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Study on Design of Music Player Based on Fuzzy Synthetic Evaluation Model

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Abstract

Concerning of the impression of uncertainty and fuzziness that consumers have on product appearance, a synthetic evaluation model of music electronic equipment that meets the modern aesthetic needs is built in order to change the randomness and uncertainty of traditional product design. Through analyzing the three basic factors and several evaluation indexes in music player design, the weight of each evaluation index is determined by the application of Analytic Hierarchy Process (hereinafter referred to as AHP), and a two-level fuzzy synthetic evaluation model is built by using fuzzy mathematics. Finally, it is verified in experiment that the uncertainty in product design can be effectively improved, which at the same time increases the satisfaction rate and success rate of product design.

Keywords: *music player; fuzzy evaluation; AHP; evaluation index*

1. Introduction

Along with the progress of technology and the development of society, music player has become a necessity of human life. The birth of music player provides storage for beautiful music so that it can be widely spread and enjoyed. The development of science and technology delivers new sound carrier and reduction technology, which entitles products with smaller volume and rotary designed by product designer to be accomplished and mass produced. From single card radio-cassette recorder to Walkman, to the current digital iPod MP3 especially the induction roller with excellent sense of control, massive amounts of storage media and ultra small and thin chip provide designers the greatest possibility and support to create integrated, simple and fashionable appearance with smooth curves and facilitate designers not to worry about the varied function keys. Each qualitative leap and prominent change of product appearance is the direct effect of science and technology. For example, as with appearance, products are changing from huge and cumbersome into small and convenient; and function keys are having easy even single-handed rather than complicated operations.

All mentioned above are the result of interweaving of product function, material, structure, texture and form, etc. attached with modern science and technology. Among these elements, material, structure, craft and electronic parts can be clearly measured and tested. In designing, only appearance and form have strong uncertainty and fuzziness, as different designers have different design style and design thought, which result to different product appearances. What's more, a larger group of consumers have stable and consistent trend of interest and need for product appearance, as a result, contradiction between designers' thought and consumers' need is generated. In this paper, several evaluation indexes are listed through analyzing the relevant factors the influence the product design; weights of all evaluation indexes are calculated by adopting AHP; and design of music player is researched based on fuzzy synthetic evaluation model by using the method of fuzzy mathematics; finally, the design is verified in experiment

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about whether this method can effectively improve the uncertainty caused by human factors in product design, whether the satisfaction rate and success rate of product design can be increased, and whether these methods can provide effective assist and support for product designing work [1-2].

2. Product Design of Music Player

Product means items that are produced based on some purposes in accordance with social and human needs. It is a kind of objective entity with specific functions made from some materials in certain structural form. For users, it is article for use; for market, it is commodity. Product design is the design of goods, namely the style of industrial goods. It is completely different from invention or utility model, that is to say, design is not a technical solution. It is stipulated in Article II of China's "Rules for the Implementation of the Patent Law" that: "A design shall mean any new design of the shape, pattern or their combination, or the combination of the color with shape or pattern, of a product, which creates an aesthetic feeling and is fit for industrial application" [3-4]. Design has the following characteristics:

(1) It refers to design of the shape, pattern, color or their combination;
(2) It must be design of the product appearance;
(3) It must be full of beauty;
(4) It must be adapted to industrial applications.

Music player product refers to electronic product with function of playing music, which itself has three functions: utility function, aesthetic function and symbolic function. Consumers have dual requirements for the music player materially and spiritually. Utility function belongs to material requirement, and the other two belong to spiritual requirements. The purpose of the music player design is to coordinate and synthesize these three requirements and two requirements. In design innovation of music player appearance, apart from three factors of the product structure (the product's weight and texture can be changed), processing technology (the product's precision and grade can be enhanced), and inherent technologies which will be taken into account by an excellent designers, the shape, color and materials are factors that change the product appearance most, especially in the design of digital electronic music products.

3. Thinking Analysis of Synthetic Fuzzy Evaluation Model

Evaluation indexes of product modeling program belong mostly to subjective indexes, and are difficult to be evaluated by traditional quantitative analysis methods such as simple scoring method, ranking & scoring method, scoring method and technology—economy evaluation method [5-6]. By introducing linguistic variables such as "good" and "poor", "very" and "no", etc. to traditional fuzzy evaluation method, the evaluation indexes are evaluated. And the final evaluation value is obtained by calculation based on the numerical fuzzy information which is achieved through fuzzy mathematic method. In result, a best model project will be selected according to the final evaluation value [7-8]. However, the traditional fuzzy evaluation method cannot determine the position of evaluation program in its market segment. This article makes some improvements for the traditional fuzzy evaluation method as follows: divide the large number of factors in the evaluation program into several levels with fewer factors, thus obtaining evaluation target set, and calculate the fuzzy synthetic value based on the target set and evaluation results from experts; and then combining with the final evaluation value gained from the corresponding market segments with standard percentage, determine to accept or reject the modeling program. Compared with various kinds of product evaluation methods in the past, synthetic fuzzy evaluation method is rational and scientific as it has good theoretical basis of strict mathematic knowledge, so that it can make more correct and objective quantitative analysis

on qualitative problems such as aesthetic quality of product appearance. Process of synthetic fuzzy evaluation system is shown in Figure 1.

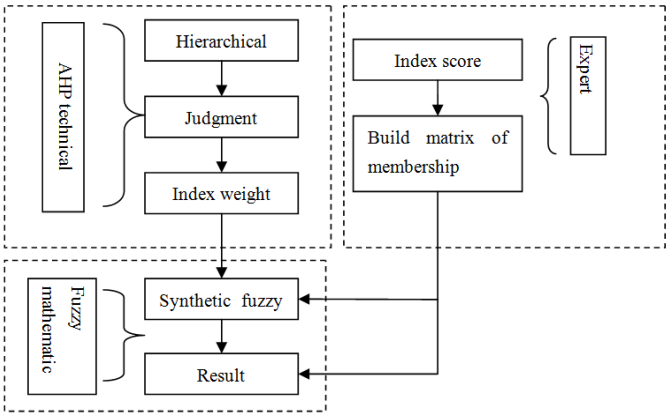

Figure 1. The Process of Synthetic Fuzzy Evaluation Method

4. Analysis on Factors that Influence Music Player Design

4.1. Modeling Analysis

Morphological appearance of the product reflects the product's structure of internal functions, directly influences people's understanding and usage for product function instructions, and is closely linked with the processing and assembly of products. While studying the shape, the characteristics of the times and the linear features of music player should also be studied. The overall modeling characteristic of modern music player is that the body is shaped by adopting the coordination of transitions among straight line, oblique line, smooth curve, curved surface and small arc, which gives a simple, smooth, straight, and stable feeling [9-10]. A perfect modeling design of music player can be expressed in the following three points:

First, the external expression of product serves internal factors. Product shall have a certain degree of self-adaptation, which is an important part of modern product design language. In order to make the music player work better and reflect faithfully technology, culture and human life of modern society, special means of expression should be used in model design so as to reflect the reliability, scientificity and advancement of the product functions.

Second, according to the product's specific efficacy and features, the coordination between product appearance and structure, the material selection of relevant parts, the selection of processing craft should be paid attention in model design so that it can form a perfect unity with the appearance and body of the equipment, thus achieving "structural beauty", "material beauty" and "craft beauty". An important step in designing music player is to choose parts, because not all of the components need to be developed separately. Most often, from the perspective of cost saving, manufacturers would require designers to choose some common parts. Therefore, how to choose the parts and to coordinate them with the overall design is a big challenge for designers to control the model trend.

Third, the design or selection of equipments, instruments and control panels that can reflect the modern science and technology should be focused so as to demonstrate further the product's epochal character, scientificity and advancement.

Figure 2. Unis Music Player

Figure 3. Clock Type Music Player

As is shown in Figure 2 and 3, both music players have geometric shape, but concerning of model, the music player in Figure 3 is better than that in Figure 2. On the whole, music player in Figure 3 conceals its external structure as far as possible. For those parts that are hard to be hidden, they are integrated with the player as one. Moreover, the application of curved surface adds intimacy to the instrument. While in Figure 2, the music player is lack in sense of unity, which can be reflected in the design of inattentive keys and screen. It is pure functionalized design with poor intimacy.

4.2. Color Analysis

In product modeling, color is the most sensitive information factor with fastest delivery. It is a head start language of art, since people have the strongest and the most direct sense and the deepest impression on color. Functions of the music player's color include two aspects: first, color has a certain stimulus on human psychologically and physically, allowing users and products to produce a resonance in the psychological and physiological; followed by functions on visual information query. Some music players' parts and operating parts can achieve good recognition, easy operability and safety through color distinction. Different characteristics of different colors can be used to express functions of music players themselves and be applied as a medium to deliver information. In addition, color and the environment where the music player lies influence each other. On the one hand, color has a strong influence on the human mind and spirit, and creates different physiological and psychological feelings for human under different environmental backgrounds; on the other hand, different colors have different emotions. A color may suggest the specific usage space that the music player is in. Color perception diagram is shown in Figure 4.

Figure 4. Diagram of Color Perception

Therefore, in designing music player, large areas of solid color or glaring color, high color contrast and strong visual impact are inadvisable, while soft, relatively bright middle tones are advisable. Solid colors can be used to embellish local accessories, which can add some vitality. For example, red color can be embellished with some complementary light green which helps alleviate physical fatigue and regulate the mood. Businesses design colors, and users expend on them, which shows that color is a link between products and users. In designing product color, an

overall aesthetic form of shape, color and quality should be combined organically with the essential contents of man, machine and the environment in order to achieve the perfect shape effect. As a result, designers shall understand well the emotions of colors and the principles of color matching. The more designers know about product colors, the more correct they master the color language and functions, and the more possible they design products that meet consumers' needs.

4.3. Material Analysis

The materials of existing music players are mainly metal, plastics and rubber which are selected by designers according to the different features of materials based on the different requirements of users. Generally, in the design of music players with strong modern sense, brushed steel is used as the main body, and materials such as plastics and rubber are used locally, so as to enhance the intimacy of music players. When designing music players for children, soft rubber is mostly chosen. As with metal, in the research on materials used in designed music players, steel is mainly adopted in outer bodies or some pressing parts as it can meet the demand for stress and rotational torque required in design. And the surface of steel shall be processed so that different visual features such as acid pickling, polishing, electrostatic spraying, fluorocarbon coating and painting, etc. can be presented, which provides better appearance effects. As for plastics commonly known as plastic cement, it is a general name of plastic high polymer materials under certain situations. In accordance with the hot melting, plastics can be classified into thermosetting plastics and thermoplastic plastics. As one of the three major organic high polymer materials (the other two are rubber and fiber) in the world, plastics have a great variety of species and crafts. The application of plastic materials can significantly reduce the self weight of the music payer and can enhance the intimacy of product. Rubber has the feature of softness, which can be used in areas that directly touch the human body, thus producing the cordial feeling. What's more, slipping can be avoided if rubber is used. Some features such as water proof and oil proof may be generated after rubber is processed on its surface. Therefore, in designing electronic parts of music player, parts enveloped by rubber can be adopted specifically; in designing music players that need to touch or collide with human body, rubber materials can be used since rubber can be deformed elastically.

5. Fuzzy Evaluation Model System of Music Player and Experimental Analysis

5.1. Sampling Projects of Music Player Appearance Design

The author collected and arranged three currently popular music players, as are shown in Figure 5, 6 and 7. These three projects represent the main appearance styles and models, and reflect the design mode of music players.

A brief analysis on appearance of three projects is as follows:

Project 1, a music player with earphones, is designed on the whole based on bionic design thinking, with lively and vital green as its dominant hue. The entire body is divided into two parts: the upper part is similar to antennas of creatures where two headphones are derived, followed with the lower living body. The two parts can be locked by rotation, and can also be jogged with each other. The design style of Project 1 has strong vitality and liveliness, and can be unified and coordinated well with the product functions. The function features and aesthetic characteristics of the product show an organically unified appearance style, with the design requirements of material, color, function and display all taken into account.

Project 2, deriving from the model of nautilus, shows a rather elegant form as a whole. The beautiful rotary shape and its sound box in the middle express a unified harmony of the whole

model. On the basis of meeting the playing function of music player, the appearance design embodies specially the spiritual aesthetic need of consumers. Just like a delicate artwork with strong sense of sculptural beauty, it also has simple colors, which give a feeling of science and technology as well as a modern sense. This project focuses more on the form, which is quite different from that of Project 1.

Project 3 takes geometric forms as its main thought of design. The curved product form protrudes the operation interface very well, with liquid crystal board in it. As a result, information such as lyrics, tracks and singers can be displayed better in the process of playing music. The colors are used implicitly with silver grey, a color with strong scientific sense, as its basic tone collocated by distinct orange. Different from the design style of Project 2, Project 3 emphasizes more on function instead of form. Therefore, the two projects present two totally different appearances.

Figure 5. Player Design Sample I

Figure 6. Player Design Sample II

Figure 7. Player Design Sample III

The analysis on above three projects provides consumers only with subjective feelings. While in designing process, without the guidance of correct numerical values, it's hard for designers to design products that meet consumers' requirements. By establishing a synthetic fuzzy evaluation model for product appearance, the same evaluation target set and evaluation criterion are adopted in different projects. As a result, the evaluation results will be equally comparable and projects can be evaluated based on the rate of numerical values. Evaluation models have the feature of comparability, so here only Project 1 is evaluated in experiment. As with the other projects, only the final evaluation results are listed. The detailed experimental process of Project 1 is as follows:

5.2. Evaluation Index

At this stage, semantic differential method is applied to obtain the sense data from experimental subjects on the appearance of the music player. The experimental subjects include young students, designers and salesmen, who are required to score the above three samples. The appearance sense data depends mainly on the factors set by evaluation indexes. According to AHP, the set evaluation system is established on four criterion layers, with 14 evaluation indexes on them. The determined evaluation index layer model is shown in Figure 5.

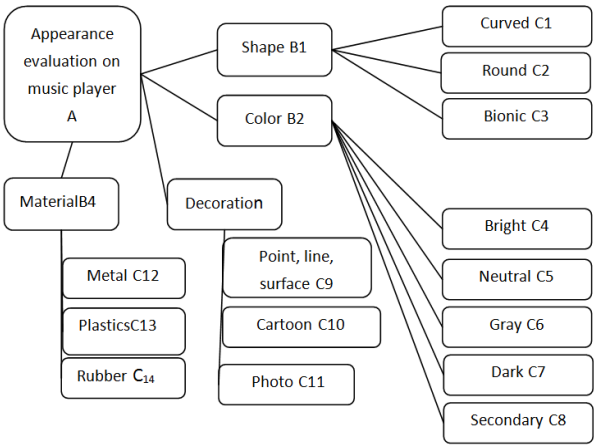

Figure 5. Hierarchy Chart of Evaluation Index System for Music Player Appearance

5.3. Determination of Index Weight

By establishing the comparative judging matrix of the music player's importance relative to evaluation target A on level-one index layer, and by asking for experts' opinions, the comparative judging results for each index are shown in Table 1.

Table 1. Level-one Index Layer

	Shape	Color	Decoration	Material
Shape	1	3	3	5
Color	1/3	1	1	3
Decoration	1/3	1	1	3
Material	1/5	1/3	1/3	1

The above comparative result is expressed in matrix as follows:

$$B=\begin{bmatrix} 1 & 3 & 3 & 5 \\ 1/3 & 1 & 1 & 3 \\ 1/3 & 1 & 1 & 3 \\ 1/5 & 1/3 & 1/3 & 1 \end{bmatrix}$$

The weight of each level-one index relative to Target A is calculated by using summation method:

$$B \xrightarrow[\text{normalization}]{\text{Column vector}} \xrightarrow{\text{Summation by row}} \longrightarrow \text{Normalizati} \longrightarrow \begin{bmatrix} 0.519 \\ 0.201 \\ 0.201 \\ 0.079 \end{bmatrix}$$

The weight set for each index of level-one index layer is:

$$W=\begin{bmatrix} 0.519 & 0.201 & 0.201 & 0.079 \end{bmatrix}$$

The judgment matrix is checked for its consistency:

$$\lambda=\frac{1}{n}\sum_{i=1}^{n}\frac{(BW)_i}{W_i}=4.161 \qquad CI=\frac{\lambda-n}{n-1}=0.054 \qquad CR=\frac{CI}{RI}=0.06$$

Matrix A is checked for its consistency by using average random consistency index of T.L.Saaty. In accordance with each average consistency index, the consistency index of Matrix A namely CI= (λmax-n)/ (n-1) and random consistency rate namely CR=CI/RI are obtained. If CR <0.1, it means Matrix A has satisfactory consistency. Judging from the calculating result, CR(0.061) < 0.1, therefore, this judgment matrix meet the requirement of consistency. The obtained Matrix W is the weight set of all indexes.

Determine the weight of level-two index layer relative to level-one index layer by applying the same method. The results are shown in Table 2 to 5.

Table 2. Index Layer of Shape

	Curved	Round	Bionic	Weight W_1
Curved	1	3	5	0.637
Round	1/3	1	3	0.258
Bionic	1/5	1/3	1	0.105
Consistency check result	λ=3.039，CR=0.019＜0.1（meet the requirement of consistency）			

Table 3. Index Layer of Color

	Bright	Neutral	Gray	Dark	Secondary	Weight W_2
Bright	1	4	1/2	3	3	0.281
Neutral	1/4	1	1/5	1	1/2	0.076
Gray	2	5	1	4	4	0.436
Dark	1/3	1	1/4	1	1	0.096
Secondary	1/3	1/4	1/4	1	1	0.111
Consistency check result	λ=5.6，CR=0.014＜0.1（meet the requirement of consistency）					

Table 4. Index Layer of Decoration

	Point, line, surface	Cartoon	Photo	Weight W_3
Point, line, surface	1	2	4	0.558
Cartoon	1/2	1	3	0.320
Photo	1/4	1/3	1	0.122
Consistency check result	λ=3.022，CR=0.019＜0.1（meet the requirement of consistency）			

Table 5. Index Layer of Material

	Metal	Plastics	Rubber	Weight W_4
Metal	1	2	4	0.558
Plastics	1/2	1	3	0.320
Rubber	1/4	1/3	1	0.122
Consistency check result	λ=3.022，CR=0.019＜0.1（meet the requirement of consistency）			

5.4. Dimensionless Treatment on Evaluation Index

Indexes of appearance design belong to qualitative index. Fuzzy statistical method can be used to quantify the qualitative indexes, the specific operations of which are as follows: qualitative indexes are judged by some experts in accordance with the grade of remarks; and frequency is counted based on the experts' judgment and achieve the degree of some qualitative indexes' membership to some remarks, namely degree of membership; finally the matrix of membership is determined. Table 6 shows the evaluator set P={P1,P2,P3,P4,P5}, and the remark set V =(excellent, good, middle, ordinary, poor)=(1, 2, 3, 4, 5).

Table 6. Table of Survey from Experts

Evaluation index		Expert I P_1	P_2	P_3	P_4	P_5
Shape B_1	Curved C_1	1	1	1	2	1
	Round C_2	3	2	1	3	2
	Bionic C_3	3	2	1	2	2
	Bright C_4	3	2	2	3	1
	Neutral C_5	2	3	2	3	2
Color B_2	Gray C_6	1	1	1	1	1
	Dark C_7	5	4	4	4	3
	Secondary C_8	4	3	3	4	1
Decoration B_3	Point, line, surface C_9	3	2	3	1	2
	Cartoon C_{10}	2	3	3	3	4
	Photo C_{11}	1	4	2	3	4
Material B_4	Metal C_{12}	2	3	3	3	2
	Plastics C_{13}	2	2	3	2	2
	Rubber C_{14}	1	1	2	2	1

Through the above table, the matrix of membership degree for each index can be calculated. The final results are as follows:

$$R_1=\begin{bmatrix} 0.8 & 0.2 & 0 & 0 & 0 \\ 0.2 & 0.4 & 0.4 & 0 & 0 \\ 0.2 & 0.6 & 0.2 & 0 & 0 \end{bmatrix} \qquad R_2=\begin{bmatrix} 0.2 & 0.4 & 0.4 & 0 & 0 \\ 0.2 & 0.4 & 0.4 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.2 & 0.6 & 0.2 \\ 0.2 & 0 & 0.4 & 0.4 & 0 \end{bmatrix}$$

$$R_3=\begin{bmatrix} 0.2 & 0.4 & 0.4 & 0 & 0 \\ 0 & 0.2 & 0.4 & 0.4 & 0 \\ 0.2 & 0.2 & 0.2 & 0.4 & 0 \end{bmatrix} \qquad R_4=\begin{bmatrix} 0 & 0.4 & 0.6 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \end{bmatrix}$$

5.5. Results of the Fuzzy Synthetic Evaluation

The index weight is calculated through the membership degree of evaluation indexes in different layers. Formula $S_i = W_i R_i$ is applied to calculate the level-one fuzzy evaluation on music player appearance. The specific calculating processes for index evaluations are as follows:

$$S_{\text{shape}} = W_1 R_1 = [0.637 \quad 0.258 \quad 0.105] \times \begin{bmatrix} 0.8 & 0.2 & 0 & 0 & 0 \\ 0.2 & 0.4 & 0.4 & 0 & 0 \\ 0.2 & 0.6 & 0.2 & 0 & 0 \end{bmatrix}$$

$$= [0.5822 \quad 0.2936 \quad 0.1242 \quad 0 \quad 0]$$

$$S_{\text{color}} = W_2 R_2 = \begin{bmatrix} 0.281 & 0.076 & 0.436 & 0.096 & 0.111 \end{bmatrix} \times \begin{bmatrix} 0.2 & 0.4 & 0.4 & 0 & 0 \\ 0.2 & 0.4 & 0.4 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.2 & 0.6 & 0.2 \\ 0.2 & 0 & 0.4 & 0.4 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.5296 & 0.1428 & 0.2064 & 0.102 & 0.0192 \end{bmatrix}$$

$$S_{\text{decoration}} = W_3 R_3 = \begin{bmatrix} 0.558 & 0.320 & 0.122 \end{bmatrix} \times \begin{bmatrix} 0.2 & 0.4 & 0.4 & 0 & 0 \\ 0 & 0.2 & 0.4 & 0.4 & 0 \\ 0.2 & 0.2 & 0.2 & 0.4 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.136 & 0.3116 & 0.3756 & 0.1768 & 0 \end{bmatrix}$$

$$S_{\text{material}} = W_4 R_4 = \begin{bmatrix} 0.558 & 0.320 & 0.122 \end{bmatrix} \times \begin{bmatrix} 0 & 0.4 & 0.6 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.0732 & 0.528 & 0.3988 & 0 & 0 \end{bmatrix}$$

Level-one fuzzy evaluation result displays the situation of level-one evaluation indexes. In accordance with the principle of maximum membership degree, it shows intuitively that the model in Project 1 has 58% degree of membership respectively for both "good" and "excellent". Therefore, its appearance has good style. Similarly, its color is "good", decoration is "middle", and material is "good". Based on level-one fuzzy evaluation, the final level-two appearance fuzzy evaluation can be made and calculated in formula $R_{\text{result}} = W_i S_i$.

$$R_{\text{result}} = W_i S_i = \begin{bmatrix} 0.558 & 0.122 & 0.057 & 0.263 \end{bmatrix}$$

$$\times \begin{bmatrix} 0.5822 & 0.2936 & 0.1242 & 0 & 0 \\ 0.5296 & 0.1428 & 0.2064 & 0.102 & 0.0192 \\ 0.136 & 0.3116 & 0.3756 & 0.1768 & 0 \\ 0.0732 & 0.528 & 0.3988 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0.4165 & 0.3379 & 0.2208 & 0.0225 & 0.0023 \end{bmatrix}$$

The final evaluation result of Project 1 is "good", and the degree of membership to this remark is 41.65%. The evaluation processes of other projects are the same to that of Project 1.

The final evaluation result of Project 2:

$$R_2 = \begin{bmatrix} 0.5212 & 0.3122 & 0.1303 & 0.0147 & 0.0216 \end{bmatrix}$$

The final evaluation result of Project 3:

$$R_3 = \begin{bmatrix} 0.3276 & 0.3458 & 0.2123 & 0.0121 & 0.1122 \end{bmatrix}$$

The above results show that three projects have good evaluation results: Project 1 and 2 are "excellent", Project 3 is "good", and Project 2 has higher data evaluation index compared with Project 1. Therefore, the appearance design in Project 2 is evaluated to be the best.

6. Conclusion

According to the analysis on evaluation factors of music player design, an evaluation index system is established. After the weight value of each index is calculated by AHP, and the matrix

of fuzzy evaluation is built by using the method of fuzzy statistics, the result of fuzzy evaluation is finally obtained. Through the analysis and summary on components of the popular music players' appearance as well as on the relations between them, the experimental results of the three cases demonstrate that, with simple operation and good effect, this method can calculate well the subjective factors existed in appearance design, which shows its important evaluation function on appearance design.

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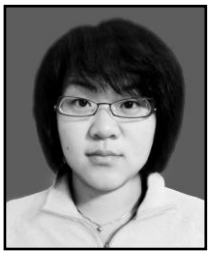

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