Multimedia Simulation-Based Architecture CAD System Model

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Abstract. With the development of science and technology, the content of multimedia simulation of construction engineering is gradually expanding, and its means and performance mode are constantly innovating, so as to build an integrated multimedia simulation system. Combined with the corresponding computer-aided design software, and applied in the field of construction engineering, to describe the temporal movement of the building structure, in order to achieve the standard of building science engineering design. In order to make the new CAD system have a higher level of integration and artificial ability, this paper proposes a building CAD system model based on multimedia simulation. The basic structure of the model includes design resource processor, entity modeler, simulation analyzer and design result demonstrator. The pre research system has realized the unified expression of shape model and behavior model, and creatively used computer graphics, computational geometry and other technical methods. This paper introduces the technical background and requirements of the model, and points out the realizability of the model of building CAD system based on multimedia simulation and the commercial prospect of its popularization and application.

Keywords: Multimedia Simulation; Architectural CAD; Three-Dimensional Data Field; Integration

1   INTRODUCTION

CAD technology and system is one of the most effective and active field in computer application research, but it also needs to be explored. This is because the current CAD model cannot meet the requirements of people's comprehensive and efficient engineering scientific research and design and production, nor make full use of and develop the potential provided by new technological achievements in recent years [1]. Compared with the computer application level of other industries, the engineering construction field is still at a low level, and has not yet played a strong advantage. Essentially traditional CAD technology is just a drawing tool to express architectural design through simple geometric figures such as points, lines and surfaces [2]. There is no direct

connection and mutual restriction between the building components drawn by it, and the subsequent use of data information in the generated two-dimensional figures is also limited, so it is difficult to provide designers with more engineering information to assist designers to complete the overall architectural design plan [3]. The traditional CAD technology has been unable to meet the needs of modern construction engineering.

At present, the software for architectural engineering design and analysis of Chinese users still cannot meet the above requirements. SAP software in the United States has relatively complete dynamic analysis function. Gallo, P. et al. pointed out and can use the method of one-dimensional wireframe to represent each stage of vibration and plastic, can still not have the real-time dynamic display of dynamic response of three-dimensional solid structure and other multimedia simulation functions [4] . Cong, j et al. used the method of computer model cooperation between real test images to establish the behavior model of tower under seismic load [5]. This test obtained more positive results in the aspect of entity visualization, the distributed virtual wind tunnel developed by Hoang, V. U. of NASA research center is based on the large-scale system of virtual reality technology [6]. The required equipment conditions are not only that the independent computer can complete, but also cannot be applied in general architectural design.

Multimedia simulation refers to the use of different media forms to describe the model information that does not care about the nature, and to establish a simulation model that reflects the system's performance form and internal motion law. In the process of simulation, it can produce a quantitative and definite dynamic evolution process of the system. In order to achieve a higher level of integration in the new generation of CAD system and the advanced function of replacing human, this paper presents and discusses the model of building CAD system based on multimedia simulation, which is a new CAD experimental system designed and developed by us under the current development of new technology. The dynamic multimedia performance model of simulation system is established to make its external media performance, form mode, behavior mode, abstract image consistent with the internal mathematical laws. The design scheme of integration of building model, dynamic fax demonstrator and structural mechanics analyzer is put forward.

2 DESIGN OF ARCHITECTURE CAD SYSTEM MODEL BASED ON MULTIMEDIA SIMULATION

2.1 Design Idea of Building CAD System Model Based on Multimedia Simulation

The application of multimedia computer technology in the field of engineering design requires interdisciplinary experts to realize communication and exchange, complementation and combination, so that the development of multimedia cutting-edge technology and the traction of complex engineering application requirements form a benign cycle of mutual promotion. Yu et al. said the advanced engineering CAD system is based on the careful study of the secondary development conditions and the expandable engineering application ability of the emerging multimedia system environment, and puts forward the feasible system development objectives, methods and strategies to achieve industrialization [7]. The design of building CAD system model based on multimedia simulation is based on the following three technical ideas.

(1) In depth understanding of the major changes in the technical basis of computer-aided engineering design. In our opinion, the most outstanding contribution of multimedia system and technology is that all kinds of media information carried on different interfaces can be integrated and processed comprehensively, which has opened a way to construct a multi-dimensional information space and system suitable for human. The rapid development of multimedia technology and global communication network brings new opportunities and challenges to the application research based on it, and provides a new environment for creativity. Therefore, when we study, design and build a new CAD system model, we adopt information describing different

media forms, including system mathematical model and physical model, as well as their spatiotemporal representation patterns, which are organically and uniformly modeled and solved.

(2) Fully understand the characteristics and performance of multimedia integrated application system. The era of single media has passed, and the application of single multimedia system cannot meet the application requirements of large-scale engineering design, especially in the field of civil engineering. The project itself has the characteristics of comprehensive information processing and needs. The traditional artificial segmentation research and division of labor method are formed due to the limitations of historical development, and some are not necessarily necessary or even harmful now, it needs to be reexamined and appropriately reformed. Therefore, for the engineering CAD system, it is necessary to re design the requirement analysis according to the current new information environment basis and the view of multimedia system. The new generation CAD system is characterized by multi-dimensional information retrieval on demand, analysis and calculation, simulation performance, and comprehensive design and production management assistance.

(3) The multimedia simulation system of construction engineering emphasizes the combination of building entity, physical attribute modeling of scene, attribute modeling of natural expression, qualitative and quantitative analysis of response of building structure system, abstract combination of simulation performance and temporal and spatial combination of image media performance. No matter from the perspective of modeling mechanism, achievement performance and simulation environment, multimedia simulation technology has corresponding breakthrough development in the field of construction engineering.

2.2 Development of CAD System Model Based on Multimedia Simulation

With the development of multimedia computer-aided engineering technology, the scientific research and production in the field of engineering can get new tools and technical support, and get progress, even breakthrough development. For example, in the relationship between behavior model and shape model, mathematical physical equation and audio-visual media experience of engineering. Hasan, Z et al. pointed out it was often unable to be expressed in a unified way in the computer in the past, but in the experimental system of architectural engineering simulation and 3D CAD developed by us at present, the coordinated work of unified representation processing and mutual control was realized [8].

Based on the existing achievements, we further put forward a CAD system design model based on multimedia simulation. The core of the system adopts the "five in one" integrated design method, which is composed of five basic modules, specifically including: design resource module, design object modeler, simulation solution analyzer, design achievement simulation demonstrator and design product submission module. Its structure is shown in Figure 1.

The main function modules of the system model are as follows:

(1) Design resource module, mainly including design rules and design case database to provide reasoning knowledge information of intelligent design; design project object information, related information, and media data acquisition interface.

(2) Design object modeler includes shape modeling and behavior modeling of design object, and establishes mapping relationship between abstract mathematical logic space and image media representation space.

(3) Simulation solution analyzer, system static / dynamic analysis and optimization solution of structural design, and provide demonstration data and control of motion state equation parameter change and scheme comparison.

(4) Design results simulation demonstrator, 3D visual representation of design body, 4D data field representation of structural analysis, the most unfavorable force warning, real-time animation generation, curve generation and other multimedia performances.

(5) Design results submission module, the standard submission of design results includes construction drawings, renderings, virtual building realization, design document generation, and has the function of storing design cases and related data into the warehouse.
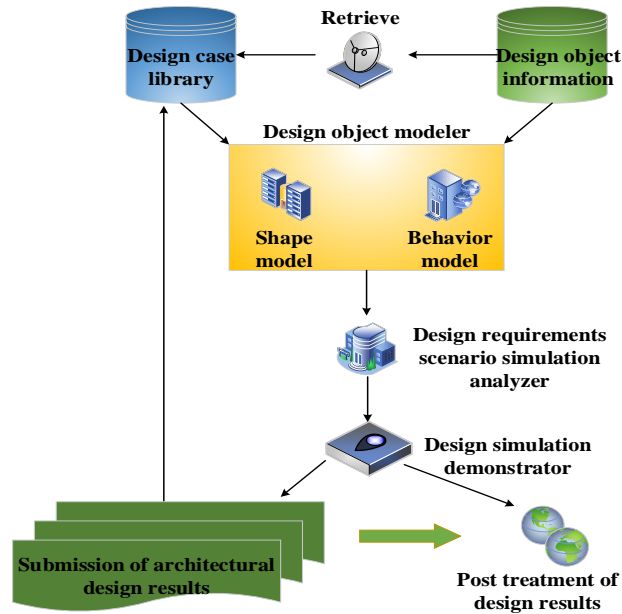

Figure 1: CAD composition structure based on multimedia simulation.

The integrated CAD system based on multimedia simulation technology is a multimedia form of engineering design from conception scheme to mechanical analysis and calculation, comparison and optimization of engineering design scheme, simulation performance and process demonstration of design scheme, and submission of user's design drawings and finished products. These main links of architectural design can be integrated in the system completely, organically and uniformly. Flow chart of architectural design based on multimedia simulation is shown in Figure 2.

As the external performance environment of multimedia simulation system, the system's simulation demonstrator processes the system model data and the system behavior data calculated by the parser, obtains the media data of image space, extends the simulation to the field described by the non-digital model, and makes the simulation result more accurate. The main functions of the system simulation demonstrator mainly include: to truly express the tower and its scene, to show the performance of the tower wind-induced vibration response, to dynamically demonstrate the tower mileage behavior, to adopt three-dimensional spatial coordinates, to reasonably judge the interaction of the system simulation object, to scientifically select the performance media of the simulation object, to control the performance of the simulation object and a variety of media to achieve consistency.
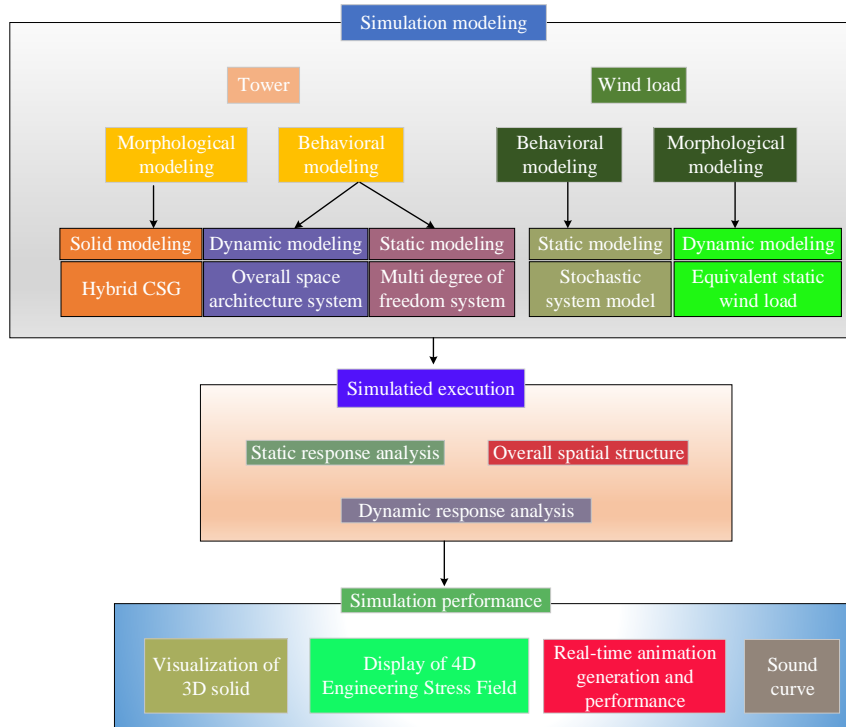
Figure 2: Flow chart of architectural design based on multimedia simulation.

3 KEY TECHNOLOGY OF BUILDING CAD SYSTEM MODEL BASED ON MULTIMEDIA SIMULATION

At present, most of the CAD software used in the architectural engineering design institutes and institutes in our country is based on the traditional division of labor in the manual design, and uses the corresponding software to assist the design of each specialty [9]. In the use of computers, the most effective is the structural calculation and the drawing of construction drawings. This is a progress of course, but far from reflecting the overall meaning and effectiveness of CAD. The design of building CAD system based on multimedia simulation is exactly the model to upgrade CAD system under the condition of the development of existing new technology. In design theory, the model of building CAD system based on multimedia simulation is based on the intelligent spatial digital information system centered on behavior modeling. It is a software system oriented to the design goal. The purpose is to make the building CAD system more integrated and humanized.

3.1 3D Morphology Modeling for Design Objects

The multimedia CAD-based architectural CAD system provides a variety of modeling methods. It uses a spatially true three-dimensional building solid model to achieve unified processing of two-dimensional and three-dimensional editing methods. Through the model and its data conversion interface, it provides input data and construction for analysis and calculation software drawing data for drawings, for which the modeling subsystem is mixed.

The main raw data of the system geometric model is the photo image of the three-dimensional solid. The steps for solving the geometric model are as follows:

(1) Use the photo image to extract the 3D solid edges.

(2) Express the extracted edges on the imaging plane of the camera coordinate system.

(3) Use the perspective projection rule to form the parametric equations of the geometric model in the camera coordinate system.

(4) In general, the number of equations in the system of equations is less than the number of unknown parameters and cannot be solved. Therefore, the constraint conditions of the basic geometric prototype need to be added to form a new equation so that the model equations can be solved.

(5) Use translation and rotation transformations to express model parameters in the global coordinate system.

(6) According to the principle of visibility, the original image is segmented with the edges of the geometric model to extract the texture data on each face of the geometric model, and the image mapping technology is used to form the texture map on each face of the 3D solid.

This method can obtain the data required for the realistic performance of 3D solids, which provides the basic conditions for the realization of a building CAD system based on multimedia simulation.

In modeling technology, the hybrid modeling method based on geometry and image is used. This is due to the specific functional requirements of the CAD system, that is, to ensure the visual reality of the building image, and to ensure the geometric accuracy required by the design and construction. In the implementation, the object model of building is divided into two precision levels of modeling and representation [10]. The CSG method is used to organize the structure of the model and draw the surface of the basic construction unit, and satisfactory results are achieved. The visualization of 3D engineering data field is the basis of simulation analysis and design. There are contradictions between the complex calculation and drawing and real-time processing. However, the constraint knowledge and inheritance relationship of building structure attributes can be used to make the efficiency of algorithm program meet the real-time requirements.

3.2   Representation Mechanism of Multidimensional Spatial Data Field

It is another important technical feature of the system model to use the integrated processing of multimedia information in time and space to fuse graphs, numbers and meanings together. In studying the simulation system of towering structure under the action of wind load, the dynamic and static representation mechanism of the force situation has been realized. On this basis, with the help of methods such as color mapping or density mapping, the space of the force field in the building structure is visualized [11]. It clearly indicates the most unfavorable position in the building structure. The finite element method is used to combine the object's geometric model, physical laws, and specific technical problems. When used in the calculation and analysis of building structural engineering design, an improved finite element meshing method is adopted so that it can be used for accurate representation The shape boundary of the object, the grid and the shape are equivalent in topology, which can divide the complex shape of any topological structure, and has high computing efficiency.

In order to realistically simulate the perspective effect produced by observing the scene from a given viewpoint, all the data of the three-dimensional geometric objects in the scene must be transformed to the screen coordinate system through perspective transformation. The screen is a projection screen that is perpendicular to the line of sight, is in front of the viewpoint, and is at a distance D from the viewpoint. Since the projection center of perspective transformation is the viewpoint, the coordinates of the projection point of a certain point on the screen can be obtained by the device-dependent transformation of the point's coordinates in the camera coordinate system. According to the similar triangle principle, the projection of P, the two-dimensional screen coordinates of the point, as shown in Figure 3.
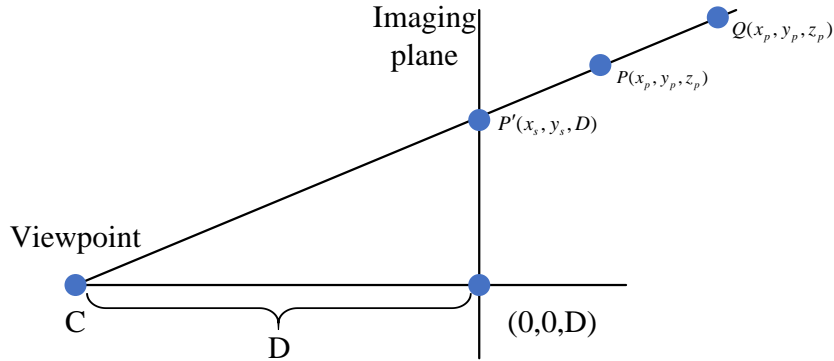
Figure 3: Imaging of perspective transformation.

It can be seen from Figure 3 that :

$$x_s = D\frac{x_p}{z_p}, y_s = D\frac{y_p}{z_p} \tag{1}$$

Because the screen is only a rectangular area on the imaging plane. The center of the area is the intersection of the line of sight and the imaging plane, so all the scenes projected on the screen are located in the view pyramid with the viewpoint as the vertex and the line connecting the vertex and the four corners of the screen as the edge. If the screen width is $2h_x$ and the screen height is $2h_y$, the equation of the four sides of the view pyramid can be determined by equation (2).

$$x_e = \pm\frac{h_x z_e}{D}, y_e = \pm\frac{h_y z_e}{D} \tag{2}$$

If the scene far enough away from the view point is not processed during drawing, the z-direction near clipping screen and far clipping plane of the view pyramid can be defined as follows:

$$z_e = D, z_e = F \tag{3}$$

The z-view cropped pyramid is transformed into a pyramid. It can be seen from Figure 3 that at any point Q on a straight line, its projection on the screen is P, but the distance between P and Q points from the viewpoint C is different. The P point is located before the Q point, thus forming an occlusion to Q. In order to reflect the distance information of P and Q from the viewpoint C, a three-dimensional coordinate component $z_s(x_s, y_s, z_s)$ is introduced as the screen coordinate system coordinates of the space point.

Obviously, the coordinate z_s of any point Q in the space can be expressed as a function of its coordinate (x_q, y_q, z_q) in the camera coordinate system, that is, the coordinate system of Q point can be obtained by its coordinate transformation in the camera coordinate system. In the camera coordinate system, after the lines and planes are transformed to the screen coordinate system, they should still be lines and planes. It can be proved that in order to satisfy these conditions, the z-transform must satisfy the equation.

$$z_s = A + \frac{B}{Z_e} \tag{4}$$

Where A and B are constants and $B\!<\!0$. For convenience, the values of z_s are normalized. That is, mapping the interval $z_e \in [D,F]$ to the interval $z_e \in [0,1]$. The transformation satisfying the conditions is as follows:

$$x_s = D\frac{x_e}{h_x z_e}, y_s = D\frac{y_e}{h_y z_e}, z_s = F\frac{1-D/z_e}{F-D}$$

(5)

Camera coordinate system is the second coordinate system needed to complete the scene transformation. The origin of the camera coordinate system is the viewpoint, and its positive z-axis direction is taken as the line of sight direction. The plane passing through the view point and perpendicular to the direction of the line of sight is the view plane. In the view plane, the vertical upward direction is the y-axis direction, and the x-axis direction is the cross product of z-axis and y-axis vector. Because the most remarkable feature of virtual reality system is to allow the virtual camera to move freely, the camera model used in the system must be easy for users to operate and control interactively. How to parameterize the geometric model of the camera effectively is the key to deal with the problem of virtual reality coordinate system. Generally, there are two kinds of parameterization of camera coordinate system, as shown in Figure 4.
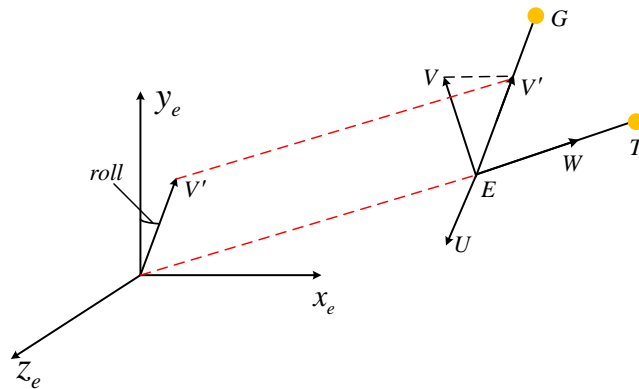

Figure 4: Camera coordinate system.

Backside culling is used to remove polygons facing away from the viewpoint. These polygons are obviously not visible because they are away from the line of sight, so they should be deleted in time to improve the efficiency of framing transformation and subsequent drawing. To determine whether a polygon deviates from the viewpoint, a geometric test is required. First calculate the normal and sight vector of the polygon, where the sight vector is the vector from the polygon to the viewpoint. Let these two vectors be N_p and N respectively, and then calculate the angle between N_p and N. If the angle is greater than 90°, that is, $N_p * N\!<\!0$, the polygon is the back side and can be deleted from the scene polygon set that needs further framing transformation, as shown in Figure 5.

3.3 Multimedia Collaborative Processing and Result Submission Technology

The virtual reality product of design object and the simulation demonstration of design scheme analysis process are provided, and the technical problems such as multimedia collaborative processing and data conversion need to be solved in the implementation [12]. For the structure of building engineering, we should consider all kinds of external loads and environmental effects,

material characteristics and structural forms, etc. so pay special attention to multimedia system and mathematical physical model to construct simulation design system [13].
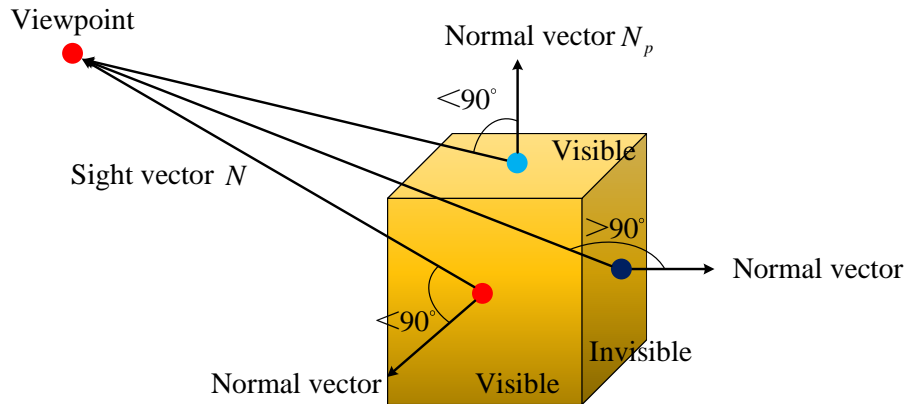

Figure 5: Back-face culling.

In this system, the mathematical model is regarded as a kind of time-varying digital media, which is integrated into the shape model of the design object, and as the internal rule and control condition of its external performance, so as to realize the combination of quantitative and qualitative methods of design research and achieve the collaborative processing and performance of multiple media. For example, the internal consistency between time series analysis and dynamic deformation of design object simulation is the basis of establishing a cooperative mechanism between simulation results demonstration and motion equation. We use autoregressive moving average model to fit the dynamic effect of random load on building entity, and achieve the requirements of relevant parts of the system.

4 ANALYSIS OF SCENARIO MODELING BASED ON MULTIMEDIA SIMULATION

4.1 Establishment of 2D CAD Drawings

An example is a 300000 ton / year acrylonitrile project of a petrochemical group. It is relatively simple to build a two-dimensional electronic map with scene CAD data. The specific methods are as follows: firstly, read the CAD data file with multimedia simulation tools, preprocess the CAD data, and filter out the useful data for the system. The vectorization of spatial data can be done with ArcGIS software. In the example system of this paper, the whole map is divided into seven layers: building plane layer, lawn line layer, road layer, workshop layout layer, pipe line layer, tank area layer and grassland layer. Overlay these layers transparently to form the map needed by the system. General layout of the project is shown in Figure 6.

4.2 Establishment of 3D Scene Model

When the planning map of the scene is known, especially the CAD data of the existing scene, the modeling process can be simplified by using the graph-based modeling method. The specific method is as follows: firstly, the CAD data of the scene planning drawing is transformed to obtain the plan outline of the whole scene, as shown in Figure 7. Because the plan outline is obtained from CAD data, its size is very accurate. Then it is imported into the 3D modeling tool software, and on this basis, the 3D models of buildings and other landscapes are established according to the height dimensions in the design drawings.
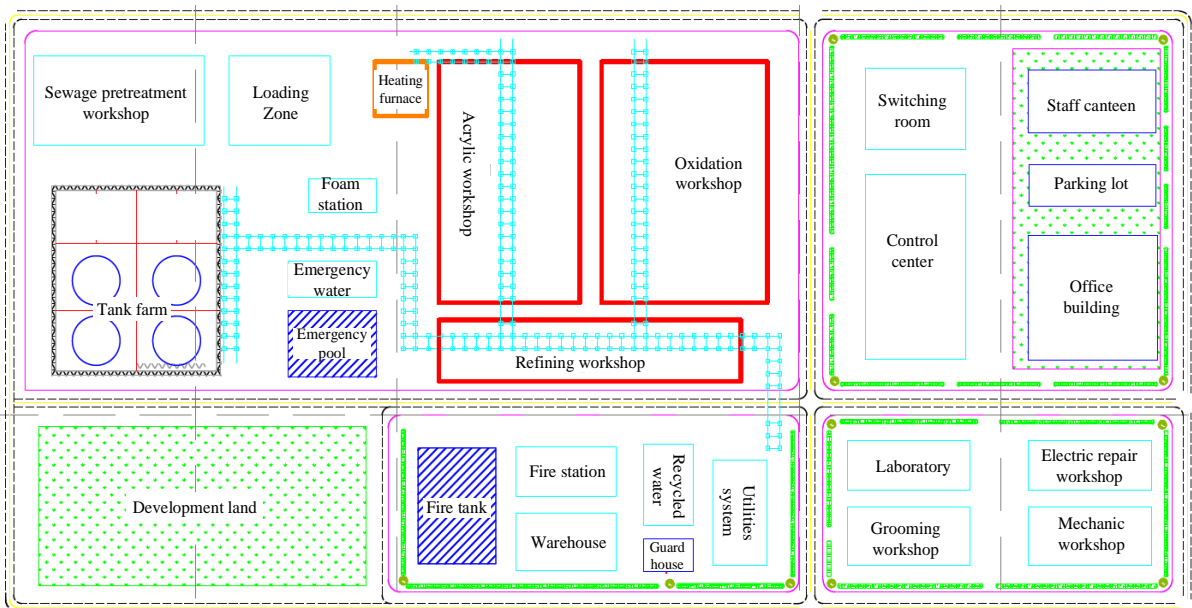
Figure 6: General layout of the project.

Figure 7: Panoramic modeling based on multimedia simulation.

When building the 3D model of a scene, the complexity of the model can be selected according to the specific application. For the application of precise model, we should refine the details of the model, but in large-scale scene, many fine models will reduce the efficiency of the system and affect the frame refresh rate. Therefore, we should ignore the non-characteristic detail information as much as possible when building the 3D model, and then make up for the loss of the simple model detail information through texture mapping to improve the reality. Simulation modeling diagram of the corner of office area is shown in Figure 8.
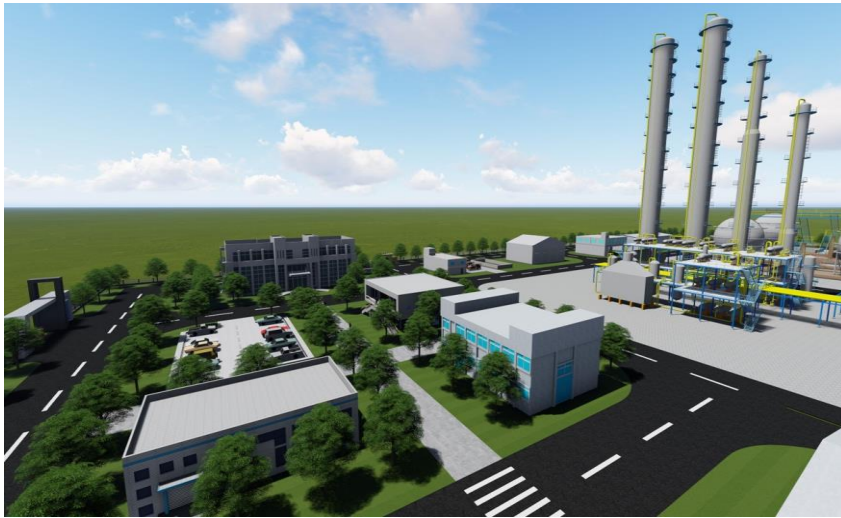
Figure 8: Simulation modeling diagram of the corner of office area.

5   CONCLUSIONS

To sum up, by analyzing the application of multimedia simulation technology in the field of construction engineering, the prototype of multimedia simulation system is constructed, so as to establish multimedia simulation system, which integrates modeling, structural analysis and simulation demonstration, so that multimedia simulation technology can play a greater role in the design of construction engineering. In the long-term process of prototype system design and development, multimedia simulation can provide great technical support for the new architectural design and analysis system. In the process of architectural engineering, system modeling, process control, result performance and other methods can be widely used to ensure the smooth progress of engineering construction, maximize economic and social benefits, and maintain the sustainable development of construction enterprises.

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