Research on the Modeling Design of Cultural Creative Products of "Leizhou Stone Dog"

Chen Lu[*], Zhu wei

School of Physics Science and Technology , Lingnan Normal University, Zhanjiang, 524048, China
[*]*Corresponding Author: cl12297@126.com*

ABSTRACT. *The culture of "Lei Zhou Stone Dog" in the western part of Guangdong Province, China, is a precious heritage of local folk customs. Based on this, this paper will discuss the innovative design method of the museum's cultural and creative products. Use the Semantic Difference (SD) method to get the perceptual image score of the target consumer group, code the modeling characteristics of stone dog, use the genetic algorithm to select, cross and mutate the process, and simulate the process of product modeling evolution. Taking electric kettle as an example, the shape description of the product after evolution has higher adaptability than before. Through the use of perceptual image modeling design experiments and interactive genetic algorithms, it has been verified that there are many ways and methods for the optimal design of museum cultural creative products.*

KEYWORDS: *Cultural creative products, Regional culture, Genetic algorithm, Electric kettle*

1. Introduction

In recent years, the development of museum cultural and creative products has received increasing attention from the product design industry. On one hand, the cultural and creative products inherit regional history and exchange local culture through traditional cultural resources. The other hand, cultural and creative products not only show cultural characteristics, but also add value in line with contemporary living habits and aesthetic tastes [1]. As a derivative of culture, people repeatedly experience and share commodities in their daily lives, which has a wide range of social benefits. However, With the explosive growth of cultural and creative products, new product development has encountered some bottlenecks. Include: the design form and product type are single, the design idea stays at the stage of copying successful cases, the phenomenon of serious homogenization, and other so on[2]. These problems are caused by the "creativity" of cultural and creative products being more designer-oriented. When selecting design elements, there is a lack of public participation and feedback, as well as a lack of more diverse design methods.

Therefore, we will take the electric kettle as an example, collect the consumer image through the means of perceptual engineering, and then combine the genetic algorithm to optimize the design of product shape, to explore the innovative design forms and methods of Museum Cultural and creative products.

Genetic algorithms have many mature applications in the design of modern industrial products. Researchers usually use the inherent logic of the algorithm to build a modeling parametric model, combined with an example to detect the optimal solution. The research mainly focus on: analyzing product image, encoding product characteristics and forming sample genes, constructing mathematical models of modeling style, compiling computer programs and other so on. Deng Xian-zhi uses a genetic algorithm to build a hierarchical solution system, establishes a product parameter model based on the evaluation of target customers, and searches for the optimal solution for plastic water bottle modeling[3]. The team of Yang Bochao took the design of modern coal mining machine as an example to study the application of interactive genetic algorithm in design of product human-machine configuration [4]. Professor Luo Shijian of Zhejiang University proposed the establishment of a creative design-oriented utensil knowledge classification framework system, which integrates cultural and scientific knowledge to conduct museum cultural and creative product interaction design [5]. Wang Wei and Li Fangyu of Southwest Jiaotong University took the Chengdu Museum as an example, and from the perspective of the design of local culture, they explored the design methods of aesthetic, regional and innovative cultural and creative products [6].

2. Product Styling Design Methods and Processes

2.1 Product Image Evaluation

Product image evaluation is a commonly used experimental method in Kansei engineering. It realizes the qualitative and quantitative analysis of product modeling by tapping the potential psychological preferences of consumers on the research object. It provides the basis for the application of genetic algorithm [7]. The Kansei design technical route is shown in Fig. 1:
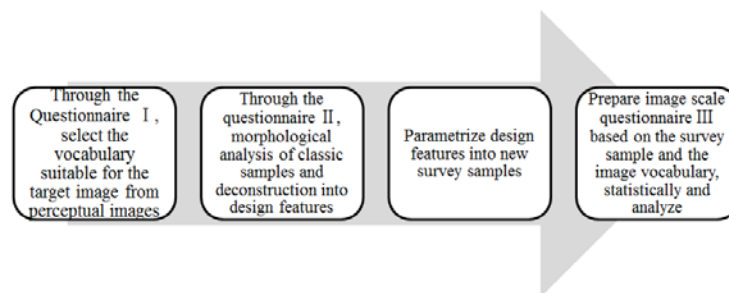

Fig.1 The Kansei Design Technical Route

Therefore, kansei design is a technical method that transforms the product design characteristics obtained from morphological analysis and survey questionnaires with the representative images to guide product development [8].

2.2 Interactive Genetic Algorithm

The steps of applying genetic algorithm to design are: establishing a computer model based on generative and evolutionary design, and building the associated model into a perceptual image design support system, using this system to provide designers with tools to assist in the generation of design patterns [9][10]. The original intention of the interactive genetic algorithm is to transform the non-linear problem into a problem of finding the optimal solution. The natural evolutionary law is used as the basic design idea, and the designer's knowledge, experience, intuition and values are combined to realize the optimal product design [11]. The general process of the interactive genetic algorithm is as follows:
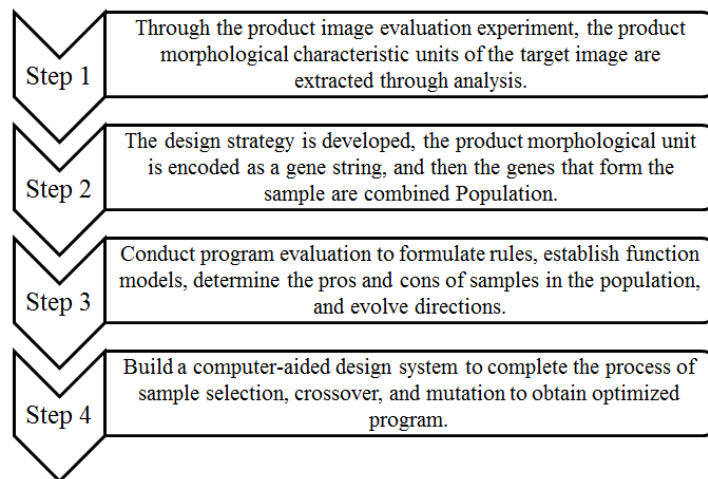
Step 1	Through the product image evaluation experiment, the product morphological characteristic units of the target image are extracted through analysis.
Step 2	The design strategy is developed, the product morphological unit is encoded as a gene string, and then the genes that form the sample are combined Population.
Step 3	Conduct program evaluation to formulate rules, establish function models, determine the pros and cons of samples in the population, and evolve directions.
Step 4	Build a computer-aided design system to complete the process of sample selection, crossover, and mutation to obtain optimized program.

Fig.2 The General Process of the Interactive Genetic Algorithm

In conclusion, creative design of product modeling can be regarded as the process of combination and reconstruction of its basic components. Because each combination of morphological features has a corresponding specific image, it is necessary to carry out image investigation experiment according to the design purpose first, then code and evaluate the product feature attribute, and get the result to establish the appropriate function. Finally, the design concept is compiled into computer language, and the logic of genetic algorithm is used to find the optimal combination scheme.

2.3 Design Idea and Research Framework of Electric Kettle

As a series of consumptions, the museum's cultural creative products are a bridge connecting historical relics and public life. Its development and sales are expected to have three effects as : (1) The role of spreading regional culture. (2) Broaden the role of the local tourist souvenir market. (3) Combine the advantages of local industries to explore the role of channels for product transformation and upgrading.

Based on the above ideas, a intangible cultural heritage in the western region of Guangdong Province, China --"Leizhou Stone Dog"-- is selected as the creative source, and the small household electrical appliances in the local advantageous industries are selected as the design examples to study the design methods of cultural and creative products. Leizhou stone dog is a series of sculpture works with basalt as the material and dog as the theme. It is the "Patron Saint" and "Mascot" in the local folk culture. Leizhou stone dog carving art originated in the Spring and Autumn Period and the Warring States Period. It is an important regional artistic symbol and cultural symbol after long-term changes, fusion and innovation of history and nationality [12]. There are tens of thousands of stone dog sculptures left in Leizhou, most of which are scattered among the people. After collection and sorting by experts, representative works of art are mainly stored in the Leizhou stone dog museum of and Zhanjiang museum.

Fig.3 Leizhou Stone Dog Sculpture

The image survey experiment is based on the potential young consumers of electric kettle. In the first stage, through the experiment of semantic and morphological influence, the suitable words which can describe the image of electric kettle are selected; then the semantic difference experiment is carried out to qualitatively analyze the sample pictures; finally, the relationship between product modeling features and image words is established, and the research purpose of this stage is to provide samples for the subsequent modeling feature coding. In the second stage, we analyze the expression of regional cultural characteristics of Leizhou stone dog carving, carry out scheme evaluation experiments in the form of expert interviews, and establish parameters such as appropriate function from the results. Then we code the initial morphological characteristics. Finally, the genetic algorithm is used to obtain the evolutionary results of the offspring as an optimization scheme. The research framework is shown in Figure 4.
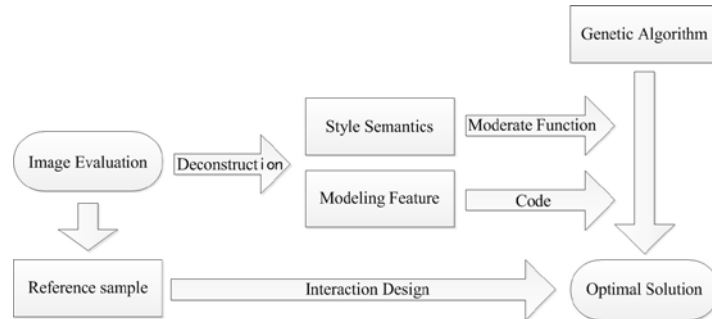
Fig.4 Research Framework of Creative Design

3. Creative Electric Kettle Modeling Design Process

3.1 Experimental Results of Product Image Survey

Five groups of image semantics suitable for describing the shape of electric kettle were selected from the semantic database by questionnaire, and Semantic Difference (SD) questionnaire was made to evaluate the sample pictures of electric kettle according to the selected five groups of image vocabulary, and the representative expression of five groups of image vocabulary was obtained. From the five groups of feeling adjectives, we choose the overall feeling evaluation adjective: "Creative - Ordinary", and analyze the correlation between the other four image phrases, and get the conclusion of "creativity" of electric kettle is related to "Lightweight", "Appreciation" and "High-grade". The experimental results are basically consistent with the consumers' impression of the product. Therefore, four target images are determined as: "Creativity", "Lightweight", "Ornamental", "High-grade" . According to the characteristics of four parts of electric kettle: spout, body, lid and handle, the electric kettle in the sample library is divided into types, and the corresponding relationship between the target image of this study and the modeling characteristics of the representative samples is obtained, as shown in Table 1.

Table 1 : the Corresponding Relation between Product Form and Semantics

Features	Spout(H1)		Body(H2)		Pot lid(H3)		Handle(H4)	
Imagery	Long	Short	Cylindrical	Oblate	Holistic	Independent	Open	Closed
Ornamental	***	*	**	**	*	***	**	**
Creative	**	***	****	*	***	**	****	*
Portable	**	***	****	*	*	****	***	**
Upscale	*	***	***	*	**	**	***	*

" * " means the score of the item in the questionnaire. Shadows represent the final selected features and images

3.2 Design Scheme Evaluation and Modeling Feature Coding

As the electric kettle widely sold on the market has a single shape and few products rich in regional cultural elements. Therefore, five ordinary kettles with obvious characteristics and high market evaluation are selected as the sample for scheme evaluation in the pictures collected by the network after expert interviews. All five samples have spout, kettle body, pot lid, and handle. The four design units meet the requirements of this study, and use regional elements or bionic elements.

After analyzing the samples of electric and ordinary kettles, according to the divided modeling features, the creative forms of regional elements such as Leizhou stone dog carving are coded, as shown in Table 2. Because the spout is mainly designed for function, the use of regional elements needs to be matched with the overall shape, witch length and short as options.

Table 2 : Characteristic Coding of Electric Kettle Modeling

Modeling Features	Feature Partition	Feature Encoding	Creative Form	Shape Coding	Final Shape Coding
Spout (H1)	Long	0	Long	\	0
	Short 1	Short	\	1	
Body (H2)	Cylindrical	0	Ornamentation	0	00, 01
	Oblate	1	Form	1	10, 11
Pot lid (H3)	Holistic	0	Ornamentation	00	000, 001, 010
	Independent	1	Form	01	100, 101, 110
			Form-buckle	10	
Handle (H4)	Open	0	Ornamentation	0	00, 01
	Closed	1	Form	1	10, 11

Code for the shape characteristics of the electric kettle in the first phase of the image investigation experiment, for example, spout is divided into "Long" and "Short", the lid is divided into "Whole" and "Separate". And then the final feature code is obtained.

Based on the above discussion, we can get the 8-bit gene code of population individuals, and the 5 kettle codes are shown in Table 3.

Table 3 5 Sample Coding Sequences

Number	Sample	Coding			
		Spout(H1)	Body (H2)	Pot lid (H3)	Handle (H4)

1		1	1	0	1	0	0	0	1
2		0	1	0	1	1	0	1	0
3		1	0	1	0	0	1	1	1
4		1	0	0	1	1	0	1	1
5		0	1	0	1	0	0	1	0

3.3 Application Steps of Genetic Algorithm

The calculation process of genetic algorithm is as follows[13] :

(1) Generation of initial groups

In this study, the population size is 5, that is, the population is composed of 5 individuals, which are: 1/10/100/01, 0/10/110/10, 1/ 01/001/11, 1/00/110/11, 0/10/100/10.

(2) Fitness calculation

The fitness function is a function to measure the degree of individual adaptation to specific problems. In this study, the target image is set as the proportion of 5 samples in 4 images, expressed as function fi (i = 1, 2,…, 5), the objective function is to take the maximum value of the function as the optimization objective, so the objective function value is directly used as the individual fitness.

(3) Selection operation

The probability proportional to the fitness is used to determine the number of individual replicates to the next generation population. The specific operation process is: first calculate the total fitness of all individuals in the group, as shown in Table 4.

Table 4 : 5 Sample Fitness Scale

Sample	Creative H1/H2/H3/H4				Upscale				Portable				Ornamental			
1	1	0	0	1	1	0	1	1	1	0	1	1	0	1	1	1
2	0	0	0	0	0	0	1	0	0	0	1	0	1	1	1	1
3	1	1	1	0	1	1	1	0	1	1	0	0	0	1	0	1
4	1	1	0	0	1	1	1	0	1	1	1	0	0	1	1	1
5	0	0	0	0	0	0	1	0	0	0	1	0	1	1	1	1

"1" means that the feature of this sample has such image; "2" means that the feature of this sample does not have such image.

From which we know $f(1)=11/16$, $f(2)=6/16$, $f(3)=10/16$, $f(4)=11/16$, $f(5)=6/16$. Then calculate the relative fitness of each individual: $f_i / \sum_1^5 f_i$, the probability that each individual is inherited into the next generation population, the sum of all probability values is 1, as shown in Table 5:

Table 5 : the Result of Initial Sample Group Selection Operation in Genetic Algorithm

Number	Initial Population	Fitness Value	Proportion	Frequency	Result
1	1/10/100/01	11	25%	2	1/10/100/01
2	0/10/110/10	6	14%	0	1/10/100/01
3	1/01/001/11	10	22%	1	1/01/001/11
4	1/00/110/11	11	25%	2	1/00/110/11
5	0/10/100/10	6	14%	0	1/00/110/11

(4) Cross operation

Cross operation is the main operation process of generating new individuals in genetic algorithm, which makes part of chromosomes between two individuals exchange with each other. The specific operation results are shown in Table 6:

Table 6 : Results Of Cross-Calculation in Genetic Algorithm

Number	Result	Pairing	Crossover	Result
1	1 10 100 01	1-3	1 10 100 01	1 00 100 01
2	1 10 100 01	2-4	1 01 001 11	1 11 001 11
3	1 01 001 11	3-5	1 10 100 01	1 00 110 01
4	1 00 110 11		1 00 110 11	1 10 100 11
5	1 00 110 11		1 01 001 11	1 00 001 11
			1 00 110 11	1 01 110 11

(5) Mutation operation

The method of basic bit variation is used to carry out variation operation, and finally a new generation of population is obtained. By comparing Table 1 and table 2, the adaptive value of the new population is obtained, as shown in Table 7.

Table 7 : the Result of Mutation Operation in Genetic Algorithm

Number	Result	Variation Point	Result(Hybrids)	Fitness
1	1 00 100 01	2	1 10 100 01	10
2	1 11 001 11	3	1 10 001 11	8
3	1 00 110 01	4	1 00 010 01	12
4	1 10 100 11	5	1 10 110 11	9
5	1 00 001 11	6	1 00 000 11	11
6	1 01 110 11	7	1 01 110 01	13

Shadows represent the chromosomes before and after mutation

It can be seen that through the evolution process of the first generation genetic algorithm, the adaptive value of the offspring population is improved compared with the initial population. Select the individuals with the highest adaptive value in the offspring population: 1 01 110 11, control table 2 The corresponding characteristics and creative forms of the creative kettle are as follows: short spout; cylindrical kettle body (simulated form); separated kettle cover (simulated form - buckle); closed handle (simulated form). The results can be used as a reference for designers to carry out interactive design. According to this, figure 5 provides a creative modeling scheme.
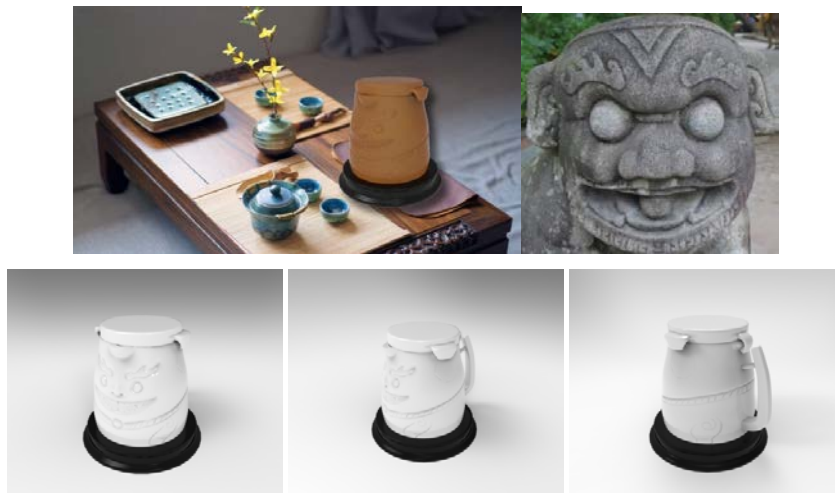

Fig.5 Modeling Scheme of "Stone Dog" Electric Kettle

4. Conclusion

Using product image survey and genetic algorithm to carry out the innovative design experiment of electric kettle modeling, from the perspective of interactive optimization design, to verify the feasibility of "Leizhou Stone Dog" as a regional cultural resource in the creative design of electric kettle, this method can also be used for the inheritance and utilization of other local cultural heritage resources.

Acknowledgement

References

[1] AN Lai-shun, PAN Sou-yong, Lu Jun, etc(2014). Experts' conversation by writing: museum collections make connections. Southeast Culture, no.3,p.11-25.

[2] YI Ping, ZHANG Qing-fen(2018). Reverse thinking in the design of museum cultural and creative products. Research on Design Art, no.6, p.97-100.

[3] DENG Xian-zhi(2012). Interactive genetic algorithm based method for product shape design. Modern Manufacturing Engineering, no.5,p.55-59 .

[4] YANG Bo-chao, DING Hua, LI Li-juan(2016). Appearance design of coal cutting machine based on interactive genetic algorithm. Coal Engineering, no. 4, p.132-134,138.

[5] LUO Shi-jian, DONG Ye-nan(2017). Classifying cultural artifacts knowledge for creative design. Journal of Zhejiang University (Engineering Edition), no.1 , p.114-123.

[6] WANG Wei, LI Fang-yu(2019). Research on the local cultural design of cultural products--a case study of chengdu museum. Design, no.03, p.139-141.

[7] WANG Xue-jie, XIAO Wang-qun(2016). Research on modeling design of industrial robot based on perceptual image. Journal of Machine Design, no.08, p.117-120.

[8] LUO Shi-jian, PAN Yun-he(2007). Review of theory, key Technologies and its application of perceptual image in product design. Journal of Mechanical Engineering, no.03, p.8-13.

[9] DU Juan, ZHENG Feng(2019). Research progress of kansei image design method and application. Journal of Machine Design, no.03, p.124-128.

[10] Jian Sun(2002). A framework for supporting generative product design using genetic algorithms: Ph D thesis. School of Design. The Hong Kong Polytechnic University.

[11] ZHANG Wen-quan, ZHAO Jiang-hong(2007). Study on Audi Brand Form Gene, Packaging Engineering , no.4, p.84-87.

[12] JU Yun-he(2008). Cultural characteristics and modeling methods of Leizhou stone dog sculpture, Art Research, no.04, p.103-106.

[13] ZHANG De-feng(2018). MATLAB R2017a artificial intelligence algorithms. Beijing: Electronic Industry Publishing House, 251-256.