Wardrobe Furniture Color Design Based on Interactive Genetic Algorithm

Xinyu Ma, Yushu Chen,* Qianwei Liang, and Jinjing Wang

With the change in consumption environment and habits, the active feedback from users on online shopping platforms serves as a valuable source of information for analyzing user demand. Color design is an important factor in shaping product style and influencing user's purchase decisions. This study combines the Latent Dirichlet Allocation (LDA) and an interactive genetic algorithm (IGA) to investigate the usability of the interactive genetic color selection method for wardrobe color design. Firstly, the LDA model was employed to cluster online review data to identify customer requirements (CRs), then summarize the perceptual evaluation factors (EFs) of color selection. Subsequently, the color selection information from market examples was used as reference to establish the initial population, and the interactive genetic color design process was completed with CorelDraw. Then, the fuzzy comprehensive evaluation method was employed to evaluate the color scheme generated from IGA. The empirical analysis demonstrated that the interactive genetic color selection method can effectively enhance both efficiency and satisfaction in wardrobe design. This study has substantial implications for both theory and practice in the field of wardrobe design and offers designers novel design concepts and methodologies.

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INTRODUCTION

Color selection is a regular task in the process of product design (Liu *et al.* 2021), which carries symbolic and associative information of products (Ding *et al.* 2019). The term “color matching” has been used by designers to mean a combination and use of different colors to show a specific visual effect. Reasonable color selection can enhance the visual perception of the product and consumer tendency. Therefore, integrating consumers’ color perception and preference into color design is a crucial part of product design and development. As a highly customized product with both decorative and practical features, wardrobe has a relatively fixed functional structure, and the color design of which has emerged as a crucial factor influencing purchasing decisions. To improve the user satisfaction and competitiveness of the products, it is necessary to take the dynamic changes in the market into consideration and update the wardrobe color selection standards continually.

Due to the impact of COVID-19 on the global economy (Huang *et al.* 2022) and the development of the Internet e-commerce industry, online shopping has provided users with a more open platform for commenting. Online review data can directly reflect the changes in the customer's requirements for the product, which is of great importance to the optimization of the product and the enhancement of the customer's satisfaction. A nonlinear time series fuzzy regression method was used to model consumer preference based on sentiment analysis of online comments. (Jiang *et al*. 2022), and later the same authors introduced a polynomial structure to optimize it (Jiang *et al*. 2023). Topic mining is one of the main methods of online review data mining. It can mine effective information from massive semantic information in the text. Blei introduced Dirichlet prior parameters based on Probabilistic Latent Semantic Indexing (PLAS) (Blei *et al.* 2003), solving the problem of missing probability model in document layer of PLAS model, and Latent Dirichlet Allocation (LDA) model. This approach realized the lexical probability distribution of topics and the topic probability distribution of documents, and LDA has gradually become a widely used topic modeling method and is widely used in the field of mining users' needs. Ma *et al.* (2016) utilized an efficient online LDA approach to overcome the big data problem of online reviews and select meaningful topics from unbalanced data. Wang proposed an unsupervised judgment method for reviewing credibility based on the sentiment latent Delicacy Distribution (BS-LDA) model, which plays an important role in determining the credibility of reviews (Wang *et al.* 2019). The LDA model, therefore, can efficiently process a vast amount of online review data, extract user demand information and feedback information from online reviews, and effectively guide product color design decisions.

In recent years, due to the variability and diversification of customer requirements, the product life cycle has also been gradually shortened, relative to the design of product shape and function; the innovation of product color design has become the key to the renewal of product iteration and rapid innovation of enterprises (Yang and Tian 2019). Most of the product color selection has been done by designers based on design experience or color trends, and its accuracy and intelligence have needed to be improved. Thus, the research of applying computer-aided technology to color design has emerged (Hsiao and Tsai 2014). Genetic algorithm (GA) is a global search technology based on natural selection and evolution. Yeh developed a prediction model based on BP neural network and used genetic algorithm for optimization to predict and optimize the color scheme of sports shoes (Yeh 2020). In product design, individual fitness was often determined by user evaluation to form an interactive genetic algorithm (IGA), such as combining the Kano model and IGA, which can fully consider the individual preferences of users (Dou *et al.* 2016). The traditional interactive genetic algorithm (TIGA) can be divided into several stages according to different interaction function requirements to form a multi-stage interactive genetic algorithm (MS-IGA) (Dou *et al.* 2016). However, consumer preferences are inherently subjective and therefore difficult to quantify. It is necessary to identify and define consumers requirements, seek commonalities between these requirements, and combine computer-aided technology to form a color scheme.

The current practices in selection of colors and color schemes in design are primarily executed by experienced professional designers, the efficiency and accuracy require enhancement. Therefore, this study proposed an interactive genetic color selection method with dual constraints of perceptual evaluation factor and color selection reference source, extracted user needs to form perceptual evaluation factor through LDA subject analysis, summarized users' perceptual needs for wardrobe, and provided designers with specific and clear color design direction. The interactive genetic color selection system was established, which can effectively improve the accuracy and efficiency of designers' color design choices, and provide reference for the wardrobe color selection of enterprises so that they could achieve close to an optimal color design for wardrobe design services.

EXPERIMENTAL

Research Framework

The primary objective of this study was to use a computer intelligent algorithm to achieve the derivation and optimization of wardrobe color scheme design by combining online review data with current wardrobe product color scheme. This study combined the LDA model with the IGA for wardrobe color design and conducted a fuzzy comprehensive evaluation of the color scheme to verify the possibility of applying IGA to product color selection in design.

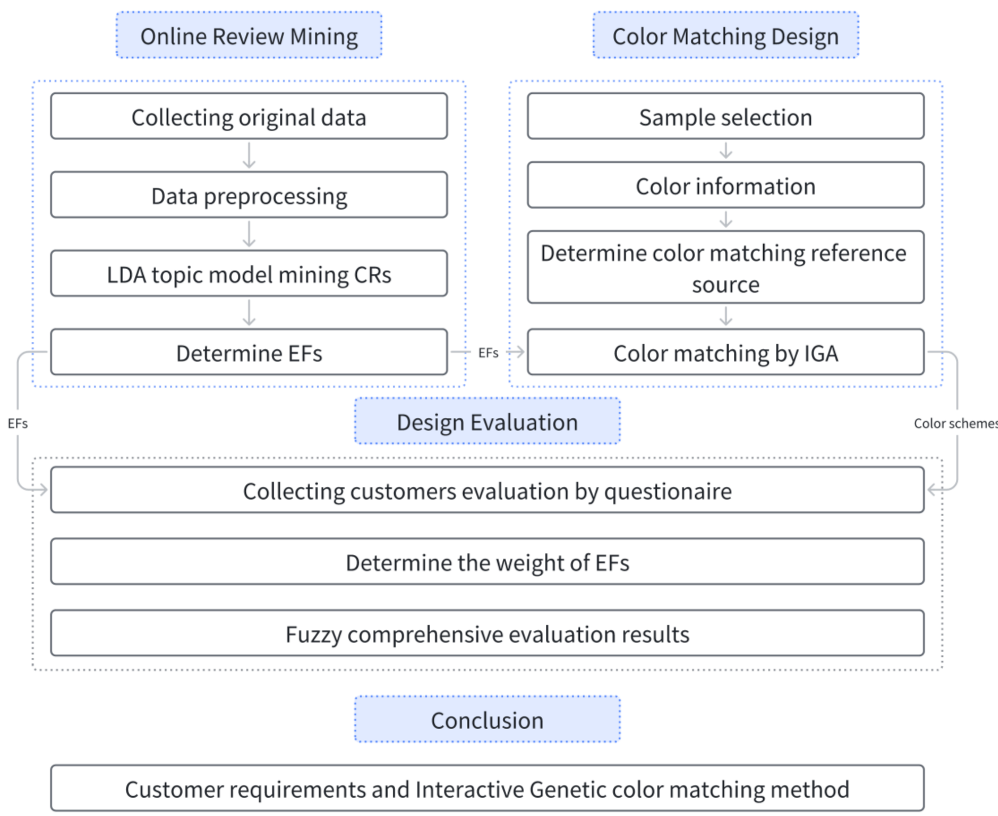


Fig. 1. Basic research framework

The study was composed of three phases. In the first phase, the web crawler technology was applied to mine the online review data of wardrobes on the online shopping platform, and the LDA model was used to obtain the original consumer requirements (CRs) after pre-processing the data. Then, the words related to the requirements of color selection were selected, the perceptual evaluation factors (EFs) of wardrobe color selection were obtained after expert evaluation. In the second phase, the color selection information of wardrobe products was extracted from the current wardrobe picture samples in the market to form the wardrobe color scheme sample library, which was used as the reference source, and new wardrobe color schemes were formed using IGA. In the third phase, the weights of each evaluation factor were determined through entropy weighting method to obtain an evaluation of the color scheme generated by the IGA. The structure is shown in Fig. 1.

Customer Review Mining and Analysis

The first phase was to complete the LDA topic model analysis of web text data that was collected by web crawler using scripts written in Python programming language to obtain original consumer requirements (CRs). The text pre-processing and topic classification were performed automatically, while the selection of topic quantity and the naming of topics were performed manually. Then the Evaluation Factors (EFs) for wardrobe color selection were formed according to experts' reviews in the field of furniture design. The mining and analysis of EFs can be divided into 2 steps.

Step 1: Data selection and preparation

The Octopus information acquisition software was used to extract the required product review data. Basic pre-processing of the original data was carried out to delete a large number of invalid comment information.

Step 2: Determining CRs and EFs

Before undertaking topic analysis, it was essential to process the data, including the segmentation of Chinese words and the deletion of stop words, which have no practical meaning. The processed online review data was input into the LDA topic model for topic classification and extraction. Latent Dirichlet Allocation (LDA) is an unsupervised form of machine learning method proposed by Blei (2003). The fundamental principle is illustrated in Fig. 2. Assuming that the number of documents is M, a total of K topics are extracted. The parameters α and β represent the a priori parameters of the Dirichlet allocation, α represents relationship between the topics, while β represents the probability distribution of the topics. The θ is the polynomial distribution parameter of the topic in the document, and φ is the polynomial distribution parameter of the word in the topic, z is a randomly selected topic from θ, and w represents the characteristic word in the text.

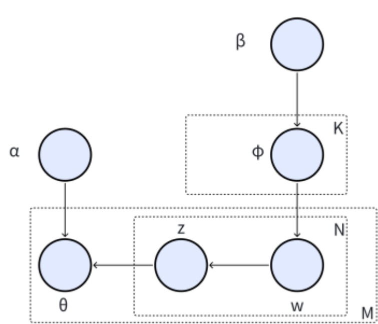


Fig. 2. Graphical model representation of LDA

The number of topics included in each corpus is then determined by the perplexity, which compares the degree of correlation difference between individual topics to determine the optimal number of topics. A low perplexity indicates a stable subject structure with minimal error. The formula for calculating the perplexity is as follows,

$$Perplexity(D) = \exp\left\{ - \frac{\sum_{m=1}^{k} \log P_{q_m}(w)}{\sum_{m=1}^{k} N_{q_m}} \right\} \tag{1}$$

where k represents the number of topics, N_{qm} represents the number of words, and $P_{qm}(w)$ represents the probability of occurrence of each word within topic q_m.

Finally select the EFs from the results of LDA topic analysis by expert review.

Color Design

The IGA was employed to re-color the current wardrobes on the market in this phase. The current color scheme was used as reference source for color selection to obtain the new wardrobe color schemes. The second phase was divided into 3 steps.

Step 1: Sample selection and color data classification

The samples with high image quality and no evident colored light environment were extensively collected. These samples were imported into Photoshop to extract three color parameters: hue (H), saturation (S), and brightness (B) to form a wardrobe color sample library.

Because color parameters were continuous data, which was not conducive to the extraction of color association rules, the K-means clustering algorithm was used to cluster the color parameters to form the feature colors, and the color scheme was classified according to these feature colors. The cluster number were determined by calculating the sum of squares of error (*SSE*) of different cluster numbers (k) as follows,

$$SSE = \sum_{i=1}^{k} \sum_{p \in C_i} |p - m_i|^2 \tag{2}$$

where C_i represents the cluster i, p is a specific color sample, m_i is the cluster centre, and *SSE* is the sum of squares of clustering errors of all color samples. Upon reaching the optimal value of k, the decline in SSE reaches a plateau.

Step 2: Association rules extraction by Apriori algorithm

Association rules represent the rules hidden in the database that have a certain association between several items. The Apriori algorithm was used to mine the wardrobe color association rules, providing a reference source for interactive genetic color selection. The dataset $D = \{t_1, t_2, t_3, \cdots, t_k, \cdots, t_n\}$ was defined as a set of tuples, where each tuple is composed of a set of color schemes denoted by $t_k = \{m_1, m_2, \cdots, m_n\}$, and a set of colors denoted by m_p(p =1,2,⋯,n). Let X, Y be the item sets in dataset D, the support of item set X can be calculated by the following equation (Wu *et al.* 2008),

$$\text{support}(X) = \frac{\sigma_x}{|D|} \times 100\% \tag{3}$$

where σ_x is the number of X contained in dataset D, and |D| is the total number of tuples in the dataset D.

If $X \cap Y = \varnothing$, then the implication $X \Rightarrow Y$ is called an association rule. The confidence of the association rule $X \Rightarrow Y$ can be calculated with Eq. 5,

$$\text{confidence}(X \Rightarrow Y) = \frac{\text{support}(X \cup Y)}{\text{support}(X)} \times 100\% \quad (4)$$

where *Support*($X \cup Y$) is the support degree of association rule $X \Rightarrow Y$.

The lift of association rule $X \Rightarrow Y$ can be calculated as follows:

$$\text{Lift}(X \Rightarrow Y) = \frac{\text{confidence}(X \Rightarrow Y)}{\text{support}(Y)} \quad (5)$$

Step 3: Color design by IGA

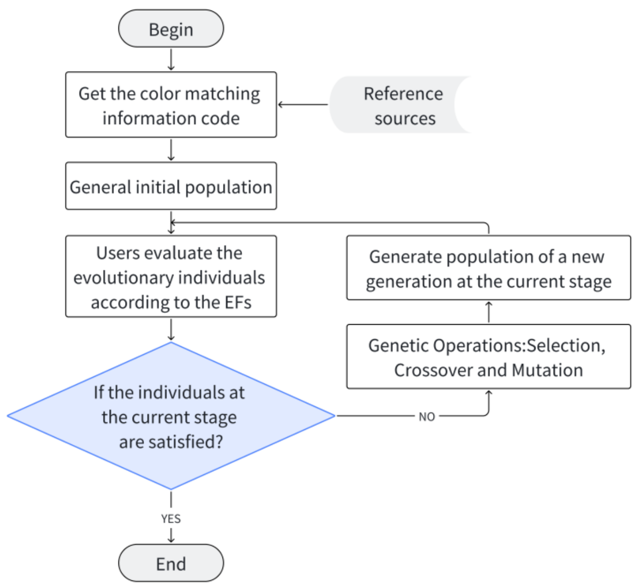


Fig. 3. Flowchart of IGA color selection method

IGA requires human evaluators to carry out the evaluation, helping to capture consumers' aesthetic intentions and preferences. However, the cognitive dissonance between consumers and designers could cause the evaluation results to be biased. Therefore, this paper limits and guides the inheritance and variation of color schemes through reference sources and evaluation standards. It took the perceptual factors obtained from the online review analysis as the evaluation standards, effectively avoiding cognitive dissonance and ineffective variation (Babbar-Sebens *et al.* 2012). The color selection process is presented in Fig. 1.

The color association rules generated above were input into the interactive genetic color selection program as the reference source, and the color codes of reference source were obtained to establish the initial population. Each color scheme in the initial population was scored, and the perceptual evolution factors were introduced as the evaluation standard. Schemes with scores lower than the set value would be eliminated, and the remaining schemes would undergo further population substitution and mutation. Through setting the mutation probability, the HSV value of the current color would be expanded to each dimension of the color space by 15% to create new color selection populations. The scoring and variation work were cycled through until a satisfactory wardrobe color scheme was produced and finally output the schemes.

Color Design Evaluation

In the third phase of the study, questionnaires were issued to users to obtain their satisfaction with the new color scheme and compared with the original color scheme to verify the rationality of IGA color selection applied to wardrobe furniture.

Step 1: Collecting customers' evaluation

The questionnaire was designed by combining the perceptual evaluation factors and the color scheme obtained by IGA.

Step 2: Determine the weight of EFs

The entropy weight method was used to determine the weight of the evaluation factors of color scheme design, and Eq. 7 is first used to normalize the data of each index,

$$P_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}; \forall i; j \tag{6}$$

where r_{ij} is the evaluation value of the scheme *i* in the factor *j*, *m* is the number of schemes, and P_{ij} is the weight of the scheme *i* under the factor *j* in that factor. Then, the entropy value of each factor was calculated:

$$e_j = -K\sum_{i=1}^{m} P_{ij} \ln P_{ij}; \forall j \quad K = \frac{1}{\ln m}, 0 \le e_j \le 1 \tag{7}$$

Finally, the weight values of the wardrobe color evaluation factors are calculated as follows,

$$\omega_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} \tag{8}$$

where ω_j is the value of weights. Weight vector is shown as follows:

$$A = \left(\omega_1, \omega_2, ..., \omega_{n-1}, \omega_n\right) \tag{9}$$

Step 3: Fuzzy comprehensive evaluation

The data of each factor is transformed by the affiliation function to establish the fuzzy evaluation matrix *R*. In the fuzzy evaluation matrix *R*, the evaluation level *j* in the evaluation factor *i* is expressed as r_{ij}:

$$R=\begin{pmatrix} R_1 \\ R_2 \\ \vdots \\ R_i \\ \vdots \\ R_m \end{pmatrix}=\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1j} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2j} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{i1} & r_{i2} & \cdots & r_{ij} & \cdots & r_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mj} & \cdots & r_{mn} \end{pmatrix} \tag{10}$$

Fuzzy comprehensive evaluation result vector was calculated as follows:

$$B=W\bullet R=\left(b_1,b_2,\cdots,b_j,\cdots,b_m\right) \tag{11}$$

where W was the scoring vector, W={1,2,3,4,5}. The final score was as follows:

$$\alpha=B\cdot A \tag{12}$$

RESULTS AND DISCUSSION

Wardrobe CRs and EFs Mining and Analysis

Taking Jingdong Official Mall as the research object, the term “Wardrobe” was searched as the keyword on the website, and the review data were crawled by means of the Octopus software. A total of 2878 review data were obtained as the initial corpus. The initial corpus was cleaned, and 2734 valid comments were obtained after deleting default and invalid comments.

The topic extraction process of the LDA model was realized using Python language. The machine learning module sklearn library was run in Python for LDA topic model analysis, and Chinese word segmentation was performed by running the third-party toolkit Jieba word segmentation in Jupyter Notebook. Equation 1 was used to calculate the perplexity under different cluster numbers. The results are shown in Fig. 4.

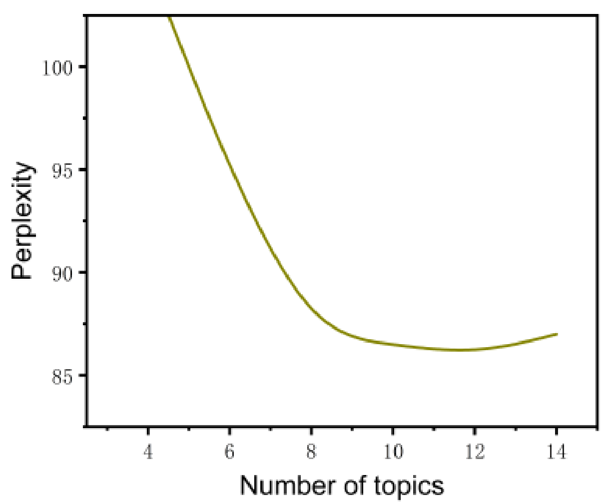


Fig. 4. Perplexity of LDA

As illustrated in Fig. 4, the number of clusters appeared to have a negative correlation with perplexity. To prevent the model from becoming overly complex due to excessive clustering, the optimal number of clusters was determined by the Elbow Method (Wu *et al*. 2008). It is apparent that the optimal topic clustering effect was achieved when the number of clustered topics was 8. The results of the LDA topic model analysis are presented in Table 1, and each topic was named according to the results.

It should be noted that the reviews of a single product may contain many negative comments on the product itself rather than the needs and suggestions for the product, so the results of the LDA model need to be further screened. This study invited 5 industrial design professionals, who have certain experience in product design and color design and asked them to select the words that can be used as the evaluation factor of wardrobe color selection image. The results are shown in Table 2.

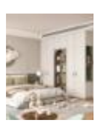
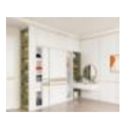
Table 1. LDA Topic Clustering Results

NOo	Topic Attribute	Main Topics
1	Service	Furniture, price, attitude, efficiency, careful
2	Product	Smell, color, pretty, affordable, bedroom, cost-effective
3	Brand	Dedicated, reliable, credible, professional
4	Quality	Panel, problem, color difference, deformation, detail
5	Distribution	Customer service, fast, delivery speed, packaging
6	Appearance	Style, concise, cozy, fashionable, bright, satisfying
7	After sale	Shopping, physical store, blemish, sales return,
8	Material	Panel, texture, technology, metals, wood

Table 2. Perceptual Evaluation Factors

No.	Code	Evaluation Factors
1	EF_1	Bright
2	EF_2	Harmonious
3	EF_3	Cozy
4	EF_4	Concise
5	EF_5	Fashionable
6	EF_6	Comfortable

Table 3. Part of the Wardrobe Color Information Database

No.	Sample Picture	Color	Color Data			Attribute
			H	S	B	
1			48	16	59	S
2			28	5	93	P
3			28	34	68	S
4			30	9	82	P
5			47	22	79	S
6			48	2	93	P

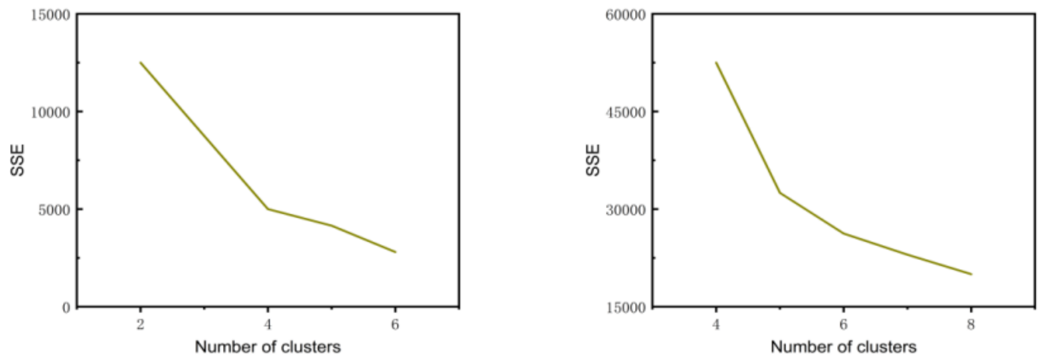
7			36	18	84	P
8			33	25	69	S
9			30	15	81	S
10			33	5	89	P
11			23	6	49	S
12			28	11	66	P

Table 1 demonstrates that consumers’ feedback on wardrobes encompasses both the sales service process and the quality, functionality, and appearance attributes of wardrobes. The topic 6 “Appearance” contains many words related to the color scheme of the wardrobe, such as ‘concise’ and ‘cozy’. Consequently, the appearance of the wardrobe is a crucial factor in determining whether users are satisfied with their purchase. The six perceptual factors in Table 2 can be divided into objective color attributes and subjective feelings, which reflect the basic requirements of consumers for wardrobe color schemes. The attributes of ‘brightness’ and ‘concise’ describe the specific characteristics of colors. It revealed that users prefer lighter colors with higher brightness and less colors. The subjective feelings of ‘warmth’, ‘fashion’, and ‘comfortable’ describe the consumers' perception of the color, reflecting their needs for the room environment. The concept of 'harmony' describes the color relationship between wardrobes and other home products.

Wardrobe Interactive Color Design

This study visited Jingdong Mall to obtain 188 samples of wardrobe product images and 188 color schemes with 368 color information through Photoshop, which were summarized to form the wardrobe color information database, as shown in Table 3. The color that dominates the overall design style of the product and occupies a large area is the primary color (P). In contrast, the color that enriches the visual level of the product and occupies a smaller area is the secondary color (S). The K-means clustering algorithm was used to cluster the primary colors and secondary colors to form corresponding feature colors. Eqs. 2 was used to calculate the SSE of different cluster numbers respectively. Figure 5 shows that the number of primary feature color clusters is 4, and the number of secondary feature color clusters is 6, and the results are shown in Table 4.

After importing the wardrobe color selection set into IBM SPSS Modeler 18.0, the Apriori model node was accessed, the minimum support was set to 5%, the minimum confidence to 30%, and finally 7 rules were generated. After eliminating the invalid rules with Lift＜1, five color selection association rules were retained, and the results are shown in Table 5. It is apparent that the primary color is a bright color with low saturation and high brightness, which provides a softer visual experience. It is an important element reflecting the dissimilarity of two wardrobe products. In the contrast, the secondary color has more variations, can bring a richer visual experience and acts in cooperation with other household products. The combination of them can correspond to different user’s perceptual factors and provide direction for color design.



(a) SSE of primary colors **(b)** SSE of secondary colors

Fig. 5. Sum of squares of clustering errors with different K values

Table 4. Feature Color of Wardrobe

No.	Color	Color Data			No.	Color	Color Data		
		H	S	B			H	S	B
M_1		42	11	85	S_1		32	14	42
M_2		60	3	99	S_2		31	28	70
M_3		42	6	69	S_3		9	14	81
M_4		180	4	61	S_4		29	15	89
-	-	-	-	-	S_5		160	18	26
-	-	-	-	-	S_6		133	9	76

In this study, the IGA color selection process was realized by invoking the VBA macro editor of Coreldraw, and the interactive product color design module was built in the form of embedded macros. The operation interface is shown in Fig. 6. The number of populations was set to four, the probability of elimination was 7.5, and the probability of variation was 0.3. The six evaluation factors were scored on a scale of 0 to 9. The outline drawing of the wardrobe was drawn first, and then the color association rules obtained above were filled into the outline as the color reference source for interactive color design, as shown in Fig. 7.

Table 5. Wardrobe Color Association Rules

No.	Rules	Sample	Support	Confident	Lift
1	M_2-S_4		27.27	66.67	3.26
2	M_1-S_2		9.09	50.00	2.44
3	M_2-S_3		9.09	50.00	1.29
4	M_4-S_5		18.18	50.00	1.29
5	M_2-S_6		45.45	40.00	1.60

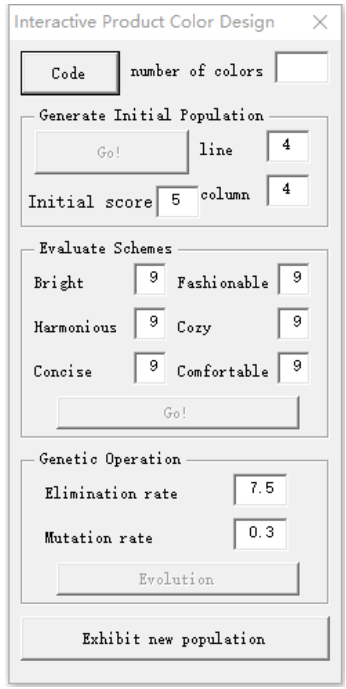


Fig. 6. IGA color design interface

The initial color selection population was generated based on the input of a color reference source into an interactive genetic color design module. Four teachers from the College of Furniture and Industrial Design of Nanjing Forestry University were invited as subjects. All of them had normal color discrimination ability and corrected visual acuity of 5.0 in both eyes. They were invited to a laboratory that had good lighting conditions and a quiet environment. The subjects sat in front of a computer and operated an interactive genetic color selection system. Subjects were required to observe each generation of mutant population for no less than 10 seconds, and the color scheme and its score were retained on the computer after the operation. The color scheme with the highest score was selected as the final result, as shown in Fig. 8.

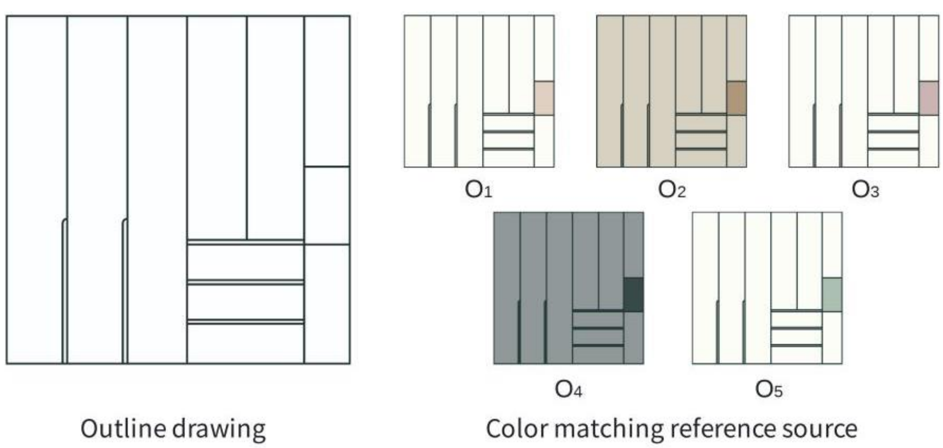


Fig. 7. Structure profile and reference sources

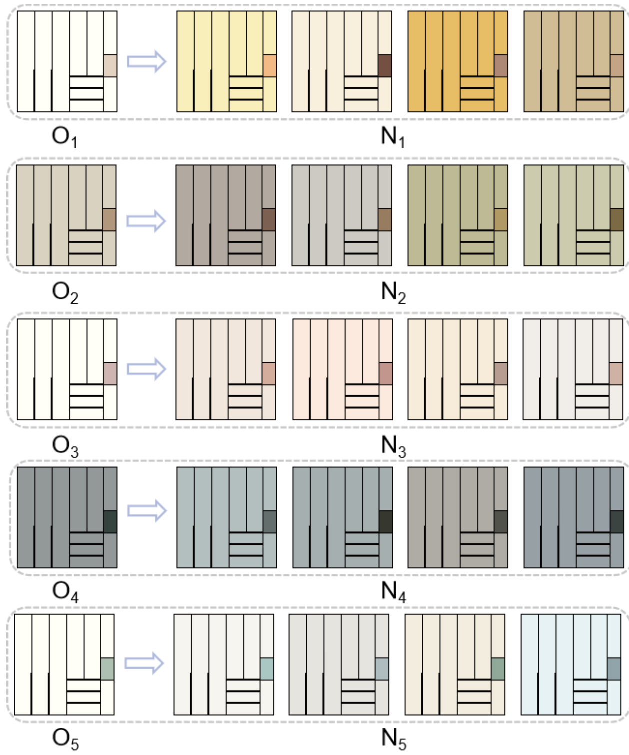


Fig. 8. Interactive genetic algorithms generate color schemes

The interactive genetic color selection method uses the color parameters of the original scheme as a reference point, expanding to encompass the various dimensions of the color space. This enables the direction of genetic variation in color to be successfully guided through the introduction of the perceptual evaluation factor, thereby facilitating the formation of a wardrobe color scheme that is more aligned with the user's specific color requirements.

Design Evaluation

A questionnaire was distributed to collect evaluations, which used “Cozy”, “Concise”, “Fashionable”, “Comfortable”, and “Harmonious” as evaluation standards. The questionnaire presented the pictures of these five groups of color schemes generated above (*N*) and the original color schemes (*O*), from which the user will select one from each group. The original color scheme and the new schemes were scored respectively. It was conducted on a 5-step Likert scale, with a score of 0 to 5 indicating from complete non-conformity to complete conformity. The questionnaire was distributed in two ways: the questionnaire distributed on the online platform collected the evaluation of consumers, and the questionnaire distributed in Nanjing Forestry University collected the evaluation of people with professional knowledge. 76 questionnaires were completed, of which 72 were valid, 48 were from the online platform and 24 were from Nanjing Forestry University. The scoring results were averaged and shown in Table 6.

The fuzzy comprehensive evaluation results were weighted by the entropy weighting method, as detailed in Eqs. 6, 7, and 8, resulting in the weights of the six perceptual evaluation factors, as presented in Table 7.

According to the fuzzy evaluation test, the fuzzy evaluation matrix of five color schemes can be obtained using Eqs. 10, and the fuzzy comprehensive evaluation value of color schemes can be obtained using Eqs. 11 and 12, as shown in Table 8. The evaluation results demonstrate that compared with the original color scheme, the score of the color scheme generated by IGA is basically the same as that of the original color scheme in group 4, and the other groups are slightly improved.

Table 6. Color Fuzzy Comprehensive Evaluation of Observed Values

No.	Evaluation Factors (EFs)					
	Cozy	Concise	Fashionable	Comfortable	Bright	Harmonious
N_1	2.86	4	3.36	3.29	3.71	3
O_1	2.75	4.2	3.23	3.35	3.58	3.34
N_2	3.36	3.93	3.43	3.29	4.07	2.79
O_2	3.21	4.02	3.13	3.46	3.76	3.05
N_3	3.29	3.93	2.93	3.29	3.5	2.86
O_3	3.53	3.48	2.87	3.75	3.85	3.02
N_4	3.29	3.5	3.29	3	3.21	3.21
O_4	3.78	3.35	4.12	3.32	3.58	3.65
NI_5	2.86	3.93	2.64	2.57	3.14	2.86
O_5	3.86	3.08	3.63	3.12	2.68	3.53

Table 7. Perceptual Index Weight

EFs	Cozy	Concise	Fashionable	Comfortable	Bright	Harmonious
Weight	0.02	0.35	0.10	0.13	0.16	0.23

Table 8. Fuzzy Comprehensive Evaluation of Value

No.	Results	No.	Results
N_1	3.71	O_1	3.62
N_2	3.88	O_2	3.54
N_3	3.65	O_3	3.37
N_4	3.49	O_4	3.5
N_5	3.39	O_5	3.16

Compared with other studies, this study applied text data mining to consumer requirement extraction, which can obtain user feedback objectively and extensively. Text mining can avoid the problems of high research cost and subjective research results compared with questionnaire survey, user interview, and other methods. In addition, this study took the color of current products in the market as a case, summarized the color selection rules by Apriori algorithm, and used interactive genetic color selection for derivative color, which can effectively avoid the problem that random colors of IGA that are difficult to control. IGA applied in color design, with a simple designer interaction selection to screen the color scheme, can achieve close to the optimal color design while also enhancing the efficiency of the color selection process and improving the product competitiveness of enterprises.

There are still some problems in this study that need further research. The evaluation results of the experimental color scheme and the original color scheme showed that the score of the experimental scheme was improved slightly. Improving the IGA to further guide the color selection in a favorable direction may be one of the directions for further research. The online review data exhibits clear temporal characteristics, but the LDA model is unable to accommodate the evolving user preferences over time.

CONCLUSIONS

1. Color selection and establishment of color schemes are important for product design, playing a significant role in product style and image positioning. In order to solve the problems of low efficiency and strong subjectivity in wardrobe color selection, this study improved the current wardrobe color selection based on extracting users' color needs for wardrobes. An interactive genetic algorithm was used to carry out an analysis of wardrobe color innovation. The study verified the effectiveness of the research through a fuzzy comprehensive evaluation method.
2. This study used the latent Dirichlet allocation (LDA) method to analyze online review data and capture consumers' requirement for wardrobe color design. Six perceptual factors were summarized, which involved three aspects: objective attributes, subjective feelings, and color coordination. From the weight analysis of perceptual factors, it became apparent that consumers prefer concise, harmonious, and bright colors. This finding indicating that for the overall home environment, the wardrobe, as a decorative and practical element, is usually not used as the main part of space decoration, but plays a role in shaping the atmosphere to fit the space style with harmonious colors. From the perspective of product design response, the market prefers to use understated and soft main colors with varied auxiliary colors to respond to user needs.
3. This study established an interactive genetic color selection system with dual constraints of perceptual evaluation factor and color reference source. A case study was conducted using fuzzy comprehensive evaluation method to verify its effectiveness. It was found that this system can effectively guide the color scheme to change in the specified direction, so as to improve the efficiency of color design. Compared with the traditional interactive genetic method, this study can avoid the invalid variation caused by randomness in the genetic process. It can optimize the existing color scheme in a targeted way, providing a new idea for the design innovation of enterprises.

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