

## Multi-image Evaluation of Product Color Design based on Grey Relational Analysis

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**Abstract:** To realize multi-image scheme selection of product color design, the grey relational analysis method was introduced into product color evaluation process. Through multi-image acquisition of product color design, users were asked to give their scores of each color scheme according to target multi-image, which were used to establish decision matrix. Ideal solution was acquired by standardizing decision matrix. Based on grey relational analysis method, the relation between product color schemes and ideal solution was calculated. Finally, the multi-image scheme selection of electric scooter color design was taken as an example to verify the efficiency of the proposed method.

### Introduction

Consumer perception of the product first came from sense of sight, but the biggest factor affecting visual perception is color. As the mainly visual language of product, color contains the inherent quality and conveys external emotion of products [1]. In product design, color emotion was described by intentional vocabulary, which reflects the customers' expectation to the product, possessing the characteristics of multi intention needs. Through the research of the evaluation of product color intention can promote the understanding of product for users and designers, thereby reduce the cognitive differences to the product [2].

Grey relational analysis method was put forward by the Professor Deng Julong [3], which most often used to analyze the degree of uncertainty correlation in order to identify the significant trends affecting the system properties, having been widely used in engineering machinery [4], children walker [5], CNC machine tools [6], electronic locks [7], color imagery Thermos [8] and other products of the evaluation. For further study of the problem of product color multi intention optimization, this paper based on the users' multi intention needs for the product color, and explore the relevance of the product color schemes and multi intention indicators ideal solution based on grey relational analysis method in order to realize optimization of the product color scheme while assist designers to make decisions. Finally, taking electric scooters color design as an example made the application verification.

### Product design's more intention acquisition

Aiming at the target products' development stage, functional applications, environmental conditions, and combining the factors of integral image, fashion color trends and competitor positioning, we will enact accurate, appropriate, unique product positioning of color image from the image of the needs of target consumer groups. The steps are as follows:

(1) Collecting the color intention vocabulary extensively, and filtering preliminarily by the color

design experts; Color Image extensive collection of vocabulary, initial screening by the color design experts;

(2) Using an open questionnaire for the consumers, and sorting imagery adjectives;

(3) Expanding the experimental survey of color image adjectives and picking out the frequency of more than 50% of imagery adjective by the experiments, which composed by the designers, consumers and enterprises personnel;

(4) Picking out the right number of target product samples, at the same time, expanding the questionnaire for selected images adjectives;

(5) Making the statistical analysis of the questionnaires, removing the adjective which does not comply with the relevant requirements of the imagery, and making clustering processing through the color images, hence ultimately determine the target color imagery product positioning.

### System modeling of gray incidence decision

According to the positioning of target products' color multi intention, the designers made product color design and got its scheme according to personal experience, creative inspiration and corporate culture. Establishing semantic differential scale in allusion to every color design scheme, and rated by the users. Assumed the number of color scheme is  $m$ , the number of intention indicators is  $n$ , then got the user of the product color scheme decision matrix  $A = [a_i(j)]_{m \times n}$ . Wherein,  $a_i(j)$  of the  $i$ -th color scheme for the  $j$ -th imagery evaluation value,  $i = 1, 2, \dots, m, j = 1, 2, \dots, n$ .

(1) The standardization of decision matrix

With regard to the multiple color schemes indicators of product color scheme, we expected the evaluation value bigger and better of every intention, and used formula(1) to standardize it.

$$x_i(j) = \frac{a_i(j) - \min_{1 \leq k \leq m} [a_k(j)]}{\max_{1 \leq k \leq m} [a_k(j)] - \min_{1 \leq k \leq m} [a_k(j)]} \quad (1)$$

Now the standardized decision matrix is  $X = [x_i(j)]_{m \times n}$ .

(2) determining the ideal solution

For the  $n$ -th Image index, users made ideal solution to the maximum evaluation value of the  $m$  color schemes, now the ideal solution is:

$$X^* = [x^*(1), x^*(2), \dots, x^*(n)] \quad (2)$$

Where  $x^*(j) = \max [x_i(j)]$ .

(3) Calculating the gray correlation coefficient

We got the ideal solution according to the formula(2), and calculated the  $i$ -th color scheme of the ideal solution in the  $j$ -th coefficient associated imagery indicators, there are:

$$\gamma(x^*(j), x_i(j)) = \frac{\min_j \min_i |x^*(j) - x_i(j)| + \zeta \max_i \max_j |x^*(j) - x_i(j)|}{|x^*(j) - x_i(j)| + \zeta \max_i \max_j |x^*(j) - x_i(j)|} \quad (3)$$

Among them,  $\zeta$  is the distinguish coefficient, the intention of which is weakening the effect that came from the absolute difference value is too big to show clearly and improving the significant difference between the correlation coefficient, generally take  $\zeta = 0.5$ .

(4) Calculating grey correlation degree

Setting the weight vector of  $n$  image index to  $W = (w_1, w_2, \dots, w_n)$ , now we can get the  $i$ th color scheme of grey correlation degree for the ideal solution according to the tape (3), the details are as following:

$$\gamma(X^*, X_i) = \sum_{j=1}^n w_j \cdot \gamma(x^*(j), x_i(j)) \quad (4)$$

Based on the result of calculating the grey correlation degree, now we can making priority ordering to the product color scheme.

### Examples of application

Taking electric scooter color design as an example. Ensuring the target user are the teenagers of

the age from 6 to 16 through on-the-spot investigation and communication with the merchants. In order to gain the user's image requirements,collecting the image adjective of description for electric scooter from web sites,books,magazines,the paper and so on , and combined with the user survey and the interview as a result of getting a total of 48 image vocabulary.Matching the words of opposite meaning,at the same time,giving the appropriate anti-sense adjectives to other perceptual words.To investigate image adjective examinations for the construction of Likert seven scale, investigating the consumers' preference degree of perceptual adjectives of the electric scooter samples.Through cluster analysis,the user's demands are the "dynamic", "fashion" and "technology", while makes it as the image positioning of product color. The color of electric scooter is designed ,which combining with the target image positioning by two designer respectively ,for a total of eight color scheme is shown in figure 1.



Fig.1. Electric scooter color scheme

Images of the target color scheme consisting imagery adjectives, now building the Likert seven scale respectively, as shown in figure 2.

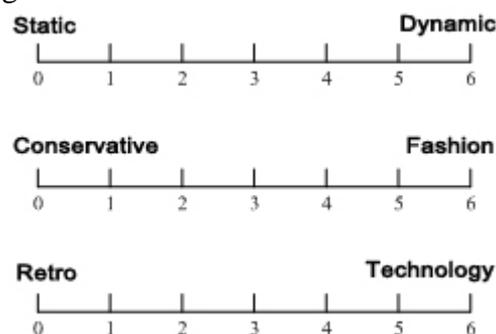


Fig. 2. Image scale

Building the network questionnaire,organizing 17 people from middle and high school students respectively (aged between 6 to 16 years old),evaluating the grade from the 8 sample schedules,as a result,it can be got that the decision matrix of the mean more image evaluation scheme of the color for product,as shown in table1.

Table 1 .Decision matrix

No.	Image mean		
	Static-Dynamic	Conservative-Fashion	Retro-Technology
$a_1$	4.25	4.02	4.28
$a_2$	3.27	4.1	4.15
$a_3$	3.56	3.95	4.33
$a_4$	3.44	4.03	4.56
$a_5$	5.36	4.59	4.6
$a_6$	5.01	4.36	4.32
$a_7$	4.27	4.91	4.9
$a_8$	5.38	4.89	5.05

According to the type (1), making the standardization of decision matrix, getting the matrix after standardization for:

$$X = \begin{bmatrix} 0.464455 & 0.072917 & 0.144444 \\ 0 & 0.15625 & 0 \\ 0.137441 & 0 & 0.2 \\ 0.080569 & 0.083333 & 0.455556 \\ 0.990521 & 0.666667 & 0.5 \\ 0.824645 & 0.427083 & 0.188889 \\ 0.947867 & 1 & 0.833333 \\ 1 & 0.979167 & 1 \end{bmatrix}$$

According to type (2) ,getting the ideal solution for:

$$X^*=[x_8(1),x_7(2),x_8(3)]=[1,1,1]$$

$\zeta= 0.5$ ,according to the (3),calculating the gray relation coefficient of color scheme and ideal solution are as following:

$$\gamma(x^*(j),x_i(j)) = \begin{bmatrix} 0.482838 & 0.350365 & 0.368852 \\ 0.333333 & 0.372093 & 0.333333 \\ 0.366957 & 0.333333 & 0.384615 \\ 0.352254 & 0.352941 & 0.478723 \\ 0.981395 & 0.6 & 0.5 \\ 0.740351 & 0.466019 & 0.381356 \\ 0.905579 & 1 & 0.75 \\ 1 & 0.96 & 1 \end{bmatrix}$$

### Test results

According to the result, it can be got that the priority sort result of color scheme are as following: Scheme8 > Scheme7 > Scheme5 > Scheme6 > Scheme1 > Scheme4 > Scheme3 > Scheme2.

The result shows that the correlation of the maximum value of the user to the image (i.e., the ideal solution) is higher for Scheme 8, Scheme 7 and Scheme 5, and the result may be a preferred color scheme for designers to further refine the design.The above process can be completed under the internet assistant, because of the limited space is not prepared here.

### Conclusion

In order to realize the multiple image evaluation of product color scheme, based on the gray correlation analysis method,the maximum evaluation value of the product color scheme is used as the ideal solution to study the gray correlation of the ideal solution. Taking the color scheme of electric scooter evaluation as an example, verify the effectiveness of the proposed method.

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