Parametric Modeling of Typical Chinese Traditional Buildings on the Basis of 3DSMax Script

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Abstract 3D modelling is an important way in simulating of historical building. Modelling methods based on laser-scanned data and automated image-based techniques are commonly used recently. In this paper, modelling method based on parametric description is proposed. One prominent feature of traditional Chinese architecture is its modular system. By studying typical structures and components of Chinese traditional buildings, parameters of different structures are summarized and simplified to establish the reasonable model. Then, the process of programming a 3D modelling system using 3DSMax script language is discussed. Through this method, after choosing the type of traditional buildings and entering necessary parameters, 3D model with different type and size can be created automatically and efficiently. The research of this paper could provide a new way of establishing 3D model for building's virtual reconstruction and walkthrough.

Keywords: Modular system, parametric modelling, 3DSMax script, virtual reconstruction

Study Significance

The most remarkable feature of Chinese traditional architecture is its timber-frame system and its carpentry techniques through thousands of years. Wooden structure buildings reflect the traditional culture of China.

Compared with ancient western buildings, which mainly using masonry structure, the durability of Chinese timber-frame buildings is much poor. They are easy to catch fire. Besides, humidity, insects, and wars all do great harm to them. It is a great pity that a large amount of historic timber-frame buildings have disappeared as time goes by. This makes the protection and reconstruction of wooden structure buildings particularly important and urgent.

Study on ancient buildings often requires 3D reconstruction of real-world objects and scenes. Traditional recording tools for historic buildings such as sketching, measured drawing, photography, videos, writing and so on, all have limitations. Due to the development of computer technology, various digital protection technologies have emerged.

A common method is using modeling software such as AutoCAD, 3DSMax, etc. to reconstruct a 3D model manually. But it is time-consuming and even impractical, especially for large-scale projects.

Using advanced measurement methods, such as 3D laser scanning, digital close-range measurements, digital information of ancient buildings can quickly obtained. 3D model can be reproduced automatically.

However, modeling method based on advanced measure techniques also has its limitations. The data obtained is geometric, lacking of structural information. To the large amount of ancient Chinese buildings with similar structures, this method is inefficient. It is available only to buildings in the real world. For those which have been ruined and no longer existed, measuring method can't be used.

Parametric modeling can overcome these shortcomings. By studying the structure of typical ancient Chinese architecture, parametric description is proposed. 3DSMax script language is used to program the script file of structural 3D models. When the script file is run, different parameters can be entered to create different models without any repeated work. Parametric modeling provides an economical and effective way for ancient building's designing and virtual reconstruction.

Parametric Analysis of Ancient Chinese Buildings

To create parametric models, parameters which can be used to express features of the ancient architecture should be decided. The more parameters used, the more complete the 3D models would be. But if too many parameters are used, the data amount of the model will be too large. Meanwhile, adaptability of the system will be poor.

During thousands of years, the structure of ancient Chinese buildings had formed a mature style and a modulus system. According to the actual measurement, the temple of Tang dynasty, "Fo-GuangSi" in Wutai Mountain has applied the "material modulus system ". During Song Dynasty, the "Building Standards" became the most perfect standard of Chinese ancient buildings. Also, "Structural Regulations" were the basis for buildings of the Qing Dynasty. These two documents are "two grammar books on Chinese architecture". Studying the standardization and modulus system of ancient buildings can greatly simplify the parameter descriptions.

Columns and beams compose the basic force system of timber-frame system, supporting the roof weight. The wall is not load-bearing. In addition, Dougong which is located between roof and the junction of beam and column is the specific structural elements of Chinese ancient buildings, which not only has the dual role of load-bearing and decorative, but also the class symbol of ancient Chinese architecture. It is an assemblage of a number of Dou(blocks) and Gong(arms).

Architecture of Ming and Qing is taken as the main studying object because they compose most of the existing historic buildings. Accordance to "Structural Regulations" of Qing, "block mouth" and "Yanzhu radius" are two modules usually used.

Large size architecture such as palaces and temples, which usually have Dougong, often use "block mouth" (the width of Gong) as the basic module. Block mouth has 11 grades. That means the block mouth has 11 kinds of size, and the size of other components take a multiple of the modulus. Size of the timber grade determines the size of components and the amount size of the whole building.

Residential buildings which do not use Dougong are also called small size architecture. It takes "Yanzhu radius" as the basic module. After determining the size of the bays or higher, the radius of Yanzhu can be calculated by the Proportion.

Besides the basic module, some basic parameters, such as the bay number, the step size, the height of the raise of the roof, and the style of beam skeleton, roof, base and so on also need to be decided. After basic parameters have been determined, size of other components such as beams, columns, base, roof and their location can determined by studying the module system.

Workflow

After parameters have determined, then how to establish 3D models of typical Chinese ancient buildings should be studied. Under present condition, to establish a new 3D modeling system is difficult. 3DSMax modeling system is used. 3DSMax script language is used to program the script file of 3D model. In the program, variable parameters and structural style is set. By changing these parameters, different kinds of buildings can be generated automatically.

The modeling system of typical Chinese traditional timber-structure buildings is mainly according to "Structural Regulations". Using script language, variety of structural components is produced, and then be assembled into a complete system of timber-structure. When the 3DSMax script file is run, structural type of building and necessary parameters should be entered, and 3D model with different type and size can be reconstructed.

Characteristics of the Script File

Max script is an object-oriented programming language. It has the general characteristics of programming languages, and covers most functions of 3DSMax, such as modeling, texture setting, light setting, animation setting and rendering. By running the script file, 3D model are created automatically.

Max script can achieve interaction with the uses by user panel. In the panel, users can freely enter the expected parameters, choosing their favorite maps, and create their own expected model. Max script can also be used to achieve real-time keyboard-interactive operation which is difficult to realize for manual modeling in common 3DSMax interface.

The Process of the Program Design

Entering Basic Parameters Such as size of "block mouth", bay number, length and width of the building, height of the roof etc.

Creating columns Deciding the arrangement of the columns (the bottom of the column is the column base).

Fig. 1 is the plan of columns with four rows of eight columns each, forming a hypostyle hall five bays in length and one in depth and with surrounding corridors.
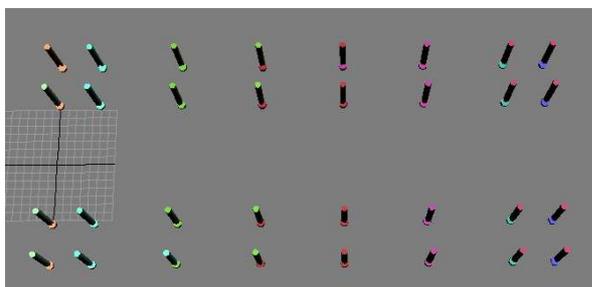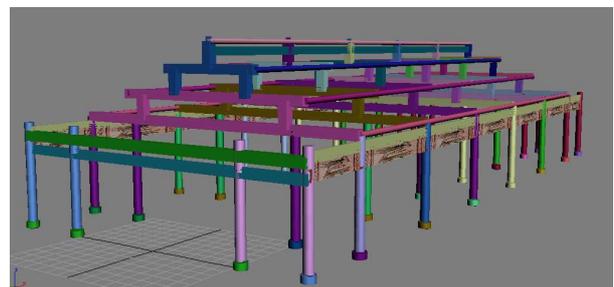

Figure 1: Plan of columns

Figure 2: Adding beams, purlins and lintels

Setting beams, purlins and lintels

Fig. 2 shows the figure of adding beams, purlins and lintels. Some usual structural styles of beams are provided to be chosen, also different types of purlins according to different roofs.

Creating walls, doors and windows Different maps of walls, doors and windows are designed to be chosen.

Set base One-story base and three-story base are designed to be chosen.

Set roof The user can choose five different kind of roof. They are: flush gable roof, overhanging and hip roof, gable and hip roof, hip roof and pyramidal roof. Fig. 3 shows the elevations with different forms of roofs, doors and windows.
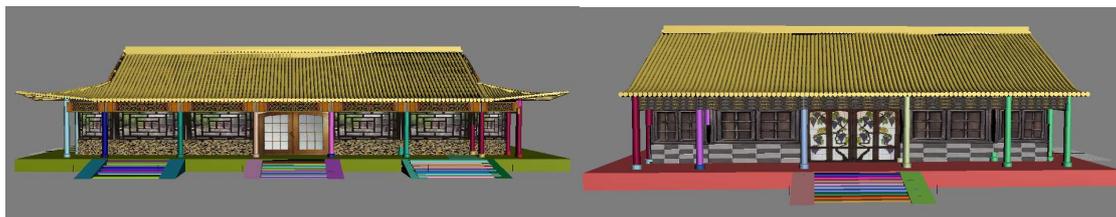

Figure 3: Elevations with different forms of roofs, doors and windows

Animation settings and real-time control settings After the main body of the building is finished, script language is also used to design the animation line, so the building can be watched from different direction. There are two kinds of animation setting. One is pre-designed path. The observation line and angle is designed unchangeable. The other is real-time controlling; the users can control their own path of movement and observation position by using the keyboard.

Other Cases

Courtyard of Beijing and Shanghai are two kinds of typical residential buildings. Their structures and forms also have distinctive characteristics and standards. The followings are the parametric 3D models of Siheyuan building of Beijing and Shikumen building of Shanghai created by script file.
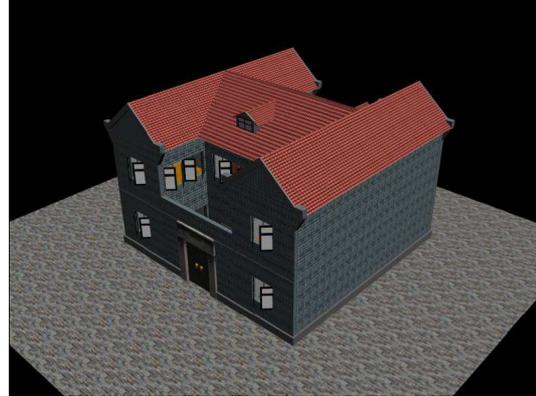
Figure 4: 3D model of Siheyuan   *Figure 5: 3D models of Shikumen*

Next are different models of China Hall in Shanghai World Expo made by script file. The height of column, the layer of the bracket and other parameters can be changed.
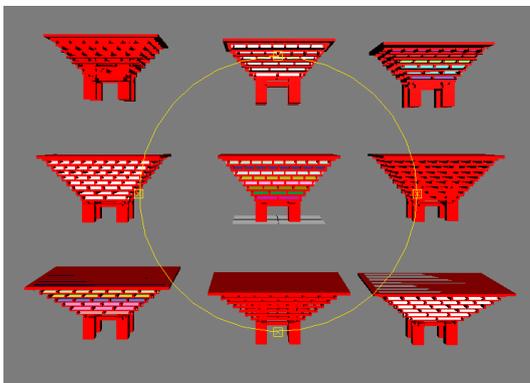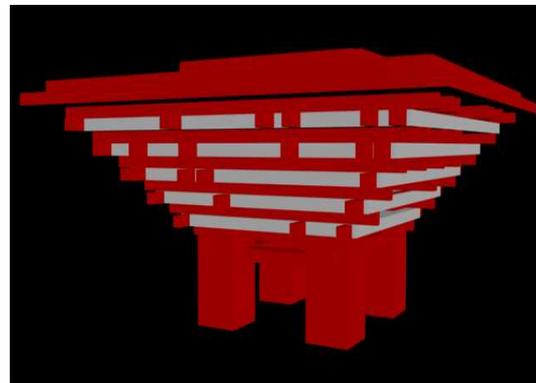

Figure 6: Different models of China Hall   *Figure 7: Rendering of China Hall*

Conclusion

Parametric modeling provides a new way to create 3D models for multimedia presentations and virtual tourism in studying and protecting Chinese ancient buildings. It also helps to design and modify archaistic architectures in the computer. Its prospects are broad and encouraging.

In future work, more steps will be taken to improve the project quality and try to assemble independent systems of different type of buildings into a whole system.

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