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Computer-Aided Design AND APPLICATIONS

Application of CAD Virtual Simulation Technology in Bionic Design of Complex Structure Industrial Products

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Abstract. In order to solve the problem of visual effect in the bionic design of complex structure industrial products, this paper proposes the application of CAD virtual simulation technology in the bionic design of complex structure industrial products. Create the overall structure model of the system, including the virtual scene simulation layer, image processing layer and data acquisition layer. In the image processing layer, after the product virtual space is constructed by using the CAD virtual simulation development platform based on stereo vision model, the 3D geometric feature model of the product is constructed by extracting the product geometric features, shape definition, and relationship setting process; In the virtual scene simulation layer, the texture rendering of the product geometric feature model is realized through the observation volume model, the product design model is obtained, and the visual scene is simulated using the scene simulation rendering tool Vega Prime to improve the handling performance of the product design model. Taking the products of an industrial product processing plant as an example, the system performance is tested. The experimental results show that when designing the same industrial products, the system time in this paper is about 100s, the time is relatively stable, the time used is the least, and the efficiency is the highest. The research has proved that the product visualization effect of the system design is good, the image quality is high, the design time can be saved and the production efficiency of the product can be improved, and the system has high practical application value.

Keywords: CAD virtual simulation technology; Product design; Visual simulation; Image processing; Data acquisition; Model design.
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1 INTRODUCTION

With the continuous progress of social economy and science and technology, many enterprises that produce industrial products will do a lot of research and development work on product functions in order to make their products invincible in the market competition, making many industrial products have a rapid development in function [1]. However, with the continuous improvement of people's living standards, in the process of using products, in order to meet the spiritual aesthetic needs, in addition to the function, the product shape also put forward higher requirements. In order to make products have better market competitiveness, the design of industrial products must solve the problem of form design [2].

However, if we develop new product forms according to the traditional design thinking, it is difficult to stand out from many similar product forms. Therefore, we must find new breakthroughs. From the perspective of social development, today's consumers are paying more and more attention to environmental protection and the harmonious development of human and nature. All living things in nature are the result of a long-term evolution process [3]. In terms of morphology, they are the product of continuous adaptation under the changing environment, that is, the product of the harmonious development of human and nature. Therefore, it is a good choice to improve and innovate the form of industrial products by using the design thinking and design method of form bionics. In today's era of higher requirements for the quality of life, if the form elements of natural objects are integrated into the product form, it will form a strong visual impact and show its advantages in modeling among similar products.

At present, most of the design of product form is to reconstruct the 3D CAD model of the object through data acquisition and data processing on the surface of the physical sample of the existing product, and use the software that can realize reverse 3D modeling design, and further use the CAD/CAE/CAM system to realize analysis, redesign, NC programming and NC machining [4]. Such a process of reverse design is difficult to make a breakthrough in form, and bionic design can just break this bottleneck. On the basis of the existing original organism, the biological prototype is collected and processed, and then CAD modeling, NC programming and NC machining are carried out. In this way, we can continue to develop the independent innovation ability of enterprises and make them in an invincible position in the current fierce market competition.

2 LITERATURE REVIEW

CAD virtual reality technology includes computer-aided technology, electronic information, simulation technology, etc. Its basic realization is to simulate the virtual environment by computer to give people a sense of environmental immersion. CAD virtual reality technology is a technique that uses computers to generate realistic 3D virtual scenes and synchronously bind the simulated environment, vision system and simulation system in the interaction process, so that users can easily obtain the perception of various sensing devices. The technology relies on high-tech hardware and software to generate molds to simulate the real world, giving people an immersive viewing experience. In other words, CAD virtual reality technology can realize 3D reality and simulate the real-world environment.

CAD virtual reality technology can realize virtual scene simulation, rely on high-tech hardware and software to create a realistic virtual environment, and users can establish connections with the characters, scenes, events, themes, etc. in the virtual environment through five senses to produce interactive and multi-sensory experience. Therefore, the CAD virtual simulation system has the characteristics of multimedia information perception, immersion and interactivity. CAD virtual simulation technology has the ability to convey visual, auditory, tactile and other information, integrate user experience into the virtual environment, display objects in the virtual world through interactive devices, and make users have a real sense of experience [5].

Product design includes product functional design, product structure design and product appearance design. The history of product design can be divided into four stages, which are: the introduction stage dominated by technological innovation the development stage dominated by product performance - the growth stage dominated by appearance - the mature stage dominated by product humanization. It can be seen that people-oriented is the ultimate goal of the transfer of design key points and the change of design concepts, and thus new product design concepts such as emotional, universal, ecological, interactive and comfortable have emerged. In order to survive and develop in the fierce market competition, each product manufacturing enterprise needs to choose the product design method suitable for its own enterprise in the process of new product development, which has also become the key stage of new product development.

Lei, R. H. Researched the modeling, execution time control and vibration control of a flexible two-link space robot. First, combining the Lagrangian method with an assumed modal model results in a good system model [6-7]. Li, N. Strategies for Improving Information Visualization in Technology-Based Multimedia Human-Computer Interfaces. Virtual reality technology uses modeling technology and 3D technology to create a relationship between the virtual environment, users and the real environment, and create multimedia products; According to the technology of virtual reality, image modification technology is used to change the local environment of the simulated image; Generation of gray background based on human visual features [8]. Akbarifar, F proposed a computer-aided, robotic approach that uses both supervised and unsupervised deep learning and is never present in evaluation [9].

Therefore, this paper studies and proposes the application of CAD virtual simulation technology in the bionic design of complex structure industrial products, and realizes product design through this system to improve the efficiency of product design and the entire product production process.

3 METHODS

3.1 Overall Structure of Product Design System

The product design system is composed of image processing module, 3D graphics modeling module, program loading module, image editing module, virtual simulation module, cross editing control module and graphics rendering module.

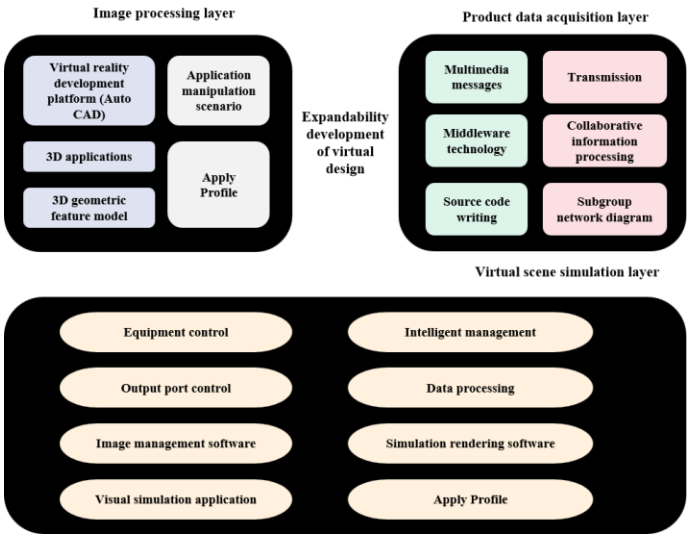

Figure 1: Overall structure of product design system.

The information collection and bus transmission of 3D virtual design of products can be realized through human-computer interactive bus development technology. The development of basic data can be achieved through rendering software, and the creation of cross compilers to assist in filtering data. The configuration of application programs and integrated development and design of 3D application files can be completed through the Model Builder 3D central component technology [10]. The output port control and application file configuration during product design can be jointly realized by VSG class library and VP class library [11]. The overall structure of the product design system is shown in Figure 1.

3.2 CAD Virtual Reality Development Platform

As a CAD virtual reality development platform for conventional visual applications, virtual reality and real-time visual simulation, product form design is completed through Auto CAD software, and Visual C++6.0 is used as the development language. The most critical way for humans to perceive the surrounding space is the visual channel, which is also the most direct way to collect spatial parameters in the virtual space. The left and right eyes in the human stereo vision model have parallax in the local binocular overlay area [12].

On this basis, the image difference of the lateral momentum is calculated. Assuming that there are two objects (U1 and U2) in the front of both eyes, the relationship between the distance between the two objects and the image difference of the lateral momentum is expressed as follows:

$$\mu = bK/(B^2 + bB) \tag{3.1}$$

Where: b and μ respectively represent the distance between the two objects and the difference between the images of the lateral momentum; The distance between the two eyes and the vertical distance between the right eye and the same object U1 are indicated by K and B. If U1 is used as a reference, the result of human perceptual distance b is:

$$\mathrm{b} = \mu \mathrm{B}^2/(\mathrm{K} - \mu \mathrm{B}) \tag{3.2}$$

The virtual space process of building products is:

1) After obtaining the image of the scanning device or self-camera, build the image through the drawing box program;
2) When editing, modifying, texture processing and replacing images, the simulated stereo vision model can be used to realize;
3) When building 3D objects and generating 3D geometric object files, it is necessary to use 3ds MAX or CAD based on the product shape;
4) Based on the processed images and 3D geometric object files generated in 2) and 3), and combined with C++library units, the virtual space is run [13].

3.3 3D Geometric Feature Model Construction of Product Geometric Features

3.3.1 Extract elements

The process of obtaining the reference elements and standard elements of the 3D geometric features of the product through extraction is element extraction, where the standard element refers to the product surface, and the reference element refers to the product surface, point or boundary line. On this basis, the required product geometric elements are extracted from the 3D model of the product as standard elements and reference elements. The process of extracting elements is shown in Figure 2.

Add the 3D geometric features of the product to the accuracy of the process of extracting elements, fix the reference elements through interaction, extract the element logo data, and finally determine and extract the logo data of standard elements through interaction. When extracting elements, the extracted data is the basis for 3D geometric feature modeling of products [14].

3.3.2 Define profile

The basic standards of product 3D geometric features generally include polygons, rectangles or squares. The relevant parameters and structural forms of product shape based on production

technology needs should be determined first, and then the 3D geometric features of the product should be created [15]. The process of defining profiles is shown in Figure 3.

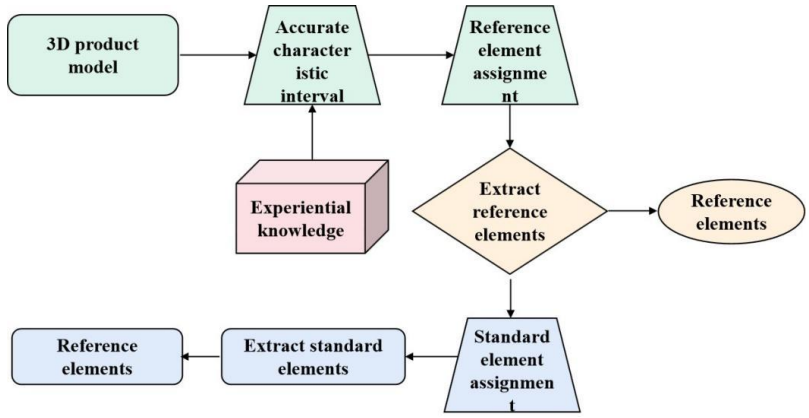

Figure 2: Extraction process of elements.

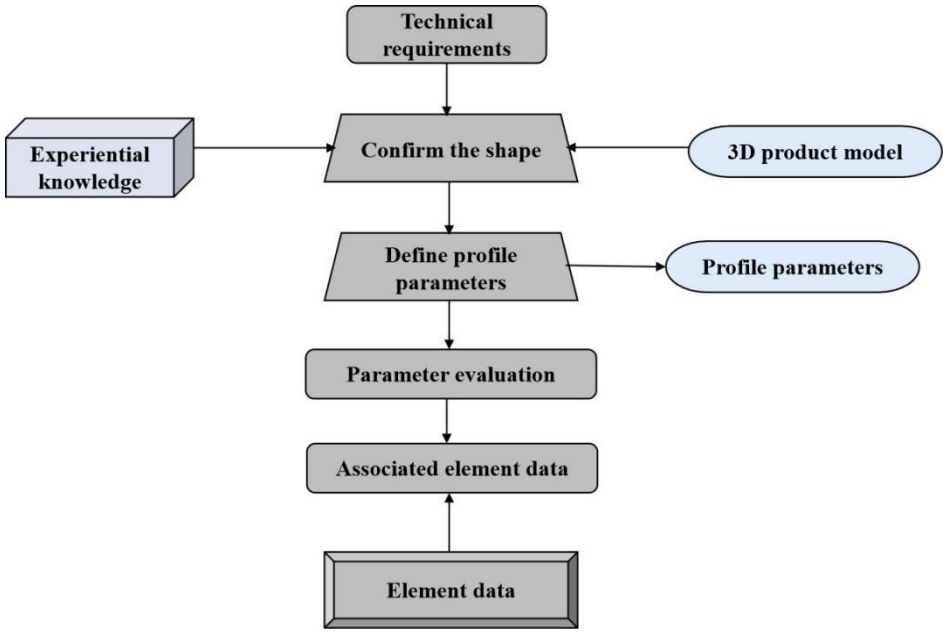

Figure 3: Define the profile process.

The specific process is as follows: based on the 3D model of the product, the product designer will confirm the geometric characteristics of the product with past experience and knowledge and interactive technology [16]. The parameters that the product shape should have can be defined at the place where the 3D geometric features of the product need to be added, such as smoothness, dimension and height, etc. The product designer can input the required parameters or modify them interactively; Judge whether the shape parameters entered interactively are reasonable; Combine the extracted standard elements, reference elements and 3D geometric feature parameter data of the product, and apply them to modeling [17].

3.3.3 Set relationship and automatic construction of 3D geometric feature model of product

Quickly create the 3D geometric feature model of the product on the 3D model of the product. The most important step is to set the relationship between the 3D geometric feature of the product and the standard elements and reference elements. The direction, continuity, spatial location and dependency of the 3D geometric feature of the product can be determined through the above text [18]. The relationship between 3D geometric features, standard elements and reference elements is divided based on the structural form of 3D geometric features of the product, as shown in Figure 4.

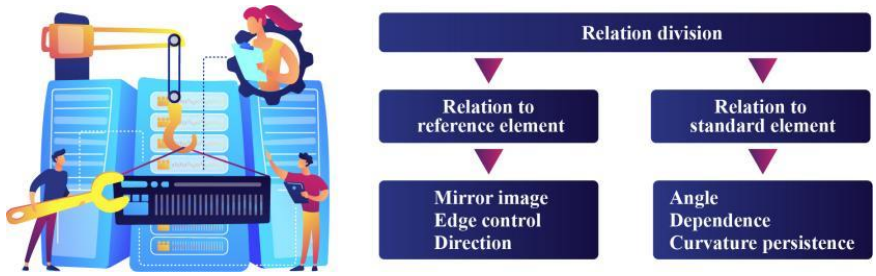

Figure 4: Relationship classification.

Among them, the relationship between the 3D geometric features of the product and the standard elements is as follows: the consistency of the 3D geometric features of the product with respect to the standard elements is expressed by dependency; The measurement value of the included angle between the standard element of the 3D geometric feature model of the product and the stretching direction is expressed by the angle; The continuous curvature of the contact position with the standard element is expressed by curvature continuity[19].

The relationship between the 3D geometric characteristics of the product and the reference element is: edge control and mirror image respectively represent the control of the 3D geometric characteristics of the product and the 3D geometric characteristics of the product on both sides of the reference element; Use the right-handed principle to judge whether the 3D geometric features of the product appear in the positive and negative directions of the reference element position, which is expressed by the direction. The process of setting the relationship is shown in Figure 5. The relationship between the 3D geometric features of the product and the standard elements and reference elements shall be set interactively and sequentially [20].

3.4 Realization of Virtual Visual Simulation of Product Design

3.4.1 Product model rendering

During product design, the texture rendering of the 3D geometric feature model of the product is realized through volume rendering. On the basis of obtaining the product design model, the virtual scene database is created in the Viewing Volume model, and the program output manipulation of the product data information in the virtual scene database is completed by using the rendering command to improve the manipulation performance of the product design model. Based on the modeling conditions such as parameters and control relations, the rapid and automatic construction of 3D geometric feature model of products is realized through the general function of 3D CAD.

3.4.2 Program output control

The 3D feature rendering and virtual scene design of the product can be realized through scene database model creation and texture rendering. Create a 3D model database in the 3D design of the product, and reconstruct the scattered features in the 3D design of the product through the database. Create a model through Multigen Creator 3.1, use the rendering command to complete the program output manipulation of product data information in the scene database, import the

product design model into Vega Prime, and combine it with the visual application program to create a product design model development library.

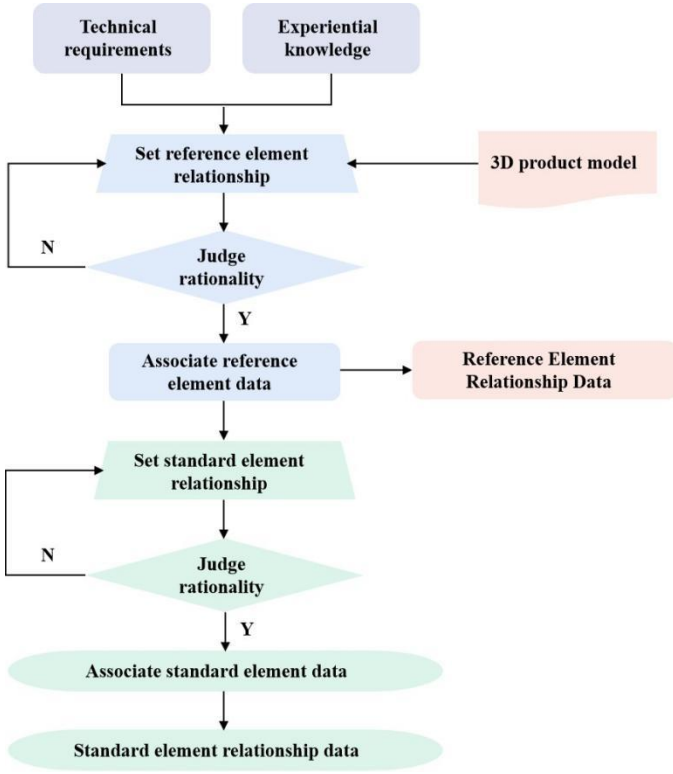

Figure 5: Setting relationship process.

The three-dimensional development of the product can be completed through programming tools such as Matlab and Vega Prime. In order to improve the handling performance of the product design model, the visual simulation rendering tool Vega Prime can be used to build the functional modules in the product design and simulate the visual scene. Create the program output control module to realize the visual simulation of product design in the visual simulation end. The network communication system is created through socket, and the program loading and network control of the product design system of CAD virtual simulation technology are completed [21].

When carrying out the bionic design of product form, the product designer should first make an overall analysis of the selected organism, decompose the organism appropriately, accurately analyze the structure of each part, retain the main part, remove the secondary part, simplify, form the simplified form model, determine the bionic form characteristics of the product, and form the bionic idea of the form. Secondly, on the basis of feature data collection, the simplified shape model is processed with 3D data in the computer, the product shape data is reconstructed, and the product shape theory is analyzed to form a bionic 3D model of product shape that meets the user's needs, and finally the product is formed.

3.5 System Simulation Test

To test the performance of the system designed in this paper, the following simulation tests are designed. The hardware configuration of the system used for the test is as follows: 800GB hard disk, 10GB memory, 3.6GHz AMDRyzen 5, 33-inch display, and 5GB DRAM. Taking the products of

an industrial product processing plant as an example, the mouse of this industrial product processing plant is designed using the system in this paper, the three-dimensional digital product design system (hereinafter referred to as the digital system), and the computer-aided product design system based on the design task model (hereinafter referred to as the computer-aided system).

4 RESULTS AND DISCUSSION

4.1 Comparison of Design Effects

By comparing the mouse effects designed by each system, it can be seen that the mouse visual effect designed by this system is better, clear and lifelike, while the effect visual degree designed by the other two systems is relatively low [22].

4.2 Comparison of Output Signal-to-Noise Ratio

Compare the output signal-to-noise ratio of mouse design images of different systems under the same number of iterations, and the comparison results are shown in Figure 6.

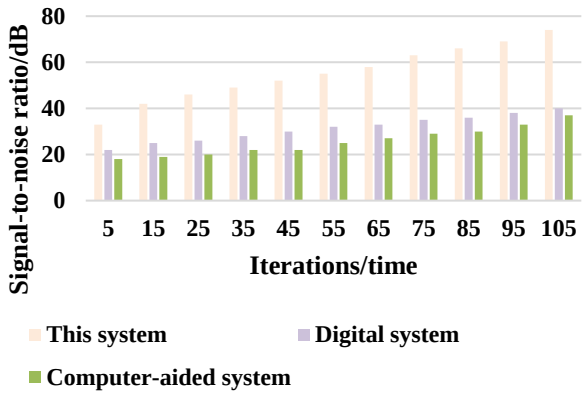

Figure 6: Comparison result of output signal-to-noise ratio (dB).

It can be seen from Figure 6 that the mouse image output signal to noise ratio designed by this system is higher, which can show that the product image quality designed by this system is higher and the practical application value is higher.

4.3 Comparison of Design Time

Three systems are used to design the keyboard, bluetooth speaker, vehicle-mounted cigarette lighter, sweeping robot and mouse of the experimental industrial product processing plant, record the design time of each system, and analyze and compare them. The comparison is shown in Figure 7.

It can be seen from Figure 7 that when designing the same industrial products, the system time in this paper is about 100s, the time is relatively stable, the time used is the least, and the efficiency is the highest. The system in this paper takes far less time to design each product of the experimental industrial product processing plant than the other two systems, which shows that using the system in this paper for product design can save production time and effectively improve product production efficiency [23].

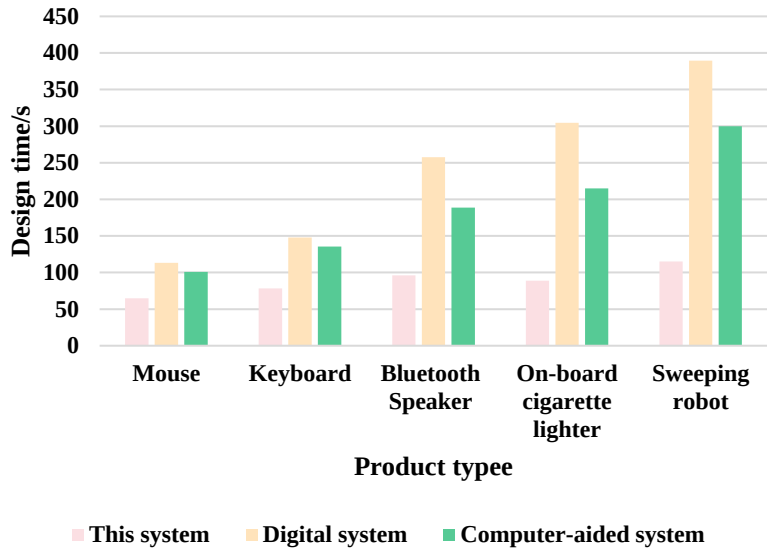

Figure 7: Comparison of design time of different systems.

5 CONCLUSION

This paper presents the application of CAD virtual simulation technology in the bionic design of complex structure industrial products. Aiming at the product design process, this paper designs a product design system based on CAD virtual simulation technology, and applies this system to the product design of an industrial product processing plant. The test results show that the visualization effect of the products designed in this system is clear and vivid, the image quality is good, and the practical application is high, which can improve the design and production efficiency of industrial products. Once any industrial product enters the market, it has the attribute of commodity. In order to reflect the value of goods, we must have both material and spiritual functions. As far as the product form is concerned, it more embodies the spiritual value of the product. Although designers can use various methods such as form combination and form analogy to design product form, bionic design is an extremely suitable method to give life to products from the perspective of humanization and emotion. The characteristics and forms of natural objects are integrated into the product appearance design by means of extraction and simplification, so that people are attracted by the appearance of the product, thus generating the desire to buy and consumption behavior, which directly brings good benefits to the enterprise.

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