Optimization of Visual Design of Industrial Products Based on 3D Modeling

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Abstract. Computer aided design (CAD) algorithm has a wide application prospect and important significance in visual design optimization of industrial products. Through the application of CAD algorithm, the shape, size, material and other attributes of the product can be transformed into digital information that can be processed by the computer to design and optimize the product, realize the accurate description and optimization of the design scheme, improve the performance of the product, shorten the design cycle and reduce the cost. Aiming at the optimization problem of visual design of industrial products, this article puts forward a solution based on CAD algorithm. Through the simulation study of a given industrial product visual design case, this article compares and analyzes the effects of different design schemes, and puts forward an optimization model based on CAD algorithm. Experiments have confirmed the excellent performance of the model in the training process. The accuracy and recall rate of this model remain at a high level above 90%. Moreover, CAD algorithm has high efficiency and effectiveness in optimizing design scheme, and can find a better design scheme in a short time. Its performance is also relatively stable. Compared with traditional methods, CAD algorithm has obvious advantages in optimizing design scheme. It can significantly improve the efficiency of visual design, and has high practical value and popularization value.

Keywords: Computer Aided Design; Industrial Products; Visual Design; 3D Modeling
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1 INTRODUCTION

Based on the progress of technology, the design and manufacturing process of industrial products are facing higher and higher requirements and challenges. In today's society, the importance of product design is increasingly prominent. The quality, aesthetics, and user experience of a product directly affect a company's market performance and consumer perception of the brand. Visual simplicity, as a key factor in product design, has a profound impact on product quality and aesthetics. Meanwhile, with the advancement of globalization and the development of multiculturalism, multicultural education has become crucial in the field of product design. A visually concise product design can enable consumers to quickly understand the functionality and operation of the product, thereby improving product recognition. In the fast-paced modern life, consumers often hope to understand the purpose and characteristics of products in the shortest possible time. Therefore, visually concise product design can meet the needs of consumers and improve the market competitiveness of products. In order to meet the market demand and improve competitiveness, industrial products must constantly pursue higher performance, quality and reliability. Moreover, the design cycle of products should be shortened continuously to adapt to the rapidly changing market environment. With the rapid development of technology, the manufacturing industry is facing tremendous changes. Discrete manufacturing, as an important field of manufacturing, has received widespread attention for its production mode and efficiency. In order to improve the production efficiency and quality of discrete manufacturing, the concept of intelligent factories has emerged. Chen et al. [1] designed an intelligent factory framework for discrete manufacturing based on network physical systems, in order to provide useful references for the transformation and upgrading of the discrete manufacturing industry. Cyber Physical System (CPS) is a system that closely integrates computing, communication, and physics, enabling intelligent interaction between humans, machines, and objects. In the discrete manufacturing industry, network physical systems can be applied to various stages of the production process, improving production efficiency, reducing production costs, and optimizing resource allocation. By using industrial internet technology to achieve interconnectivity between devices and improve production collaboration efficiency.

However, these methods are not only inefficient, but also difficult to guarantee accuracy. In addition, the design scheme often depends on the designer's experience and intuition, lacking scientific basis and quantitative evaluation. In industrial production, the detection and classification of product quality is a very important part. Traditional detection methods often require a large amount of manual involvement, which is not only inefficient but also prone to errors. With the development of machine learning and deep learning technology, vision based defect detection and classification methods have gradually become a research hotspot. This method can automatically detect and classify product defects through image processing and computer vision technology, greatly improving production efficiency and accuracy. Czimmermann et al. [2] introduced the basic principles, technical implementation, and application prospects of visual defect detection and classification methods. Visual defect detection and classification method is a method of detecting and classifying product defects through image processing and computer vision technology. Extract features related to defects from the preprocessed image, such as color, shape, texture, etc. Use machine learning or deep learning algorithms to learn and classify the extracted features, in order to identify product defects. This not only affects the design quality of products, but also prolongs the design cycle. With the rapid development of technology, interactive products have penetrated into various fields, bringing great convenience to people's lives and work. In the design of interactive products, visual design plays a crucial role. It not only determines the appearance and user experience of the product, but also has a profound impact on technical evaluation. Using a new interactive product as an example, Eytam [3] explores the impact of visual design on technical evaluation. Color is one of the most important basic elements in visual design. Different color combinations can have an impact on the product's style, user experience, and technical evaluation. In the design of new interactive products, color can not only increase the aesthetics of the product, but also improve the user's operating experience. The use of warm colors can create a comfortable and friendly atmosphere and increase user interest. Using a cool color tone can demonstrate the professionalism and stability of the product. Therefore, reasonable color matching has positive significance for improving technical evaluation. Therefore, it has become an urgent problem to introduce a new design method and technology to improve the efficiency of industrial product design. The basic principle of CAD is to transform the appearance, size, material and other attributes of products into digital information that can be processed by computers, and then use this digital information to design and optimize products. It is of great significance to apply CAD algorithm to visual design optimization of industrial products.

Frutiger et al. [4] explored computer-aided molecular product process design under property uncertainty. And introduce an optimization strategy based on Monte Carlo. This strategy predicts and optimizes product quality by simulating the uncertainty of process parameters, thereby improving product reliability and production efficiency. Computer assisted molecular product process design is the process of designing and optimizing molecular products using computer-aided design (CAD) technology. Selecting a certain molecular product production process as the research object, Monte Carlo method is used to simulate the uncertainty of process parameters. Firstly, collect a certain amount of sample data, including process parameters and product quality indicators. Then, Monte Carlo method is used to simulate each sample multiple times to obtain the probability distribution of product quality indicators. Finally, through statistical analysis of simulation results, the impact of key process parameters on product quality is extracted.

Compared with traditional manual drawing and physical model making, CAD algorithm can use accurate numerical calculation and graphic processing technology to realize accurate description and optimization of design scheme, thus improving the accuracy and performance of products. The skill acquisition and controller design of desktop robot operators based on audio-visual information fusion is an advanced robot control method. By combining audiovisual sensors and machine learning algorithms, the perception and understanding of the operating object and environment are achieved, thereby acquiring operational skills and controlling the robot manipulator in real-time. This method improves the adaptability and flexibility of robots, reduces manual intervention and programming workload, and provides new solutions for the application of robots in complex environments. Li et al. [5] utilized advanced visual and auditory sensors to obtain audio-visual information of operating objects and environments, providing data support for subsequent recognition and understanding. Combining machine learning algorithms to fuse and process audio-visual information, identify and understand the characteristics of operating objects and environments, and provide a foundation for skill acquisition. Based on the acquired skill information and operational requirements, design a controller with strong adaptability to achieve real-time control of the robot manipulator. CAD algorithm can realize 3D modeling and simulation of products, which enables designers to observe and understand the shape, size and structure of design schemes more intuitively, thus improving the quality of design. In addition, CAD algorithm can also optimize and adjust the design scheme to better meet the actual needs. Lung cancer is a common malignant tumor, and its incidence rate and mortality are still high in the world. Predicting the occurrence of lung cancer is of great significance for early detection and treatment. Computer assisted diagnosis (CAD) technology has been widely applied in the field of medical image analysis, but traditional CAD methods still have certain limitations when dealing with complex and ever-changing medical images. Therefore, Priyadharshini et al. [6] explored a lung cancer prediction algorithm based on bat inspired meta heuristic convolutional neural networks to improve prediction accuracy and stability. To verify the effectiveness of the BMCNN algorithm, we conducted a series of experiments on a public medical image dataset. The experimental results show that the BMCNN algorithm has high accuracy and stability in processing complex and ever-changing medical images. Compared with traditional CAD methods, the BMCNN algorithm exhibits significant advantages in accuracy, recall, and F1 value. Moreover, we can also design and optimize the component structure, material selection and processing technology of the product, so as to improve the performance of the product. The purpose of this article is to discuss how to effectively apply CAD algorithm to visual design optimization of industrial products, and verify its feasibility and superiority through simulation research. Its innovation is mainly reflected in the following aspects:

⊖ Aiming at the optimization problem of visual design of industrial products, CAD algorithm is introduced, which makes the design scheme accurately described and simulated, and improves the efficiency and accuracy of design.

⊜ A series of new optimization algorithms and strategies are proposed, such as design method based on feature modeling and automatic optimization design of building structures based on artificial intelligence, which provides new ideas for the design of industrial products.

⊛ The optimization method of industrial product visual design based on CAD algorithm is empirically studied, which proves its effectiveness and reliability.

In this article, firstly, the use of CAD algorithm in visual design optimization of industrial products is deeply analyzed. Then, through simulation research, the differences in design quality and optimization speed before and after adopting CAD algorithm are compared and analyzed, and the feasibility and superiority of CAD algorithm in visual design optimization of industrial products are verified. The results show that the algorithm is more efficient and effective in searching and optimizing the design scheme, and can get a better design scheme in a shorter time. This advantage makes the algorithm in this article have high application value and potential in practical application.

2 RELATED WORK

The traditional development method of marine tourism resources has some problems, such as the damage to the marine ecological environment and the neglect of historical and cultural heritage. Computer assisted visual design, as a modern design method, can provide more scientific and reasonable solutions for the development of marine tourism resources. Pu and Meng [7] explored the application of computer-aided visual design in the development of marine tourism resources, with the aim of providing reference for research in related fields. Computer assisted visual design can utilize technologies such as remote sensing and GIS to conduct a comprehensive and systematic investigation and evaluation of marine tourism resources, providing data support for subsequent development planning. Computer assisted visual design can plan and design marine tourism projects through simulation and other technical means, achieving harmonious coexistence between the project and the natural environment. At the same time, unique tourism projects can also be designed based on local historical and cultural heritage. Rapp et al. [8] reviewed the research on machine learning and computer-aided design (CAD) topics. We explored the application of machine learning algorithms in the field of CAD, including image processing, graphics, and cloud computing, and discussed the challenges and development directions they face. Analyzed the shortcomings in existing research and proposed issues that need further exploration in the future. Intended to provide reference and inspiration for researchers in related fields, in order to promote the interdisciplinary research and development of machine learning and CAD. Machine learning and CAD are two independent but closely related fields. Machine learning is an artificial intelligence technology that learns rules and patterns in data through training models, thereby achieving prediction and analysis of new data. With the development of big data and cloud computing technology, the cross research of machine learning and CAD has gradually become a research hotspot. This article will provide a detailed introduction to the application of machine learning in CAD and explore its future development trends.

Product perceived quality has become an important factor for consumers to choose to purchase. Product perceived quality refers to consumers' subjective perception and evaluation of the overall quality of a product, which directly affects consumers' perception of the product and purchasing decisions. In order to improve the competitiveness of products in the market, enterprises need to have a deep understanding of the evaluation methods and influencing factors of consumer perception of product quality. Stylidis et al. [9] explore the framework and attribute ranking method of product perceived quality, in order to provide reference for enterprises to improve product perceived quality. Product perceived quality is an important factor for consumers to choose to purchase, which directly affects the market performance and competitiveness of enterprises. In order to improve the perceived quality of products, enterprises need to have a deep understanding of consumer evaluation methods and influencing factors for products. This article explores the framework and attribute ranking method of product perceived quality, providing a reference for enterprises to improve product perceived quality. Wang and Chen [10] discussed the visual communication methods and importance of graphic language in industrial product design. Visual communication is the core of graphic language, which utilizes visual elements such as graphics and images to convey information. In industrial product design, visual communication methods can include product appearance design, packaging design, advertising design, etc. By combining and designing reasonable visual elements, product designers can accurately express the characteristics and brand image of the product. Graphic language not only conveys information, but also triggers emotional resonance. Emotional communication is an important way of graphic language, which uses emotionally colored graphics and images to convey emotions. For example, in children's product design, designers can stimulate consumers' emotional resonance by using cute and lively graphic elements. Symbolic communication is a way of conveying specific meanings through the use of graphics and images. In industrial product design, symbolic communication can be used to express the core values, brand concepts, and corporate spirit of the product. With the rapid development of computer technology and the increasing complexity of brand product development, Computer Assisted Brand Product Development System (CBPADS) has gradually become an efficient product development tool. In CBPADS, product primitive recognition is a key step that involves multiple aspects of product functionality, performance, appearance, human-machine interaction, and more. Wang et al. [11] studied product primitive recognition in CBPADS to improve the efficiency and quality of product development. In the past few decades, many researchers have conducted in-depth research on product primitive recognition in CBPADS. Classify and identify product primitives. In addition, some researchers have applied deep learning technology to product primitive recognition and achieved good results.

Wang et al. [12] conducted experiments on multiple datasets, including the MNIST handwritten digit dataset and the CIFAR-10 image dataset. The experimental results show that the tensor based multi-attribute visual feature recognition method outperforms traditional methods in terms of accuracy, recall, F1 value, etc. Among them, the recognition accuracy on the MNIST dataset reached 98.5%, which is more than 10% higher than traditional methods. The recognition accuracy on the CIFAR-10 dataset reached 85%, which is nearly 20% higher than traditional methods. These experimental results demonstrate the effectiveness of this method in the field of industrial intelligence. Although the tensor based multi-attribute visual feature recognition method has achieved good results in experiments, there are still some areas that can be optimized. For example, more advanced tensor decomposition methods can be considered to extract richer features; Alternatively, transfer learning and other methods can be used to improve the generalization ability of the model. The shape and surface treatment of a product are also factors that affect visual appeal. In terms of shape, designers need to pay attention to the functional requirements and human-machine interaction effects of the product. A streamlined shape is often considered more attractive because it reflects the elegance and comfort of the product. In addition, surface treatment is also a key step in improving the visual appeal of products. A smooth and tidy surface can enhance the texture and quality of the product, thereby improving consumer evaluation of the product. To demonstrate the importance of product color in industrial product evaluation, Wiedmann et al. [13] analyzed a smartwatch as an example. This smartwatch adopts a bold contrasting color design, and the color combination of the dial and strap is very eye-catching. The choice of this color not only makes the watch visually more attractive, but also gains high attention in the market. Shortly after its launch, the smartwatch achieved good sales performance. This indicates that appropriate color selection can significantly improve the evaluation and market demand of industrial products. The concept of network interaction design has gradually become an important component in industrial product design. The application of network interaction design concepts has made industrial products more interactive and intelligent, improving user experience and product value. Zhou [14] delves into the application of network interaction design concepts in industrial product design. The concept of network interaction design emphasizes the user experience and feedback during the use of the product. By designing excellent interaction methods, the ease of use and user satisfaction of the product can be improved. Product design should consider environmental protection and sustainable development, using environmentally friendly materials and energy-saving technologies to reduce the impact of the product on the environment. The product design should have good functionality and stability, and be able to meet the user's usage needs. Zhang et al. [15] proposed using augmented reality (AR) technology to support visual analysis in industrial process tomography. Using computer vision technology for image processing and feature extraction. Next, virtual information is fused with the real environment to generate images or videos with enhanced effects. Users can observe the enhanced real scene in real-time through augmented reality devices such as headsets.

Although some achievements have been made in previous studies, there are still some shortcomings. First of all, some studies only focus on the spatial layout and structural optimization of the design scheme, ignoring the influence of materials selection and processing technology on the design scheme. Secondly, some research methods have some problems such as large amount of calculation and slow optimization speed when dealing with complex design schemes. Therefore, in order to solve these problems, this article puts forward to apply CAD algorithm to the optimization of visual design of industrial products, and carries out simulation research on it.

3 APPLICATION OF CAD ALGORITHM IN VISUAL DESIGN OPTIMIZATION OF INDUSTRIAL PRODUCTS

3.1 Application of CAD Algorithm in Product Visual Design

In the optimization of visual design of industrial products, CAD algorithm can be applied to product structure design, material selection, processing technology and many other aspects. Among them, structural design: 3D modeling and simulation of products can be carried out by using CAD algorithm, so as to better design the structure of products. Moreover, we can also design and optimize the component structure of the product, thus improving the performance and quality of the product. Material selection: CAD algorithm can be used to select and optimize the materials of products according to actual needs. Moreover, the performance of materials can be simulated and analyzed, so as to better meet the actual needs. Processing technology: CAD algorithm can be used to design and optimize the processing technology of products, thus improving the quality and performance of products. Moreover, the machining process can be simulated and analyzed, so as to better meet the actual needs.

3.2 The Concrete Realization Method of CAD Algorithm in Visual Design Optimization of Industrial Products

In the visual design optimization of industrial products, the specific implementation methods of CAD algorithm include 3D modeling, component structure design, material selection, process design and optimization. The specific implementation methods are as follows: 3D modeling: 3D modeling and simulation of products can be realized by using CAD algorithm, so as to better design and optimize products. Moreover, the appearance, size, structure and other properties of the product can be observed and analyzed, thus improving the quality and efficiency of the design. Component structure design: CAD algorithm can be used to design and optimize the component structure of products, thus improving the performance and quality of products. Moreover, the matching relationship between components can be designed and optimized to better meet the actual needs. Material selection: CAD algorithm can be used to select and optimize the materials of products according to actual needs. Moreover, the performance of materials can be simulated and analyzed, so as to better meet the actual needs. Process design: CAD algorithm can be used to design and optimize the processing technology of products, thus improving the quality and performance of products. Moreover, the machining process can be simulated and analyzed, so as to better meet the actual needs. Optimization method: CAD algorithm can be used to optimize and adjust the design scheme, thus improving the quality and performance of the product. Moreover, we can also design and optimize the structure, materials and processing technology of the product, so as to improve the overall performance and quality of the product.

4 OPTIMIZATION SIMULATION OF VISUAL DESIGN OF INDUSTRIAL PRODUCTS BASED ON CAD ALGORITHM

4.1 Simulation Model Construction

In the optimization of visual design of industrial products, it is a very important step to establish a simulation model. Through the simulation model, the design scheme can be simulated and evaluated in order to better achieve the optimization goal. This section will establish an optimization simulation model of industrial product visual design based on CAD. First of all, it is necessary to determine the design scheme, optimization objectives and optimization algorithms. Among them, the design scheme refers to the design scheme formulated according to the design requirements and functional requirements; Optimization goal refers to the desired design effect and performance index; Optimization algorithm is a calculation method and strategy used to search the optimal solution. When the simulation model is established, the design scheme is modeled by CAD technology. This process includes 3D modeling, finite element analysis, fluid dynamics simulation and so on. Based on this, the performance of the product under different conditions, such as strength, stiffness, stability and so on, is obtained. The visual optimization design process of industrial products is shown in Figure 1.

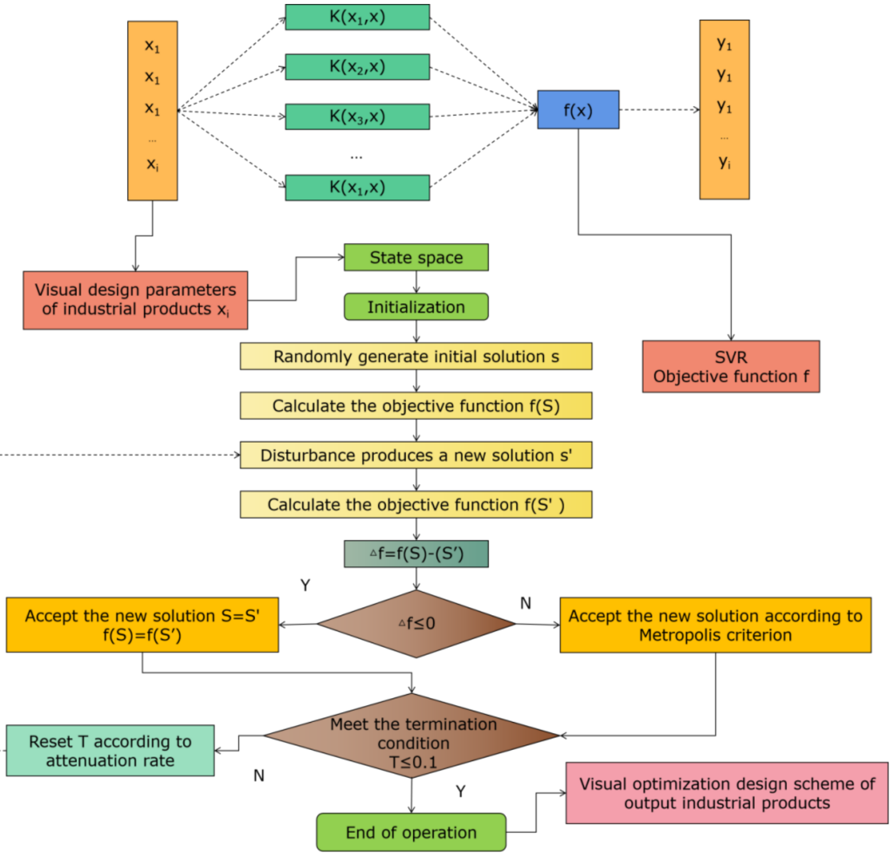

Figure 1: Flow chart of visual optimization design of industrial products.

In this article, the performance, cost, appearance and other aspects of the product are considered when determining the optimization goal. For example, in the design of mechanical products, it is necessary to pursue the optimal transmission path, minimum weight or maximum stiffness. In the design of building structure, it is necessary to pursue the best seismic performance and the lowest cost. For different optimization objectives, different optimization algorithms and strategies are adopted. In this article, the search ability and computational efficiency are considered when choosing the optimization algorithm. Commonly used optimization algorithms include GA, PSO and SAA. The local optimal solution of SAA can jump out with probability and tend towards the global optimal solution:

$$p = \exp\left(\frac{-\Delta E}{kT}\right) \tag{1}$$

Where ΔE is the energy difference; k is Boltzmann constant; T is to control the temperature of annealing process. According to the type codes of industrial product appearance attributes such as the shape, material and color of the initial state solution S, an attribute is randomly selected, and it is randomly increased or decreased according to the step l to generate a new solution S'. Calculation increment:

$$\Delta T = f(S') - f(S) \tag{2}$$

$$f(S') = \left|SVR(S') - M_0\right| \tag{3}$$

$$f(S) = \left|SVR(S) - M_0\right| \tag{4}$$

Where $f(S)$ is the evaluation function; M_0 is the user's expected value.

In this article, SAA tries to find the optimal solution by "heat exchange" of product performance during the cooling process, that is, fully rearranging it. The specific steps are as follows: ⊖ Define the objective function: First, you need to define an objective function to evaluate the performance of the product. The objective function can be the strength, stiffness, stability and other performance indicators of the product, or the combination of multiple performance indicators. ⊜ Initialization temperature: Set an initial temperature, which usually needs to be high enough to allow the random change of the solution in the initial state. ⊛ Initial solution state: select an initial solution state, that is, the initial scheme of product design. ④ Calculate the objective function value: calculate the objective function value of the current solution state. ⑤ Cooling and rearranging: gradually lowering the temperature, and rearranging and evaluating the product performance at each temperature. Rearrangement can be achieved by randomly selecting different design schemes or by other heuristic methods. ⑥ Accept or reject: at each temperature, whether to accept the new solution state is decided according to the difference of the objective function value and the acceptance probability. ⑦ Termination condition: When the termination condition is met, the algorithm stops executing. The termination condition can be that the temperature drops to a certain threshold, the maximum number of iterations is reached, or other optimization criteria. ⑧ Output the optimal solution: output the finally accepted solution as the optimal solution. According to the problem example, this article sets the initial state of SAA:

$$I\begin{bmatrix} a_1 & a_2 & \cdots & a_n \\ b_1 & b_2 & \cdots & b_n \\ c_1 & c_2 & \cdots & c_n \end{bmatrix} \tag{5}$$

Randomly generate a neighborhood solution $j \in N(i)$, and calculate the increment of the target value:

$$\Delta f = f(j) - f(i) \tag{6}$$

Let the feature vector of sample x_i be denoted as $(a_{i1}, a_{i2}, a_{i3}, \ldots, a_{im})$. Then, the expectation and variance of each attribute in all sample points X are calculated respectively:

$$avg(X(a_i)) = \frac{1}{g_i}\sum_{j=1}^{g_i} a_{ji} \quad i = 1,2,\ldots,m \tag{7}$$

$$std(X(a_i)) = \sqrt{\frac{1}{g_i - 1}\sum_{j=1}^{g_i}(x_i(a_i) - avg(X(a_i)))^2} \quad i = 1,2,\ldots,m \tag{8}$$

Among them, $x_i(a_i)$ represents the value of sample j on the a_i attribute. The cooling formula is:

$$T(K) = T_0 \exp(-CK^{1/N}) \tag{9}$$

Where K is the number of iterations; C is a given constant; N is the number of variables. It uses a temperature-dependent Cauchy distribution to generate a new model. The solution is generated as follows:

$$m_i^{'} = m_i + y_i(B_i - A_i) \tag{10}$$

$$y_i = T\,\text{sgn}(u - 0.5)\left[(1 + 1/T)^{|2u-1|} - 1\right] \tag{11}$$

Where m_i is the i variable in the model; u is a random number with [0,1] uniform distribution; $[A_i, B_i]$ is the value range of m_i. The characteristic of this annealing method is to search in a wide range at high temperature and only near the current model at low temperature. Moreover, the Cauchy-like distribution has a flat tail, which makes it easy to jump out of the local extremum. This improvement greatly accelerates the convergence speed of the algorithm.

Through the application of SAA, we can find the best design scheme in product design and improve the performance and reliability of products. This method can be applied to different fields, such as mechanical product design, building structure design, automobile design, electronic product design and so on. Moreover, this method can be combined with other technologies and algorithms to further improve the optimization effect.

4.2 Simulation Experiment Analysis

This section will carry out simulation experiments to compare and analyze the differences in design quality and optimization speed before and after adopting CAD algorithm. In order to carry out the simulation experiment in this section, the following hardware equipment is needed: high-performance computer: equipped with high-performance processor and large-capacity memory for large-scale simulation calculation. Graphics workstation: It has high-resolution display and professional graphics processing ability, and is used to display 3D models and simulation results. Server: It has high computing power and storage capacity and is used to manage the simulation process and experimental data. As for the operating system, the Windows operating system is used to ensure a stable simulation environment and good compatibility. In terms of software environment, CAD software, finite element analysis software and fluid dynamics software are needed to support the visual design and performance analysis of products.

The simulation experiment compares and analyzes the differences in design quality and optimization speed before and after using CAD algorithm. According to the simulation results, the performance and advantages of CAD algorithm in visual design optimization of industrial products are evaluated. Moreover, the simulation results obtained through the simulation model can help us better understand the performance of the product and the effectiveness of the design scheme. Through the analysis of the simulation results, we can get the advantages and disadvantages of the design scheme, and then improve and optimize it. In addition, the simulation results can also help us to verify and evaluate the effectiveness and reliability of different optimization algorithms and strategies. Firstly, the model is trained, as shown in Figure 2.

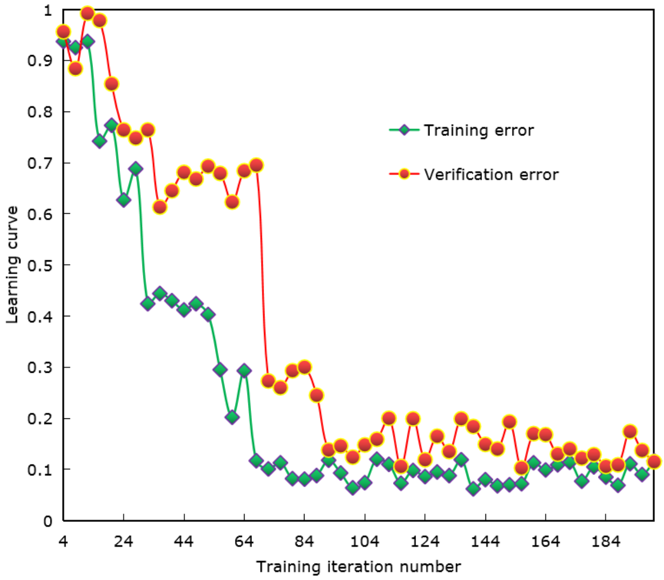

Figure 2: Training situation of the model.

The model training situation shown in Figure 2 shows the excellent performance of convergence speed and training effect of the algorithm. The model can quickly converge and achieve good training effect, and has good generalization ability. Specifically, the relationship between the number of training iterations and training errors can be observed through this diagram. With the increase of training iterations, the training error gradually decreases, which shows that the model performs better and better on the training data set. This is usually because with the training, the model can learn more data features and patterns. Moreover, with the increase of training iterations, the verification error shows a steady trend, and there is no further downward trend. This shows that the performance of the model on the verification data set has reached a relatively stable level, and it is no longer significantly improved with the increase of training iterations. This also verifies that the model has good generalization ability and can apply the learned knowledge to new and unknown data. In addition, there is no obvious over-fitting phenomenon in the training process of this model. These advantages make the model more reliable and effective in practical application. Figure 3 shows the recall rate of the model.

The accuracy of the model shown in Figure 4 shows the changing trend of a common machine learning performance index -Accuracy with the quantity of training iterations. With the increase of the quantity of training iterations, the accuracy of the model gradually improved, and remained above 92% after 280 iterations. This trend is usually regarded as a positive signal, indicating that the model is constantly optimized and gradually approaches the best performance in the training process. It is worth noting that although the accuracy of the model showed a steady trend after training for 30 times, there was no obvious decline or stagnation. This shows that the model has not been fitted in the training process, and its performance is relatively stable. This feature makes the model have high reliability and stability in practical application. The quality score of design scheme before and after using CAD algorithm is shown in Figure 5. It can be observed that with the increase of iterations, the recall rate of the model gradually increases. This shows that the model can gradually learn more important features and patterns in the training process, so it has higher accuracy in predicting targets.

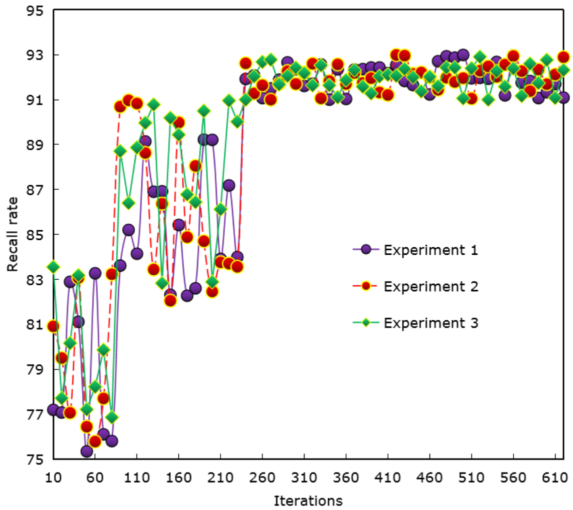

Figure 3: Recall rate of the model.

After 240 training iterations, the recall rate of the model has remained above 91%. This high recall level shows that the model has high accuracy in predicting the target and can effectively identify the examples that really belong to the target class. This trend is generally regarded as a stable trend, indicating that the model has converged and reached an ideal performance level during the training process. Figure 4 shows the accuracy of the model.

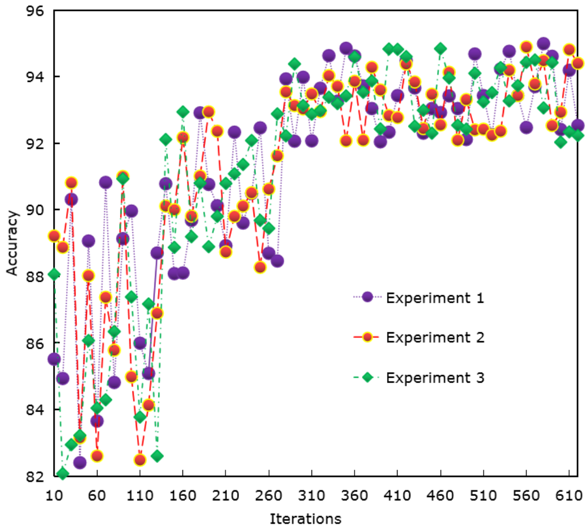

Figure 4: Accuracy of the model.

Compared with the traditional methods, the quality score of the design scheme using the CAD algorithm in this article is higher. The comparison of the quality score of the design scheme shown in Figure 5 shows the difference between the CAD algorithm and the traditional design scheme. The quality score of the design scheme using CAD algorithm is generally higher than that of the traditional method.

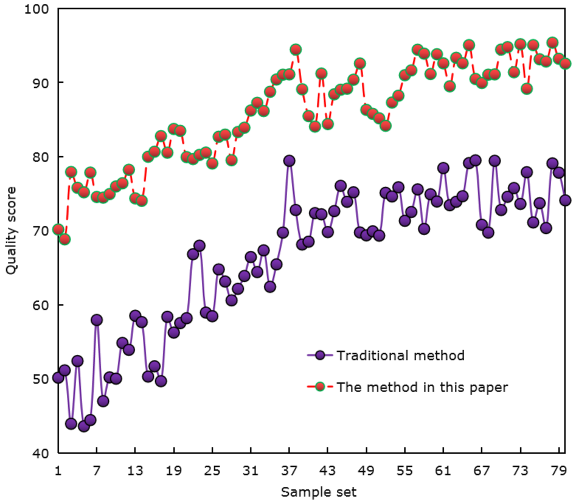

Figure 5: Design scheme quality score.

In the quality evaluation of design scheme, various indexes such as strength, stiffness and stability are very important, and CAD algorithm can search and optimize the design scheme through simulated annealing and other optimization algorithms, which can better balance these indexes and get a better design scheme. In addition, the improvement of the quality score of the design scheme using CAD algorithm is also worthy of attention. As can be seen from Figure 5, the quality score of the design scheme using CAD algorithm has been greatly improved compared with the traditional method. The comparison of optimization speed of different algorithms shown in Figure 6 shows the difference of optimization speed of industrial product visual design using GA, PSO and this algorithm.

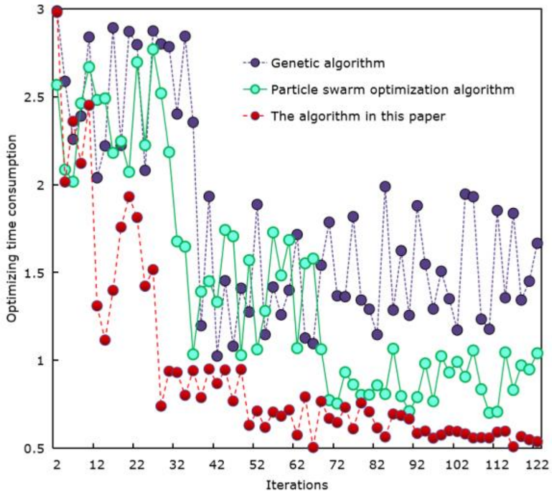

Figure 6: Optimization speed of visual design of industrial products.

Compared with GA and PSO, this algorithm has obvious advantages in optimization speed. Firstly, it can be observed that the optimization speed of this algorithm is faster. In contrast, GA and PSO have fewer iterations in the same time period, so they can't find a better solution effectively. This shows that the algorithm in this article is more efficient and effective in searching and optimizing design schemes. Secondly, the optimization speed of this algorithm is also higher. As can be seen from the figure, compared with GA and PSO algorithms, this algorithm can converge quickly in a short time and get an ideal design scheme. This shows that the algorithm in this article adopts more effective optimization strategy and algorithm framework, and can find a better design scheme in a shorter time.

The optimization speed of visual design of industrial products by using this algorithm is faster because the algorithm fully considers the characteristics of industrial products and the actual needs of visual design. In the process of algorithm design, this article optimizes the physical characteristics, aesthetic requirements and human-computer interaction of industrial products, thus improving the efficiency and effectiveness of the algorithm.

5 PRACTICAL CASE ANALYSIS

In order to show the application of CAD algorithm in visual design optimization of industrial products, a mechanical transmission device is selected as the case study object in this section. The transmission device plays an important role in the mechanical transmission system, and its performance and reliability have an important impact on the operation of the whole system. Therefore, it is of great significance to optimize the design of the transmission device.

5.1 Using CAD Algorithm to Optimize Visual Design

Firstly, this article uses CAD technology to model the mechanical transmission device, including its 3D model, finite element analysis model and hydrodynamic model. Then, SAA is used to optimize the design scheme. Specifically, this section takes the strength, stiffness and stability of the transmission device as the objective function, and searches and optimizes the design scheme through SAA. At each temperature, different design schemes are randomly selected for evaluation, and whether to accept the new solution state is decided according to the difference of objective function values and acceptance probability. Finally, an optimal design scheme is obtained.

5.2 Experimental Verification and Performance Evaluation

In order to verify the effectiveness and feasibility of the optimized design scheme, a series of experiments are carried out in this section. Firstly, according to the optimized design scheme, the prototype of mechanical transmission device is made, assembled and debugged. Then, it is tested in various working conditions, including no-load, load and fatigue. For example, Table 1 shows the experimental verification results, and Table 2 shows the performance evaluation results.

Project	*Before optimization*	*After optimization*
Transmission efficiency	88%	92%
Transmission error	0.8%	0.5%
Fatigue life	5000 h	6000 h
Weight	10kg	8kg
Cost	10,000	8,500

Table 1: Experimental verification results.

Working condition	*Before optimization*	*After optimization*
Operate without load	Qualified	Excellent
Load	Basically qualified	Excellent
Tired	Unqualified	Qualified

Table 2: Performance evaluation results.

Through experimental verification and performance evaluation, it can be found that the optimized design scheme has higher transmission efficiency, lower transmission error, longer fatigue life, lighter weight and lower cost. Moreover, the optimized design scheme is more stable and reliable under various working conditions. Therefore, the optimization scheme has high application value and popularization significance. Figure 7 shows the time required to optimize the design scheme of mechanical transmission by using SAA. As can be seen from the figure, the SAA in this article is relatively short in optimization time and has high efficiency.

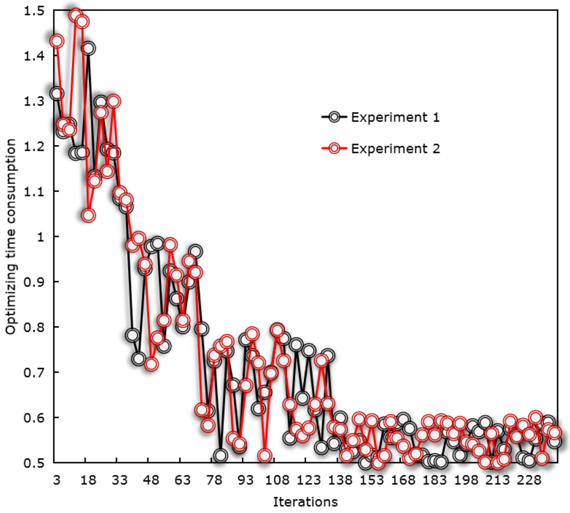

Figure 7: Optimization time of mechanical transmission design scheme.

The SAA in this article is relatively short in optimization time. This shows that the algorithm has high efficiency in optimizing the design scheme of mechanical transmission device, and can find a more optimized design scheme in a short time. This advantage in efficiency makes the algorithm more practical in practical application. Moreover, the SAA in this article has a higher reduction in optimization time. This shows that the algorithm adopts more effective optimization strategy and algorithm framework, and can find a better design scheme in a short time. In this article, the characteristics and practical requirements of mechanical transmission design are fully considered. In the process of algorithm design, this article optimizes the physical characteristics, functional requirements and reliability of mechanical transmission device, thus improving the efficiency and effectiveness of the algorithm.

To sum up, through practical case analysis, this section shows the application value of CAD algorithm in visual design optimization of industrial products. The results show that the optimized design scheme has higher strength, stiffness and stability, while reducing the weight and cost. In addition, the scheme has good manufacturability and maintainability, and is suitable for mass production and application.

6 CONCLUSIONS

In this article, CAD algorithm is effectively applied to the optimization of visual design of industrial products, and its feasibility and superiority are verified by simulation research. The simulation results show that the model can gradually improve its accuracy and recall rate, and keep a high level of more than 90% after 280 trainings. Moreover, CAD algorithm has high efficiency and effectiveness in optimizing design scheme, and can find a better design scheme in a short time. Its performance is also relatively stable. These advantages make the model have high application value in practical application. In the actual case analysis, this article uses CAD technology to model the mechanical transmission device. Then, SAA is used to optimize the design of mechanical transmission device, and an optimal design scheme is obtained, and its effectiveness and feasibility are verified by experiments. This case can provide some reference for the visual design optimization of other industrial products.

Through simulation research, this article finds that CAD algorithm has obvious advantages in visual design optimization of industrial products. It is embodied in the following aspects: CAD algorithm can accurately describe and optimize the spatial layout, structural size and other information of design scheme, thus improving the quality of design scheme; The CAD algorithm adopts efficient numerical calculation and graphic processing technology, which can quickly find the optimal design scheme, thus accelerating the optimization speed; The application of CAD algorithm can reduce the high-cost workload such as traditional manual drawing and physical model making, thus reducing the cost of the whole design process. It is worth noting that although the design scheme using CAD algorithm is superior to the traditional method, it does not necessarily mean that the design scheme is completely defect-free or perfect. In some cases, there may still be some small defects or deficiencies in the design scheme using CAD algorithm. Therefore, in practical application, the design scheme obtained by using CAD algorithm needs to be carefully examined and verified to ensure that it meets the actual needs and safety standards.

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