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Research on jewelry design geometry model database based on perceptual engineering system

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Abstract

In this paper, we investigate the geometric model database of jewelry design based on the perceptual-engineering system, as jewelry products often focus on the exquisite and unique shape, the preciousness of the selected materials and the excellence of the production process. Firstly, the paper introduces the relevant analysis methods, namely structural equation analysis, Bi-LSTM and conditional random field (CRF), to be used for perceptual engineering analysis, followed by the construction of semantic imagery space. This paper implements the extraction of keywords for perceptual information about the appearance and users of jewelry design works based on a bidirectional long and short term memory neural network (BI-LSTM) and conditional random field. The analysis shows that "rough - elegant", "robust - soft", "inexpensive - high-class", "complex - simple "The mean values of the five groups of perceptual words "popular-personalized" in the 10 samples were 3.6421, 3.9451, 4.1328, 4.03791, and 3.84617, respectively, with an overall bias toward elegant, soft, high-class, simple and personalized, and a mean score of 4.1371. Finally, the establishment of jewelry design geometric model database based on the user perceptual information extraction system and the constructed semantic space is of greater significance for jewelry designers to improve their design efficiency.

Keywords: *Sensible engineering; structural equations; Bi-LSTM; conditional random field; database*

Introduction

The era of emotionality is coming - design that aims to move users emotionally takes the stage. For modern jewelry design, product emotional design is proposed on the basis of excessive attention to product function, but ignoring the actual emotional needs of people, and has become a crucial part of product design in the present day (Zeng, Liu, Wang, Zhang, & Yuen, 2014). At present, we are in the era of excess consumption, and the rapid development of science and technology has further improved people's living standards, and a variety of products have appeared in the market, and at such times, it is more important to focus on the satisfaction of personal spirit and personality level, and pay attention to the appearance, shape, volume, color and other emotional features of product design, thus making the purpose of consumption is no longer purely functional needs, but more for emotional The purpose of consumption is no longer purely functional, but more for emotional needs (A L Z, 2014; Luke, 2011; Wannarumon,

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Pradujphongphet, & Bohez, 2013).

In the era of democratization of consumption, people are increasingly pursuing personalized performance, so the concept of "flexible" production has been extended in product manufacturing, which is a variable production based on customized requirements. The current state of consumption has led designers to abandon the modernist mechanical design that overemphasizes function and ignores the emotional needs of human beings, thus paying more and more attention to the concept of "human-centered" design, emphasizing human psychological needs, personalization, uniqueness and customization. This has further given rise to emotional design, and perhaps the future of consumer goods will not only have practical functions, but also, consumers will be able to satisfy their emotional needs to the greatest extent (Duan, 2021). Technological change has brought opportunities for industrial transformation and development - the infinite possibilities brought by advanced manufacturing. In the future, emotional design is bound to develop in the direction of multidisciplinary intersection in the process of research, and consumers' emotional needs are caused by a combination of external and internal factors (Qu S, 2019; Zhang G W 2014). Therefore, at this stage, when human "sensibility" is gradually becoming the core competitiveness, how to make better cooperation between academic, engineering, psychological, cognitive and social science disciplines based on the effective guidance of cross-border thinking and the use of advanced technology to create an emotional design that belongs to each person is an urgent issue for designers. It is an urgent issue to be solved.

In the literature (Qian Z Y, 2016; Z., 2016), the techniques, processes, elements and design concepts of jewelry design are explained systematically, and the creative inspiration of the works of many Western masters of jewelry design is analyzed to propose thought patterns for innovative jewelry design. As an independent visual art, modern jewelry has become a symbol of interpreting individual language. The modern jewelry design concept is also influenced by the world famous architect Mies van der Rohe's "less is more" style of modernist architecture, which makes its jewelry style gradually develop in a direction closer to the design art of simplicity, abstraction, three-dimensional geometric planes and ultra-abstract geometric planes. The literature (Bertoni F, 2004) mentions that the design process of jewelry in the minimalist style is also the inevitable formation process after the synthesis, refinement and sublimation of the artistic connotation of this style. Minimalism does not mean that it is simply the same as the pursuit of simplicity, but how to use the language of abstract form with less repetition to express the basic structural content that makes things more complete and richer, and how to use the content of the basic structural form with the least complexity to express certain spiritual essence of things and their own existence. The literature (Nagamachi, 2002; Schütte & Eklund, 2005) talks about the fact that concepts related to sensual engineering were already taught at Hiroshima University, Tsukuba University, and Chiba University in Japan as early as 1991. Subsequently, Shinshu University in Japan was the first to establish a department of sensual engineering, and

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thus began specialized education in sensual engineering. The department gathered experts from various disciplines, including engineering, art, psychology, and literature, and established the research and education philosophy of "knowing the intention of the mind, grasping the information of the heart, and creating objects of the mind" under the leadership of Professor Yoshio Shimizu. Literature (Liu, Wang, Chen, & Chen, 2012) Korea, which has close ties with Japan, has also been influenced by this design philosophy, and many universities have established their own departments. In addition to university education, Hyundai Motor and Samsung Electronics are already designing products with the theory of sensual engineering. Korean officials intend to promote "sensual engineering technology" in this century.Firstly, this paper introduces the structural equation model and conditional random field model, and constructs a keyword extraction model for consumers' evaluation of jewelry pieces using a bidirectional long and short term memory neural network (Bi-LSTM) with conditional random field (CRF) to extract keywords for jewelry piece evaluation from pre-processed appearance review texts. Subsequently, on the basis of the keyword extraction model for jewelry work evaluation, the entity information provided by the keyword extraction model is used to establish the semantic imagery space, and a jewelry design geometric model database is built based on the semantic space. The establishment of jewelry design database is beneficial for designers to complete jewelry design efficiently and improve customer satisfaction.

Perceptual engineering analysis model

Structural equation analysis

The process of user's expression of perception is influenced by potential psychological factors (such as purchase motivation, regional culture, purchasing power factors, etc.), and mining the influence of potential psychological factors on user's perceptual experience can make the process of user perception analysis more differentiated, so as to obtain perceptual information about the same product from people with different attributes. In order to better obtain the influence of users' potential psychological factors on users' perceptual cognition, this paper selects the structural equation model in the econometric method for quantitative analysis of users' perceptions.Structural equation modeling is an analytical technique for analyzing the correlation of variables through their covariance matrices, and is widely used to uncover the influence of underlying factors. Structural models are able to perform both multiple regression analysis and path analysis, and clearly analyze the utility of individual variables on dependent variables and the correlation between variables, a feature that has led researchers to apply them to the process of user-tailored product design. For example, Yan Bo et al. combined structural equation modeling and artificial neural networks to build a user perception model and applied it to smartphone product design to analyze the impact of user perception factors (perception of range, perception of fluency, etc.) on user satisfaction and usage experience. To assist in the design of smartphone products, Sabir et al. used structural equations to analyze the influence of design dimensions such as functionality, aesthetics, and symbolism on customer satisfaction of smartphones, while

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exploring the mediating role of user affective factors in the influence process.

Perceptual engineering application system based on user needs analysis

The perceptual engineering application system based on user needs analysis is from the consumer's point of view, and the designer pre-determines the design solution based on his professional knowledge, and perceptually evaluates the design solution through the perceptual engineering application system, thus assisting the designer to grasp the perceptual performance of the current design solution, fully understand the possible impact of the design solution on the user, and determine the feasibility of the design solution, so as to continuously optimize update, and finally get the optimal design solution. For example, Li et al. combine virtual reality modeling technology and perceptual engineering to build a product perceptual design system, which enables customers to understand the product and its use comprehensively, so that they can make pertinent perceptual evaluation and assist designers to develop the product better. Consumers co-design the product with the designer through an interactive interface, while providing real-time feedback to the designer on satisfaction through questionnaires and measurements, enabling the designer to collect accurate user perceptual information at the pre-design stage of the product. From the above, it can be summarized that the databases involved in the perceptual engineering application system based on user requirements analysis are mainly the perceptual vocabulary database, the product database and the knowledge database.

Sense vocabulary database

The perceptual vocabulary database is responsible for storing the perceptual vocabulary collected through various means, such as literature review, questionnaire interviews, etc;

Product database

The product database is responsible for storing and analyzing the design parameter data, sample pictures and video and other design production information of the product samples;

Knowledge database

The knowledge database is responsible for storing the expressions of functions between perceptual imagery and design elements obtained through statistical analysis methods.

Conditions Randomized Airport

In the text keyword extraction task, in the judgment of whether a word is extracted or not, considering both the word information from the context and the following context will improve the accuracy of extraction (Xiong et al., 2014).

In order to better enable the model to learn the text context information and complete the keyword extraction of jewelry design text, Bi-LSTM is selected as the algorithmic model for entity recognition in this paper.However, although the Bi-LSTM takes into account the information

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between the hidden layers of the neural network at different word positions, the output of the label category at each position is independent, and the final output at the current position is not affected by the previous output. For example, the phrase "The car handles very well." For example, for the lexical labeling task of the phrase "The car handles well.", using Bi-LSTM, the "verb" may be output as the labeling result for the word "handle" because the algorithm does not consider the previous lexical labeling result of "the car's The algorithm does not consider the lexical annotation result of "car's", but in fact, the lexical annotation of "handling" should be labeled as "noun". This kind of semantic confusion is common in car appearance review texts, so it is not only necessary to let the hidden layer of the model learn the front and back position information, but also to let the output of the model consider the front and back position output information (Tan, 2001). To address this situation, this paper uses a conditional random field algorithm to relearn the output results of the BI-LSTM model and to make predictions for lexical classification.The variables associated with the conditional random field are first defined and are shown in Table 1.

Table 1: The meaning of variables about CRF

Marker variables	Description
X	The given input sequence
y	Real output for a given sequence
X	Input sequence variables
Y	Output sequence variables
$\tilde{y}$	Output sequence of model prediction
$\tilde{y}$	The possible values of y
D	Maximal clusters in undirected graphs
Ψ_D (Y_D)	Strictly positive functions defined on D
Z	Normalization factor
λ_k	The weights of the transfer function on the k th edge, usually 0 and 1
K_1	x Number of all possible cases of transfer
K_2	Number of all possible values of state y
q_k	The transfer eigenfunction on the k th edge
μ_l	The weight of the state function on the l th node
S_l	The state characteristic function on the l th node, usually 0 and 1
e_k	Unified representation of transfer eigenfunctions and state eigenfunctions
ω_k	Unified representation of transfer weights and state weights on the k th edge
Start	Denotes the value of y at the beginning of the sequence
Stop	Indicates the value of y at the end of the sequence
α	Forward vector
β	Backward vector
δ_i (y')	Denotes each possible value of the marker y at position i
ϑ_(i+1) (y')	Record the value of the marker that brings $\delta_{i+1}(\hat{y})$ to position i

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Definition of Conditional Random Fields

Conditional random field (CRF) is one of the discriminative models, which is based on the principle of solving the conditional probability distribution of the output with respect to the input, i.e., $P(Y \mid X)$. In the learning task, the conditional random field applies the great likelihood estimation method to obtain the conditional probability model $\hat{P}(Y \mid X)$ based on the sample space of the training set; when predicting, for a specified input sequence x, the output sequence that maximizes the conditional probability $\hat{P}(\tilde{y} \mid x)$ is output $\tilde{y}$. The conditional random field is widely used in word separation , lexical annotation, named entity recognition, and other natural language applications, and the most commonly used is the linear chain conditional random field, as shown in Figure 1.

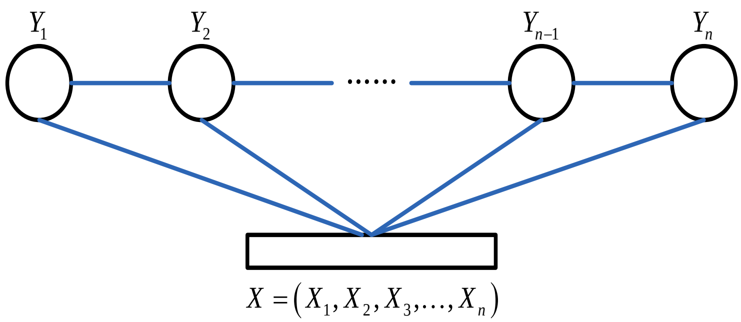

Figure 1: The sketch map of linear condition random field

A linear chain conditional random field is actually a probabilistic model of an undirected graph whose joint probability distribution is usually expressed as the product of functions of random variables on its largest cluster (a complete subgraph consisting of the largest number of vertices), i.e.

$$P(Y) = \frac{1}{Z} \prod_{D} \Psi_D(Y_D) \tag{1}$$

$$Z = \sum_{Y} \prod_{D} \Psi_D(Y_D) \tag{2}$$

where the product is carried out on all the maximal clusters in the graph. It can be seen from the linear chain structure graph that its maximal clusters are defined on two close nodes.

Therefore, the linear chain conditional random field is defined as follows: let $X = (X_1, X_2, X_3, \ldots, X_n)$, $Y = (Y_1, Y_2, Y_3, \ldots, Y_n)$ are both sequences of linearly characterized

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variables, and if the sequence Y satisfies Markovness in the state where X is known, i.e., as shown in equation (3), then P(Y/X) is said to be a linear chain conditional random field.

P(Y_i |X,Y_1,Y_2,Y_3,…Y_(i-1),Y_(i+1),Y_n)=P(Y_i |X,Y_(i-1),Y_(i+1)

i=1,2,3,…,n(i=1,n" when only one side is considered") (3)

Assuming that X takes the value $\boldsymbol{x},\boldsymbol{Y}$ takes the value $\boldsymbol{y}$, the conditional probability parameterization of P(Y/X) takes the following form:

$$P(y|x) = \frac{1}{Z(x)} exp\left(\sum_{i,k} \lambda_k\, q_k(y_{i-1}, y_i, x, i) + \sum_{i,l} \mu_l\, s_l(y_i, x, i)\right) \quad (4)$$

$$Z(x) = \sum_y \exp\left(\sum_{i,k} \lambda_k q_k\left(y_{i-1}, y_i, x, i\right) + \sum_{i,l} \mu_l s_l\left(y_i, x, i\right)\right) \quad (5)$$

In Eqs. (4) and (5), t_k represents the feature function on the edge, called the transfer feature, which usually takes values of 0 and 1 depending on the current and previous positions, and s_l represents the feature function on the node, which usually takes values of 0 and 1, called the state feature, depending on the current position. The above two feature functions can be expressed together as equation (6).

$$e_k\left(y_{i-1}, y_i, x, i\right) = \begin{cases} q_k\left(y_{i-1}, y_i, x, i\right), & k = 1, 2, \dots, K_1 \\ s_l\left(y_i, x, i\right), k = K_1 + l, l = 1, 2, \dots, K_2 \end{cases} \quad (6)$$

Summing over $e_k\left(y_{i-1}, y_i, x, i\right)$ at each sequence position gives

$$e_k(y, x) = \sum_{i=1}^{n} e_k\left(y_{i-1}, y_i, x, i\right) \quad (7)$$

Also the weight coefficient ω_k corresponding to $e_k\left(y_{i-1}, y_i, x, i\right)$ is unified as follows:

$$\omega_k = \begin{cases} \lambda_k, & k = 1, 2, \dots, K_1 \\ \mu_l, & k = K_1 + l, l = 1, 2, \dots, K_2 \end{cases} \quad (8)$$

Then equations (4) and (5) can be simplified as:

$$P(y \mid x) = \frac{1}{Z(x)} \exp \sum_{k=1}^{K} e_k(y, x) \quad (9)$$

$$Z(x) = \sum_y \exp\left(\sum_{k=1}^{K} \omega_k e_k(y, x)\right) \quad (10)$$

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The 3 basic problems of the conditional random field

The application of linear chain conditional random fields to text sequence tasks involves 3 basic problems: probability calculation, learning and prediction problems.

(1) Probability calculation

The problem of calculating the probability of a conditional random field is to calculate the conditional probabilities $P(Y_i = y_i \mid x)$ and $P(Y_{i-1} = y_{i-1}, Y_i = y_i \mid x)$ and the corresponding mathematical expectations under known conditions, usually using the forward-backward algorithm, which is briefly described below.

Since the nodes at each position of the linear chain random field are influenced by the two nodes before and after them, respectively, for each indicator $i = 0,1,\ldots,n,n+1$, the forward vector $\alpha_i(x)$ can be defined:

$$\alpha_0(y \mid x) = \begin{cases} 1, & y = start \\ 0, & \text{Otherwise} \end{cases} \quad (11)$$

$$\alpha_i^T(y_i \mid x) = \alpha_{i-1}^T(y_{i-1} \mid x) M_i(y_{i-1}, y_i \mid x) \quad (12)$$

$$M_i(y_{i-1}, y_i \mid x) = \exp\left(\sum_{i,k} \lambda_k q_k(y_{i-1}, y_i, x, i) + \sum_{i,l} \mu_l s_l(y_i, x, i) \right) \quad (13)$$

$\alpha_i(y_i \mid x)$ in Eq. (12) represents the non-normalized probability that the marker at position i is y_i and the first part of the marker sequence from 1 to i, y_i can take the value of m and thus is $\alpha_i(x)$ is an m-dimensional column vector.

Similarly, for each indicator $i = 0,1,\ldots,n,n+1$, define the backward vector $\beta_i(x)$ in the opposite way:

$$\beta_{n+1}(y_{n+1} \mid x) = \begin{cases} 1, & y_{n+1} = stop \\ 0, & \text{Otherwise} \end{cases} \quad (14)$$

$$\beta_i(y_i \mid x) = \beta_{i+1}(y_{i+1} \mid x) M_{i+1}(y_{i+1}, y_i \mid x) \quad (15)$$

$$M_i(y_i, y_{i+1} \mid x) = \exp\left(\sum_{i,k} \lambda_k q_k(y_{i+1}, y_i, x, i) + \sum_{i,l} \mu_l s_l(y_i, x, i) \right) \quad (16)$$

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where $\beta_i(y_i \mid x)$ denotes the non-normalized probability of the sequence of posterior part of the markers at position i with marker y_i and from $i+1$ to n.

The probability of a sequence of markers being marker y_i at position i and the probability of markers y_{i-1} and y_i at positions $i-1$ and i are calculated using the back and forth vectors:

$$P(Y_i = y_i \mid x) = \frac{\beta_i(y_i \mid x)\alpha_i^T(y_i \mid x)}{Z(x)} \quad (17)$$

$$P(Y_{i-1} = y_{i-1}, Y_i = y_i \mid x) = \frac{\beta_i(y_i \mid x)\alpha_i^T(y_{i-1} \mid x)M_i(y_{i-1}, y_i \mid x)}{Z(x)} \quad (18)$$

$$Z(x) = \alpha_n^T(x) = \beta_1(x) \quad (19)$$

Using the above two types of vectors, the mathematical expectations of the joint distribution $P(X,Y)$ and the conditional probability distribution $P(Y \mid X)$ can be calculated as shown in equations (20) and (21):

$$\begin{aligned} E_{P(Y|X)}[e_k] &= \sum_y P(y \mid x) e_k(y,x) \\ &= \sum_{i=1}^{n+1} \sum_{y_{i-1}y_i} e_k(y_{i-1}, y_i, x, i) \frac{\beta_i(y_i \mid x)\alpha_i^T(y_{i-1} \mid x)M_i(y_{i-1}, y_i \mid x)}{Z(x)} \end{aligned} \quad (20)$$

$$\begin{aligned} E_{P(X,Y)}[e_k] &= \sum_{x,y} P(x,y) \sum_{i=1}^{n+1} e_k(y_{i-1}, y_i, x, i) \\ &= \sum_x \tilde{P}(x) \sum_y P(y \mid x) \sum_{i=1}^{n+1} e_k(y_{i-1}, y_i, x, i) \\ &= \sum_x \tilde{P}(x) \sum_{i=1}^{n+1} \sum\nolimits_{y_{i-1}y_i} f_k(y_{t-1}, y_i, x, i) \frac{\beta_i(y_t \mid x)\alpha_i^T(y_{i-1} \mid x)M_i(y_{i-1}, y_i \mid x)}{Z(x)} \end{aligned} \quad (21)$$

Among them, $k = 1, 2, 3, \ldots, K$.

With equations (11) to (21), for a given x and y, α_i and $Z(x)$ can be calculated by one forward scan and β_i by one backward scan, thus calculating the expectation of all probabilities and features.

Model learning

In the model parameter learning problem for a linear chain conditional random field, given an

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observation sequence X and a corresponding labeled sequence Y, K of eigenfunctions $e_k(x, y)$, the conditional probability $P_\omega(y \mid x)$ under the condition that the model parameters are ω_k satisfies the following relation:

$$P_\omega(y \mid x) = \frac{\exp \sum_{k=1}^{K} e_k(y, x)}{\sum_y \exp\left(\sum_{k=1}^{K} \omega_k e_k(y, x)\right)} \quad (22)$$

Our goal is to find all the model parameters ω_k so that the conditional probabilities can be calculated from the above equation. The gradient descent method is usually used to solve this problem, and the solution idea is briefly described below.

Before using the gradient descent method, it is first necessary to define the optimization function, which is commonly used as a log-likelihood function, as shown in equation (23):

$$L(\omega) = \log \prod_{x,y} P_\omega(y \mid x)^{\bar{P}(x,y)} = \sum_{x,y} \bar{P}(x, y) \log P_\omega(y \mid x) \quad (23)$$

where $\bar{P}(x, y)$ is the empirical distribution, which can be obtained through prior knowledge and in the training set samples. In order to use the gradient descent method, we need to minimize the negative log-likelihood function, i.e.:

$$\begin{aligned} r(\omega) &= -\sum_{x,y} \bar{P}(x, y) \log P_\omega(y \mid x) \\ &= \sum_{x,y} \bar{P}(x, y) \log Z_\omega(x) - \sum_{x,y} \bar{P}(x, y) \sum_{k=1}^{K} \omega_k f_k(x, y) \\ &= \sum_{x} \bar{P}(x) \log Z_\omega(x) - \sum_{x,y} \bar{P}(x, y) \sum_{k=1}^{K} \omega_k e_k(x, y) \\ &= \sum_{x} \bar{P}(x) \log \sum_{y} \exp\left(\sum_{k=1}^{K} \omega_k e_k(y, x)\right) - \sum_{x,y} \bar{P}(x, y) \sum_{k=1}^{K} \omega_k e_k(x, y) \end{aligned} \quad (24)$$

The derivative of ω is obtained:

$$\frac{\partial r(\omega)}{\partial \omega} = \sum_{x,y} \bar{P}(x) P_\omega(y \mid x) f(x, y) - \sum_{x,y} \bar{P}(x, y) f(x, y) \quad (25)$$

After obtaining the expression for the derivative with respect to ω, the optimal ω can be solved iteratively using the gradient descent method.

Model prediction

The prediction problem of conditional random airports can be regarded as solving an optimal path problem, as shown in Figure 2. In the optimal path problem solution, the conditional randomized airfield uses the Viterbi algorithm as the solution method, and the application process of the Viterbi algorithm in the prediction problem is briefly described below.

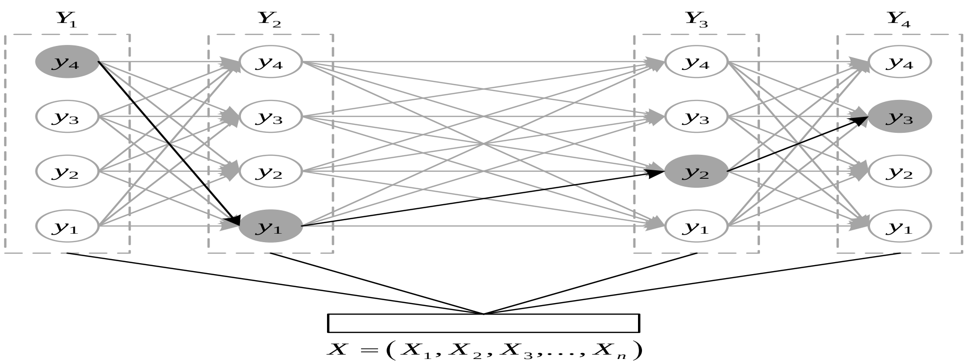

Figure 2: The sketch map of vertibi algorithm

First, define the first local state $\delta_i(\hat{y})$, which represents the maximum probability corresponding to each possible value $\hat{y}=1,2,3,\ldots,m$ of marker y at position i, and the expression of marker $\hat{y}$ at position $i+1$ can be obtained recursively according to the definition as:

$$\delta_{i+1}(\hat{y}) = \max_{1\le j\le m}\left\{\delta_i(\hat{y}) + \sum_{k=1}^{K}\omega_k e_k\left(y_i = j, y_{i+1} = \hat{y}, x, i\right)\right\}$$
$$\hat{y} = 1,2,\ldots,m \tag{26}$$

Another local state $\vartheta_{i+1}(\hat{y})$ is also needed to record the value of the marker that brings $\delta_{i+1}(\hat{y})$ to position i, which is subsequently used to retrace the optimal solution.

The recursive expression of $\vartheta_{i+1}(\hat{y})$ is:

$$\vartheta_{i+1}(\hat{y}) = \underset{1\le j\le m}{\operatorname{argmax}}\left\{\delta_i(\hat{y}) + \sum_{k=1}^{K}\omega_k e_k\left(y_i = j, y_{i+1} = \hat{y}, x, i\right)\right\}$$
$$\hat{y} = 1,2,\ldots,m \tag{27}$$

Under the condition that the *K* eigenfunctions and the corresponding weights of the model are known and the number of possible tokens *m* of the observation sequence *x*, the flow of the Viterbi algorithm is obtained as follows:

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a) Initialization

Initialize the two local states $\delta(\hat{y})$ and $\vartheta(\hat{y})$ separately:

$$\delta_1(\hat{y}) = \sum_{k=1}^{K} \omega_k e_k \left(y_0 = start, y_1 = \hat{y}, x, i \right), l = 1, 2, \ldots, m \quad (28)$$

$$\vartheta_1(\hat{y}) = start, l = 1, 2, \ldots, m \quad (29)$$

b) Recursion

Performing recursion for $i = 1, 2, \ldots, n-1$, we get

$$\delta_{i+1}(\hat{y}) = \max_{1 \le j \le m} \left\{ \delta_i(\hat{y}) + \sum_{k=1}^{K} \omega_k e_k \left(y_i = j, y_{i+1} = \hat{y}, x, i \right) \right\} \quad \hat{y} = 1, 2, \ldots, m \quad (30)$$

$$\vartheta_{i+1}(\hat{y}) = \underset{1 \le j \le m}{\operatorname{argmax}} \left\{ \delta_i(\hat{y}) + \sum_{k=1}^{K} \omega_k e_k \left(y_i = j, y_{i+1} = \hat{y}, x, i \right) \right\} \quad \hat{y} = 1, 2, \ldots, m \quad (31)$$

c) Termination

$$y_n^* = \underset{1 \le j \le m}{\operatorname{argmax}} \, \delta_n(\hat{y}) \quad (32)$$

d) Return path

According to the optimal solution obtained under the termination condition, backtracking is performed from back to front, and the optimal marker sequence is finally obtained.

$$y_i^* = \vartheta_{i+1}\left(y_n^* \right), i = n-1, n-2, \ldots, 1 \quad (33)$$

$$y^* = \left(y_1^*, y_2^*, y_3^*, \ldots, y_n^* \right) \quad (34)$$

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Sample collection

Jewelry design work sample collection

The study first collected suitable design samples, and then selected clear and compliant frontal sample images according to the theme and direction of the study, a total of 32 samples, with the focus group method combined and reduced to 10 research samples.

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Collection of work perceptual vocabulary

In addition to the descriptive words of merchants, I also collected 75 perceptual phrases from related literature, books, magazines, posters, websites, interviews, etc., as shown in Table 2.

In order to test the difference between the different groups of perceptual discourse and the sample construction of semantic imagery space, the 10 groups of perceptual discourse pairs were divided into two groups for testing. 10 samples of jewelry design works were matched, and the questionnaire was set up and distributed with the semantic difference scale.

Table 2: Jewelry design works sensual vocabulary

Number	Emotive vocabulary	Number	Emotive vocabulary	Number	Emotive vocabulary
1	Natural	26	Advanced	51	Grand
2	Innovative	27	Textured	52	Classic
3	Bright	28	Simple	53	Abstract
4	Artificial	29	Monotonous	54	Tender
5	Traditional	30	Nostalgic	55	Sedate
6	Lovely	31	Rural	56	Romantic
7	Mature	32	Lively	57	Rough
8	Young	33	Conflicting	58	Homegrown
9	Warm	34	Refreshing	59	Mysterious
10	Icy	35	Intellectual	60	Sensual
11	Cheap	36	Sweet	61	Raw
12	General	37	Ambitions	62	Tacky
13	Attractive	38	Eye-catching	63	Modern
14	Bright	39	Idyllic	64	Female
15	Kindly	40	Vintage	65	Neutral
16	Passionate	41	Clean	66	Robust
17	Heavy	42	Exotic	67	Stiff
18	Gorgeous	43	Generous	68	Comfortable
19	Relaxed	44	Healthy	69	Cultured
20	Rustic	45	Pure	70	Harmonious

Table 3: The 10 selected sentimental phrases divided into two groups

The first group	The second group
Simple-Romantic	Rough-Elegant
Calm – Vibrant	Complex - Simple
Traditional – novel	Popular - individual
Plain – mysterious	Robust - soft
Figurative – abstract	Evaluation - high grade

Establishing semantic imagery space

The two sets of perceptual pairs were imagery linked with 15 design samples, and the questionnaire was designed by the semantic difference method, which was completed by using

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the semantic difference scale 5 steps with the combination of perceptual pairs, as shown in Tables 4 and 5 below. taking rough - elegant as an example,

1 represents obviously rough; 2 represents more rough; 3 represents neutral imagery, not rough nor elegant; 4 represents more elegant; 5 represents obviously elegant.

Table 4: Semantic Differences Scale (Questionnaire 1)

	1	2	3	4	5	
Rough and tumble	☐	☐	☐	☐	☐	Elegant
Q	☐	☐	☐	☐	☐	Simple
Popular	☐	☐	☐	☐	☐	Personalized
Rigid	☐	☐	☐	☐	☐	Soft
Affordable	☐	☐	☐	☐	☐	Upscale

Table 5: Semantic Differences Scale (Questionnaire 2)

	1	2	3	4	5	
Simple	☐	☐	☐	☐	☐	Romantic
Calm	☐	☐	☐	☐	☐	Vibrant
Traditional	☐	☐	☐	☐	☐	Novelty
Plain	☐	☐	☐	☐	☐	Mysterious
Figurative	☐	☐	☐	☐	☐	Abstract

After the questionnaire was designed, 100 students of jewelry design related majors were selected for two tests, and the valid samples were 91 and 87 after recovery.

So that the mean value was calculated to show the correspondence between the degree of discourse and the sign, and the summary graph of the mean value is shown in Figure 3 and Figure 4.

In the first group of perceptual discourse, sample 3 has the highest rating in the "rough - elegant" group of perceptual discourse with 4.91807. Indicating that sample 3 has the highest degree of relationship with the "rough - elegant" group of perceptual discourse. Sample 2 scored the highest in the "robust-feminine" group with 3.9314, indicating that sample 2 has a more pronounced feminine imagery.

Sample 5 scored the highest in the "Affordable-high class" set of perceptual phrases, with 4.84862, indicating that it has more obvious high-end imagery.

Sample 2 and sample 6 scored higher in the "complex - simple" set of perceptual pairs, with 4.93438 and 4.92257.

Respectively, indicating that sample 2 and sample 6 have more obvious simple imagery.

The highest rating in the "popular-personal" set of perceptual repertoires was 4.0841 for sample 2, indicating that sample 2 had a more pronounced personal imagery.

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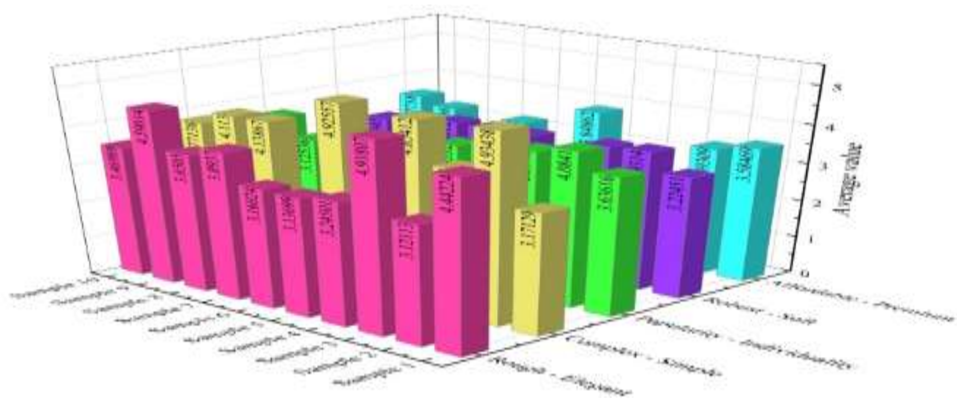

Figure 3: Mean of the first set of perceptual discourse matches

The second group of perceptual discourse matched with the sample in the same way as the first group was interpreted sequentially, where sample 8, in addition to the first group of perceptual discourse matched with the sample imagery with high ratings for all 5 groups of perceptual discourse, also had high ratings for all 5 groups of perceptual discourse in the second group of perceptual discourse matched with the sample imagery, with obvious romantic and novel imagery, as well as obvious energetic imagery and more obvious mysterious and abstract imagery.

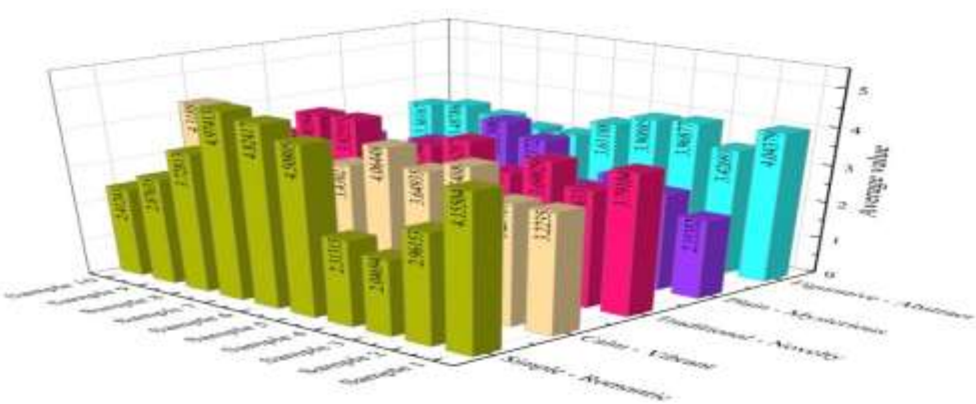

Figure 4: Mean of the second set of perceptual discourse matches

Build jewelry design geometry model database based on semantic space

Although the jewelry designed according to the emotional vocabulary can well express the emotion of the work, but as jewelry works in the shape of a relatively single, less change, can not match the individual needs of the customizer and its occasion needs, the most basic function of jewelry is still to increase the aesthetics of the wearer, adapt to its corresponding occasion, express its personality characteristics. So in the premise of expressing the emotional needs should also take into account the beauty of the jewelry and the applicability of the occasion, so that the wearer can be more acceptable and love.

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Through the collection and collation to establish a 3D jewelry model database including design jewelry models, jewelry accessories models, and network jewelry model collection platform as a whole. The design jewelry models can come from some jewelry designers' design works, either complete jewelry works or semi-finished accessories.

For complete jewelry, the modeling of semantic transformation can be combined in the form of pendant or inlay. For semi-finished jewelry, the semantic transformation modeling can be combined in the form of accessories, or as jewelry set into semi-finished jewelry. For jewelry accessories, the program can also provide other jewelry accessories such as finished rings, mounts, pins, etc., in order to combine them with the corresponding wearing accessories after the jewelry design is completed.

The web jewelry model collection platform is a special platform provided by this program to search for many jewelry modeling websites, because the jewelry accessories in the database are not enough to meet the needs of all customizers, and the number of jewelry models is expanded as much as possible under the premise of reaching agreements with other jewelry modeling platforms to meet the production needs.

Conclusion

The study of jewelry design geometric model database based on perceptual engineering system needs to collect the key words of users' descriptions of jewelry, and when evaluating the two selected groups of perceptual vocabulary, everyone rated the first group of perceptual descriptions as overall favoring elegant, soft, high-grade, simple and personalized, with an average score of 4.1371. Meanwhile, the five pairs of perceptual vocabulary of the second group were all rated highly, with obvious romantic, novel imagery, but also with obvious energetic imagery and more obvious mysterious and abstract imagery, with a mean value of 3.9461.

This paper establishes a semantic imagery space based on the collected samples, and then builds a database.

Through the construction of semantic space to enrich the jewelry design geometric model database, it gives new vitality and vitality to the jewelry modeling design and makes the jewelry more reflective of visual impact. The application of sensual engineering in modern jewelry design is not only the need of market development, but also the trend of modern jewelry design development.

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