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Research on genetic algorithm for modeling optimization design of art product

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Abstract. With the rapid development of China's economy and the continuous progress of high and new technology, scholars at home and abroadhave more and more research on the modeling design of art product. It provides a theoretical basis for the modeling design of product, which directly affects the survival and development of the product and guide the future direction of product design and development.Therefore, it is of great significance and value to design the product image and make a comprehensive and scientific evaluation of its shape.Starting from the product semantics,this paper proposes a BP neural network algorithm based on genetic algorithmoptimization method of product modeling design scheme, and constructs a modeling evolutionary design model of product based on semantics. By constructing the gene encoding and gene string and fitness function of art product modeling,this paper optimizes the modeling design scheme of art product and forms a new scheme, and the applicability of the method is verified by the modeling design of art product.

Key words. The modeling design of product, Optimization design, Genetic algorithm.

1. Introduction

The modeling design of art product is creative design for the molding, color, surface decoration and material of the product, thus endow the product with new forms and new qualities. At present, the optimization design of the product modeling scheme is mostly made by human operation, and it is difficult to form a complete and exact product scheme,in addition,the situation is more complicated in the face of a larger programs set. Therefore, it is necessary to find a suitable mathematical algorithm for intelligent optimization. As a highly parallel, random and adaptive search algorithm, genetic algorithm has been widely applied in personalized product design, conceptual design, product optimization design and intelligent design[1]. With the rapid development of artificial intelligence, multiple swarm intelligence algorithms (such as genetic algorithm, particle swarm optimization and ant colony

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algorithm) are constantly discovered. Because of its strong global optimization ability and faster convergence speed, it is used to optimize the neural network to improve the generalization performance of the network[2−4].

In view of this, according to the algorithm model of genetic algorithm, this paper optimizes the modeling design of art product, provides effective assistance and support for conceptual design and improves the design efficiency[5].

2. Related Research Based on Product Modeling

2.1. Technical features of product modeling

People are in different times and have different spiritual yearnings.When the molding image of the mechanical product owns the spiritual significance of the times, and conform to the characteristics of the times,these "shape", "color" and "quality" with special infectious force will show the characteristics of the times that reflect the scientific level of the times and the contemporary aesthetic concept, this is the product'stemporal spirit.In 40s, before and after the end of World War II, because of the turmoil and suffering caused by the war,people are in a heavy mood and hope to have a peaceful and safe environment. Therefore,at that time,the mechanical products mostly adopted the arc shape with soft sense,and appeared the fashion of "streamlined" products, then formed the characteristics of industrial modeling in this era.In 50s,because of human physiology and World War II, people are tired of overstaffed, tension - sensitive streamlines, and visual psychological desire to be able to get some calm and stretch.The molding of industrial products conforms to the idea of most people (The development of science and technology has also gradually broken the "streamlined" monopoly) and gradually straightens the curve,so there is a kind of time modeling with the characteristic of straight line enlarging curvature[6−7]. From60s to 70s, due to the further development of science and technology, especially the emergence of large quantities of new materials and new processes,the product modeling in the manufacturing processhas thepossibility ofrefinement, simplicity, affirmation and change square straight,so the rectangle and trapezoidal shape that oblique broken straight and move broken staticappeared,which enlivened the atmosphere of visual art.After 80s, as large-scale integrated circuits, digital control, microcomputer, Mechatronics and other forms of technology are changing with each passing day, and new materials and new technologies such as plastic plating, engineering injection and so on emerge in an endless stream, the development trend of industry is bigger and higher.In this diverse and excellent situation, the aesthetic requirements and standards of people from reason to concept are or are going to qualitative transition.As a product modeling,it truly reflects people's bold and persistent pursuit for high technology,and geometric modeling is used to make layout and composition more concise, clear, rational and abstract, full of diversified performanceof geometric beauty and mathematical beauty,naturally become the fashion of modern product modeling[8−9].

2.2. Design concept of product modeling

In the modeling design of art product,it is necessary to focus on the two principles of color design and proportionality design.

(1)Color design

In the whole product image, color first acts on human visual perception, and can be said to be "pioneer".If the product color is well handled,it can coordinate or make up some of the shortcomings in the modelingto make it more perfect,and it is easy to get the favor of consumers, so that it can get twice the result with half the effort.On the contrary,if the product color is not handled properly,it will not only affect the function of the product, destroy the overall beauty of the product modeling, but also easily reduce the people's working moodand make people feel boring, dreary, indifferent or even depressed, so that distract the operator's attention and reduce work efficiency.Therefore,in the molding design of the product,color design is an important work that cannot be ignored, and the choice of color is very important[10].

(2)proportionality design

The right proportion and scale are the foundation and frame of the perfect modeling.Generally speaking,under the premise of not violating the function of the product and the material and technical conditions,the proportion can be a combinationformof variouschange to show the quantitative relationship ofmodelingbetween the whole and local or local and local, such as big and small, coarse and fine and length and short.The scale is relatively fixed,it refers specifically to the adaptive extent and scope betweenthe size of object and size of the human body or a certainstandard.If the modeling is only a good proportion without a correct fixed scaleto the constraints, then the design will certainly fail.Therefore,the order of the correct modeling design should first determine the scale,and then determine and adjust the proportion of the modeling objects according to the scale.For example, the barricade of the bridge, the shield of the machine,the trunk of a car, the seat of a bicycle and the penholder of fountain pen, which are the first to take into consideration the scale of the object, that is, the length, width, height and diameter of the body size adaption, and thenconsider the proportion and detail adjustment of the object.

3. Art Modeling Design

3.1. Modeling design model

The modeling evolution design model of art products is shown in Figure 1,which includes two main parts: 1)Transformation of modeling design space and evolutionary design space; 2)The modeling evolution design. Using semantic quantization description to realize the transformation from modeling design space to evolutionary design space, which includes the determination of the elements of the modeling design,the encoding of the modeling gene and the semantic quantization description of the target product modeling.Through semantic quantitative description of product modeling,the modeling design elements of product and the semantics of product are converted to the same perceptual cognitive space.In the evolutionary design

space,genetic algorithm (GA) is applied to modeling element space searchthrough genetic variation, fitness evaluation, and evolution by generation, and once the semantic requirement of the target product is reached,the gene can be decoded, and the corresponding product modeling elements can be obtained.

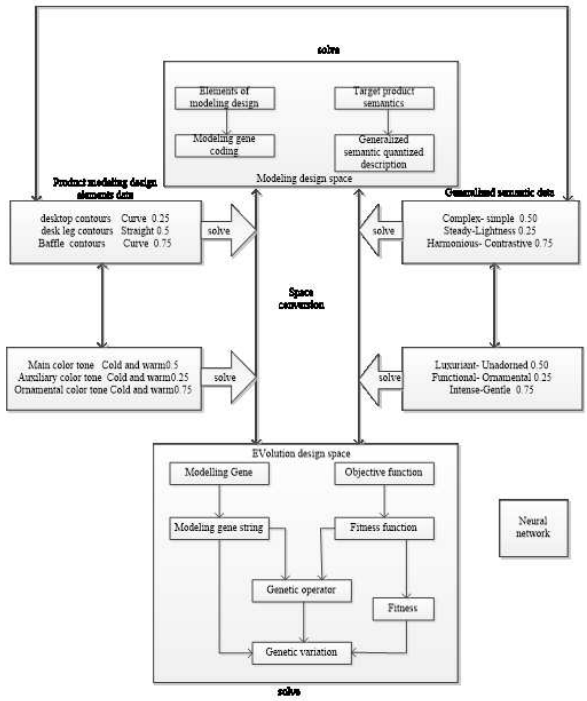

Fig. 1. Modeling evolutionary design model

3.2. Gene encoding and gene string of art product modeling

The gene of product modelingisa product modeling elementdetermined by product semantic description and modeling features, and it is the basic design element to express the modelingstyle.The encoding method of the art product modeling geneis determined by the modeling feature of the modeling gene, and for the specific product design,it only need to distinguish the modeling features of the product modeling elements,and do not have to express their modeling features accurately.Therefore,in general, the fuzzy semantic quantization method is used to express the feature information of the product modeling elements.In order to facilitate BP network processing (such as fitness function), the range of the value of the modeling gene is selected as (0, 1), and 0 and 1 respectively represent the two extremes of the modeling features, such as straight and curve of lines, cold and warm of color.In the actual process of the modeling design of product,in order to avoid the great difference between it and the actual design goalcaused byextreme values, and the modeling gene is taken as (0.1, 0.9) and encoded in real numbers.In the modeling design of product semantic

constraints,a modeling gene string corresponds to a possible design scheme, that is, a solution.The length of a gene string is the same as the number of the product modeling elements.A genetic gene represents a modeling element,andone-to-one correspondence. Genetic genes use numerical (0.1, 0.9) to represent the level of modeling elementsso that a genotype canspecificallyrepresentthe modeling or structure type of a product's modeling element.Taking the desk as an example,its modeling genes and judgment criteria are shown in Table 1.

Table 1. The modeling genes and judgment criteria of the desk

Modeling feature category	Category number	Modeling gene	Standard of judgment (Value)	
			0	1
Form elements	1	The shape of the upper contour of the desk	Straight	Curve
	2	The shape of the bottom contour of the desk	Straight	Curve
	3	Contour on both sides of the desk	Straight	Curve
	⋮	⋮	⋮	⋮
Color elements	10	Desktop main color	Cold	Warm
	11	Desktop auxiliary coloring	Cold	Warm
	12	Tabletop adornment Color	Plain	Gorgeous
	⋮	⋮	⋮	⋮
Connection relations	19	The form of the connection between the desktop and the desk leg	Irrelevant 0, across 0.5, contain 1	
	20	The form of the connection between the desk leg and the baffle	Irrelevant 0, across 0.5, contain 1	
	21	The form of the connection between the desktop and the baffle	Irrelevant 0, across 0.5, contain 1	

4. Research on Genetic Algorithm for Modeling Optimization Design of Art Products

4.1. Genetic algorithm- BP Neural network algorithm model

In the BP neural network, a single sample has an input and an output,and there are usually several hidden-layers between the input layer and the output layer. Actually, in1989,Robert Hecht-Nielsen proves thata continuous function in any closed interval can be approximated by a hidden-layer BP network, which is the universal approximation theorem.Therefore,athree-layer BP network can complete the mapping from any dimension to other dimensions.These three layers are the input layer (I), the hidden layer (H), the output layer (O). As shown in Figure 2,and the algorithm flowchart is shown in Figure 3

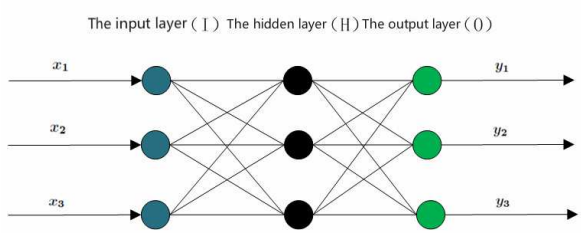

Fig. 2. The composition of BP neural network

In the BP neural network,the number of nodes in the input layers and output layers is determined, while the number of nodes in the hidden layer is uncertain, and calculating the number of nodes by empirical formula:

$h = \sqrt{m+n} + a$ (1)

h is the number of nodes in the hidden layer, m is the number of nodes in the input layers, n is the number of nodes in the output layers, and is a constant between 1∼10.

In the BP neural network,the process of reverse transmission of error signals is more complex, and it is based on the widow-Hofflearning rules.Suppose that all the results of the output layer are d_j, and the error function is as follows:

$$E(\omega, b) = \frac{1}{2}\sum_{j=0}^{n-1}(d_j - y_j)^2 \tag{1}$$

Activation function is:

$$f(x) = \frac{A}{1 + e^{-\frac{x}{B}}} \tag{2}$$

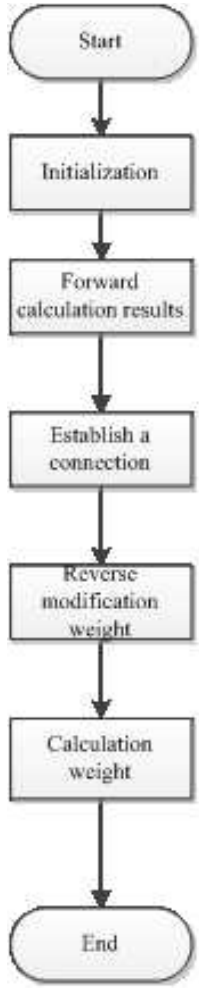

Fig. 3. algorithm flow chart

4.2. Code implementation

In this paper,the object-oriented programming language JAVA is used to program the BP neural network, and the development tools are eclipse.A part of the code program is shown in Figure 4.

4.3. Example verification

This article takes the desk as an example, and the reference sample shown in Figure 5.Through the analysis, it can be found that the reference sample is rigid in modeling and single in color, and it is difficult to meet the needs of consumers.Therefore, starting from the modeling design,the product form elements, color elements and

```
private void forward(int start, int end, double[][] weight, double[] yuzhi, double[] setIn,double[]
    //inputNum,hiddenNum,w,hidden_y,in,hidden_in,hidden_out
    for(int n=0;n<end;n++)
    {
        double sum = 0;
        for(int m=0;m<start;m++)
            sum += setIn[m]*weight[m][n];
        begin[n] = sum - yuzhi[n];
        after[n] = Sigmoid(begin[n]);
    }

}

private double Sigmoid(double d) {
    // TODO Auto-generated method stub
    return 1/(1+Math.exp(-d));
}

private void Calculate_err() {
    Calculate_err_out();
    Calculate_err_hidden();

}
private void Calculate_err_out() {
    sqr_err = 0;
    for(int k=0;k<outputNum;k++)
    {
        delta_out[k] = (out[k]-out_out[k]) * out_out[k] * (1-out_out[k]);
        sqr_err += (out[k]-out_out[k])*(out[k]-out_out[k]);
    }
    sqr_err = sqr_err/2;
}
```

Fig. 4. A part of the code program

semantic quantitative description of connection relationsis used as the evaluation objective to express the product's modeling features and optimize them.The modeling semantic constraints of the plate style desk are shown in Table 2.

Fig. 5. Sample picture

Table 2. Semantic modeling table

The modeling semantic constraint of product		
Form elements	Color elements	Connection relations
Popular- Personalities	Vulgar- Elegant	Rugged- Delicate
Male-Feminine	Gentle- Intense	Discomfort- Comfortable
Traditional-Modern	Harmonious- Contrastive	Inconvenient- Convenient
Endocentric - Exocentric	Classical- Fashionable	Complex- simple
Straight- Curvilinear	Economic- Expensive	Functional- Ornamental
⋮	⋮	⋮

The BP network is used as the fitness evaluation model,the input layer is the modeling gene of plate style desk,and the output layer is the semantic quantitative description of plate style desk.The input nodesare the form element, the color element and the modeling gene of the connection relationship, and the number of nodes is 21.The output nodesare the form element, the color element and the semantic constraints of the connection relationship, and the number of nodes is 27.The number of nodes in the middle layer is 20 and the number of layers is 4.This paperselectsthirty desk samplestoinvestigate the value of the modeling elements of the desk and semantic quantitative evaluation, and choose a certain number people of different professional to take part in the survey, such as designers, teachers, students and so on.Set the evaluation weights of people of different professional,and get the test sample value to train the BP network according to the way of weighted average of each person, then a trained BP network as an evaluation model for solving fitness function.The output result is shown in Table 3.

Table 3. Result table

Category number	Modeling semantic constraint	The reference desk	Solution one	Solution two	Solution three	Solution four	Solution five
1	Form semantics	0.6	0.6	0.8	0.6	0.7	0.75
2		0.6	0.3	0.8	0.6	0.8	0.9
3		0.5	0.3	0.6	0.5	0.7	0.6
⋮		⋮	⋮	⋮	⋮	⋮	⋮
12	Color semantics	0.8	0.8	0.6	0.8	0.7	0.9
13		0.35	0.8	0.6	0.35	0.65	0.25
14		0.9	0.7	0.7	0.9	0.1	0.8
⋮		⋮	⋮	⋮	⋮	⋮	⋮
23	Connection relations semantics	0.65	0.7	0.8	0.65	0.7	0.75
24		0.5	0.8	0.9	0.5	0.4	0.75
25		0.7	0.8	0.8	0.7	0.7	0.7
26		0.75	0.4	0.9	0.75	0.4	0.2
27		0.9	0.8	0.8	0.9	0.9	0.8
Error			0.010	0.006	0.007	0.009	0.007

The errors of solution two,solution three, solution five and the style evaluation indexthe reference desks are similar or identical, but their corresponding modeling elements indexare different, that is, the form of solution is varied.This is the purpose of using genetic algorithms to assist design. It hopes that the modeling of design scheme and the target product modeling semantics are the most similar, and the genes of different molding products can be obtained to makea comprehensive optimization design of the modeling scheme.In addition,because of the fuzziness and uncertainty of the semantic description,and the following will study the semantic collection and investigation systembased on network to improve the semantic constraint set of product modeling.

5. Conclusion

On the basis of the existing art product scheme modeling,according to the semantic constraint,this paper realizes the fast and intelligent drive between the art product semantics and the art product modeling scheme, and produces the optimal design scheme, and realizes the agility and intelligence of the art product design.Due to the factors thataffect the modeling featuresof a product include form elements,

color elements, connection relationships, material elements, and combination relationships, and the next step will refine the product's genes tomakea comprehensive optimization design of modeling scheme.Therefore,the study of this paper is of great value to the optimization design of art products, and to a certain extent, it has promoted the research of genetic algorithm.

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