RESEARCH ON THE THREE-DIMENSIONAL ABSTRACTION AND DESCRIPTION OF REALITY

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ABSTRACT:

The method of how to abstract reality into a two-dimensional map is already mature, but with the development of three-dimensional GIS, we have to be up against the problem how to describe the reality in a 3D means. Although there are already many 3D GIS software and systems from various corporations, the standard for 3D abstraction and description of real world is still poor. In the paper we have done some elementary research on this issue, we think that there are three key matters which should be implemented including Description Contents, Abstraction Method and Expression Model. And according to the above, we put forward several new concepts and methods that are 3D Geographic Element System, Spatial Granularity for 3D Description (3DSG), 3D Partition of Building and Model Databases of City. In 3D Geographic Element System we define ten kinds of abstract elements to express the reality. 3DSG is used to confirm the subtle degree that we describe the real world and acquire 3D spatial data, and we put forward four principles to estimate 3DSG which are application integrated, applicable, practicable and regional. Buildings are the main sites that humans perform their daily activities, and are difficult to describe for the complex structures, so we bring a partition method to implement accurate expression of buildings. By 3D Partition we divide a building into three parts: Mainbody, Character and Adjunct. Model Databases of City is used to realize the efficient reconstruction of city, and it is composed of Building Character Database, Building Texture Database, Ground Texture Database and Independent Object Database.

1. INTRODUCTION

Since the birth of the people, they have never stopped exploring the living environment in order to improve their adaptability to the reality. Mature abstraction and description of reality is essential to distribute the existing knowledge and advance the scientific level of the whole people. In the different periods of human evolvement, limited by the science and technology developing level, there are various means that people used to abstract and describe the world, such as language, character, graph, table and map. Among these means, map played a very important role. Using intuitionistic symbol and exact position, map gives a comparatively detailed description of reality, and has been used in all kind of fields. But in nature map is a projection from the three-dimensional world to a two-dimensional plane, so there is a great loss of the side information. At the same time a good deal of abstraction, generalization and synthesization are used in cartography, and thus there are limitations of information transmission in a certain degree. With the development of related technologies, it is possible to express the world vividly in a three-dimensional means, either physical or digital. To reconstruct a three-dimensional world, many corporations produced their own software and systems, but there is still lack of the standard for 3D abstraction and description of real world.

The world is composed of various things which have different modes, states and attributes, and it is unpractical and unnecessary to describe and express them in a way the same as the realistic prototypes. So experts in different application domains determine the contents, types and hiberarchy of description according to their own actual demands. For example, in the domain of city management, the emphases are put on describing the surface things including buildings, streets, crossroads, terrain and so on; but in the domain of mine and geology, the research objects are located under the ground, and geology, mineral resources and rocks are absolutely necessary elements. Therefore, it is nessary to develop different 3D description and expression standards aiming at different application fields. City, as an important habitat where people perform their daily activities, is a main site which civilization is created, developed and distributed. Accurate 3D reconstruction of the city based on geographic information technology can provide not only scientific support to make decision for a lot of national departments, but also information service for public. In the following paper we do some elementary research on how to realize three-dimensional description and expression of city.

The paper thinks that there are three key matters which should be implemented including Description Contents, Abstraction Method and Expression Model. And accordingly the paper put forward 3D Geographic Element System, Spatial Granularity for 3D Description, 3D Partition of Building and Model Databases of City, and tested the efficiency through practice.

2. 3D GEOGRAPHIC ELEMENT SYSTEM

In order to realize 3D expression of city, the first problem is about description contents, that is, to construct geographic element system of 3D expression of city. With many years development of cartography, it has become mature and founded a graphic element system which consists of habitation, water system, traffic feature, ambit, terrain and physiognomy, vegetation and so on. It has been proved that these elements can meet a majority of users' need to a certain extent through many

years' practical application. But with applications going deeply, the expression contents needed are more and more subtle, the expression element system can not satisfy the requirements of describing the city in a three-dimensional means, so it is imperative to build 3D Geographic Element System of city.

Referring to cartographic element system of two-dimensional map and field surveying in some cities, we think that there should be at least ten types of things in 3D Geographic Element System, which are Building, Water System, Traffic Feature, Ambit, Terrain, Physiognomy, Vegetation, Pipe, Wall and Bar, and Independent Object.

3. SPATIAL GRANULARITY FOR 3D DESCRIPTION

The realistic world is complicated and various, there are even many differences among the same kind of things. Taking buildings for example, they include cloud-kissing skyscrapers as well as rough shanties. It is difficult to estimate the enormous workload if we want to express all objects no matter they are large or small. The other problem needed to be resolved is how to determine the hiberarchies of objects, whether or not the object is necessary to be expressed, and what degree is suitable if it is necessary, thus we should establish a uniform standard to follow. Therefore, in the paper we put forward a concept of Spatial Granularity for 3D Description (3DSG), which can be used to decide whether we should store the information and express the object by distinguishing their hiberarchy and subtle degree.

The Spatial Granularity for 3D Description has important and instructional significance for practical work when reconstructing a 3D city. Firstly, it provides a standard and a criterion for the 3D spatial data acquisition. Date acquisition is a key matter in 3D city reconstruction, which also needs maximum workload. The difficulty to acquire three-dimensional data has become a bottle-neck problem obstructing the development of 3D GIS. The main reason is lacking of related standards. 3DSG will resolve the problem to a certain extent by supplying standards. After the determination of 3DSG, we don't need to consider those features under Granularity, and consequently unnecessary work can be reduced. Secondly, we can improve modelling efficiency of complex buildings with 3DSG, by simplifying and omitting lots of trivial things. With the development of modern architectural technology, architectural style becomes more and more multiplex. And the traditional "matchbox" buildings are gradually replaced by modern architecture which has different styles and complex structures, accordingly buildings are much more difficult to reconstruct. By partitioning buildings details according to 3DSG, unimportant characters can be omitted and thus we can realize the efficient reconstruction of city.

Because of complexity and diversity of realistic world, and various application domains, 3DSG is not a constant value, but a variable which would be determined each time according to the size of a description scope, the subtle degree of different applications and actual data collection capability. For example, when constructing 3D scene aiming at exhibiting city style and features, the emphasis is to describe the whole view of the city. And such as squares, evident buildings, streets and crossroads must be described with high precision but some fundamental infrastructure of city such as power networks, we should only select and express some substations and circuitroies of higher grade. Or else, we would confuse description hiberarchies and destroy the integrated aesthetic feeling of scene if in the terms of the same granularity. On the contrary, if the application domain is electric department, the scene is primarily served for inquiry and analysis of power networks, the description granularity of power establishment must higher than other things.

In the process of 3D Digital Weihai construction, we have done some elementary research on the determination standard of 3DSG. The successful construction of Digital Weihai proved that granularity description is necessary. Summarizing the material practice, we think there are four principles that should be considered when determining 3DSG:

1. Application integrated, because different applications have different emphasis.

2. Applicable, that is, the 3DSG should satisfy the application demands but should not pursue high precision eyelessly.

3. Practicable, the determination of 3DSG should be combined with data acquisition methods.

4. Regional, the 3DSG of different regions is different from each other, the emphases is put on important regions.

4. 3D PARTITION OF BUILDING

With the development of modern city, there are variety of cities and thousands of different geographic objects, it is difficult to find a single object model suitable for all geographic objects. It also obstructs application and development of 3DGIS in many fields. However, there are commonness and similarity to a certain extent when any object has been divided. For examples, a tree can be divided into the crown, the trunk and the root, a table is consist of board and legs, the structure of a man includes head, upper limbs, body and legs and so on. Therefore, we can similarly divide complex geographic objects into simple sections. The process of partition complex spatial objects into sets of simple objects is called 3D Partition. Buildings, as the main elements of city, have different structure styles. It is difficult to reconstruct them one by one, while they can be expressed as a series of normal geometries through 3D Partition which improves construction efficiency of city.

3D Partition of Building is divided into logical partition and physical partition, the former means dividing buildings at cognitive hiberarchy, such as roofs, walls and foundations; while the latter means dividing buildings into some simple geometries according to certain rules from the building structure point of view, such as tetrahedrons. In the paper, 3D Partition of Building is primarily logical partition. In the light of the building structure and human cognitive habits, we think that any building can be divided into three parts, which are Mainbody, Character and Adjunct. Mainbody is the chief parts of a building and usually with a normal shape. Character is a part of a building, which represents characteristic details different from the others buildings, such as roofs, eaves, outdoor-floors and etc. Adjunct is not a part of a building but existed with the building, such as antennae, satellite receivers and hanging object etc. Fig.1 demonstrates 3D Partition of two typical buildings.

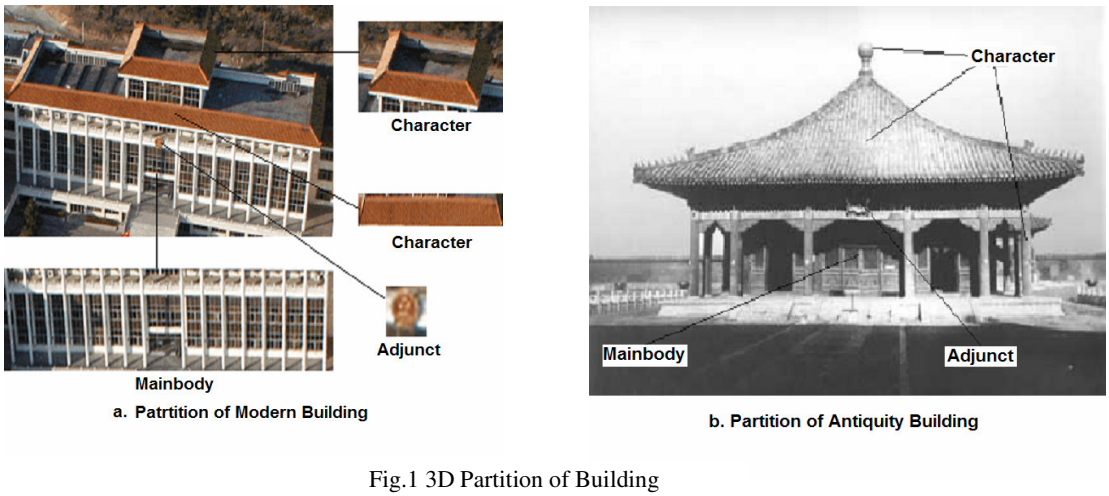

Fig.1 3D Partition of Building

5. 3D MODEL DATABASES OF CITY

With the development of architecture material and architecture technology, buildings represent different earmarks of different times. Even at the same time, buildings for different purposes have dissimilar appearances. Only in the building roof, there are various types (Fig.2). Because of the complexity of realistic world, 3D digital expression is also complex. At small regions with few buildings, it is possible to collect data of every building, but with the increasing of data at large areas, the abstraction method must be used. Building character appearance, such as colour, texture, roof shape, eave shape and etc, can be summarized to some typical styles because of the limited architecture material and architecture technology. If we construct Model Databases of City firstly, by applying the models directly or with little modification the workload is reduced sharply. In the paper we founded the 3D Model Databases of City which is composed of Building Character Database, Building Texture Database, Ground Texture Database and Independent Object Database. Fig.3 shows the structure and contents of the 3D Model Databases of City.

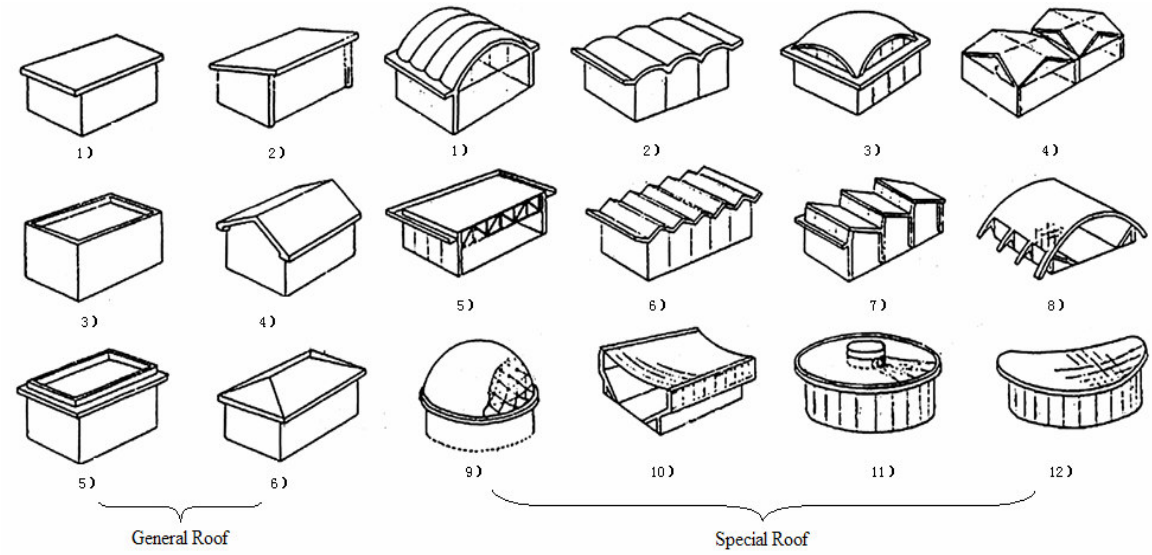

Fig.3 Roof Types

6. APPLICATION

Fig.4 shows a typical scene of Weihai, which is a beautiful city in the east of China. We apply the methods and technologies discussed above in the scene construction. In the scene, there are six kinds of features including building, vegetation, independent object, traffic element, terrain and physiognomy. Among all the objects in the scene, the mainbody of buildings are solely modelled using the geometric and texture information, the character and adjunct of buildings are the elements of the building character database, the textures of lawn and road are picked from the ground texture database, and some other features including trees, street lamp and flag mast are all the elements of the independent object database.

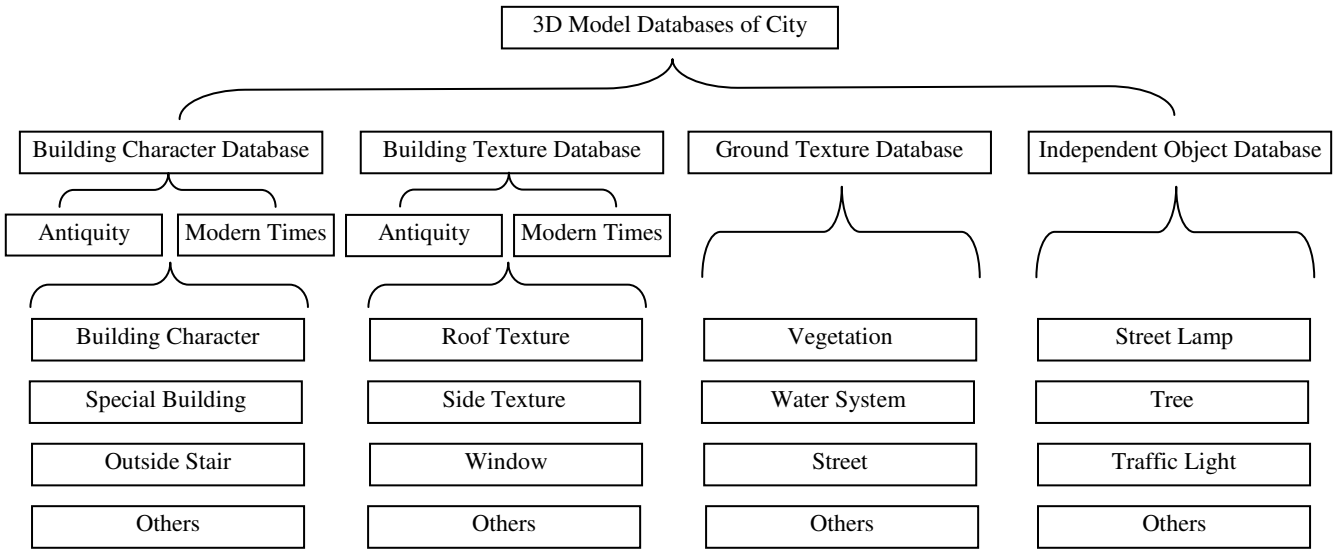

Fig.3 3D Model Databases of City

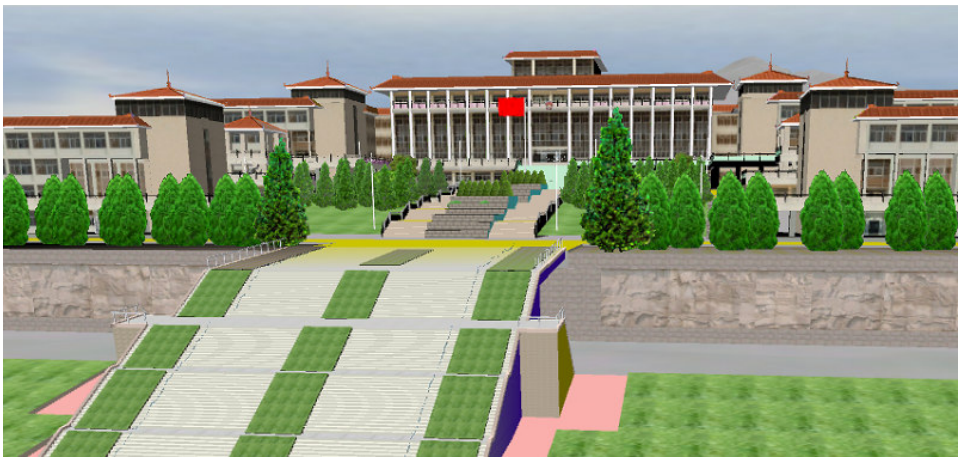

Fig.4 Reconstructed City Scene

7. CONCLUSIONS

When we want to reconstruct the real world in a digital environment, it is the first task that implementing the abstraction and description of reality. It means that we should firstly determine the description contents, abstraction method and expression model. So aiming at solve these problems, we built the 3D Geographic Element System, and put forward concepts of Spatial Granularity for 3D Description and 3D Partition of Building, and founded 3D Model Databases of City to reconstruct scenes efficiently. By put these methods and technologies in practice of Digital Weihai Project, the conclusion can be drawn that the efficiency could be increased greatly by applying them.

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