Research on Industrial Product Modeling Design Method Based on Deep Learning

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Abstract. In order to use deep learning theory to model the appearance of industrial products, in order to use its advanced technology to improve the efficiency of industrial product modeling design, a deep learning-based industrial product modeling design method is proposed. The ingenious points of appearance design can be found through the deep learning database. The modeling structure of industrial products is analyzed from three aspects of right-angle modeling, bevel modeling and special-shaped modeling, and the projection can be transformed by the calculation method of the model. Reduce the time required for calculation under hardware conditions. In the three-dimensional distribution area m × m of the product, the texture segmentation of the image pixel intensity at the maximum pixel point is carried out to complete the 3D geometric modeling of the industrial product modeling design. The 3D modeling, modeling evaluation and modeling storage operation of the industrial product modeling elements are carried out to realize the industrial product modeling design. The experimental results show that the industrial product modeling design method based on deep learning has better output performance, higher product fidelity and better visualization effect.

Keywords: Deep learning · Industrial products · Modeling design · Modeling structure

1 Introduction

"Industrial design" was born in the process of evolution from "handicraft economy" to "industrial economy". Since the birth of modern design, there have been controversies about the relationship between form and function in design. Affected by large-scale industrialization, the design master Mies' slogan "less is more" was highly respected once it was put forward. From modernism to internationalism, function is always the first element of design. Due to the post-war turmoil and the development of science and technology, postmodernism and pop style, represented by pop style, have gradually become popular and replaced modernism [1, 2]. They pursue the expression of form and pure decoration. Although this trend of formalism is very exploratory, it soon declines because it violates the economic law of industrial production. The new modernism and multiple design styles after that are diversified explorations after the game of form and

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function of design. Nowadays, the function and form in industrial design are no longer simply opposites. The harmonious unity of the two is the trend of modern industrial product design. In the process of industrial product design, the conflict arising from the fusion of shape and structure ensures that the product realizes its function, and at the same time, through the shape design, the competitiveness of the product in the market is guaranteed.

In recent years, in addition to being widely used in the field of engineering technology, the research on deep learning has also developed a variety of application versions in other non-technical fields such as teaching. These new studies find that deep learning is very useful in non-technical fields from a certain angle. Product modeling design is an interdisciplinary subject. In addition to the technical field, it also extends to many non-technical fields, such as aesthetics and psychology. This article focuses on and expects to solve the main problems, how deep learning should be applied to effectively solve the technical and non-technical modeling design problems.

In terms of theoretical research, compared with the United States, Russia and other countries, the promotion of deep learning education has penetrated into secondary schools, even primary schools, the gap is indeed obvious. In China, the related courses of deep learning education are only opened in a few colleges and universities, and the practical application defects in the business sector are even greater. In the current research on deep learning [3]. Category is limited to theoretical research and academic discussion. This situation should be paid attention to.

The core content of product design methodology is innovative methods. The theoretical development and methods of modern product design urgently need to apply the theoretical research results of deep learning to the process of product modeling design. It is foreseeable that the only way for enterprise design innovation in my country is the gradual promotion and application of deep learning research results in actual production.

Yan Bao [4] in order to use virtual reality technology to model the appearance of industrial products, so as to facilitate the use of its advanced human-computer interaction technology to improve the efficiency of product modeling design, this paper proposes a method of industrial product modeling design based on virtual reality technology. Firstly, the influencing factors and aesthetic principles of industrial product modeling design are analyzed, and the overall framework of virtual design environment is constructed; then, the stereo vision model is established, and the virtual environment is created by Vega virtual reality development platform; finally, the effect analysis of product modeling in virtual environment is given. By applying virtual technology to product modeling design, product modeling and human-computer interaction effects can be evaluated and improved before product manufacturing, so as to shorten the development cycle and reduce product production costs. In order to effectively improve the efficiency of product modeling design, Li Qiuwen [5] designed an industrial product modeling design system based on improved differential evolution algorithm. Firstly, the process and logical process of product modeling design are analyzed, and then the specific system workflow is given according to the functional structure of requirements. Finally, the improved differential evolution algorithm is proposed and applied to product modeling design. The system software is implemented by. Net development platform. The system

running test results show that the system can assist designers to design industrial products and provide a good technical support for further innovation design. Li Jiangyong [6] In order to solve the problem of brand characteristics of product modeling in industrial design, he proposed a product modeling design method based on brand image, and explored the correlation between corporate brand image and product modeling design. Carry out modeling design research with hydraulic excavator as the research object, locate product modeling image according to brand image characteristics, develop product modeling with brand image characteristics, realize sustainable innovation of product modeling design under brand culture, and further enhance product market competition Strength and brand recognition have verified the product modeling design method based on the corporate brand image. Jin Wenkui et al. [7] explored the application of three-dimensional anthropometry technology in the design of wearable products. Methods based on the introduction of the concept of fitness, the new characteristics of the combination of 3D anthropometry technology and wearable product design were analyzed in view of the human body data challenges encountered in the design practice of wearable industrial products, and the product adaptation design strategy based on 3D anthropometry was summarized. Conclusion more detailed data, information and knowledge of human body can be obtained through 3D anthropometry technology, which can improve the adaptability of wearable product design and better explain the user-centered design concept.

Based on the above research background, this paper applies deep learning to industrial product modeling design, analyzes the modeling structure of industrial products through right angle modeling, oblique angle modeling and special-shaped modeling, and transforms the projection through the calculation method of the model. In the three-dimensional distribution area of the product, the image at the largest pixel is processed by texture segmentation, and the 3D geometric model of industrial product modeling design is constructed to realize the industrial product modeling design. The effectiveness of this method is verified by simulation experiments.

2 Modeling Design Method of Industrial Products

2.1 Analyze the Structure of Industrial Products

The appearance modeling of industrial products has a certain purpose. It is restricted by the structure, function, material and technology of industrial products. However, the starting point of the design is to satisfy industrial products in terms of function, and to optimize the design in terms of structure, the rationality and suitability of the design must be fully considered to ensure the balance of the entire shape [8]. Analyze the appearance of industrial products through the deep learning database, and divide the product models into three categories: direct, oblique, and irregular. Through the analysis of various pictures, as shown in Fig. 1.

Through the deep learning database, you can find the ingenious points of appearance design, which can better serve the industrial product styling.

The main purpose of the establishment of deep learning elements is to make the product modeling design meet the requirements of technical beauty. The so-called technical beauty is the product of the integration of science and technology and art. It unifies the

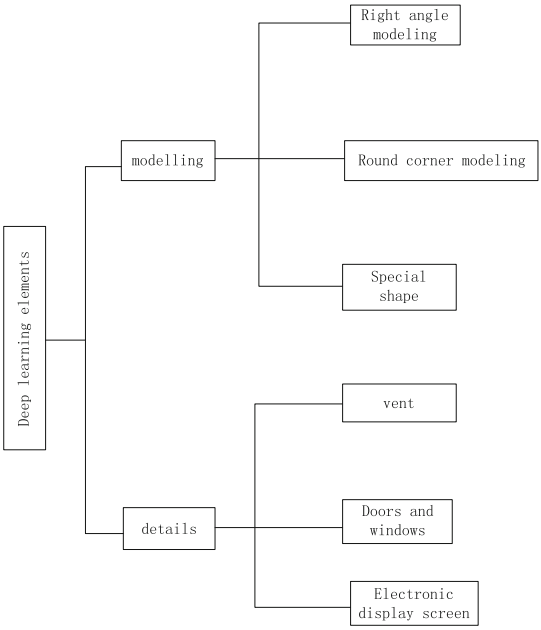

Fig. 1. Structure of deep learning database

law and content of the form through technical means, and achieves a unified aesthetic feeling in the sense. In the future design, the modeling design is analyzed according to the following factors, which is more conducive to the product design.

(1) Functional and structural beauty. Functional beauty reflects the technical rationality of industrial products. Functional beauty is also an aspect that attracts consumers. Its technical quality determines the product's status in consumers' eyes, but it needs to be distinguished between primary and secondary functions; Structure is a system composed of products according to certain principles, and different structures will produce different shapes. Structure, materials and technology are interrelated.
(2) Beautiful workmanship. Material is the basis of realizing product structure, its concrete manifestation is the beauty of texture, to some extent, it is the deepening of technology; technology is the means of product realization, any product want to get the shape of beauty must be implemented through the corresponding process.
(3) Color and standard beauty. The color of the product is dependent on the shape of the product itself. The color can increase the visual power, attractiveness and appeal of the product, and can actively attract people's attention. The beauty of color comes from the harmony and contrast of colors, which changes with the changes of the times; any product should have corresponding specifications, that is, product standardization. The production process of a product requires the cooperation of various disciplines. And the part that can be planned is standardized production.

2.1.1 Analysis of Right Angle Modeling of Industrial Products

In deep learning elements, right-angle modeling is divided into three cases, the first is that all four corners are right angles: the second is the upper right angle, the lower bevel or rounded corners; the third case is the lower right angle, the upper one Bevel or rounded corners [9].

Right angle modeling is widely used in textile machinery design and CNC machine tools. Because of its less change in shape, we need to pay attention to the change and unity in the use of modeling. Right angle modeling gives people a neat aesthetic feeling, but in product design, it is easy to appear that the modeling is too neat, too unified and unchanged, which makes the product modeling appear dull, boring and lack of vividness. In the shape change, when designing a single object, its shape is determined by its structural characteristics. When unifying its shape, the product can be changed appropriately, such as adding decorative lines and chamfering; for serialized products, Because its different product structures and functions determine the different forms of products, resulting in differences in the sense of form, the main task of its appearance design is to use various elements to form a unified set of products under the premise of change. However, it should be noted that the function of the product itself should not be affected by blindly seeking unity, or the processing technology of the product is complex and the cost is high.

The structure, function, industry and other factors of industrial products determine the objective conditions of product modeling. When changing and unifying, the following two principles should be followed [10].

The proportion of segmentation should be coordinated and unified. The proportion relationship between the whole and the part, the part and the part, the part and the detail of the same product should be selected as much as possible, so as to strengthen the interrelation between the various parts. The unity of proportion can strengthen the rationality and make the product design achieve a unified overall effect.

The unity of linear style and color. Regardless of what kind of product is designed, the overall shape of the product is regarded as a whole. The overall contour line and the contour lines between the parts of the product should be roughly the same, and the line type needs to be divided into primary and secondary. The color is unified to form a whole with the line type.

2.1.2 Analysis of Oblique Angle Modeling of Industrial Products

To some extent, the bevel shape is a transformation of the right angle shape. In the case of the right angle shape structure unchanged, in order to break the rules of the shape, the product shape is cut or chamfered. In terms of styling, pay attention to the proportion of the product. The relationship between the overall length, width, and height of the product and the relationship between the whole and the part, and the part and the part. The good ratio is not produced through intuition and estimation, but conforms to the corresponding scientific laws.

In the deep learning elements, the oblique modeling is divided into the upper oblique angle, the lower right angle, the upper right angle, and the four corners are all oblique

angles. In recent years, people have less choice for all the corners for right angle modeling, adding the oblique angle and fillet into the line, making the streamline modeling more formal. At the same time, the cultural characteristics of the enterprise and the cognition of the brand should be fully considered in the design. In modeling, overlap, segmentation, moving and adjacency are used to change. In terms of segmentation, large-scale equipment usually adopts digital scale and hierarchical scale. The digital ratio is $1 : \sqrt{2}$ and $1 : \sqrt{3}$. It is a proportional relationship established by integer multiples. Its basic form is a rectangle, which is very helpful for the design of large industrial products; the hierarchical ratio is the connection between the midpoints of each adjacent side of the geometric shape. Therefore, a reduced version under the same form is formed, and a continuous form will appear after multiple repetitions, forming a hierarchical system, which is of great help to product redesign.

2.1.3 Analysis of Abnormal Shape of Industrial Products

The special shape is a form with a large change, and most of it is a large angle chamfer or slope to obtain a change in appearance. Shaped shapes tend to feel unstable, and some shapes with large changes feel bulky. Stability has two basic meanings in terms of product appearance. One is that the weight of the product itself meets the conditions of stability; the other is visual stability, and the appearance of the product pays attention to weight. Not only to meet the actual stability of the product, but also to meet the visual stability. Therefore, in the design, the sense of weight should also be consistent with the actual situation, as well as the integrity of the precision. Not only the structural stability, but also to make the product shape light and have a sense of speed. Large scale equipment are all products of industrial assembly line operation. In the aspect of appearance modeling, the selection of materials should be fully considered under the condition of meeting the modeling rules. The combination of different materials can produce different sense of quantity. Attention should be paid to the stability of the shape when modeling.

In special-shaped product modeling, it is necessary to ensure the balance of the product, so that the product modeling form can form a contrast of different forms on both sides of the fulcrum, such as large and small, sparse and dense, thus forming a kind of static in motion and dynamic in static. The orderly beauty. In the design, we should pay attention to the key points, and form the visual primary and secondary in the treatment of the key points, so as to avoid the constant wandering of the line of sight, thus giving people a feeling of clutter and tediousness. The appropriate use of curves can increase the sense of change in the shape of products, and the curves will give people different feelings in emotion and performance.

Highlighting the key points of product modeling can be seen from four aspects. First, the product form contrast, such as straight lines and curves, simple and complex; second, color contrast, using light colors to set off dark, cool and warm colors; Third, the contrast of materials, such as metal and non-metal, plastic and glass; fourth, the use of line changes and perspective to guide the line of sight to focus on one place.

Through the deep learning database, we can find the ingenious points of appearance modeling design, and analyze the modeling structure of industrial products from three aspects of right angle modeling, oblique angle modeling and special-shaped modeling.

Next, we can process the industrial product modeling through stereo vision to better serve the industrial product modeling.

2.2 Stereo Vision Processing Industrial Product Modeling

Non - uniform rational B - splines (NURBS), which is widely supported in advanced 3D modeling, is used for 3D modeling:

$$P(t) = \frac{\sum_{i=1}^{n} w_i p_i B_{i,k}(t)}{\sum_{i=1}^{n} w_i B_{i,k}(t)} \tag{1}$$

Where: p_i represents the model vertex; w_i represents the weight of the relationship between the vertices; $B_{i,k}(t)$ represents the basis function, the calculation formula is as follows:

$$B_{i,k}(t) = \frac{t - t_i}{t_{i+k-1} - t_i} B_{i,k-1}(t) + \frac{t_{i+k} - t}{t_{i+k} - t_{i+1}} B_{i+1,k-1}(t) \tag{2}$$

During the measurement of industrial products, the angle of view θ can be converted into the projection size of the product through correlation calculation, as shown in Fig. 2.

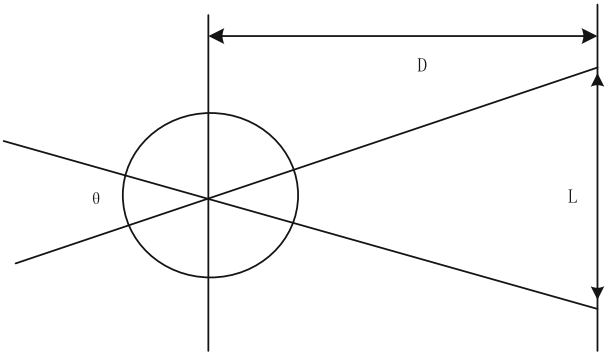

Fig. 2. Definition of viewing angle θ

The view angle θ is defined as follows:

$$\theta = 2 \arctan\left(\frac{L}{2D}\right) \tag{3}$$

In order to generate stereoscopic visual effects in a VR environment, the human body's binocular vision and visual movement perception technology need to be used. The three-dimensional perception of human beings mainly comes from binocular parallax. Therefore, the stereo vision model needs to calculate two pilots separately to generate two monocular views. In the stereo vision model, if the point $I(X_i, Y_i, Z_i)$ on the

three-dimensional space object is projected on the Z plane, two points $I_l(X_{sl}, Y_{sl})$ and $I_r(X_{sr}, Y_{sr})$ are generated. There are:

$$X_{sl} = \frac{X_i \times k + \frac{Z_i \times d}{2}}{k - Z_i} \tag{4}$$

$$Y_{sl} = \frac{Y_i \times k}{k - Z_i} \tag{5}$$

$$X_{sr} = \frac{X_i \times k - \frac{Z_i \times d}{2}}{k - Z_i} \tag{6}$$

$$Y_{sr} = \frac{Y_i \times k}{k - Z_i} \tag{7}$$

Since the results of formula (5) and formula (7) are consistent, formula (4) and formula (6) can be expressed as:

$$X_{sl} = \frac{X_i + \frac{d}{2}}{1 - \frac{Z_i}{k}} - \frac{d}{2} \tag{8}$$

$$X_{sr} = \frac{X_i - \frac{d}{2}}{1 - \frac{Z_i}{k}} + \frac{d}{2} \tag{9}$$

Where: d is the distance between the eyes; k is the length between the viewpoint and the projection plane. The time needed for calculation can be reduced under the condition of limited hardware.

2.3 3D Geometric Modeling of Industrial Product Modeling

According to the above-mentioned stereo vision processing of industrial product modeling, the 3D geometric model modeling analysis of industrial product modeling is performed, and the feature rendering and virtual view design of product 3D modeling are performed by combining texture rendering and scene database model construction methods. The product modeling design model development environment based on deep learning designed in this paper is built in 3DStudio MAX and Softimage software environment R_2:

$$g(x, y) = h(x, y) * f(x, y) + \eta(x, y) \tag{10}$$

Where: $h(x, y)$ is the texture rendering disparity function in product design; the symbol * represents convolution. The texture tracking and template grid segmentation methods are used for 3D combined modeling in the product modeling design process, and the vector edge clipping method is used to reconstruct the feature space of 3D product modeling. The feature distribution of the pixel set for model construction is obtained as:

$$g(x, y) = f(x, y) + \eta(x, y) \tag{11}$$

Where $\eta(x, y)$ is the scale to adjust the mesh size. Based on statistical shape model, two-dimensional surface reconstruction in product modeling design is carried out.

$$J = \sum_{k=1}^{n}\sum_{i=1}^{c} u_{ik}^{*m} d(x_k, v_i) + \beta \sum_{k=1}^{n}\sum_{i=1}^{c} u_{ik}^{*m} d(\overline{x}_k, v_i) \tag{12}$$

Connecting the points into polygons, the configuration weight of the output product design design is:

$$w(i, j) = \frac{1}{Z(i)} \exp\left(-\frac{d(i, j)}{h^2}\right) \tag{13}$$

Among them:

$$Z(i) = \sum_{j \in \Omega} \exp\left(-\frac{d(i, j)}{h^2}\right) \tag{14}$$

Combined with the edge pixel decomposition method, the image feature segmentation in the process of product modeling design is carried out.

$$\hat{f}(x, y) = \begin{cases} g(x, y) - 1, & g(x, y) - \hat{f}_{\text{lee}}(x, y) \geq t \\ g(x, y) + 1, & g(x, y) - \hat{f}_{\text{Lee}}(x, y) < t \\ g(x, y), & \text{else} \end{cases} \tag{15}$$

According to the topological structure information of the image, the image pixels are grouped, and the joint estimated parameter of the volume model reconstruction of the product modeling is obtained as $\hat{f}(x, y)$. According to the smoothing operator in the product modeling image design, the adaptive reconstruction is performed to obtain the scale information of the product 3D geometric modeling Parameter Nl:

$$N_l = \begin{cases} 1, & l = 0, L \\ 2\pi \cdot \frac{D}{2} \cdot \sin \eta / l_{\text{taiangle}}, & l = 1, 2, \cdots, L - 1 \end{cases} \tag{16}$$

In the formula: l triangle $= \pi \cdot$ D 2L represents the wrinkle information of the image, and L is the total length of the designed product edge contour.

In the product's three-dimensional distribution area M $\times$ M, texture segmentation is performed on the image pixel intensity at the maximum pixel point to realize 3D geometric modeling of industrial product design.

2.4 Industrial Product Design Program

At present, the product modeling design methods based on computer-aided design mainly include:

(1) Digital design, which mainly adopts digital modeling technology;
(2) Parallel design, which mainly uses the crossover, reorganization and optimization of the product design process to shorten the product development cycle;

(3) Virtual design. This method mainly uses virtual reality technology for 3D visualization design.

Through the above demand analysis, it can be seen that the industrial product modeling and design system should have the following functions: the generation of parts; the search and matching of the prototype Library of parts; the generation of product design scheme. As shown in Fig. 3.

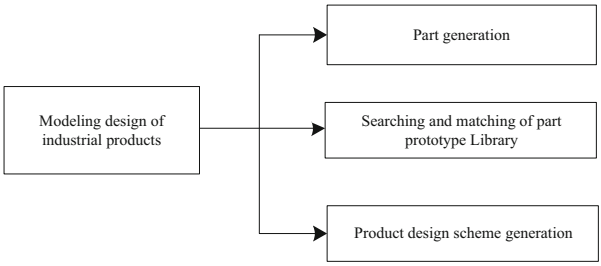

Fig. 3. The functional structure of industrial product modeling design system requirements

This article applies deep learning to product modeling design, and the workflow is shown in Fig. 4.

As can be seen from Fig. 4, in the process of deep learning, 3D modeling, modeling evaluation and modeling storage operations are carried out on the modeling elements of industrial products to realize the modeling design of industrial products.

3 Experimental Analysis

In order to test the performance of this method in the realization of product modeling design and 3D virtual reality simulation, simulation experiments are carried out. The experiment uses Matlab for image algorithm processing in product modeling design, establishes a three-dimensional visual simulation platform for product modeling design on the Vc.net platform, builds a client for visual analysis of product modeling design, and establishes a human-computer interaction interface for visual simulation control. Using Microsoft Visual Studio development components to realize the data collection and information processing of product modeling design, the distribution range of the designed interpolation points is 200 × 300, the pixel level distribution is 400 × 400, and the number of samples collected for the three-dimensional information of product modeling is 2 000, the sample number of discrete product modeling elevation point data is 1024. According to the above-mentioned simulation parameter setting, the product modeling design is carried out. Taking a robot arm product as an example, the original design effect diagram is shown in Fig. 5.

Using the method of this paper to optimize the product design, combined with texture rendering and 3D reconstruction technology, the optimized product modeling design results are shown in Fig. 6.

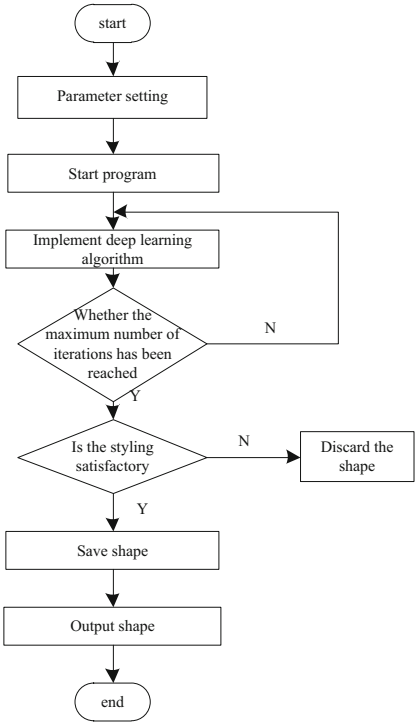

Fig. 4. Industrial product modeling design process

Fig. 5. Original image of product modeling design

Analysis of Fig. 6 shows that the use of this method for product modeling design improves texture rendering and scene performance, and the product has a higher visualization and fidelity. Analyzing the output signal-to-noise ratio of different methods for product modeling design, the results obtained are shown in Fig. 7.

Analysis of Fig. 7 shows that the output signal-to-noise ratio of the product modeling image designed by this method is higher, indicating that the quality is better.

Fig. 6. Optimized product design results

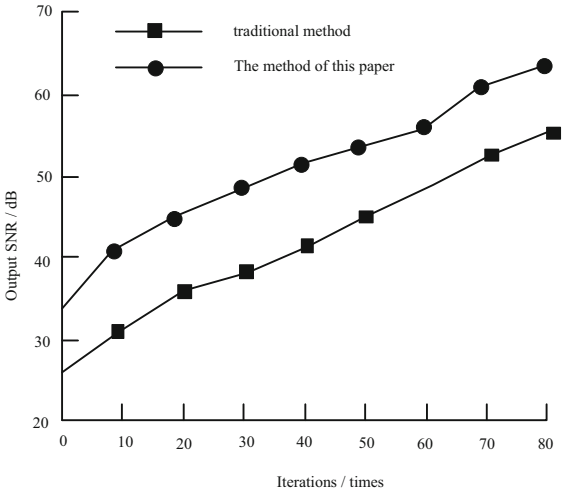

Fig. 7. Output performance comparison

4 Conclusion

This paper proposes a research on the design method of industrial product modeling based on deep learning. The results show that the output performance of this method for product modeling design is better, the fidelity of the designed product is higher, and the visualization effect is better.

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