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APPLICATION OF DEEP LEARNING ALGORITHM IN VISUAL OPTIMIZATION OF INDUSTRIAL DESIGN

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Abstract. In order to understand the application of degree learning algorithms in industrial design visual optimization, the author proposes an application research based on deep learning algorithms in industrial design visual optimization. The author first starts with the basic principles of deep learning algorithms and provides a detailed explanation of the basic structure of the single-layer network of deep learning algorithms, as well as the restricted Boltzmann machine and its training process. Finally, an example of the performance improvement brought by the application of deep learning technology in handwritten digit recognition was given through an automatic encoder, and a simple summary of deep learning technology was made. Secondly, the NCI matching algorithm is used to match industrial design products and reconstruct the point cloud of industrial products to accurately detect their features. On this basis, deep learning algorithms are applied to construct a visual optimization model for industrial design, determine the output format of the model scene and the output situation of industrial design, and process the model according to the changing characteristics of the industrial design model to comprehensively edit the data of the model. Finally, targeted optimization of the industrial design visual optimization model is carried out based on the technical characteristics of deep learning algorithms, in order to complete the industrial design visual optimization. The experimental comparison results show that the industrial design visual optimization method optimized in this design has higher visual clarity than the traditional industrial design method, reaching 98%. Greatly improves the visual clarity of industrial design.

Key words: Deep learning: Industrial design; Visual optimization

1. Introduction. Industrial design, also known as industrial product design, is formed by industrial development and division of labor, which is significantly different from other art, craft production, and production activities. It is also an interdisciplinary product formed by the joint action of various disciplines, technologies, and aesthetic concepts. Industrial design can generally be divided into four categories, namely communication design, product design, environmental design, and design management, including mechanical design, clothing design, graphic design, network design, display design, animation design, architectural design, and many other branches. Industrial design involves various knowledge such as sociology, psychology, aesthetics, photography, mechanical construction, color, and ergonomics. In a broad sense, industrial design is a set of highly feasible design schemes from creative conception to design establishment, aimed at achieving a specific purpose. It is also a series of behaviors expressed through scientific methods and methods. The broad definition of industrial design includes all design processes that use modern means for production and service.

In a narrow sense, industrial design is product design, which responds to the demand for tool and equipment production in the connection between humans and nature. It includes the material equipment design of a series of tools, instruments, products, and other materials that meet the needs of survival and development. Because industrial design has been dominated by product design since production, product design is also known as industrial design. As a highly professional academic term - visual optimization design, it is a design that expresses and disseminates the information to be expressed through visual communication media. With the continuous development of science and technology, the development and utilization of new materials and energy, and the field of visual communication design is gradually expanding. Visual optimization design includes display design, printing design, packaging design, impact design, visual environment design, etc.

The research on visual optimization design in industrial design is the process of conveying the product itself, product promotion and design information, and consumers' visual perception of the product through visual communication design. It also focuses on the targeted research and design of integration issues for consumers in the process of purchasing and consumption. When optimizing visual design, it is necessary to position the

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visual experience throughout the entire process, in order to elevate the quality of the product and enhance its taste.

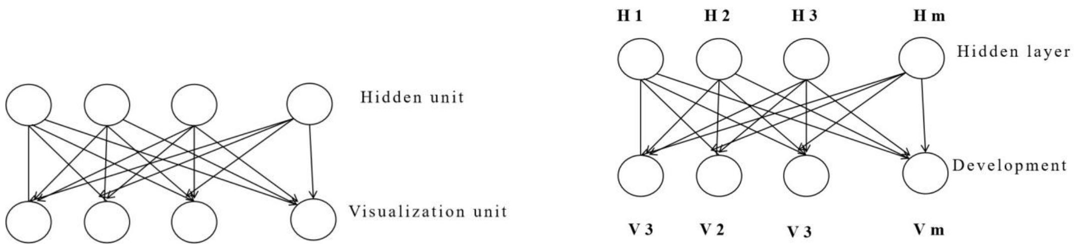
With the continuous progress of the times, people's quality of life is increasingly improving, so there is also an increasing emphasis on the visual aspect of industrial design. In the 21st century, this visual design has become a visual culture that permeates people's lives. The formation of visual culture is not accidental, but a product that conforms to the development of the times. In the context of global economic integration, the level of technology is constantly improving. With the application of various new technologies, industrial production is also constantly incorporating visual design concepts. Under the influence of this visual design concept, many industrial products pay more attention to personalized design while meeting the rationality of the product. Not only that, many industrial products widely solicit people's opinions at the beginning of design, achieving an organic integration of industrial products and art, so that people can not only feel practicality but also meet their own aesthetic needs.

In today's constantly advancing technology, science and technology itself can be regarded as an art, and its added value has greatly exceeded its usage function. In this context, modern industrial design is also advancing with the progress of the times, with obvious characteristics. For example, modern industrial design is no longer limited to the original intention of visual cultural design, not only for the aesthetics of industrial products, but also to increase the connotation and usability of products. In addition, modern industrial design is based on visual culture, through the organic integration of art and technology, in order to increase industrial production and enhance the popularity of industrial products. Therefore, the vigorous development of industrial design is an inevitable trend of the times, which has important practical significance for the inheritance of human civilization and the dissemination of art and culture [1, 2].

2. Literature Review. Human activities cannot be separated from human senses, and human perception determines the process of activity. As a crucial research field in cognitive psychology, the field of perception mainly includes the five senses of human beings, namely vision, hearing, smell, touch, and taste, vision is the most important of the five senses. Perception is the overall understanding of things formed in the mind through the direct effect of external information stimuli on the senses. External information directly affects perception, and human perception is influenced by their own stored knowledge and experience. Different human individuals are also affected differently, resulting in differences in human activities. Therefore, the sensory perception stimulated by external information and human past knowledge and experience determine the cognition of things. Among many forms of perception, visual perception exists as the most core form of perception, and its research significance is also the most valuable compared to other forms of perception. At the same time, it serves as one of the main channels to obtain a large amount of external information. However, human attention is limited and can only allocate a certain amount of resources to the visual system. Visual selective attention will play a role in this process, and visual selective attention mainly reflects eye movement at the physiological level of the human body. Therefore, eye movement research is particularly important, which can obtain the cognitive mechanisms and characteristics of users when observing objects.

Through research on the visual perception process, it has been found that it mainly consists of three parts: capturing visual stimulus information, organizing visual stimulus information, and generating cognitive responses to stimulus information. The entire process can be reflected as follows: The eyeball captures external visual stimulus information, then obtains and processes the stimulus information through the brain, and finally generates corresponding cognitive responses.

Deep learning is a new area of machine learning research that relies on neural networks to generate experimental models of human brain analysis, learning, cognitive processes, goals, and visual information in the human brain. A representative success of this is the "Auto Encoder" proposed by Hinton in 2006, which has been very successful in encoding. Previous neural network studies have also attempted to address this issue, but have not achieved significant results due to the lack of deep network models and training problems. Deep learning is machine learning that aims to generate deep patterns that typically include at least three hidden layers. This type of network with many hidden layers is difficult to train using simple neural network algorithms such as the BP algorithm. This is due not only to the need to process large data samples and the slow training process, but also to the fact that it is not easy to exchange internally rather than global optima, which have disadvantages. Moskola, W. et al. A restricted Boltzmann machine (RBM) was introduced as a simple model



(a) Boltzmann machine (b) Restricted Boltzmann machine

Fig. 3.1: Boltzmann Machine and Restricted Boltzmann Machine

of a single-layer network and a deep network was trained by hierarchical training. This type of effect has been demonstrated using automata and laid the foundation for deep learning concepts and models [3].

There are three main steps in deep learning: Firstly, training the system in an unsupervised manner, which involves extracting layers from a large number of unlabeled samples and automatically forming features without guidance. This process is similar to how people automatically form different types of information impressions in their brains after receiving image and sound information through sensory systems such as the eyes and ears. Secondly, alignment. This process uses some labeled samples to classify features, and further adjusts system parameters based on the classification results to optimize the system's performance in distinguishing different types of information. Similar to people knowing what a deer is, what a horse is, or what voice quality is good and what is bad. Thirdly, testing is conducted to test the learning effectiveness of the system using unknown sample data, such as the correct classification rate of samples, the correlation between quality evaluation and subjective evaluation.

Only the ideas are visible, and another layer of deep learning is hidden behind the last layer, making it difficult to determine how much information they contain. It's like seeing an animal, from being updated to making a final decision like a horse, from the brain gradually abstracting information at the same level. It's not easy to tell. But to train a deep network layer by layer, it is necessary to specify the information data of each hidden layer and show their relationship. Good for those who know a lot. Peng, Z. et al. The solution is to use RBM as the core process of the network and train the network layers from the bottom up until the desired results are produced at the top level. The learning process of all layers is the same: The lowest layer uses data as input and output data as output; Upper layers use the output of lower layers as input and generate information based on the upper layer. For example, the input can be any number of digits and the output can be 0-8. The input and output dimensions of each layer, as well as the number of layers in the deep network, can be written without special restrictions as needed [4].

In the visual design of traditional commercial design, the floor plan is often used as the basic equipment to solve this, creating visual illusions, interactions and realism. algorithms. Those. NCI matching algorithms are used to match these models to product models and verify their features. Deep learning algorithms are used to test business models and gain design insights [5, 6].

3. Methods.

3.1. Deep learning models and training methods. A restricted Boltzmann machine is an improvement of the random network Boltzmann machine. As shown in Figure 3.1 (a), the learning process of the network is slow because the units in its layers are interconnected. In 1986, Somlensky introduced a constrained Boltzmann machine consisting of a visible layer and a hidden layer without interactions between units in the layers, as shown in Figure 3.1 (b). Using RBM for inference in this way is very effective.

Assuming that the RBM has n visible units and m hidden units, it is recommended to use vectors v and h to represent the states of the visible and hidden units, where vi represents the state of the ith visible unit. and hj represents the state of the jth hidden unit. room. Therefore, for a set of states v and h, the joint probability

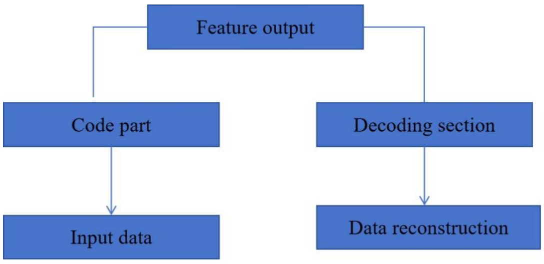


Fig. 3.2: Automatic coding

of the RBM system can be expressed as a power function using equation (3.1):

$$E(v,h) = -\sum_{i-1} w_{ij}v_i, h_j - \sum_{i-1}^{n} vi, b_i - \sum_{j-1}^{m} h_j cj \tag{3.1}$$

Infashion, w_{ii}; Ci is a measure of RBM. Among them, w_{ij} represents the coupling strength between visible unit i and hidden unit j, b_i represents the bias of visible unit i, and c_j represents the bias of hidden unit j. The task of learning an RBM is to estimate the values of these parameters that fit the training data.

Given the choice u of the training data, the latent class probability is based on the condition that the value of the latent class depends only on the distribution of the specified classes (3.2):

$$p(h_j)\sigma(\sum_{i-1}^{n} w_{ij}v_i + c_i) \tag{3.2}$$

Similarly, the conditional probability of the explicit unit can be conveniently calculated as equation (3.3):

$$p(v_j) = \sigma(\sum_{j-1}^{m} w_{ij}h_i + b_i) \tag{3.3}$$

3.2. Handwritten Digit Recognition. Autoencoders are the best example of deep learning. It consists of several layers of RBM. The working principle is that the input data enters the multi-layer RBM, converts high data into low data, completes the encoding process, and forms a middle layer process. Then, starting from each layer, the parameters of each layer generated by the coding process are reused, and the input data is reconstructed to arrive at a decision work(as shown in Figure 3.2). The entire network achieves fine-tuning of model parameters by minimizing the cross correlation between input data and reconstructed data, enabling the intermediate code layer to output more essential features [7, 8].

Here is an experiment using a 5-layer automatic encoder to classify handwritten digits in the dataset MNIST. The process is as follows: Firstly, preprocess the input data by converting the pixel values of the original digital image 29×29 into row vectors of 1×755. Therefore, during the training process, a four layer automatic encoder network with 794 units in the display layer and 1100-550-260-40-20 in the hidden layer can be established; Secondly, convert the original pixel intensity values between 0 and 265 to grayscale values between 0 and 2; Finally, the 65000 training samples in the database were divided into 650 small batches in groups of 120, and each training cycle processed these 650 small batches in sequence. The weights were only updated after each small batch ended [9, 10].

After the training of the automatic encoder is completed, the labeled samples can be used to test its classification performance and calculate the error rate. Table 3.1 compares the error rates of the automatic encoder introduced here with other classifiers. It can be seen that using automatic encoding machines can improve classification performance. It should be noted that the number of hidden layers and hidden layer units in deep learning networks can affect classification results, and there is currently no objective inference method for these quantities, so they have greater flexibility.

Table 3.1: Recognition performance of different classifiers on MNIST database

learning algorithm	Error rate%
automatic coding (1100 - 550 - 260 - 40 - 20)	1.3
BP algorithm	1.54
nearest neighbor method	2.9
Linear classifier	8.5
40PCA+particle algorithm	3.4
Support vector machine	1.5

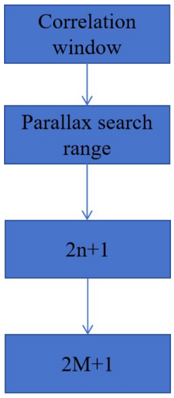


Fig. 3.3: Schematic diagram of NCI matching algorithm

3.3. Recognition of Visual Characteristics of Industrial Products. Before optimizing the visual design of industrial products, identify the visual features of industrial product design to improve the visual optimization effect of the design. View the industrial design to be visually optimized, streamline the number of product grid faces, use NCI matching algorithm to match industrial design products, and remove hidden objects from the products. The schematic diagram of NCI matching algorithm is shown in Figure 3.3.

In Figure 3.3, first give a point in the upper view and search for a matching point in the lower view based on neighborhood similarity. This neighborhood is a window that matches with the authentication point as the center. Reconstruct the point cloud of industrial products, give a three-dimensional point, use a normalization function to represent the projection of product images, and perform matching and feature tracking between industrial product images [11, 12].

Set the reference plane as p (n), k (n), and estimate the position of the three-dimensional point by finding the maximum average value of NCI. The calculation formula is as follows (3.4):

$$v(p) = \frac{1}{D(F) - 1} \tag{3.4}$$

3.4. Optimization of Visual Features in Industrial Design. Building intelligent models for business modeling based on deep learning algorithms. Use deep learning techniques to simplify the modeling process during development. First, based on the deep learning algorithm, prepare the design data of the business scene, clarify the business background information, maps and animations of the design process, satisfy the need for dimensional analysis of the design in three dimensions, and reduce the computer operation. Define the model output from the scene model and business model output and get a 3D scene that matches the actual business model. For design clarification, refer to the final EHF data for relevant design information [13, 14].

Applying deep learning techniques to create specific business models will create an image of a design model with differences, as not all models can achieve complete design. According to the business model image of the whole model, in order to ensure a good image of the business model design and reduce the model design error,

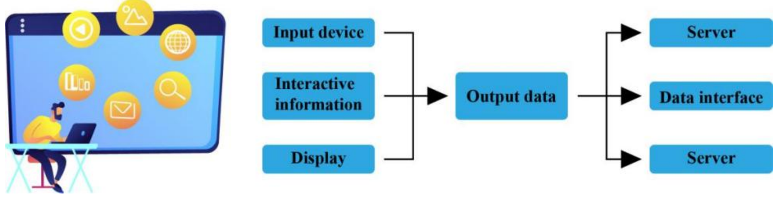


Fig. 4.1: Experimental Environment

the special model (3.5) is as follows.

$$I_1 - I_2 = \frac{1}{N} \cdot \sum_m i \tag{3.5}$$

In the formula, I_1 and I_2 respectively represent the industrial product models before and after error control; $\frac{1}{N}$ represents the model parameters for control optimization; $\sum_m i$ represents the image quality of industrial products.

After determining that the error of the optimized model meets the expected standards, detailed model parameters for industrial design are obtained through deep learning algorithms, and comprehensive data evaluation and analysis are conducted using the effectiveness of virtual simulation to obtain corresponding parameter data. After constructing a visual optimization model for industrial design, use the graphic acceleration process in deep learning algorithms to deeply interpret the industrial design model. On this basis, industrial design is optimized and processed according to the changing characteristics of industrial design models. On the basis of achieving real-time display of model information, the display effect of industrial product models is improved. Perform comprehensive data editing of the model using deep learning algorithms, using equation (3.6) to accelerate the model [15, 16].

$$d(m) = min(x - e) \tag{3.6}$$

In the formula: d (M) represents the vector length of the image; X-e represents the distance parameter from point a to point é within the industrial model product; Min is the optimization parameter. Set direction parameters based on the key points of industrial design to enhance the robustness of matching, and make targeted judgments on the visual optimization model based on the technical features of deep learning algorithms to ensure that the visual optimization effect of industrial design meets the expected goals.

4. Experimental Comparison.

4.1. Experimental Environment. The experimental environment mainly includes the Aiamond 3D Fire GL graphics card, which uses a 256-bit graphics scanner; The hard drive is a SCSL hard drive with 256 GB of memory; Large capacity external storage device; ADSL broadband network modem, etc. The specific experimental environment is shown in Figure 4.1. In the figure, the hardware mainly receives relevant industrial visual information; The purpose of input and output devices is to interact with the virtual environment through visual, auditory, and tactile means, mainly including displays, joysticks, and data gloves, to establish connections with the virtual environment; The data interface is connected to the tested machine to view experimental data in real-time. In the experiment, 20 simple industrial designs, 20 slightly difficult industrial designs, and 20 complex industrial designs were selected and compared using traditional methods and the author's design methods [17, 18].

4.2. Experimental Conclusion. Comparing the visual clarity of two industrial designs, the highest clarity is 100%. The higher the clarity, the better the optimization effect of industrial design. The experimental comparison results are shown in Figure 4.2.

From Figure 4.2, it can be seen that traditional methods have higher clarity in simple industrial design, while for slightly difficult and complex industrial design, visual clarity is poor and cannot display more industrial

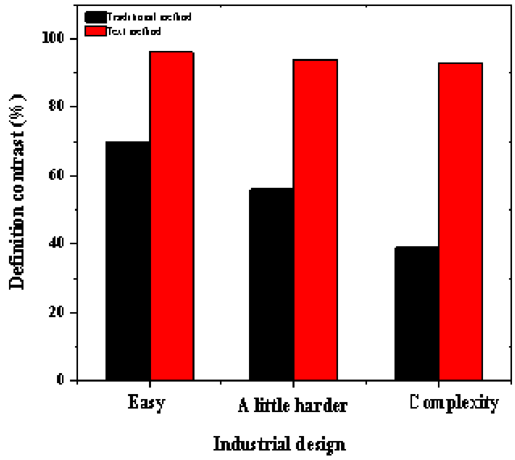


Fig. 4.2: Experimental comparison results

designs. The author's method has high clarity in simple industrial design, but for slightly difficult and complex industrial design, the visual clarity of industrial design remains unchanged and can still display more industrial design information [19, 20]. Explanation: The industrial design visual optimization method designed using deep learning algorithms can be displayed and processed according to the changing characteristics of industrial design, presenting a clearer industrial design effect.

5. Conclusion. Deep learning is how to use multilayer techniques to learn and represent the distributed capabilities of data models. It minimizes the requirements for quantitative and descriptive data models and automatically extracts many hierarchical features needed for classification using layerless learning methods. It has many features that differentiate it from existing machine learning. Currently, this technology is in the early stages of development and some important issues still need to be resolved. However, breakthroughs such as autoencoders show that deep learning has new ideas and great potential, which will have a significant impact on technologies such as machine learning and artificial intelligence in the coming years. The visual optimization method designed by the author for industrial design has higher visual clarity than traditional methods, which can improve the visual clarity of industrial design and provide certain assistance for industrial design, helping to promote the development of industrial design.

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