Research on Parametric Modeling and Digital Reproduction of Ancient Buildings on the Southern Silk Road

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Abstract. This paper takes the parametric modeling technology of ancient buildings on the Southern Silk Road as the research object, and conducts a more in-depth analysis of the types, forms, advantages, and shortcomings of parametric modeling in ancient building modeling with a wealth of cases to demonstrate profound theories in simple language. The parametric modeling of the dwellings of Bai ethnic group in Dali was used as a case for verification. This paper is a more in-depth research paper on the digital modeling of ancient buildings, which has positive reference significance for this kind of research and production.

1. Significance and value
The Silk Road was an important business route for trade exchanges between China and other countries in ancient times. Generally, the Silk Road refers to the Northern Silk Road starting from Xi’an (ancient Chang’an). However, in the south of China, there was a southern Silk Road with a longer history. The Southern Silk Road, like the Northern Silk Road, has made great contributions to world civilization. It has played a great role in foreign trade, ethnic migration, and cultural exchanges.

Historically, long-term border trade existed in the southwest region long before the Han Dynasty troops entered the southwest region. Border trade promoted economic and social development and mutual cultural exchanges, and various ethnic groups gradually merged. Multiple economic and cultural centers in the southwest region gathered in the main roads of the Southern Silk Road, and gradually formed a network of market towns and a cluster of buildings along the direction of the Southern Silk Road. It can be seen that the Central Plains culture has played a role in the cultural development of the southwest region, and it also contains a comprehensive pattern of multiple cultures such as sorcery, Taoism, Buddhism, and Confucianism. Therefore, while promoting regional cultural exchanges and playing a significant role, the Southern Silk Road has greatly enriched and developed the unique culture of various ethnic groups along the route.

Architectural art is an important part of national culture and art, and a microcosm of the development of human society and culture. The research, display, and dissemination of buildings along the Southern Silk Road can more fully reflect the cultural development of the Southern Silk Road and have greater cultural and artistic value. In recent years, due to various reasons, the disappearance of traditional architecture has become a heartbreaking fact.

Collecting and sorting out the characteristic building information on the Southern Silk Road and visually designing the information has become the main method for digital protection of ancient
buildings on the Southern Silk Road. The parametric modeling of ancient buildings is an important step and foundation for the visualization of ancient building information.

2. The concept of parametric modeling of ancient buildings
The "parameters" mentioned in the research of this paper refer to the data that have a decisive effect on the volume, modeling expression, material and texture coordinates UV of ancient buildings. The main scales of the parameterized model are controlled by parameters. The changes of these parameters will have a real-time impact on the actual performance of the model. From another perspective, the parameterized model is actually the visual performance of various parameters through a certain correspondence.

Compared with the non-parametric model, the parametric model has the following advantages:

![Figure 1. Cuboid model in different parameter states](image1)

![Figure 2. Model distribution under different parameters](image2)
(1). The parameterized model is "live". By changing the parameters, the model can be modified in all aspects until it is satisfied. Take a simple cuboid modeling as an example, the shape of the same cuboid under different length, width and height parameters.

(2). For models with repetitive characteristics, path deformation characteristics, and surface deformation characteristics, it is particularly suitable for model creation through parametric modeling. For example, the walls of ancient buildings have obvious deformation characteristics along the path and the repeating characteristics of unit construction. They are especially suitable for creation using the parametric modeling function of 3D modeling software. Figure 3 shows the different distribution results obtained by modifying different quantity parameters for the traditional column path distribution operation of ancient buildings.

(3). The diversification of parameters makes the acquisition of digital 3D models of ancient buildings more flexible and accurate. In the modeling process, we can continuously change the "parameters" to change the shape of the model, through real-time changes, observation, modification, and observation until the ideal model is obtained. Therefore, through diversified parameter settings, the designer can continuously make artistic modifications to the model, and finally achieve the desired visual effect. In a parametric modeling environment, the establishment of 3D models has become easier to achieve than before.

The so-called diversification of parameters means that the parameter is not necessarily a number, it may be a variable curve, a variable surface, a color, an adjustment pointer, a point's spatial position, etc. In a broad sense, any variable information related to modeling can all be understood as "parameters." In 3D modeling software, the applications of diversified parameters are numerous. As shown in Figure 3:

Figure 3. Distribution of sofa chairs in

The sofa chairs in the picture are distributed along the path through a specific algorithm. The distribution route and number of sofa chairs are closely related to the path. The three scenes in the figure are the distribution of sofas chairs under different path states, and the path can be changed in length and bending style at any time, which can be described as endless changes that better meet the needs of design modeling.
3. Modeling examples of ancient buildings on the Southern Silk Road

In this chapter, taking the author's parametric modeling of ancient buildings of Bai ethnic group in Dali, Yunnan, China as an example, we will conduct a more in-depth and practical exploration of the parametric application in the modeling of ancient buildings on the Southern Silk Road.

3.1. Acquisition of materials

The basic form of material is digital photos. Conduct digital processing for digital photos. Part of the digital photos are taken to clearly record and express the residential buildings. The digital processing of this type of photos mainly includes cropping, toning, and adjusting the size of the image.

![Figure 4. Extraction from photos to available materials](image)

In addition, most of the photos were taken to obtain the creative materials, and the processing of this part of the photos is slightly more complicated. It is necessary to process the required picture materials from the digital photos, which requires the use of many functions of Photoshop, including color toning, image transformation, common drawing tool, filter, etc. As shown in Figure 5, available materials are obtained from digital photos through digital processing.

3.2. Digital processing and modeling of measurement data

This type of digital processing refers to the drawing of more accurate CAD drawings based on the collected surveying and mapping data, marking the exact size of buildings and building components, and showing accurate architectural styles. The following figure shows the surveying and mapping of Bai ethnic group's houses in Dali.

![Figure 5. Parameterized modeling model of Bai ethnic group's residence in Dali](image)
Parametric modeling can be performed on large building components such as walls, floors, roofs, doors, and windows, which not only has high modeling efficiency, but also ensures the accuracy of the overall building in terms of scale. (1) Extrude command for plane graphics; (2) Lathe command for plane graphics; (3) Loft command for plane graphics and paths; (4) Parametric modeling plug-ins, such as the RailClone plug-in; (5) Various modification commands with parameters. The above five can be used as parametric modeling methods. The following figure shows the effect of 3D software parametric modeling.

3.3. Digital sculpture modeling processing of architectural details
Ordinary parametric modeling can meet most of the building model generation needs, but Chinese ancient buildings paid attention to decoration, and wood carvings were used in large quantities in building construction, and the modeling is complicated. Ordinary parametric modeling methods cannot meet the needs of modeling, and digital sculpting technology is needed to solve the artistic modeling of complex models.

Digital carving is a virtual carving using a computer. It imitates reality to sculpt existing or non-existent objects. In the virtual world, digital sculptors can use software to sculpt any real or virtual objects based entirely on their imagination. The software currently used in digital sculpting includes: Autodesk Mudbox, zbrush, 3D Paint, etc. These software have certain differences in interface design, operating specifications and methods, but they are basically the same in simple using principles.

In order to facilitate the "symmetric" engraving operation of the model in Mudbox, the position of the model needs to be placed at (0,0,0) in world coordinates. In the dialog box, set the model's "absolute: world" coordinates (X, Y, Z) to (0, 0, 0), and the center of the created cuboid model is placed at (0, 0, 0) in the world coordinate system. The following figure shows the operation process of restoring real ancient building construction through digital carving.

4. Suggestions on ancient building modeling technology
4.1. Try to use parametric modeling methods to make simple models
Too many surfaces of the building 3D model will cause the file capacity to increase, the display and operation of the model will be slow, and the 3D file download time will increase. Traditional non-parametric modeling easily leads to an increase in the number of model surfaces, so parametric modeling methods should be used as much as possible when modeling.
4.2. Use textures to represent complex models
In order to enhance the running speed of the 3D scene, it is best not to make more complex objects into 3D models when building the model. You can use the method of simple model and texture. Such as window frames, railings, fences, wood carvings, etc. This is because these objects will only increase the number of models in the current scene file, and there will be aliasing and flickering during real-time rendering. For complex objects, we should try to use textures to express, the effect is also very delicate and real. As shown in the figure below, the "Three Drops of Water" gatehouse of the Bai people's residence in Dali, the complex wood carvings and paintings in the center use simple models and textures.

5. Conclusion
The three-dimensional model is an important form of digital expression of the material form of traditional culture, and the acquisition of the model plays an important basic role in the final cultural transmission benefits. Parametric modeling technology is an effective means to obtain scientific and reasonable ancient building models, and the research and practice of this technology is more meaningful. This paper only discusses and summarizes the parametric modeling and digital expression experience of the author's projects. With the development of software and hardware technology, parametric modeling will further develop in the direction of diversification, intelligence and become easier to realize that will better serve the digital heritage of culture.

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