# ORGANIZATION MULTI-SCALE 3D MODEL DATA TO MEET NETWORK TRANSMISSION

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**ABSTRACT:**

Existing research mainly fucus on organization and visualization of 3D building models in circumstances which are the main spatial objects, yet multi-scale representation of geometry and texture information still not taken into account, especially multi-scale transmission suitable for the network environment is a key point needed to be break. Thus, an organization method for multi-scale 3D model data to meet network transmission is proposed in the paper: (1) A multi-scale 3D model data structure based on the spatial point index is constructed, and which is integrated with multi-scale textures representation. (2) A method of 3D model data multi-scale partitioning orgnazation based on hierarchical quadtree structure is applied to adapt to multi-scale scheduling and transmission of 3D model data. And a prototype system is developed on GeoGlobe software. The experiment result shows that according to the movement of view point in the 3D scene, our approach can dynamic transmit the multi-scale, partitioned tiles of 3D model data to effectively reduce the data quantity of transmission and improve the performance of scene rendering.

## 1. INTRODUCTION

With the rapid development of computer technology and visualization technology, 3D spatial data structure, data model and visualization technique in the field of GIS, especially "Digital City" modeling and visualization has made considerable progress.

3D urban models as an important content of of digital city, mainly apply vector-structured data model as the fundamental of data structure and data model, to describe building models in the scene. And there are a greate many different data structure and data model of 3D urban model have been proposed. Typically, Formal Data Structure (FDS) based on 3D vector graph and Simplified Spatial Model (SSM) based on FDS etc。

The research of spatial data model and data structure above mainly focuses on the construction of 3D urban model, representation of 3D building model and spatial topological relationships, while data compression and storage, especially for LOD models of 3D buildings are rarely considered.

For visualization technology of 3D-GIS in network environment, research on spatial data management, transmission and visualization of the massive terrain, images and vector data are in progess, including mass terrain data compression and transmission based on wavelet theory and viewpoint-related terrain scene simplification, meanwhile some application systems are developed, which capable of small range 3D urban landscape visualization int network environment。But for large-scale landscape establishment, still needs to be further researched.

This is mainly due to: As the visible range from the viewport in 3D scene get larger, the building model can be with larger data volumn, more geometric complexity, resulting in highly efficient algorithms for mass geometry data management, operation and rendering are strongly required. At the same time, data transmission in the network environment should also be taken into account. Both of the above two aspects are urgent research issues of visualization technology for large range 3D city landscape in the network environment.

For application of digital city, a number of research institutions and companies city are underway of software development for 3d digital city. Like 3D urban model software CyberCity GIS of Swiss ETH Zurich University, MultiGenCreator, SiteBuild3D of MultiGen, etc. Domestic software as CCGIS of GeoStar Wuhan, VRMap of LingTu Beijing.

These products, focusing primarily on in stand-alone or C/S environment , the massive data management of 3D digital city, research on 3D urban models and application models (such as the illumination analysis model) and research on integration of visualization technology and VR.

## 2. RELATED WORKS

Traditional 3D model data organization mainly based on 3D-GIS data structure and data model. Typically, 3D building models are described with vector-structured data model. For example: A Formal Data Structure (FDS) based on 3D vector graph (Molennar, 1992)；V3D model (Xinhua Wang, Armin Gruen, 1998); Simplified Spatial Model (SSM) based on FDS (Zlatanova, 2000); A method of 3d modeling based on K simplex and CSG（Ming Sun, 2000）；Object-oriented concept model of 3D Entity (Shi W Z, 2003), etc.

On the fundamental research above, further study about Levels of Detail (LOD) of 3D urban model are researched by many researchers. Such as 3D model LOD dynamic creation, and R-tree structure is applied for data storage and management (Kofler M, 1998). Different form computer graphics, GIS concerns more about issues as abstracted representation, modeling and consistent management of the hierarchical detailed models. Kêninger proposed a method of hierarchical aggregation for different types of objects from the perspective of urban planning. Kolbe further expanded the aggregation relations of LOD, and probed into solution of geometric, topological and thematic modeling for 3D urban model. Beside, some researchers studied the representation of 3D model LOD combined with database technology(Jun Li, 2000). A uniformed representation of vector data, raster data, Continuous surface and discrete entities for 3D urban model, with capability of multi-level of details representation (Qing Zhu, 2007) .

Not yet fit for the establishment of large-scale urban landscape in network environment.

Recent years, There has been increasing attention to the issue of the application of 3D spatial information online services as the promotions of Google Earth, Virtual Earth, and Skyline, etc, while there is no domestic software of fully competitive at the time. So there is urgent need to research for similar and products and technologies of independent intellectual property rights.

With the development of computer technology, 3D visualization, distributed data storage and management technology, taking advandage of distributed computing platforms to provide management, transmission, on-line real-time visualization of massive 3D urban models, and 3D urban geographic information services, will be the development trend of "digital city" in the future.

The existing research aforementioned, mainly focus on organization and visualization for 3D building models as spatial objects, yet multi-scale representation of geometry and texture information still not taken into account, especially multi-scale transmission suitable for the network environment is a difficult point needed to be break.

## 3. 3D MODEL DATA STRUCTURE AND DATA MODEL BASED ON SPATIAL POINT INDEX

Compare to 3D FDS, SSM and OO3D, LOD of 3D urban model does not necessarily care much about editing, designing and managing of 3D objects, while it focus greatly on the following 2 characteristics: (1) Representation of LOD. (2) Data compression of geometric model.

On the server side, there is no demand of 3D visualization; therefore organization of spatial data will be emphasis on. Reducing the spatial data redundancy after the spatial relationship of 3D models is determined, which is the essential of spatial data compression.

In the current research of 3D urban model reconstruction, in order to realize functions of 3D objects editing and managing, spatial data is essentially organized with point line, surface and volume elements, and the hierarchical relationship of all objects is quite clear, but suffers data redundancy to some extent.

While the motivation of point index based 3D reconstruction is geometric data optimized storage (compression). The main idea is: the point indices, with additional joint sequence form directional faces which then construct 3D volume. This way of data organization is suitable for regular volume structure reconstruction of 3D urban landscape. If the surface objects exist in constructing process, surface object index can also be established to further reduce data redundancy and optimize data compression.

The logical hierarchical relationship of spatial objects in point index based 3D buiding reconstruction is discussed above, from which a point index oriented data model be established. The structure of data model is shown in the graph, OID refers to the ID of the spatial object which is global unique. Attribute refers to all the information of the spatial object, besides geometry character, including index sequential ID for the points, texture attributes and indexed sequential for surfaces, etc. Relation refers to corresponding relationship of spatial objects, like one-to-multiple mapping, multiple-to-one, one-to-one, etc.

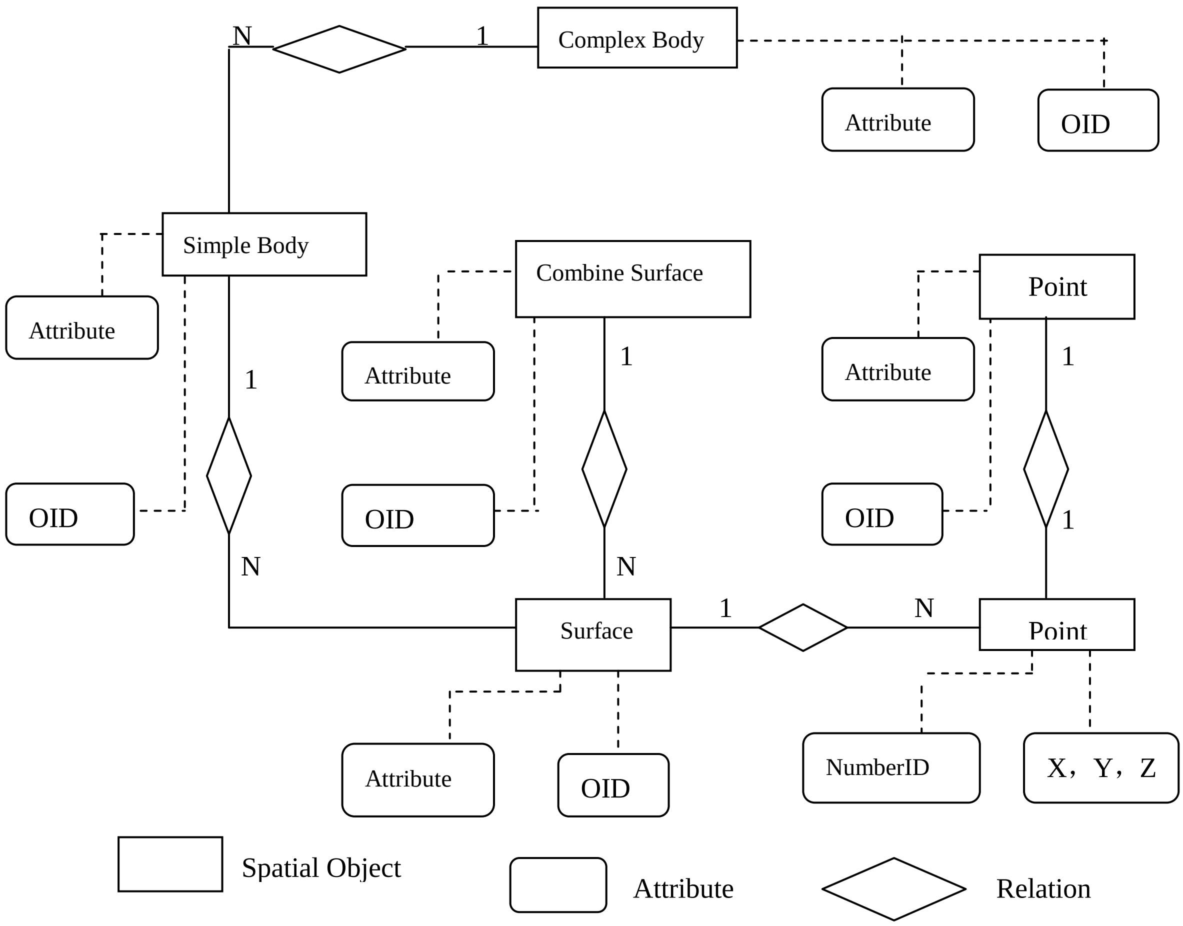


Figure.1: 3D model data structure based on point index

The point index based data model above, especially for fitting 3D urban model reconstruction in network environment, mainly takes point, surface as the basic structure for spatial geometric elements construction. By defining spatial forming sequences, directions and spatial relations about point, surface to reconstruct volume model.

## 4. ORGANIZATION OF MULTI-SCALE 3D MODEL DATA

Due to the particularity of the 3D building model, the organization are greatly different from other spatial data like terrain, image. The spatial representation of 3D buildings model includes texture data and geometrical data, therefore, the representation of both have to be take care of, meanwhile data transmission and real-time rendering issues should also be considered in the process of constructing the data pyramid of 3D building models. To adapt to the need of network transmission, a multi-scale layer and tile partitioning organization will be applied to the data model above. According to the quad-tree structure, the organized multi-scale 3D model data can be indexed.

Layer partitioning organization: By geometrical and texture characteristics, multi-scaled geometric model library and texture library of the point index based 3D modelsof grain, its structure are shown below:

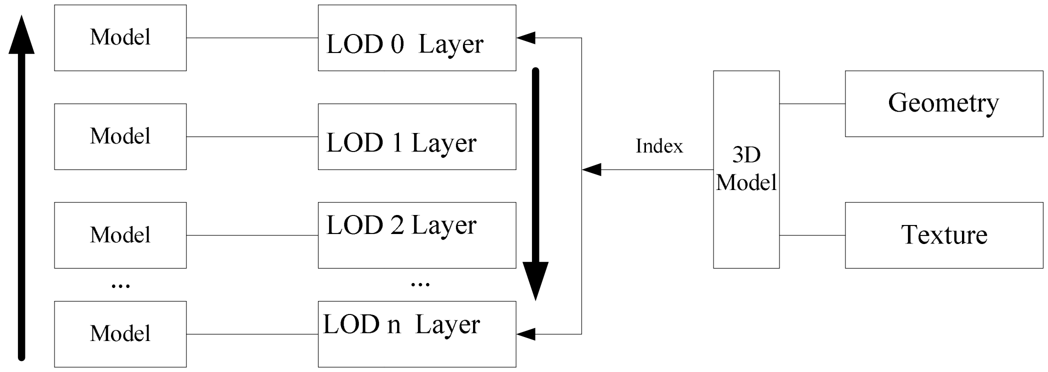


Figure.2: Layer partitioning organization structure

The principle of the layer partitioning is based on the geometric complexity and texture resolution of 3D models. Geometric complexity can be simplified with existing mesh simplification algorithm, while for textures, a multi-resolution texture library can be created, for each level of detail of 3D model , one texture with corresponding resolution will be attach to it. The structure of a texture library is illustrated as followed:

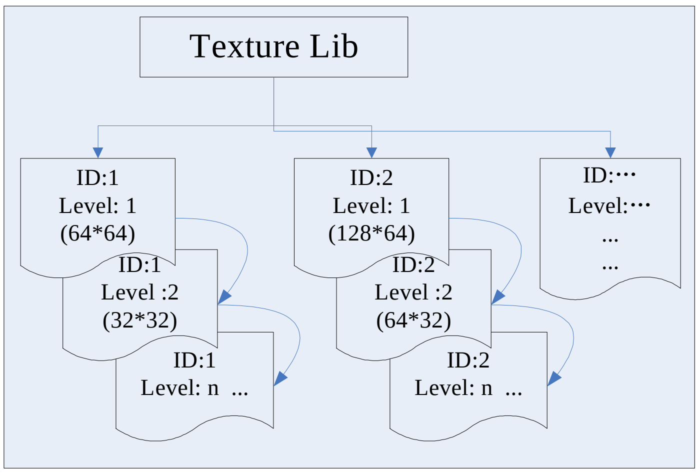


Figure.3: Multi-resolution texture library

Tile partitioning organization: Subspace-partition the whole range of scene space into different tiles for each layer, then according to the centrobaric location of the 3D model, calculate the code of it in the quad-tree, and insert the data (including geometric data and texture data) into corresponding tile.

Finally, Creating quad-tree structured spatial index for partitioned data file, and a multi-scale layer and tile partitioning organization is established.

## 5. EXPERIMENTS

According to the 3D model data structure and organization method aforementioned, limitless zoom, seamless browsing the large-scale urban landscape have been implemented on the 3D virtual digital earth platform GeoGlobe, meanwhile simple spatial query, calculation and analysis implemented as well.

3D models of the buildings in part of Shenzhen are selected as experimental data (about 20 thousand buildings, the coordinates and texture image of which are collected by field survey), Geometric data is about 300MB, texture image data 2GB, divided into 5 Levels of Detail (LOD) .

For each level of detail the number of 3D model objects and the data volume (in average) in one tile are shown in following table:

| LOD Level | Model Object | Tile/KB |
|---|---|---|
| LOD 0 | 6.2 | 589 |
| LOD 1 | 5.1 | 529 |
| LOD 2 | 4.6 | 572 |
| LOD 3 | 3.3 | 639 |
| LOD 4 | 1.8 | 695 |

Table1. Data volume of tiles in each layer

And for large range of city landscape real-time interactive browsing on the platform GeoGlobe, the average refresh rate reaches 37 frames per second (FPS), which indicates that our data organization method can effectively reduce data transmission overhead to ensure 3d browsing efficiency for large range landscape. The final effect as following:

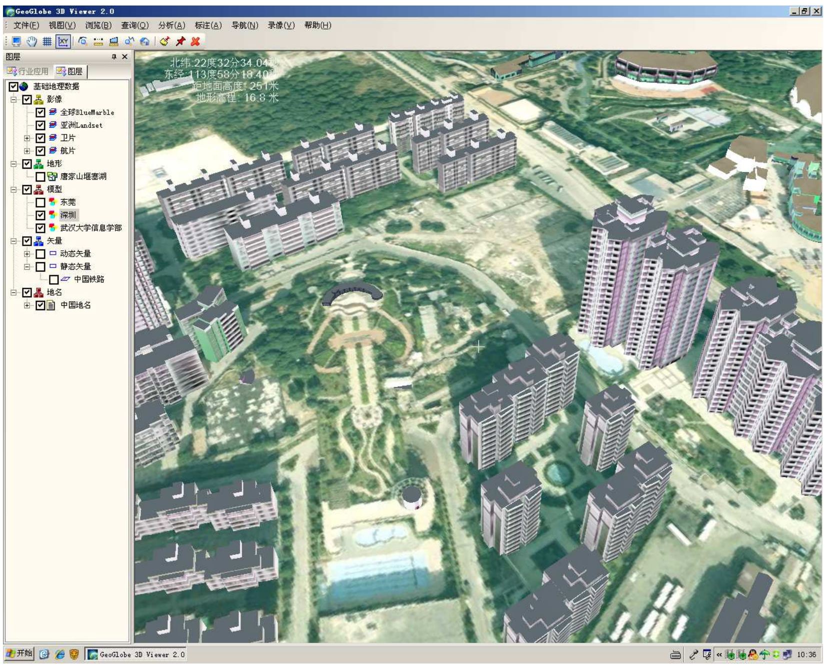


Figure.4: Large range complex model rendering in GeoGlobe

## 6. CONCLUSION

Data organization of large range complex 3D models in network environment is discussed in the paper, to adapt to the efficient network data transmission of multi-scale complex 3D models. Firstly, a spatial point index based data structure for 3D complex model is constructed, and on the basis of which a 3D model data organization method of multi-scaled hierarchical quad-tree structure is proposed, which has the capability for efficient data transmission and viewpoint related rendering as he experimental results shown.

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