








## CAD 3D Simulation Software Design based on Computer Aided Design

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**Abstract.** In order to solve the problem of CAD three-dimensional simulated soft decoration design, a three-dimensional simulated soft decoration design for traditional indoor soft decoration based on computer-aided design is proposed. Firstly, the indoor model is established by 3DMAX software, and the model is imported into the OpenGL 3D graphics standard library module. Secondly, the basic geometric elements are used to draw the indoor soft decoration scene elements, and the scene elements are constrained through the through wall, overlap and size constraint functions to ensure the reasonable layout of the indoor soft decoration agent area and enrich the indoor model. After the enrichment, the indoor model is transmitted to the transformation unit of Direct3D rendering engine module to implement the soft decoration layout. Finally, the lighting unit and rasterization unit are used to render the indoor layout, obtain the optimal indoor soft decoration effect, and output the three-dimensional simulation image of indoor soft decoration. This design paradigm is more efficient in terms of editing and has superior operating performance. The suggested approach may quickly complete the soft decorating three-dimensional simulation of the target room, demonstrating the system's three-dimensional simulation capability. It is proved that the software simulated by the system has strong authenticity, the average running time of editing operation is 327ms, and the user satisfaction is high.

**Keywords:** Computer; CAD ; Three-dimensional simulation; Soft decoration design; Aided design, 3D MAX software.

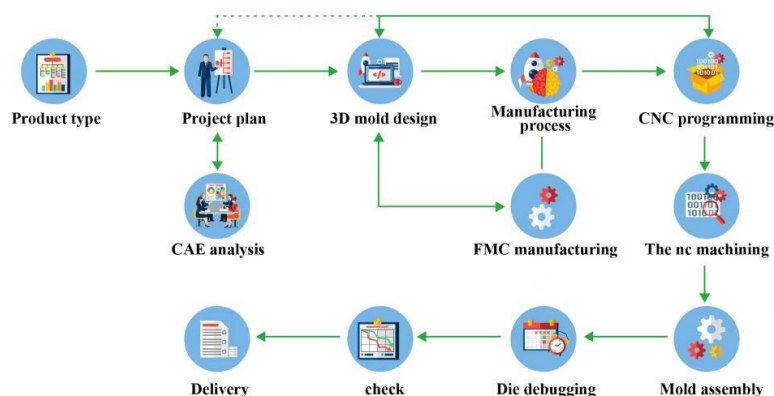
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## 1 INTRODUCTION

Indoor soft decoration, also known as indoor furnishings, refers to the later decoration and layout of furniture, cloth art, lighting and so on in the space of family or commercial buildings [1]. With the rapid development of China's economy and the improvement of people's living standards, we gradually pay attention to the quality of family decoration. A good indoor design will address scale, resolve function, develop a desired aesthetic, and affect productivity. People are happier and calmer when their homes are well-designed [2]. It has the power to inspire trust, empathy, pride, innovation, security, and vigor. Everything from custom built-ins to custom closet design may be used to create a room where everything has a place. Designers spend time learning about your lifestyle and then creating a space that is personalized to it. The quality of home decoration not only refers to the quality of furniture materials, but also the color matching and living comfort. The quality of decoration can directly reflect the cultural connotation and life taste of residents. When formulating the interior soft decoration scheme, designers usually need to communicate with customers and modify the design through the software that can directly display the interior design. Therefore, a three-dimensional simulation system that can truly simulate the interior soft decoration is of great significance to improve the quality of home decoration design [3].

Interior designers may employ 3D models to better communicate ideas to consumers through three-dimensional visualization, resulting in higher project acceptance rates. With 3D interior decoration, clients have greater power since they may edit or adjust overall design. The traditional 3D simulation system of indoor soft decoration usually selects the geometric modeling method to obtain the indoor scene information. Although the cost is low, the performance of development tools is poor, resulting in the lack of authenticity of the system and the inability to obtain the real color matching and decoration materials. The design method outlined here will help designers create floor plans, see rooms in 3D, and design various components of the space for both aesthetic and practical purposes. To provide a realistic portrayal of a space, everything is done digitally. It will also help designers increase their work. The soft decorating three-dimensional simulation of the target room will be completed swiftly by the model, displaying the system's three-dimensional simulation capacity [4].

This paper designs a 3D simulation system of indoor soft decoration based on computer Direct3D. The system combines OpenGL software and Direct3D software to effectively improve the authenticity of 3D simulation of indoor soft decoration, make customers truly feel the effect of indoor soft decoration design and layout, and improve the quality of indoor soft decoration design, as shown in Figure 1.



**Figure 1:** Short, centered caption, terminated with a full stop.

The basic structure of the software has been illustrated in the figure. The software has various functions which will help for decorate the indoors according to the surrounding. This will meet people's requirements for living environment in the design process.

## 2 LITERATURE REVIEW

With the development of social productive forces and the continuous improvement of people's living standards, the requirements for the environment in the living space are also higher and higher, especially for the spiritual and cultural requirements of the living space environment and the attention to the requirements of high-grade life, so they invest more energy and financial resources to improve their quality of life. After meeting the most basic living functions, people began to pursue the comfort and beauty of the living environment. People are eager for a rich and colorful life and also want to have elegant taste, which requires that indoor decorations not only emphasize artistry and aesthetic connotation, but also be closer to life. This requires designers to have both design ideas and meet people's requirements for living environment in the design process [5].

The progress of science and technology has promoted the development of soft decoration design industry, thus promoting the development of indoor environment design. Interior design trends have altered considerably over the last decade, and it appears that rather than springing from grassroots design groups, journals and popular fashion channels are now defining the latest patterns [2]. Colors are incredibly important in interior design and are regularly incorporated into the most recent interior design trends. Colors elicit emotions in those who will be in your presence; therefore, they may make or break your thoughts [6]. In order to produce in line with current trends, colors should complement the style, design, and mood of the home. In past seasons, warm hues were replaced with cooler colors such as purple [7]. Koehler, M believes that the development of the two industries promotes the innovation of design, which stimulates people's continuous pursuit of fashion. The combination of these factors promotes the continuous improvement of people's requirements for living space environment [8]. Interior design involves all aspects of the building process that have an impact on the finished result. This includes designers' furniture and color selections, as well as a range of other factors. Wasted space is every homeowner's greatest fear [9, 10]. Unusable or underutilized areas are doubly aggravating in a brand-new home built to your preferences. This will not happen because of Godd's design [11, 12].

The new smart technology will calculate the square footage of your new home to guarantee that it contributes to the overall product. Interior design will frequently incorporate factors like light, color, and the usage of certain textiles. These features are meant to improve your quality of life while also adding to the attractiveness of your house [13, 14]. Xu, X. believed that the sprout of interior environment design had been produced very early. From the perspective of ideology, this consciousness had been produced since human beings began to build nests with wood [15]. Safaiezadeh, B. believed that the industry of interior environment design was gradually formed after the reform and opening up [16]. Wang, J believes that after 30 years of development, the level of indoor environment design has been greatly improved, but there is still a big gap compared with the design level of foreign countries [17]. Of course, there are also some excellent indoor environment design works in China. Ge, Y. believes that soft decoration design is an indispensable part of indoor environment design. Different soft decoration designs reflect different personal tastes and can better set off the diversity of the overall interior design [18].

Soft furnishings are those parts of your house that complement the interior design and provide a soothing atmosphere. Soft Furnishings include everything made of soft material, such as mattresses, curtains, pillows, covers, sofas, bed sheets, and so on. All of these variables work together to create enjoyable and a comfortable living environment [19, 20]. Soft furnishings are an integral aspect of modern interior decoration. This term arose as a result of the increasing usage of soft fabrics in living and drawing rooms to add beauty to the space while also giving comfort in daily situations [21, 22]. Sun, C. believes that with the continuous development of soft

decoration design, although the proportion in interior design is increasing, soft decoration design and hard decoration design are inseparable in the best interior design [23]. Vitek, O believes that with the increasing growth of the country and the increasing improvement of people's living standards, international cultural exchanges bring people's desire to pursue a higher quality of life [24]. Yang, J. believes that Chinese, European and other exaggerated soft clothing designs can be seen everywhere: from a family to shopping malls, hotels and other public places [25]. This provides more space and market potential for soft decoration design.

Le, K believes that this emerging industry will develop rapidly under the infinite space and market prospect, and soft decoration design will be everywhere in the near future [26]. Soft decoration may improve the look of any living space. High-quality fabrics create a sense of comfort, fullness, and warmth. High-quality soft furnishings strategically arranged in various places are essential to interior design endeavors. That is the demand of modern-day housing. Based on the current research, a CAD three-dimensional simulation software design based on computer-aided design is proposed. The design combines OpenGL software with Direct3D software. Firstly, 3DMAX software is used to establish the indoor model, and then OpenGL software is used to add indoor scene elements and restrict the scene elements to enrich the indoor model. Finally, the final layout and shading of furniture are carried out through Direct3D software to realize the effective three-dimensional simulation of indoor software, so as to provide a reliable analysis basis for indoor design [27].

### **3 CAD 3D SIMULATION SOFTWARE DESIGN BASED ON COMPUTER AIDED DESIGN**

#### **3.1 Soft Decoration Design**

##### *3.1.1 Contrast*

In order to better meet people's needs for interior decoration, interior designers introduced the concept of soft decoration design art. Soft decoration design has strong set off functional characteristics in interior design. Interior designers decorate some unique furnishings in terms of style and shape, and make the indoor space of the building artistic, which not only adds a bit of interest to people's daily life, but also effectively improves people's quality of life. Through the matching and replacement of several different colors, the furnishings of soft decoration design can be transformed into several interior design effects with different styles, which make the residents full of freshness [28]. For example, in a room with a small space, interior designers can lay part of it under the tea table and decorate it with sofa cushions or cloth art full of decorative features, which can not only set off the warmth in the space, but also effectively highlight the theme of the indoor space [29]. At present, the main application of environmental art in China lies in interior decoration and design, and its scope is very wide. Excellent soft decoration design art can better set off the characteristics of space, which is also one of the important functional characteristics of soft decoration design.

##### *3.1.2 Hierarchy*

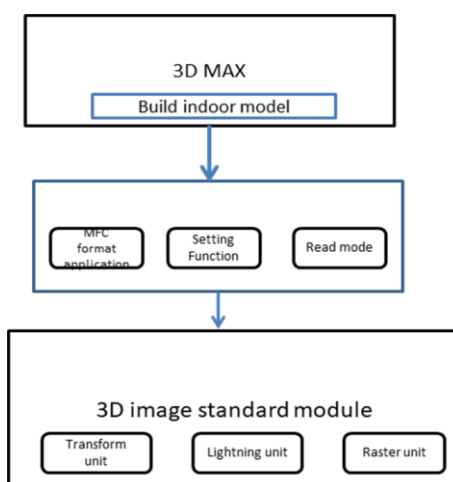
From the perspective of decoration effect, if interior designers only carry out interior decoration design through hard decoration, the space will appear monotonous to varying degrees, while the art of soft decoration design can effectively alleviate some defects of hard decoration, make the whole space have strong hierarchy, and have a more sense of harmony in terms of the overall effect. The furnishing method of furniture is a very important content in the art of soft decoration design, which mainly includes the two forms of separation and organization, and the selection process of furniture and other furnishings also has a lot of skills. Interior designers need to comprehensively consider and screen the form, color and texture of furniture according to the characteristics of residents' personality, hobbies and identity taste, so as to finally make the whole interior space present the best state [30]. Through soft decoration design to add a sense of hierarchy to the interior space, interior designers can consider the following two aspects:

First, when the hard windows are insufficient in shape, position and other forms, interior designers can decorate them through soft curtains, and determine the material, style and color of curtains through the area of design space, the distinction between light and dark surfaces and the reasonable matching of colors between other home decoration materials. This can further beautify the interior design; second, when interior designers encounter dead corners in space design and are difficult to deal with them, they can place some furnishings of green plants in this position. This can not only effectively guide and transition the dead corner visually, increase the sense of hierarchy of indoor space, but also purify the indoor air, and meet the basic requirements of residents to get close to nature to a certain extent [31].

## 3.2 3D Simulation System

### 3.2.1 Overall structure of 3D simulation software installation system

The overall structure diagram of indoor soft decoration 3D simulation system is designed based on OpenGL software and Direct3D software, as shown in Figure 2. The system selects windows7 as the operating system, uses 3DMAX7.0 software for indoor soft decoration 3D model and animation, and uses the combination of OpenGL software and Direct3D software as the 3D program development tool. Additionally, 3ds Max is a computer graphics tool used to create 3D models, simulations, and digital photographs. It is one of the most popular applications in the computer graphics business and is well renowned for having a powerful toolset for 3D artists.



**Figure 2:** Overall structure of three-dimensional simulation soft installation system.

OpenGL software and Direct3D software are included in the scope of program interface. OpenGL software can display the required functions by using points, lines, simple graphics and complex curves and surfaces, and can be operated on UNIX, windows7 and other platforms. The main function of OpenGL software is to draw indoor scene element graphics and send them to Direct3D software for final processing [32]. Direct3D software is a 3D drawing programming interface, which uses Direct3D software to classify different hardware with the same function through abstract processing. 3DMAX software is used as the modeling tool to establish the indoor model, which is saved to the 3DS format file after the modeling is completed. The 3DS format is a format stored in the form of "block", including various scene data and editing windows in the room to be soft installed. The indoor model established by 3DMAX software is used to draw the indoor soft decoration scene elements and enrich the model by using the OpenGL 3D graphics standard library module. Convert the enriched model into "x" format file and add it to the Direct3D rendering

engine module for layout and rendering operation. After editing, output the final 3D simulation image of indoor soft decoration.

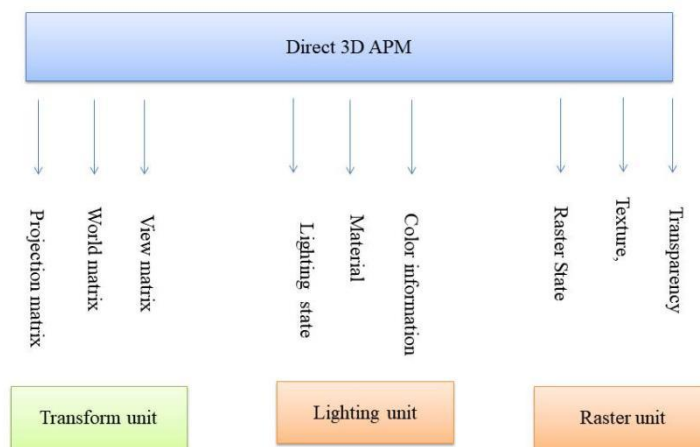
### 3.2.2 OpenGL 3D graphics standard library module

Import the 3DS format file established by 3DMAX software into OpenGL software. OpenGL software does not support reading 3DS format files directly. Therefore, it is necessary to convert 3DS format files into C format files that can be read by OpenGL software by using third-party tools such as view3d. The .h and .gl format files generated when converting C format files are imported into the program framework of OpenGL software, and the required models can be obtained in OpenGL software by code compilation. The above process may lead to the loss of scene elements such as soft furniture or decorations. However, the system in this paper does not add system scene elements such as furniture when using 3DMAX software to establish the indoor model, so the above process is feasible in this system.

### 3.2.3 Direct3D rendering engine module

Direct3D software can provide real-time 3D support for the model. It is an intelligent image operation software, which realizes 3D operation through graphics hardware interface. Direct3D software only supports "x" format files, and OpenGL

After the 3D graphics standard library module is enriched, the model is converted into "X" format file and added to the Direct3D rendering engine module for operation. The Direct3D rendering engine module mainly includes transformation unit, lighting unit and rasterization unit. The specific structure diagram is shown in Figure 3.



**Figure 3:** Direct3D rendering engine modules.

## 3.3 Application of CAD in 3D Simulation Soft Decoration Design

### 3.3.1 Module establishment

When designers draw schemes manually, they often use various templates. For example, the toilet template (there are all kinds of washbasins, bathtubs, toilets, urinals, etc.) and the furniture template allow all kinds of sofas, chairs, wardrobe, etc., which can greatly speed up the drawing speed, improve the drawing quality, and make the scheme neat, standardized and beautiful. It is necessary to set such a template in the software. Some basic elements of indoor layout are made into a graphics library. There are standard settings according to the standard, and there are no standard settings according to several specifications used as usual to make a two-dimensional

graphics library. Of course, it is more ideal to correspond the three-dimensional model library to the two-dimensional graphics library (that is, to meet the projection relationship). In terms of CAD technology, there are no technical obstacles [33].

### 3.3.2 Preparation of construction drawings

In practical application, few people use CAD for interior design and construction drawings. This is because of the slow speed. The electrical, plumbing and engineering budget of interior design can be CAD, because computer workers have developed corresponding software for them. In theory, interior design and construction drawings are mainly flat, vertical, section and detail drawings of architectural drawings, but interior design is different from architectural design. Almost all building components have national and regional standards, while the shape, size, material and structure of interior design are complex and difficult to unify. This is the difficulty of software design. The second is the immaturity of CAD technology. If 3D modeling can quickly generate solid model, it should not be a problem to quickly generate its local section and section to solve the problem of quickly defining and modifying solid model and quickly generating section drawing. For example, the section bubble of the designed door pocket includes the shape, size, material of the door frame, the shape, size, material of the decorative line, the connection relationship between the decorative line and the door frame, the connection relationship between the door frame and the wall, the section of the door leaf, and the node diagram of the connection between the door pocket and the door leaf [34].

## 4 EXPERIMENTAL ANALYSIS

### 4.1 Application of 3D Simulation Software Installation System

#### 4.1.1 Comparison of system operation

The system mainly operates through the mouse and keyboard, edits the three systems with different functions, and counts the function operation and time consumption of the three systems. The operation test results of the three systems are shown in Table 1.

<i>Function</i>	<i>Function Operation Key</i>	<i>Running Time / Ms</i>	<i>Function Operation Key</i>	<i>Running Time / Ms</i>	<i>Function Operation Key</i>	<i>Running Time / Ms</i>
<i>Shift Left</i>	4	251	4	725	4	574
<i>Shift Right</i>	4	265	4	788	4	580
<i>Shift Right</i>	4	274	4	763	4	766
<i>Back Off</i>	3	251	5	752	5	624
<i>Narrow</i>	5	265	3	812	4	521
<i>Enlarge</i>	3	283	5	756	3	453
<i>Rotate</i>	2	250	1	833	5	670

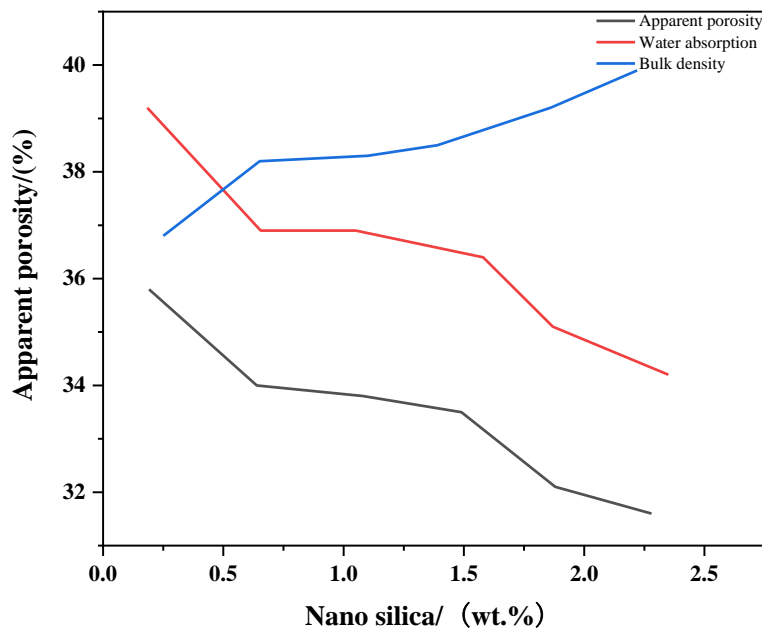
**Table 1:** Comparison of system operation.

By comparing the operation results of the three systems in Table 1, it can be seen that the three systems can realize the basic operation of the system. The average running time of editing operation of this system is 327ms, while the average running time of editing operation of Untiy3D system and Smart3D system are 755ms and 637ms respectively. According to the statistical results, this system runs faster for editing operation and has better operation performance [35].



#### 4.1.2 Time comparison of 3D simulation of indoor soft decoration

Make statistics on the indoor soft decoration of each room in the three-dimensional simulation sample room of the system, and compare the system with Untiy3D system and Smart3D system. The statistical results are shown in Figure 4. It can be seen from the statistical results in Figure 4 that the time used for indoor soft decoration 3D simulation of four rooms in this system is significantly lower than that of untity3d system and smart3d system, and the time used for simulating four rooms does not exceed 8000ms. It shows that the system in this paper can complete the soft decoration three-dimensional simulation of the target room in a short time, which verifies the three-dimensional simulation performance of the system [36].



**Figure 4:** Comparison of three-dimensional simulation time.

#### 4.1.3 Layout of indoor soft decoration Agency area

In order to obtain the best indoor soft decoration effect, the indoor soft decoration Agency area should be reasonably arranged. Indoor soft decoration mainly refers to the indoor layout through indoor furniture, household appliances, decorations and other indoor decoration objects. The above decoration objects are used as system scene elements, and the decoration objects that can cooperate to complete a certain function are used as a group of system agent areas [37]. The problem of indoor soft decoration is actually to optimize the layout of the agent area, that is, to make the system scene elements complete the reasonable location distribution in the target space. In order to obtain the constraint specification in the process of indoor soft decoration, the constraint specification should be obtained according to the functional requirements of indoor decoration and indoor soft decoration, and the constraint cost function should be solved to obtain the optimal indoor soft decoration layout result. Let the set of agent area layout in the target space be  $C=(Q,S)$ , where  $Q$  and  $S$  represent the agent area set and the target space feature set respectively, and  $Q_i = \{ \}$   $Q_1, Q_2, Q_k$ . The  $i$ -th proxy region in the target space is described by  $Q_i = (g, (a, b), \alpha, l, w)$ .  $g$  and  $(a, b)$  represent the work type and the location of the proxy region



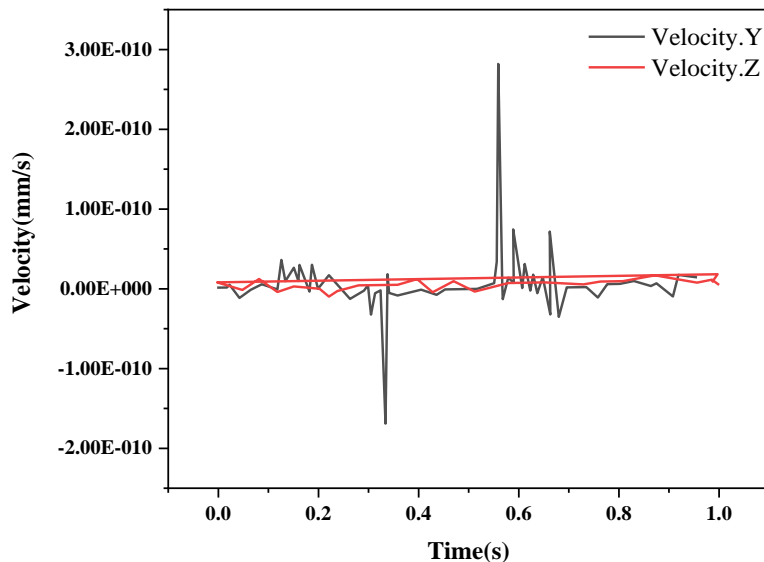
respectively;  $a$  represents the direction of the agency area;  $l$  and  $w$  represent the length and width of indoor rectangular space respectively. The specific location of the proxy area is the coordinates of the lower left corner of the rectangular space. The constraint function mainly represents the constraints on the layout of the agent area when arranging the indoor target space. During indoor soft decoration, the indoor scene elements shall meet the decoration function and visual requirements. In order to meet the above conditions, three constraint functions, through wall constraint, are proposed. Indoor scene elements need to be arranged within the target space. If indoor scene elements pass through the wall during the layout process, the constraint function will punish the scene elements passing through the wall [38]. The through wall constraint function is obtained by the difference between the size of the proxy area and the indoor sideline polygon, as shown in Formula 4.1:

$$(1+x)^n = 1 + \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} + \dots \quad (4.1)$$

## 4.2 3D Simulation Design

### 4.2.1 Realization of 3D simulation design

No matter using any modeling technique of three-dimensional simulation technology, in order to realize the solid printing of design elements, we must go through four steps of "style determination - prototype design - three-dimensional model - solid model". After determining the design style and design element modeling in the above, we must conduct three-dimensional modeling of the design model through computer software, scan and slice layer by layer through computer software, save the slice data as the STL code file of the computer, and upload it to the three-bit simulator [39]. The 3D printer will judge whether the size of the model is appropriate and whether it needs the assistance of supporting materials according to the coordinates generated by these STL code files, and feedback the information to the computer. In the software, you can see whether the production of this design element is established, so as to verify whether the previous design can achieve the expected effect as shown in Figure 5:



**Figure 5:** Stop Computer feedback effect.

The case mainly involves the following technical contents:

- 1) 3D modeling: In this case, the virtual model of the design is built through 3dsmax software. In terms of scale, because it is limited by the printing size of the three-bit simulator itself, the scale of 1:20 is selected for modeling. Under the modeling technique of long lines and large lines, the virtual model is made by means of two-dimensional line modeling. Because it is necessary to realize solid printing on the model, the "seal start end" and "seal end" need to be specially set at the seal of the virtual model to ensure that the virtual model has no open edge and is a completely closed model. After modeling, it needs to be saved as STL code file for three-digit simulator software to read [40].
- 2) Slice by slice scanning: Import the previously stored STL code file into the host computer software repeater host of 3D printer, and then observe the placement position of the printed object in the computer through the printer software repeater host. Select the "center" and "drop" options to place the required printed object straight to the appropriate printing origin. When everything is ready, click the slic3r option in the operation bar with the left mouse button to scan and slice the printed object layer by layer, cut the three-dimensional model into several plane graphics, and record the line segments of the object in the form of coordinates of points.
- 3) Data return and virtual display: After scanning the virtual model layer by layer through the 3D printer upper computer software repeater host, wait for a period of time proportional to the size and complexity of the virtual model, the upper computer software will send the data back to the computer, and virtually display the physical shape after the estimated printing in the small window of the computer. If the virtual estimated physical modeling meets the requirements, the next step is to set the system parameters of the 3D printer to realize the entity production of the virtual model; If there is still a certain gap between the physical modeling of Virtual Prediction and the conceived modeling, or if it cannot be formed, it means that the object is too complex, the default height gap of the system is too large, and the configuration parameters can be adjusted in the menu until the virtual physical shape of the prediction is up to [41].
- 4) Set parameters: After the slicing of the virtual model is completed and the reasonable Virtual Prediction physical modeling is obtained, it is necessary to determine different parameter settings according to different print models. When modifying the configuration parameters in the menu bar of repeater host, the upper computer software of 3D printer, the variables that mainly affect the production of solid model mainly include nozzle temperature, default hot bed temperature, layer height, filling density, printing speed and so on. The change of nozzle temperature and default hot bed temperature is mainly based on the melting point of different materials; The layer height determines the fineness of the printed object; The density of a hollow object determines whether it is filled or not; The printing speed can change the accuracy of the printing entity. The slower printing model can allow each coordinate to be cooled for sufficient time, so that collapse is not allowed.

Through observations, it was discovered that the suggested system can complete the soft decorating three-dimensional simulation of the target room in a short amount of time, demonstrating the system's three-dimensional simulation performance. The design process discussed here will assist designers in creating floor plans, seeing rooms in 3D, and designing various components of the space for both aesthetic and functional reasons.

## 5 CONCLUSION

To sum up, in order to facilitate interior designers to better design indoor soft decoration and improve the authenticity and real-time of the three-dimensional simulation effect of indoor soft decoration, this paper designs the three-dimensional simulation design of indoor soft decoration based on computer. The design method outlined here will help designers create floor plans, see rooms in 3D, and design various components of the space for both aesthetic and practical purposes. To provide a realistic portrayal of a space, everything is done digitally. It will also help

designers increase their work the system combines OpenGL software with Direct3D software. Firstly, 3dmax software is used to establish the indoor model, and then OpenGL software is used to add indoor scene elements and restrict the scene elements to enrich the indoor model. Finally, the final layout and rendering of furniture are carried out through Direct3D software to realize the effective three-dimensional simulation of indoor soft decoration, so as to provide a reliable analysis basis for indoor design. The work given appears to be decent, but there is room for improvement. People are gravitating toward warm tones and natural components in interior design trends, which appear to be more eco-friendly. This will result in a more sensible layout of the interior soft decorating agent area, as well as an enhancement of the indoor model.

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