework can effectively guide the entire process of conversion, publication, integration and application of BIM models in 3DGIS scene, and proves good practicability and operability.

1. Introduction

Three-dimensional geographic information system (3DGIS) has the characteristics of spatial management, macro planning, decision analysis, etc., but the expression of real buildings can only be replaced by the skin model with elevation information, which is difficult to describe the internal structure of the object, thus limits the development of 3DGIS to the micro world [1-2]. Compared with 3DGIS, the Building Information Modeling (BIM) technology has great advantages at microstructure and information expression. On the one hand, it can integrate the graphics and non-graphic information of buildings and present them in a virtual three-dimensional real scene [3]; On the other hand, through the establishment of an information flow model, the loss of information in the transmission process of various stages of the building is reduced [4]. BIM generally focuses on micro and detailed management for a single project or a single building, but lacks overall planning and design. When it comes to large-scale regional or long-term projects, it is difficult to achieve unified management, visualization and analysis of BIM data [5].

The development process of 3DGIS and BIM are quite similar, they both are half-automated and three-dimensional visualization processes developed by manual drawing with the help of computer technology [6]. There is a strong similarity between them but no substitute, it is a complementary relationship. 3DGIS reflects the real world, BIM constructs the real world, their thinking mode and implementation process are mutually inverse [7-8]. Therefore, the integration of 3DGIS and BIM is the
key to realizing the multi-dimensional application, and has gradually become a research hotspot in academia and industry.

There are diverse software and data formats of 3DGIS and BIM, in order to realize the integration of them, the current research trend is mainly to establish the conversion relationship from the respective data standards. The general standard of BIM is Industry Foundation Classes (IFC). Correspondingly, in GIS, City Geography Markup Language (CityGML) is used to represent and transmit city 3D objects. There are large differences in the description method and data format between them. Table 1 summarizes the two from the description of geometric information, semantic information and appearance information [9-11].

Table 1. Comparison of Data description between IFC and CityGML standards

|                  | IFC                                                                 | CityGML                                      |
|------------------|----------------------------------------------------------------------|----------------------------------------------|
| Geometrics       | Basic geometric figure parameterization operation to build entity    | Vertex and normal sequence express solid outline |
| Semantics        | Hierarchical link relationship of component structure, description of life-time attributes | Multi-level LOD from simple to complex for buildings, components and auxiliary facilities |
| Appearance       | Common materials used in the construction industry, without texture | Rich texture maps and material information    |

In order to establish the connection and conversion relationship between these two standards, researchers have carried out various attempts. Existing studies mainly start to establish the conversion relationship between the geometric and semantic information of the IFC and CityGML standards, but there are few cases that pay attention to the integrity of the appearance information during the conversion process, resulting in poor performance of the converted model [12-13]. The lightweight requirements of BIM models are not been taken into consideration, and also do not form a conversion, processing and management framework for the integration of BIM and 3DGIS data.

In view of this, this article proposes a framework for the conversion and integration from BIM model to 3DGIS scene, discussing the extraction and processing of primitive and attribute information, model lightweight and shared scheduling, and integrated management throughout the life cycle. The experiments take one BIM model of the Changjiang Water Resources Committee as an example, use this framework to realize the integration of the BIM architectural model in the 3DGIS scene.

2. Extraction and processing of primitive information and attribute information

Within the existing BIM model exchange standards, only materials are used to identify the model type, which often fails to meet the requirements of high-quality visualization. In order to ensure the BIM model integration effect in 3DGIS scene, aiming at the commonly used A platform (AutoDesk Revit), B platform (Bently Microstation) and C platform (Catia 3DExperience), the technical routes for primitives and attributes extraction is proposed, and finally an optimized conversion model and attribute database are formed, as shown in Figure 1.

For the optimization of primitive information, all types of BIM models can be exported to the FBX graphic exchange format, and then imported into 3dsMax or other software for editing and optimizing the material and texture. In this process, the engineering structure and model sharing relationship of BIM components will be lost, but the component ID is retained in the component. Therefore, the engineering structure can be reconstructed in the extraction of attribute information, and the model sharing relationship can be reconstructed in model scheduling optimization.

For the extraction of attribute information, Revit and Bently data can be exported to IFC format, Catia can be exported to 3dxml format, other data types need to find the corresponding intermediate format, and analyze and process according to the format description and other information to obtain the ID table, engineering structure and attribute information of each stage.
3. BIM model lightweight and shared scheduling

To meet the performance of large data, 3DGIS dynamically schedule according to different viewpoint distances, and loads the data corresponding to the scale and level of detail (LOD). Similar to 3DGIS, BIM models have different requirements for accuracy in different scales, but they are different from the level of detail description in 3DGIS. LOD in BIM often refers to the level of development in the model stage, emphasizing the life cycle of five levels from LOD100 to LOD500. In order to realize the lightweight of models at different scales, it is necessary to establish the corresponding relationship and abstraction between BIM and 3DGIS models at each level, and use dynamic scheduling technology to switch between different levels. This paper draws on the idea of CityGML with 3DGIS lightweight tech on BIM model as shown in Figure 2.

CityGML expresses the 3D Scene through five levels from LOD0 to LOD4, except for LOD0 that describes the urban terrain, other levels can respectively establish corresponding relationships with BIM model. After completing the extraction and combination of component information, the model sharing technique is adopted to reduce data amount, geometry simplification and texture compression are also
used to simplify models at all levels, which will further reduce resource while ensuring the model quality. The processed models at all levels are then managed by scene root node, which will dynamically schedule models according to the viewpoint distance in the 3DGIS scene.

4. The life-cycle integrated management of BIM data in 3DGIS

The advantage of GIS lies in spatial data management. Therefore, after completing BIM data conversion and optimization, it is necessary to transfer data in the various stages of demand, planning, design, bidding, construction, handover and maintenance, etc. in 3DGIS Integration framework to achieve integrated data life-cycle management.

Figure 3 shows the integrated data life-cycle management combining BIM and 3DGIS, including four levels as data, service, model and application. The data layer includes distributed storage metadata, thematic data, 3D terrain, 3D city models, and converted BIM data; the service layer includes directory services, web map services (WMS), web feature services (WFS), and network coverage Service (WCS), Web 3D Service (W3DS) and BIM model component retrieval and query service; Model layer includes GML, CityGML that follows OGC standards, and GeoBIM that has emerged and improved in recent years [14]; Application layer is integrated management of 3DGIS As a basis, it provides functions such as service discovery, three-dimensional browsing, query, and analysis, and on this basis, develops the full life cycle application of BIM data.

5. Applications

In order to verify the validity and operability of the proposed framework in this paper, the 3D basic data of the Changjiang Water Resources Committee area is used to build a 3DGIS scene, and one Revit format BIM building is used for conversion and integration. The detailed conversion and integration process are shown in Figure 4. The left side shows the conversion and processing flow of BIM data, and the right side shows the organization and management model from data to application. Data, services, models, and applications are performed through different icons to distinguish and describe the types of results formed in the figure on the left.

The contents of the three dashed boxes in the figure correspond to the three technical points of this article: the extraction and processing of primitive and attribute information, the lightweight and shared scheduling of BIM model, and the integrated life-cycle management in 3DGIS. For the BIM building
model in Revit format, the attribute database and optimized model are obtained according to the extraction and processing methods of primitives and attribute information. The optimized model can be further correlated with the CityGML model at the LOD level for lightweight and sharing schedule processing to form a unified 3DGIS scene for roaming and management. In the meanwhile, the BIM attribute database is combined with external related materials to customize services and related applications at each stage.

![Diagram](image)

**Figure 4** BIM and 3DGIS data integration process under the technical framework of this article

Figure 5 shows the integration results of BIM data from different levels. Figure 5(a) shows the appearance model under LOD2 in the scene; Figure 5(b) shows the internal structure after closing the external wall under LOD3; Figure 5(c) shows the detailed distribution and composition of components under LOD4 with mouse click to obtain attribute and highlight the BIM components. The switching of each level is automatically completed by the change of the viewpoint distance, which better realizes the conversion and integration of BIM in the 3DGIS scene. At the same time, as it has formed the intermediate results of data, services, and models, it can be combined with the business needs to realize the life-cycle management and maintenance of digital buildings.

![Image](image)

**Figure 5.** Integration of BIM model in 3DGIS scene with multi-level LOD application

6. Conclusion
This paper proposes a solution for the conversion of graphic information, the extraction and integration of attribute information, the lightweight of BIM models, shared scheduling, and the integrated management of the whole life cycle, constructs a framework for the conversion and integration from BIM models to 3DGIS scenes.

The proposed framework in this paper can realize the integrated management of 3DGIS and BIM at the macro and micro levels. In the future, we can further study the key technologies of BIM model online publishing, cache construction, information compression, etc., and give full play to the advantages of 3DGIS and BIM.

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