

RESEARCH ON DIGITAL MODELING PATH BASED ON IFC EXTENSION AND BIM LIGHTWEIGHT

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Abstract: This paper focuses on the digital modeling of tunnels and underground engineering. Explore key technological breakthroughs from IFC to BIM. Firstly, the architecture of the IFC standard and its extension in the field of infrastructure (such as the IFC-Tunnel project) are introduced, and the IFC information model suitable for tunnel engineering is constructed by extending the component entities and establishing hierarchical associations. Secondly, the essence and implementation requirements of BIM are analyzed, and the idea of an online tunnel BIM platform based on WebGL is proposed, which is combined with GLTF format to solve the problems of inconsistent data format and difficult transmission of 3D model, so as to realize model lightweight and Web-side visualization. Finally, it is pointed out that the combination of IFC and BIM can promote the digitalization of tunnel construction, combine real-time simulation and advanced geological forecasting, improve decision-making efficiency and reduce construction risks, and provide a new path for tunnel engineering informatization.

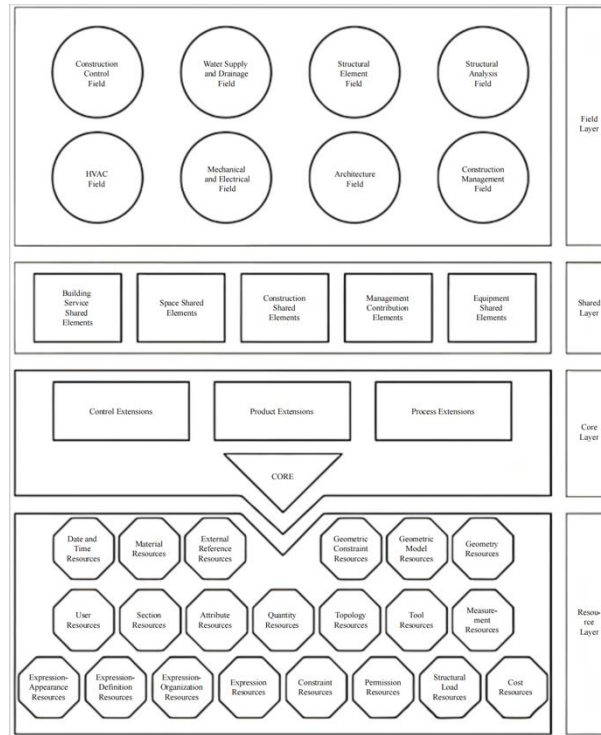
Keywords: GLTF format, GIS Modeling, IFC Standard, BIM Technology, WebGL Visualization

1. INTRODUCTION

The IFC standard is a standard for the description of building product data developed by the international buildingsmart organization for the AEC (ArchitectureEngineering andConstruction) field. The Industrial Foundation Class (IFC) is a comprehensive data model that allows for detailed geometric and semantic descriptions of buildings and is widely used as a standard for BIM data exchange independent of software vendors. It was developed by the international non-profit organization buildingsmart and published in 2013 as ISO Standard 16739. Prior to the IFC4 version, the IFC standard was mainly for buildings. However, due to increasing international demand, the standard is being significantly expanded to support the infrastructure.

The IFC-Tunnel extension project follows the official bSI Project Implementation Guidelines (buildingSMART International 2015) that came into effect in 2015. They define two basic components to be implemented for each project: the organizational structure, the development process. IFC uses the express language to define the Building Information model, borrowing from the step standard. After decades of development, the IFC standard has been widely used in the storage and interaction of Building Information Modeling (BIM). IFC provides an object-oriented model structure for construction engineering data, and its structure is shown in the figure[1].

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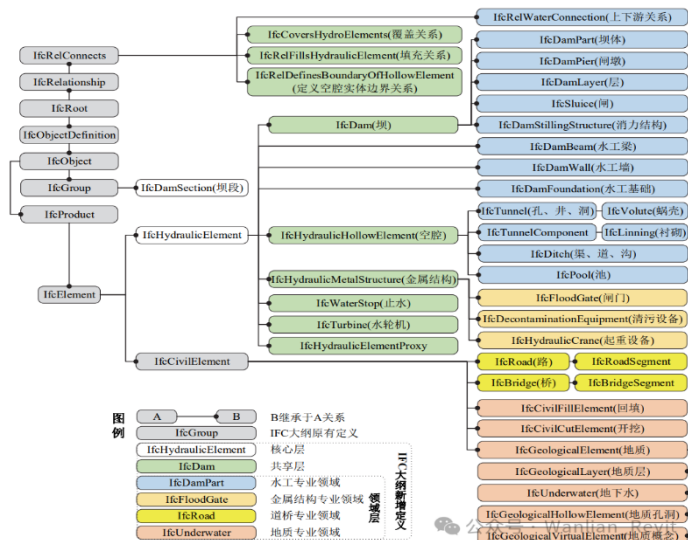
The IFC model structure consists of 4 levels. The first layer is the resource layer, which provides resource-related definitions that can be called at a high level. The second layer is the core layer, which provides the core data definition of the construction project, including a kernel module and three extension modules such as control, product and process. The third layer is the shared layer, which defines concepts and objects that are common to multiple areas of expertise. The fourth layer is the domain layer, which provides corresponding definitions for each professional field of architectural engineering.

1. Define the structure of the engineering information model based on IFC

take IFC as the basis of the engineering information model structure, and expand the original IFC structure to form the engineering information model according to the special components and relationships of the project. As the carrier of Building Information Modeling, most of IFC's definitions can be applied to the engineering field, including:

- 1). a relatively complete definition of 3D geometric description, which supports the creation of 3D models;
- 2). Rich resource description, covering time, materials, engineering quantity, manpower and machine consumption, cost, participants, structural load and other aspects;
- 3). Various types of basic value types and units, supporting the expression of various physical quantities;

4. Some of the entities of construction projects can be directly applied to the project.



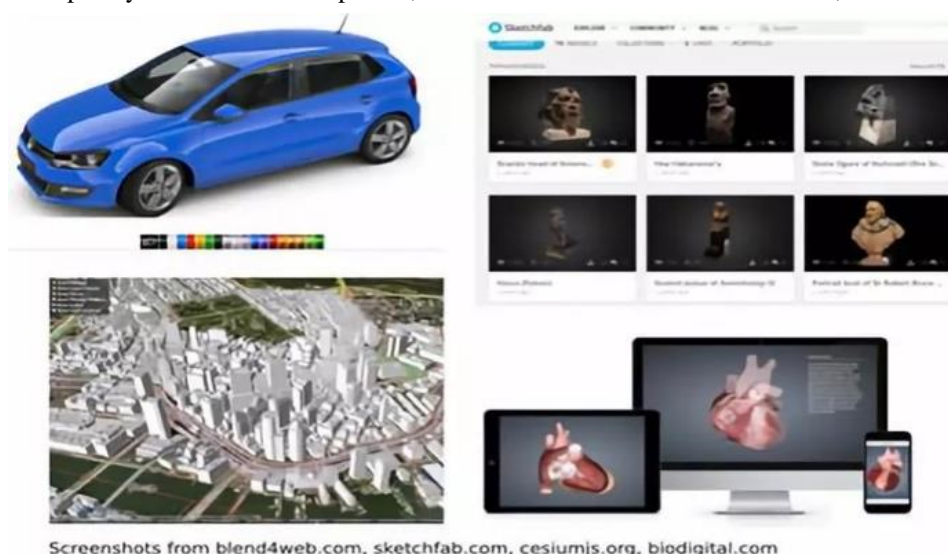
2. On this basis, the IFC development for the project mainly includes the following two aspects:

1) expanding the project component entity and its related definitions. According to the information characteristics and actual requirements of the project, the definitions of the corresponding component entity, component category entity, enumeration type, attribute set, quantity set and resource type of the project are added on the basis of the IFC model structure.

2) Establish hierarchical relationships and related relationships. The new entity should establish a hierarchical relationship based on object-oriented principles and integrate with the hierarchical relationship of the original IFC structure. On this basis, the association relationship between the new entities in the domain and the association between the new entities and the original IFC entities are established. The new definition hierarchical relationship of Engineering Information Model (IFC) is shown in the following figure:

Background: At present, digitalization is replicating the real world in the virtual world, digital cities, digital museums, online shopping malls in the three-dimensional display of goods, digital asset delivery and other scenarios, the use of three-dimensional models can provide a more realistic immersive experience, and the application of content display based on three-dimensional models is increasing. A large number of 3D graphic content to be transmitted and shared through the Web, there are many 3D modeling software at present, the 3D model data format between the various companies is not uniform, such as Maya, 3dMax, Blender, etc., there are more than 70 different 3D graphic file formats, applied to different scenes, and most of the models established by the existing 3D modeling software are not considered to be disseminated on the Internet, so the 3D model leaves the modeling software, and it often becomes very difficult to view. It is not conducive to the sharing and dissemination of models. The display of 3D models on browsers or mobile terminals is mainly realized through WebGL and OpenGL, but 3D models often have a large amount of data and a variety of 3D model data formats, which is not conducive to the development of applications, especially on the mobile side, limited by network speed, memory, computing power and other limitations, loading, browsing interaction, rendering effects, etc. are easily limited, affecting the user experience.

1. About Three - Dimensional Models: The essence of the 3D model is the combination of points, lines, surfaces, volumes, materials, and animations, so there is GLTF, JPEG in the 3D graphics industry, and everyone's models are converted into a unified data format for easy transmission on the Web. GLTF=GL Transmission Format, is a standard developed by the Khronos Group team, is a 3D scene data transmission format, Khronos Group is also



the developer of OpenGL, collada and other standards, 3D graphics field leader. Through this data format, it is easy to improve the rendering of the model, avoid a large number of import/export between various 3D processing programs when the texture binding, material rendering, animation effects and other problems, and the most important point is that the model can be lightweight, and can retain excellent rendering effects, including the famous 3D graphics sharing platform Sketchfab, Web3D GIS engine Cesiumjs.

At present, online 3D visualization engines such as Threejs, Cesiumjs, Babylonjs, and xeogljs all support gltf data.

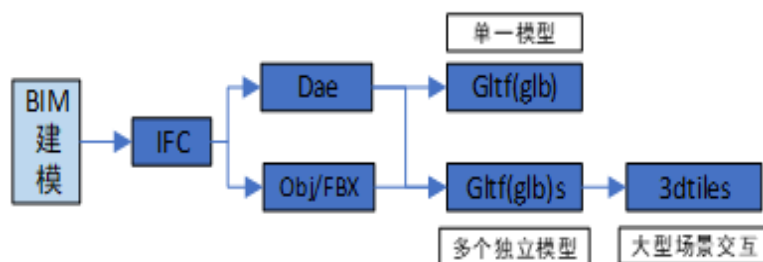
2. From IFC to BIM:

(1). BIM is Building Information Modeling, and the software that builds Building Information Modeling is known as BIM modeling software, such as Autodesk CAD, Revit, and many more. When many people talk about BIM,

they often have the most intuitive impression that 3D modeling is equivalent to architectural models, but they often ignore the information. Why use a BIM solution? In order to integrate the information of the entire life cycle of the project into a unified "model", all the engineeringAll participants complete their respective responsibilities in the "model" and leave information for other participants to apply the information to improve the efficiency of information flow and reuse, and the degree of "transparency" of information determines the efficiency of the process (efficiency is a comprehensive trade-off of time, quality, cost and other factors). What is the role of BIM software?

- 1) Engineering information integration - survey information, design information, construction information, operation and maintenance information integration (entry, integration, production)
- 2) Information visualization - provide visual presentation of information
- 3) Auxiliary decision-making - information reproduction based on existing model information and data, each participant is the producer of information and data, and information data are records of objective activities; Information is the description of the activity state of objective things, and it is the result of data processing Data = information + data redundancy BIM is the product of the development of 3C technology, but the essence is a collection of information organization, information production, and information presentation, but information organization involves data format issues, information production involves process problems, and information presentation involves three-dimensional modeling, visualization and other issues, so the implementation of BIM should not be confined to the form, but should be defined from the needs to define its presentation form. For example, it is not necessary to have large-scale localized modeling software, and all data is directly transferred to the cloud, referred to as cloud BIM. The parametric structure scheme of the online tunnel BIM platform defines the tunnel engineering structure form is relatively simple, parametric modeling can be realized, and the large-scale three-dimensional modeling software can be used to realize online modeling based on WebGL technology, and the data is directly stored in the cloud, at the same time, the more critical link of tunnel engineering construction is the construction stage, due to the unclear geology, involving frequent construction dynamic design, the application of information technology can play an important role, under the traditional way, there is a lack of unified information platform that all parties can participate in, It is difficult to dynamically change the model information according to the construction situation, and the parameterization method combined with the online information platform can be quickly implemented, that is, the cloud BIM platform for the construction of tunnel engineering, which is a hypothesis.

(2).Large-scale BIM models and 3D reality models can be shared and interacted with based on the Web. At present, there are many BIM modeling software, such as Autodesk, Bentley, CATIA, etc., but fortunately, BIM models also have a unified data exchange standard IFC (Industry Foundation Class).The IFC data format makes it easy to import and export models between BIM software. However, in order to realize the online display of the model, this involves the lightweight of the model, and the current BIM modeling software providers have their own model lightweight cloud platform. One is for data security, and the other is to show technical strength. How to develop an online BIM lightweight web platform based on open source programs? Solution: WebGL-based online 3D visualization for presentation and interaction.



- 1) The essence of BIM model data: description information + geometric information
- 2) Existing unified data exchange standard: IFC data standard
- 3) Basic technical route: through the analysis of IFC file content, separation of geometric information and corresponding description information, the presentation of geometric information is realized by the 3D engine, and the description information is obtained by querying the IFC file content according to the component, material, information, etc. BIM model visualization.

4) Model conversion:

<1>IFC->obj+mtl+jpg (geometric mesh + material information + texture picture) -> gltf, (glb binary data format), discard the description information. Basic tools: The obj to gltf tool developed by the Cesium team enables lightweight and online loading of BIM models.

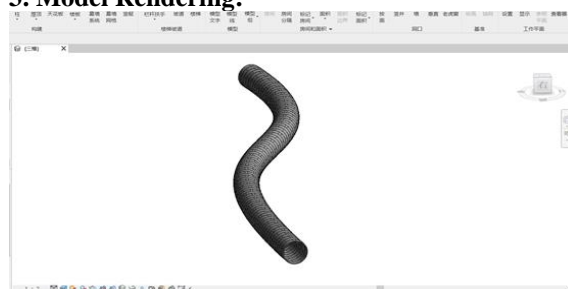
<2>IFC->Dae->gltf (glb binary data format), collada is an xml-based digital asset exchange scheme for interactive 3D applications, so that 3D authoring applications can freely exchange digital assets without loss of information, and gltf is a json format for data organization, and there is a lot in common between the two. Furthermore, Gltf->3dtile, organized into tile data, can be dynamically loaded by associating the spatial relationships of a large number of geometric models. This is the method used by the Cesiumjs library of the famous Web3D GIS engine to load the BIM model, and the traffic BIM is often said to be combined with GIS.

<3> XBIM (eXtensible Building Information Modelling), extensible, wexbrim binary format, only retains the Label-> ID and geometry and material information of the model components in IFC, and saves them in binary format, IFC->wexbim data compression is quite amazing, XBIM also provides WebGL-based js libraries, but there are several other 3D engine libraries that are so mature, Unable to load model in mobile browser.

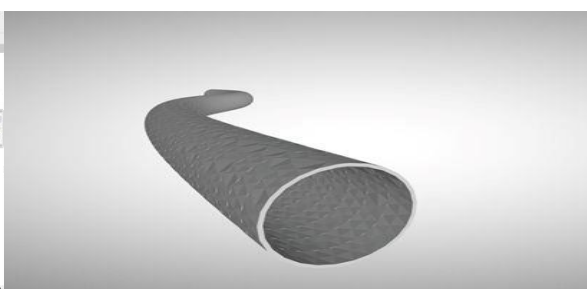
<4> BIMServer: BIM server developed based on Java combined with BIMsurfer provides a complete solution for online visualization and interaction of IFC data files. The core behind it is IFC openshell, which parses IFC data files and converts models.

<5>The shield tunnel model constructed by adaptive segments in revit has a file size of 10.4MB, and the exported IFC data file has 8.91MB, if the file size is stored in obj data format, the file size is 19.9MB when converted into a dae file by the method described in 2), and then converted into a gltf file is only 5.90MB, and converted into a glb file, that is, the binary gltf file has 3.92MB. And after being converted into a wexbim file by the XBIM tool, it is only 885KB, which is less than 1MB, which is more than 10 times compressed, which is quite amazing! The specific technical characteristics need to be studied.

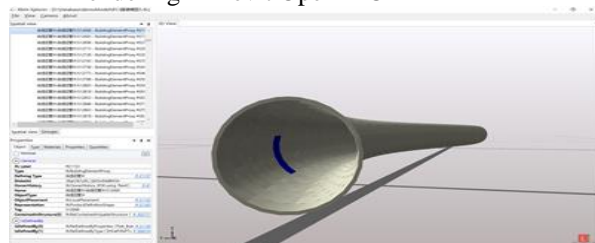
3. Model Rendering:



Rendering in Revit Open IFC



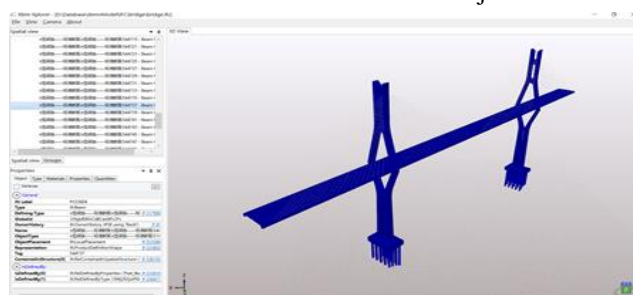
Model Residential Model



Directly in xBim Software:



obj Model



xBim opens IFC and turns blue....

4..Summarize It can be seen that GLTF as a 3D data transmission format can maintain the original rendering effect and geometric information of the model very well, and has a good effect in data compression, at present, most of the WebGL3D engines support the import and export of GLTF, the technology is mature, but for the loading of large, super-large models still need other technical solutions, such as 3dtile data organized into the form of tiles. However, there is no doubt that the application of GLTF as a unified 3D graphics conversion format can easily organize data and share models, and has a wide range of application scenarios, such as data sharing based on BIM models, online visual development and application of monitoring and inspection. BIM is moving towards the Web, and the combination of the Internet of Things and GIS is an inevitable trend, but the role of BIM in it is more important to visualize and provide description information of the 3D model.

In terms of tunnel excavation face information sharing, using three-dimensional reconstruction technology. there are mature technical solutions for image-based 3D reconstruction, but often the 3D reconstruction model file size is large, and if you want to share it on the Web, especially for movement the transmission and loading speed will be very slow.

if you want to completely save the image data of the excavation face after tunnel excavation, the number of pictures collected on site is very large, and the data volume will be very high, so it is not necessarily efficient to directly transmit images for viewing. For example, the following excavation face needs at least 78 images to be completely covered, with a total of about 241MB, but after 3D reconstruction and preservation in GLTF data format, the real information of the site can be completely preserved, and the file size is only one-tenth of the image data.

The generated model can be easily used for online browsing and sharing, and has a very realistic rendering effect, which can be viewed in the 3D viewer, which has a great effect on realizing the transparency of tunnel information and jointly constructing a "transparent tunnel".

5.Outlook.: IFC and BIM model transformation and advantages: IFC standard provides a structured framework for construction engineering data, By extending it to build information suitable for tunnels and other projects Converting the BIM model into GLTF format can effectively solve the problems of inconsistent data format and difficult transmission of 3D model, realize data compression while maintaining the rendering effect and geometric information, and facilitate the sharing and display of the model on the Web side, laying the foundation for BIM to go to the Web, and combine with the Internet of Things and GIS. Application prospect of tunnel information model:By integrating full-cycle data through IFC, achieving parametric visual planning with the WebGL platform, and merging BIM and GIS, the system breaks down information barriers, optimizes plans, and avoids spatial conflicts, thereby enhancing planning efficiency and systematization. Additionally, by combining advanced geological forecasting with real-time simulation for early warning of potential risks, the system converts the imagery of the excavation surface into a lightweight GLTF model for secure information sharing. Furthermore, the IFC model can synchronously update information on changes to components, thereby reducing the likelihood of accidents and safety hazards.

The unified format of IFC enables data reusability, GLTF compression reduces energy consumption, the model aids in the development of precise operation and maintenance plans, and it also supports mechanized construction, thereby conserving resources, lowering costs, and reducing carbon emissions.

2. REFERENCES

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