Analysis of Data Exchange between BIM Design Software and Performance Analysis Software Based on Revit

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Abstract. Performance-based analysis of buildings is a process of guiding the design process through simulation analysis in the early stage of engineering design, and it is an inevitable trend of BIM technology development. In the process of BIM forward design, it can effectively improve the efficiency of forward design. How to break through the data interaction barrier between design software and performance analysis software and effectively use BIM design software data for performance analysis is an urgent problem to be solved in the industry. Based on the Revit platform, this paper analyzes the methods and requirements of BIM data transmission, realizes the performance analysis of data conversion based on Revit through cases, and finally summarizes a set of prerequisites, methods and key points of development requirements based on secondary development. The research results will provide reference for the later development of data conversion plug-ins and other tools, and promote the development of BIM data collection and transmission.

1. Introduction

At present, BIM technology in China focuses on basic application, and the mature application points are building, structure, electromechanical professional model building, collision inspection, clear height analysis, pipeline synthesis and so on.

With the popularization of BIM technology, national policy requirements and so on, more and more project owners require BIM forward design. The foundation of BIM technology lies in the integration and application of multi-party data resources. Based on this, it can improve the collaborative efficiency of forward design, and carry out all kinds of information and professional analysis and application that traditional design can't achieve, thus extending the design content and broadening the design boundary.

However, at present, due to the complexity of the current data formats, there are still obstacles of data interaction among various softwares, which leads to data faults in the actual project implementation process, and it is impossible to effectively transfer and utilize data.

Performance analysis is an important link in the process of forward design. How to effectively utilize the data information in BIM model, convert it into relevant data format, and import performance analysis software to complete the subsequent simulation, so as to reduce the response period of continuous verification and optimization of design, thus improving the efficiency of forward design of BIM as a whole, which needs urgent research.

This paper focuses on the research of data docking processing method between BIM design software represented by Revit and various performance-based analysis software, analyzes the ways and requirements of BIM data transmission, and summarizes the premise, ways and main points of development requirements of secondary development through the performance-based analysis process, so as to effectively break through the barriers of data interaction between different softwares.
2. Technology Status at Home and Abroad

It is understood that foreign countries have data transmission processes and methods that meet their own standard system due to the high popularity of BIM, perfect product series of software-related companies and convenient docking. For example, Autodesk will no longer sell Ecotect Analysis license from March 20th, 2015, and will integrate Ecotect Analysis and other similar functions into the Revit product family. At present, Revit software can automatically perform partial performance analysis in the cloud by logging in its account with embedded Insight module. However, the analysis process is uncontrollable, and the response speed is slow because the server is abroad, so the domestic utilization rate is not high.

Some domestic design institutes also began to study the data transfer between BIM software represented by Revit and performance analysis software, and explored and practiced on different types of projects. In many types of projects, the simulation analysis software based on Revit has been applied, and the practices of solar radiation, energy consumption simulation, wind environment and thermal environment have been carried out, but the solutions to the difficulties in data transmission have not been clearly explained.

Other documents also show that some universities and enterprises are also studying the data docking between different softwares based on Revit, etc., and the effectiveness of the method needs further testing and verification.

3. BIM Data Conversion Methods and Requirements

3.1. BIM data conversion mode

The data conversion in BIM technology generally includes the following three forms.

3.1.1. Direct conversion. Performance analysis software usually has modeling function, and then directly carries out simulation analysis. However, its modeling function is not easy to operate, and complex modeling can't be established. However, the areas that often need performance analysis are mostly heterogeneous or spatially complex areas. Only by analyzing the modeling function in the software, its model accuracy is insufficient. Analysts need to draw a lot of time to extract dimensional data and model according to architectural modeling information, such as Dwg format drawings, which leads to huge workload and waste of data.

3.1.2. Intermediate format conversion. Most performance-based analysis softwares already have data input interfaces represented by GBXML format, but often BIM models export GBXML format, and then import it into analysis software. Because of the jumble of model data, the transmitted data can not be effectively filtered and simplified, which leads to errors in model identification, fragmentation of walls and so on, which needs to be cleaned up. As the complexity of BIM model increases, the situation becomes more serious. Therefore, although the simulation software is connected by this data interface, it has not been effectively used. The conventional method is to use the built-in model of the simulation software or other methods to build models and then import them, which increases the workload of designers, and the refined BIM model data has not been effectively used.

3.1.3. Common standard conversion. IFC is an open building engineering data standard. Theoretically, no matter what BIM software is used to build the model, the exported IFC data is standard and can be transmitted and shared. However, according to the literature, the development and related evaluation of IFC standard in the field of BIM performance analysis think that in theory, IFC standard basically meets the data conversion requirements of design. However, in practical application, when different softwares exchange IFC files with each other, all major softwares use their own databases to match their platforms. However, because most databases are not constructed in strict accordance with IFC standard format, it is inevitable that the information is true or wrong when IFC files are input and output. Therefore, the IFC-based data exchange needs further development before it can be used in engineering practice.
3.2. BIM data conversion requirements

In the process of BIM data conversion, attention should be paid to:

- The openness and transparency of the conversion process, including the selectivity of the conversion content and the reminding and recording of errors and warnings in the conversion process, facilitates the controllability of the initial model data;
- The availability of the conversion results, the converted model should not only match the geometric dimensions of the model, but also the attribute information data of components should meet the requirements of the next analysis, and the miscellaneous data can be deleted automatically according to the performance-based analysis type;
- The stability of the standard (interface) should not be interrupted due to data loss or other reasons in the process of conversion.

4. Analysis of Data Transfer Process of Performance Analysis Software Based on BIM

The most common performance analysis is the simulation of external wind field. The building specialty usually uses Rhino and other software to build the model. It is necessary to export the building model to sat format file and preprocess the model in Revit. The building pretreatment process mainly includes model simplification, calibration and export setting. Finally, the calculation parameters are set in performance-based analysis software to generate simulation results. The whole process is shown in figure 1.

![Figure 1. Analyze the overall process diagram.](image)

4.1. Model simplification

The model simplification process aims to eliminate redundant elements in the building model, such as floors, stairs, bathroom tools, electrical equipment, handrails, etc., which have no practical significance in performance analysis, but will affect the reading accuracy of the model. Using the filtering function in Revit can greatly improve the operation efficiency of this process. It should be noted that after a large number of elements are deleted, the building model may have some problems such as unclosed rooms, incorrect elevation, etc. In order to ensure that the performance-based analysis software can effectively read the building model, calibration is still needed before exporting the model.

4.2. Model simplification

Common errors in the process of building model export and identification mainly include uncalculated space volume (performance-based analysis platform needs to identify three-dimensional targets), elevation error (height difference of buildings on the same floor), unclosed rooms (missing floors and walls), etc. Aiming at these problems, the building model is calibrated.
There are several main reasons for the problem of uncalculated space volume. First, the wall surface of the model built by other model building software is not closed, and there are unclosed areas that are not easy to be found by naked eyes. Second, there are too many curved surfaces in the model, and the curved surfaces will be converted into several finely divided planes after data processing, which will lead to identification errors or take too long in the identification process. Third, windows and doors and so on.

Unreasonable building calculation settings can be eliminated by checking "Area and Volume" in "Room Area Calculation" in Revit; Error in elevation may be caused by deleting the floor or wall by mistake, or the building model may not be initially set. Preview the building model through the detailed information in the "Export Settings" menu, highlight the room with error and modify the corresponding elevation parameters. Similarly, deleting the floor or wall by mistake may also lead to the problem that the room is not closed. Quickly find out the wrong room by highlighting and supplement the corresponding missing elements.

4.3. Export settings
The preprocessed building model needs to be exported to a file format suitable for performance-based analysis software identification, using gbXML format.

4.4. Simulation analysis
Use the wind environment simulation and analysis platform to simulate the outdoor wind environment of buildings. Using the meteorological parameters of Chengdu in spring and referring to the size of building model, a reasonable calculation domain is set up. The calculation accuracy can be controlled by the grid size in the calculation domain. The smaller the grid, the more accurate the calculation and the more time it takes. Three calculation accuracies, namely accurate, moderate and rough, are used for testing, and the required calculation time is shown in figure 2. Pareto is introduced to improve the calculation efficiency of parameter identification. The results show that the most improvement in calculation time can be obtained by changing the model from accurate to moderate when the degree of accuracy reduction is approximately the same. Therefore, generally speaking, setting moderate accuracy is the most cost-effective choice.

The simulation results of wind speed, wind pressure and air age of an example building group are shown in figure 3-5. The simulation results show that the building model conversion is accurate, the performance analysis platform identification is effective, and the calculation results are reasonable.

![Figure 2. Influence of model accuracy on calculation time.](image-url)
5. **Performance Analysis Data Exchange Requirements**

The key problem to improve the efficiency of performance-based analysis is to optimize data pertinently to meet the requirements of effective identification by analysis software, thus correctly reflecting the
shape and ensuring the accuracy of simulation results. At the same time, the manual model calibration work in the analysis software is reduced, such as surface unclosed processing, window hole extraction and so on, in order to reduce the subsequent analysis time and improve the efficiency.

6. Data Exchange Method Based on Software Secondary Development

Based on the development idea of software secondary development, the exchange method of concrete components is as follows:

- **Heterogeneous volume of building**
  The heterogeneous volume of a building is formed by staggered rectangular volumes, which will lead to too many staggered surfaces. Regardless of the internal situation, it is necessary to fuse the shape into a large quantity, and cut the large quantity by Boolean operation to obtain an effective volume model with only the outer skin, which can be used in the external wind field simulation and other scenes.

- **Window**
  Due to the thickness of the window and too many windows, the surface of the model is not in the same plane as that of the wall, and there are too many details. Where there is a window, only the plane coordinates of its wall are retained as its positioning, and the size of the window is only defined by the numerical positioning of the maximum outer frame of the window, and other details are deleted.

- **Door**
  Data simplification method of the same window.

- **Abnormal outer skin**
  The abnormal skin model consists of several triangular meshes. The smoother the abnormal skin, the more triangular surfaces it has, which leads to too many triangular surfaces and too much data processing after entering the analysis software. It is necessary to adjust the coarseness of the mesh, and control the number of average points in XYZ three directions, so as to control the number of triangular surfaces under the guarantee of meeting the fitting abnormity.

- **Other types of models**
  Data simplification method of the same window. For example, the models of plants, external shapes, people and furniture in the models are filtered by filters and deleted. Among them, the human model can be retained when it is necessary to simulate human comfort.

- **Unclosed point**
  The unclosed points in the model that are not visible to the naked eye will cause errors when entering the simulation generation grid. Before entering the simulation software, it is necessary to automatically detect along the outer skin line with a certain starting point, and remind you when encountering data inconsistency.

7. Summarize

Performance-based analysis of buildings is an inevitable application trend in the process of forward design. In order to break through the barriers of data interaction between different softwares, BIM design software data is effectively used for performance-based analysis. Based on the performance analysis case of Revit, this paper puts forward the data exchange method based on the secondary development of software and the key points of development requirements. The research results will provide reference for the later development of tools such as data conversion plug-in and promote the development of BIM data collection and transmission. It is believed that with the development of tools such as plug-in for secondary development of data conversion, the development of BIM data collection and transmission will be promoted, and the efficiency of BIM forward design will be continuously improved, gradually reflecting the advantages of engineering design informationization.

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