

## Based on Grey Correlation Analysis Method of New Classic Furniture

### Product Design Evaluation Model

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*Abstract: By using grey correlation analysis method, we can find out the optimal product design. Three design solutions of new classical furniture product as an example, according to the calculation of grey correlation analysis, we select the optimal design solution which conform to the survey result of user experience. According to the calculation, plan A is the best design solution, and plan C is not ideal. Grey correlation evaluation model can really optimize the design process, improve the accuracy and scientificity of designers' options and play a supplementary role in design work.*

*Keywords: grey correlation analysis method, new classic furniture products, evaluation model, the optimal design scheme, the product design*

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## 1. INTRODUCTION

China's classical furniture has a long history, the Ming Dynasty is the pinnacle of classical furniture. New classical furniture integrates modern popular elements into the classical furniture, so that it is more in line with the modern aesthetic visual enjoyment. The new classical style is rapidly becoming popular in China in recent years, and the new classical furniture design work is increasing. After the completion of the furniture design, the designer usually want to make a choice in several similar programs, usually based on their own experience or preferences. With the development of the new classical furniture production process and the improvement of the public aesthetic, society requires designers to choose more scientific and standardized design options. In order to improve the accuracy of the selection and avoid more subjective factors, we establish the model based on the grey correlation method in the appraisal model of the neo classical furniture design, which combines quantitative factors and qualitative factors, and analysis based on expert scoring for each index, to choose the furniture design more reasonable.

## 2. GREY RELATIONAL DEGREE MODEL

The gray in the gray system is refer to the system of partial information known and partial information is unknown. It is mainly used in the research of incomplete information system, and determine unknown information in the system through the known information in the system, so as to realize the goal of the whole information system [1].In the selection of furniture design, we can only estimate some factors rather than quantitative all of the data, so we can think of design scheme is a grey system.

Relevance is a measure of the magnitude of the relationship between the factors that vary with the time or the object in two system. So in this paper, we combine relevance with gray system, and analyze the similarity or dissimilarity between the development trends of factors by using grey correlation degree analysis method. We judge whether a variety of new classical furniture design is good or bad and find out an ideal design scheme which is most similar to the new classical furniture design, by calculating the measure scheme design and expert evaluation of a variety of new classical furniture the most ideal design scheme of correlation degree to.

## 3. GENERAL STEPS OF GREY RELATIONAL DEGREE

According to the basic theory of the gray correlation analysis method, the calculation method and application and improvement in recent years are analyzed, we propose the following calculation method combining with the actual situation of new classical furniture.

### 3.1 determine the comparison sequence

Assuming that the designer needs to choose the most ideal solution from the group to be evaluated.

The evaluation of these schemes involves evaluation indexes, and the comparison sequence of each design scheme can be expressed as:

$$X_i = \{x_i(k), k = 1, 2, \dots, n\}, i = 1, 2, \dots, m$$

At the same time, the reference sequence should be set according to the ideal scheme:

$$X_0 = \{x_0(k), k = 1, 2, \dots, n\}$$

### 3.2 Non dimensional treatment of data

The evaluation of furniture has a variety of evaluation indicators, which are different in dimensions and orders of magnitude and cause inconvenience in the establishment and solving

of the model. Therefore, in this paper, we deal with the data of each evaluation index to make it no dimensional, and the formula is as follows:

$$X'_i = \frac{x_i(k)}{\bar{X}_i}$$

$$X'_0 = \frac{x_0(k)}{\bar{X}_0}$$

Among them:

$$\bar{X}_i = \frac{1}{n} \sum_{k=1}^n x_i(k), \quad k = 1, 2, \dots, n$$

$$\bar{X}_0 = \frac{1}{n} \sum_{k=1}^n x_0(k), \quad k = 1, 2, \dots, n$$

### 3.3 difference treatment

The correlation coefficient measures the correlation between the two systems, which is mainly reflected in the similarity degree between the reference sequence and the comparison sequence in the curve shape:

The closer the shape of the two curves is, the larger the correlation coefficient is, that is, the more close to the design scheme and the ideal scheme represented by the sequence. On the contrary, if the curve shape of the two have large difference, then the correlation coefficient is smaller, and the gap between the design and the ideal is larger. Therefore, in this paper, we express the difference between the two sequences using the difference of correlation degree, and the specific formula is as follows:

$$\Delta_i(k) = |x'_i(k) - x'_0(k)|, \quad k = 1, 2, \dots, n$$

Maximum difference and minimum difference are shown as follows:

$$\Delta(\max) = \max_i \max_k \Delta_i(k)$$

$$\Delta(\min) = \min_i \min_k \Delta_i(k)$$

### 3.4 correlation coefficient

The correlation coefficient between the evaluation index numbered I of the design scheme numbered k and the design scheme numbered I of the local scheme can be shown as follows:

$$\gamma_i(k) = \frac{\Delta(\min) + \rho \Delta(\max)}{\Delta_i(k) + \rho \Delta(\max)} \rho \in (0,1) \quad k = 1, 2, \dots, n \quad i = 1, 2, \dots, m$$

In the formula, the  $\rho$  is resolution ratio, which improve the difference between the coefficient of correlation coefficient. In this paper, We use mean value method to carry on the centralized processing of the related information, to represent the correlation coefficient between the reference sequence and the comparison sequence.

$$\gamma_i = \frac{1}{n} \sum_{k=1}^n \gamma_i(k) \quad k = 1, 2, \dots, n \quad i = 1, 2, \dots, m$$

The larger the correlation coefficient is, the greater the degree of association between the comparison sequence and reference sequence, which indicates that the proposed scheme is more close to the ideal scheme.

#### 4. EXAMPLE CALCULATION

After establishing the model, we evaluate three new classical style chairs with the method of gray correlation. And the design diagram is shown in Figure .1:



Fig.1 Three design schemes for the chair of the new classical style

When evaluating the scheme, we take function, economy, innovative, beauty, people-oriented, sustainable development of the six design principles as the main evaluation index [11-12], and invite experts to evaluate them. And the expert grade statistics are shown as follows:

Tab 1 Expert grade statistics

	Ideal alternative	Plan A	Plan B	Plan C
function	10	8	9	6
economy	10	7	6	8
innovative	10	9	8	5
beauty	10	9	7	6
people-oriented	10	6	7	7
sustainable development	10	8	6	7

To have a more intuitive understanding about the three schemes, we expressed the correlation degree between design scheme and ideal scheme in curve shape, and the result is as follows:

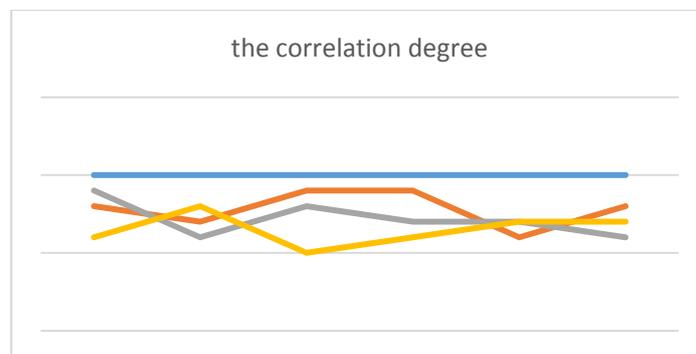


Fig.2 Correlation graph

As you can see, the design of three each have advantages and disadvantages, we are unable to determine which of the scheme of intuitive is more ideal, and in this case using the gray relation analysis model is very necessary.

#### 4.1 reference sequence and compared sequence

We set the six indicators of the ideal scheme out, and get the reference sequence shown as follows:

$$X_0 = \{10,10,10,10,10,10\}$$

According to the experts' grades about the three design schemes, we can get compared sequence shown as follows:

The compared sequence of Plan A:

$$X_1 = \{8,7,9,9,6,8\}$$

The compared sequence of Plan B:

$$X_2 = \{9,6,8,7,7,6\}$$

The compared sequence of Plan C:

$$X_3 = \{6,8,5,6,7,7\}$$

#### 4.2 dimensionless processing

In order to calculate conveniently, we make the original data dimensionless and the steps are shown as follows:

First of all, according to the formula (5)(6) , calculate the average of each sequence evaluation index:

$$\bar{X}_0 = \frac{10 + 10 + 10 + 10 + 10 + 10}{6} = 10$$

$$\bar{X}_1 = \frac{8 + 7 + 9 + 9 + 6 + 8}{6} = 7.83$$

$$\bar{X}_2 = \frac{9 + 6 + 8 + 7 + 7 + 6}{6} = 7.17$$

$$\bar{X}_3 = \frac{6 + 8 + 5 + 6 + 7 + 7}{6} = 6.5$$

Then according to the formula (3)(4),we can calculate the new reference sequence and compared sequence after the dimensionless processing.

$$X'_0 = \{1,1,1,1,1,1\}$$

$$X'_1 = \{1.02,0.89,1.15,1.15,0.77,1.02\}$$

$$X'_2 = \{1.26,0.84,1.12,0.98,0.98,0.84\}$$

$$X'_3 = \{0.92,1.23,0.78,0.92,1.08,1.08\}$$

### 4.3 difference processing

In order to compare the correlation degree between ideal solution and scheme, we take differential treatment according to the formula (7):

$$\Delta_1 = \{0.02, 0.11, 0.15, 0.15, 0.23, 0.02\}$$

$$\Delta_2 = \{0.26, 0.16, 0.12, 0.02, 0.02, 0.16\}$$

$$\Delta_3 = \{0.08, 0.23, 0.22, 0.08, 0.08, 0.08\}$$

As you can see, the maximum and minimum difference of sequence are shown as follows:

$$\Delta(\max) = \max_i \max_k \Delta_i(k) = 0.26$$

$$\Delta(\min) = \min_i \min_k \Delta_i(k) = 0.02$$

### 4.4 calculating the correlation coefficient

According to the formula (10), we calculate the correlation coefficient and take distinguish coefficient as 0.5:

$$\gamma_1 = \{1, 0.63, 0.54, 0.54, 0.42, 1\}$$

$$\gamma_2 = \{0.38, 0.52, 0.6, 1, 1, 0.52\}$$

$$\gamma_3 = \{0.71, 0.42, 0.43, 0.71, 0.71, 0.71\}$$

By comparing calculation we got the sequence of the connection degree of each evaluation index and reference sequence index, but the information is relatively dispersed, so we still can't judge whether the three design schemes are good or bad.

To intuitively show the pros and cons of each design scheme, we obtain the concentrated correlation coefficient after the correlation information centralized processing with the method of average:

$$\gamma_1 = 0.69$$

$$\gamma_2 = 0.67$$

$$\gamma_3 = 0.615$$

As you can see  $\gamma_1 > \gamma_2 > \gamma_3$ , namely the plan A design is most close to ideal alternative, and the plan C has the greatest difference between the ideal design.

In order to verify the correctness of the grey correlation evaluation model, we invited 100 customers to vote for the three chairs, and the results are shown as follows:

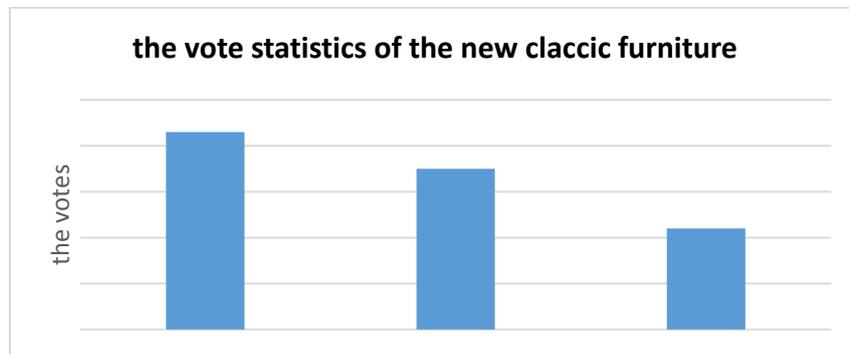


Fig.3 Votenum of user experience

From the figure, we know that the user experience of the plan A is the best and the plan C is the worst, which proved that our calculation result is reliable.

## 5. CONCLUSION

Through calculation, we can find that plan A is the best design scheme, and plan C is not ideal. And the subsequent user experience research results also proved this conclusion. So the grey correlation evaluation model can really play a supplementary role in designer work. By combining mathematical means with new classical design concept, we can improve the accuracy and scientific of the designer options, and improve the design level.

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