Application of 3D-aided Design in Urban Planning

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Abstract. To better express the design scheme, planners have always expected to present the design scheme vividly before construction and implementation. Compared with traditional aided design expression methods such as expression charts, sand table models, animation, etc., aided design techniques can show the design scheme better, which is conducive to adjusting and optimizing the scheme. In this paper, the concepts, characteristics, implementation methods of scheme expression charts, sand tables, 3D animation, aided design, and other scheme representation means as well as their application in the field of urban planning are briefly introduced. In addition, the latest application study of aided design technique in urban planning management of Shanghai and its application in the project of “Solicitation of planning schemes for both sides of Huangpu River” are briefly discussed.

Keywords: Urban Planning, Aided Design, 3D Modeling, Simulation, Real-time Rendering

1. Introduction
To express the planning idea and design intention better, planners always hope to show it vividly before the construction and implementation of the design scheme, that is, the aided design of the planning scheme [1-2]. Currently, the main methods of planning scheme aided design are as follows: Planning schemes are expressed intuitively based on the form of highly skilled art household perspective or bird's-eye view. The advantage of this method is that it can produce better performance effect. The disadvantage is that the painter must have high professional performance skills, and the performance effect is single, static and discrete [3-4]. The other is to make the sand table model of the design scheme in proportion. The advantage of this method is that it can better show the overall effect of the design scheme, and can analyze and observe it from various perspectives, with a good sense of 3D. The disadvantage is that it is difficult to observe it from the point of view of human without using certain equipment. Meanwhile, as the sand table model is mostly one-time, it is difficult to use continuously, it is not conducive to the optimization and adjustment of the scheme, and it is prone to waste costs [5-6].
Currently, more and more planners have turned to computer techniques instead of traditional copying and modeling method to produce new performance effects. In recent years, almost every important design has adopted some form of computer representation, including computer representation, scheme animation, aided design or simulation model. In this way, planners can communicate with customers and discuss various problems related to scheme design on the computer at any time. Hence, “aided design” is a relatively simple and practical preliminary aided design performance effect. Its better application is to add data interconnection function based on the “Aided design”. Hence, in the “Aided design” scene, the city target and other digital information (such as texts, sounds, pictures, horizontal and vertical section design drawings, 3D models, and other animation materials) are connected in a super chain, so that various design information can be presented to users in a more convenient and diversified manner.

2. Key technologies of aided design
As per the requirement of “Aided design” of design scheme, to achieve the preliminary performance effect of aided design, two technical cores, i.e., 3D modeling and simulation, should be addressed. Through the establishment of 3D model to describe the nature of urban architecture, environment, human and their relationship, and to reproduce them on the computer. The key technologies include: the construction of the basic model is the basis of applying the computer-aided 3D technique to generate the virtual city 3D environment. It can reconstruct the realworld objects (such as buildings, bridges, etc.) in the corresponding 3D virtual world and save some physical properties as required by the system. To build the model, the geometric model of the object should be built first, and the spatial position and the attributes of the geometric elements should be established. For example, building 3D geometric model is built by CAD or 2D drawings; large-scale city virtual scene is built by GIS data and satellite, remote sensing or aerial photos, etc. To enhance the reality of the virtual environment, we should describe the construction materials, facade, environment, lighting, and shadow of the urban objects in detail. “It is required that the computer can determine the spatial position and direction of users’ viewpoint in the 3D virtual scene at any time based on the 3D modeling of the urban scene, based on the signal transmission of the interactive devices such as the mouse, keyboard, game handle, etc., visual angle and field of view, and real-time rendering and simulation of 3D virtual scene. Hence, users can have a strong sense of experience and optical coherence.

For a feature C of urban architecture and its corresponding value V, a binary can be established, which is the feature element of things. However, it should be noted that as urban architecture has the characteristics of emanation, the same thing can have multiple feature elements, and at the same time, a feature element page is not unique to one thing. It should be noted that the features in the concept of urban architecture refer to the names of features such as voltage, current, and power. Feature element is a binary that combines feature name and quantity value, often known as “Features”.

A thing has more than one feature, if n has n features \( c_1, c_2, \ldots, c_n \) corresponding quantity value \( v_1, v_2, \ldots, v_n \) description, it can be expressed as follows:
\[ R = \begin{bmatrix} N & c_1 & v_1 \\ c_2 & v_2 \\ \vdots \\ c_n & v_n \end{bmatrix} \]  

(1)

R represents a high-rise urban building, where \( R_i = (N, c_i, v_i), (i = 1, 2, 3, \ldots n) \) a sub urban building called R, R can be abbreviated as:

\[ c = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{bmatrix}, \quad v = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} \]  

(2)

Aided design is a modern high-tech with computer technology as the core. The high-performance computer processing technique is the key to influencing system performance directly. It is a high-performance computer processing technique with high computing speed, strong processing capacity, large storage capacity, and secure networking characteristics, mainly including the following research contents.

3. Application process of 3d-aided design in urban planning

For a high-quality aided design system, expensive external equipment is first required, including high-resolution helmet display, stereoscopic projection display, high-precision data glove, etc. Secondly, to complete the real-time rendering of complex scenes, it also requires high-performance graphics workstation and corresponding software. Such expensive equipment software can be accepted in some specialized fields (such as military or aerospace). However, its application to daily urban planning management is challenging. The efficiency and costs of the image-based modeling technique is far less than that of the geometry-based modeling method, as shown in Figure 1. Currently, the image-based modeling method has become a new and effective method of basic modeling in aided design technique and is accepted by the academic community in general.

It should be noted that the assistant design system usually uses the hybrid 3D modeling technique based on image and the 3D modeling technique based on geometry to create the virtual world as the single 3D modeling technique based on imaging can only create the real and existing urban real environment, while for the non-existent and virtual planning and design scheme, it requires the geometric CAD modeling.
Although the speed of computer operation and the acceleration performance of graphics hardware have been significantly improved in recent years, compared with users’ pursuit for complex, realistic, real-time models, it still lags behind the actual application requirements. As a result, users often have to make a trade-off for the following three aspects in the practical application: the complexity and accuracy of models, the authenticity and beauty of drawings, and the real-time performance of result presentation in the urban planning field.

For example, for the application of roaming inside a building, the 3D geometric model of the building is composed of about 1.7 million triangular patches; the geometric model of a thermal power plant is as many as 13 million triangular patches. Although the processing speed of top graphics computer can reach millions of triangular pieces per second currently, it is challenging to meet the requirements of the real-time display to deal with the above-mentioned complex application topics, not to mention the application in the field of urban planning involving dozens or even hundreds of buildings and workshops.

To this end, Shanghai urban planning administration and Shanghai Feitian remote sensing palm Space Technique Co., Ltd. have conducted in-depth research on this issue based on a 3D data model with leading international level mastered by the company. It can implement hundreds of times compression of conventional 3D data and can achieve rapid transfer and management of large amounts of 3D data on a shared computing platform. In this way, the organization management and real-time call of the massive 3D data model can be addressed effectively.

4. Project application

As one of the series of research on the aided design technique system, the aided design technique has been applied to the work of “the collection of planning schemes for both sides of the Huangpu River”. The project started in March 2001 and ended in May 2002. It was presided over by the Shanghai Urban Planning Administration Bureau and jointly undertaken by Shanghai Urban Planning Information Center, Shanghai Surveying and Mapping Institute, and Shanghai urban planning and Design Institute.

Over years of research, primarily through the application of aided design technique in the project of...
“Solicitation of planning schemes for both sides of Huangpu River”, the 3D aided research group of Shanghai urban planning administration explored a set of effective technical solutions with Chinese characteristics in the 3D aided urban planning management. The problem of massive 3D data compression management and efficient CAD engine. The engine is fast and does not need to be equipped with a high-end video card. It can easily realize the smooth translation, rotation, viewpoint transformation of large area real-time 3D city model and real-time display of city 3D scene by using a common computer. See Table 1 for specific test data. Open results data. It can use general 3D Max data format or open WRL data (some VRML data format) for data exchange and conversion, which has strong data openness.

| Machine type | Test computer part configuration | Call speed |
|--------------|---------------------------------|------------|
| 1 Desktop    | P IV 1.7g, 512M, Elsa 32m graphics card, 60g hard disk | Very fast  |
| 2 Desktop    | P IV 1g, 512M, 3D lab 32m graphics card, sics20g hard disk | Very fast  |
| 3 Desktop    | P III 800512m, Elsa 32m graphics card, 60g hard disk | Faster     |
| 4 Desktop    | P II 350256m, save48m graphics card, 8g hard disk | Slower     |
| 5 Laptop     | P III 800512m, Elsa 32m graphics card, 20g hard disk | General speed |
| 6 Laptop     | P II 266128m, s38m graphics card, 10g hard disk | Slower     |

5. Conclusions
The aided design technique can not only provide vital help to the aided design of the urban planning and design scheme but also effectively assist the urban planning and construction management, which plays a significant role in the new construction, renovation, and historical preservation of key urban areas, etc. Although the application study of aided design in urban planning started relatively late in China, with the enhancement of China's national strength and continuous improvement of science and technology level, aided design technique will be extensively applied in the field of urban planning and construction in China as the aided design technique keeps growing and the application threshold continues to decrease.

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