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From 'Usable' to 'Empathetic': Research on Digital Interface Visual Design from the Perspective of Sensory Engineering

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Abstract. Under the tide of information, UI design has become the core lever for measuring the quality of digital product experience. As various applications permeate daily life, the quality of interfaces has been increasingly magnified. Researchers at home and abroad have devoted their efforts to this, distilling multiple sets of experience paradigms and operational guidelines. Regrettably, the mainstream thinking is still trapped in a two-dimensional flat framework. When interaction technologies are advancing rapidly and functional information flows are surging in a multi-dimensional and three-dimensional manner, the old logic can no longer fulfill the demand for a user-centered quality experience. First, an emotional indicator framework is established through human-computer engineering. In the weight setting part, the grey correlation is incorporated into the group analytic hierarchy process, and the modified analytic hierarchy process (AHP) is used to calculate the comprehensive weights, thereby weakening the subjective flaws of the traditional AHP. Then, in response to the ambiguity of the evaluation, the intuitionistic fuzzy set is integrated with the TOPSIS (technique for order preference by similarity to an ideal solution) ideal similarity ranking method to construct a new comprehensive evaluation model. This study verifies the applicability of human factors engineering in the emotional design of digital interfaces, providing a quantitative path and practical guidelines for the paradigm shift from "usability" to "empathy".

Keywords: UI design, analytic hierarchy process, TOPSIS, digital interface visual design.

1. Introduction

With the widespread and rapid development of global digital computing business, the interaction between digital products and people has increasingly become the main theme of human-computer interaction. The human-computer interaction interface has evolved from the original mechanical interface to the current digital interface. The digital interface not only provides more functions but also brings new problems. Various highly concentrated operations and multiple functions are concentrated on a display screen that is only a few inches or even only a few centimeters in size. The high-density integration of functions has severed the direct and intense operational relationship with the resulting outcome in the mechanical interface. The buttons have lost their observable connection with the actual response of the product. Therefore, in this application context, UI design (User Interface Design) is proposed as a design theory. The aim is to study how to provide a better recognizability, usability, and reliability for the user interface in increasingly complex situations, and to reduce the time users need for training and practice when operating the product [1-3].

A successful UI design not only provides users with a pleasant experience and smooth operation during use, but also becomes an important factor for the success of digital products. Therefore, the importance of UI interface design has been elevated to an unprecedented new level. Nowadays, the process of the birth of a large number of digital products cannot do without the step of UI design. Digital products include software products as well as the terminal devices that implement specific functions through software products. The cost consumed by UI design accounts for a significant proportion in the software product development process [4]. According to a survey conducted in 2002, 50% of the code related to software products is directly related to the implementation of the software interface. 30% of the software development budget is spent on the research and development of the software interface. Approximately 80% of the software lifecycle costs are spent on maintenance after the software is released, and of these, 64% of the expenses are directly related to the maintenance of the user interface. Thus, UI design not only determines the "face" of digital products but is also a very crucial part of the entire product. Therefore, UI is increasingly receiving attention from software developers and users. A good UI interface can enhance user satisfaction, reduce the sense of distance between humans and machines, improve the efficiency of human-computer interaction, increase work efficiency, and generate immeasurable economic benefits [5].

The evaluation of human-machine interface is an important means for supervising the quality of human-machine interface design, improving the safety and reliability of the interface, enhancing its comfort, and guiding the design of the interface. It is also an important guarantee for improving the efficiency of human-computer interaction. Currently, in the field of human-machine interface evaluation, many scholars have conducted a large amount of research work. Reference [6] addressed the multi-attribute of the human-machine interface and the fuzziness of the evaluation, and adopted the FAHP method combining fuzzy comprehensive evaluation and analytic hierarchy process to evaluate the usability of the human-machine interface in the garage. Li et al. [7] evaluated and ranked the layout schemes of the human-machine interface by converting the evaluation index information in the human-machine interface into Vague numbers and using the comprehensive evaluation method based on Vague number distance and superiority and inferiority point. Singh et al. [8] established an evaluation index system for aspects such as the content transmission, usability, and emotional factors of the human-machine interface, and used the TOPSIS method to rank the digital human-machine interface schemes.

In recent years, with the development of human factors engineering and the deepening of the "people-oriented" design concept, people's evaluation of products no longer focuses solely on the completion of tasks, but incorporates the subjective feelings of using the product, emphasizing the influence of interface elements on the user experience. Good interaction design not only involves efficient and simple operations, but also should create a favorable impression on people. The relevant experiments have shown that the emotional design and rational design of the display interface have a significant correlation, confirming the inference that "beautiful design is also practical" [9]. References [10,11] focused on the interface information of the product and analyzed the perceptual imagery and aesthetic experience of users regarding the layout of the interface. However, the evaluation method was overly complex. Thakur et al. [12] proposed 13 layout features for the aesthetic imagery of the human-computer interface layout and conducted quantitative analysis on them. However, for different human-computer interfaces, the emphasis on the factors of aesthetic imagery varied, thereby affecting the objectivity of the evaluation. Welihinda et al. [13] based on the human-machine interface, in response to the problem that the practical value of the traditional one-dimensional variable perceptual engineering model was not high, proposed a multi-dimensional variable perceptual engineering model. However, in the evaluation process, the deconstruction of product form features was relatively complex. Xin et al. [14] took the printer human-machine interface as the evaluation object, extracted four aesthetic imagery indicators of balance, overallness, simplicity, and unity, and calculated the comprehensive aesthetic degree of its layout scheme. However, the determination of the index weights was too subjective. Ferrante et al. [15] studied a large number of subjective evaluation imagery words of human-machine interfaces by domestic and foreign scholars, and summarized that the factors influencing the aesthetic imagery of human-machine interfaces include balance, proportion, simplicity, and correspondence. However, their evaluation system had too many indicators and was complex to calculate, and had little practical guidance for interface design.

Based on the problems existing in the above research, and considering the emotional factors of humans in human-computer interface design as well as the grey and fuzzy characteristics of human-computer interface evaluation, this paper proposes a multi-image comprehensive evaluation method for human-computer interfaces based on affective ergonomics. By applying the method of human-machine interface aesthetics, an aesthetic imagery analysis of the human-machine interface is conducted, aesthetic words are extracted, and an aesthetic index evaluation system is established. Considering the grey and fuzzy characteristics of expert judgments, the grey correlation analysis method is introduced into the AHP method. By integrating multiple expert judgment information, the cognitive characteristics are quantitatively described, achieving a more scientific and reliable weight allocation. At the same time, considering the fuzziness of aesthetic evaluation, the transformation scale is used to convert the aesthetic evaluation into an intuitive fuzzy number, and an intuitive fuzzy TOPSIS comprehensive evaluation model is established. This enables a comprehensive evaluation and ranking of the human-machine interface design scheme, improving the scientificity and rationality of the evaluation system.

2. User Experience Design of Digital Products

User experience does not refer to how a product functions (although this sometimes has a significant impact on user experience). User experience refers to "how the product interacts with the outside world and functions", that is, how people "come into contact with" and "use" it. This interaction usually involves a set of operable interfaces and various buttons, such as alarm clocks, coffee machines, and cash registers all have their own operation panels and adjustment buttons. Sometimes, the interaction occurs on a simple physical device, such as the fuel tank cap of a car. But regardless of what object it is, as long as people use it, user experience will be generated. Just to name a few, such as newspapers, seasoning jars, reclining armchairs, cardigans with open fronts, etc.

Nowadays, digital products have become an integral part of the lifestyle in the information age. The interaction mode between digital products and users is rather complex, especially for devices with a large amount of computing capabilities or handhold devices. For instance, personal computers and smart phones (Smart phone). The interface through which these digital products communicate with users is the user interface (User Interface).

Therefore, the user experience generated by humans and these digital products can be basically equivalent to the user experience generated by them through their UIs. For instance, the completion of all functions of the iPhone is almost entirely dependent on the touchable screen. Thus, the majority of user experience design in digital products is actually the design of user interfaces. The design of the user interface generally encompasses three aspects of consideration: form, behavior, and content. As shown in Figure 1. Interaction design focuses on the behavior of the product, and also pays attention to how to establish connections between the behavior, form, and content. Similarly, information architecture focuses on the structure of the content, but it must also pay attention to the behavior used for accessing the content [16,17], as well as how to present it well to the user. Industrial design and visual design focus on the form and service of the product and service, but they also need to ensure that this form must support the use of the product, so they also need to pay attention to behavior and content. The interrelationship of these three elements determines that in the design of user experience, it is necessary to balance and coordinate the attention paid to all aspects.

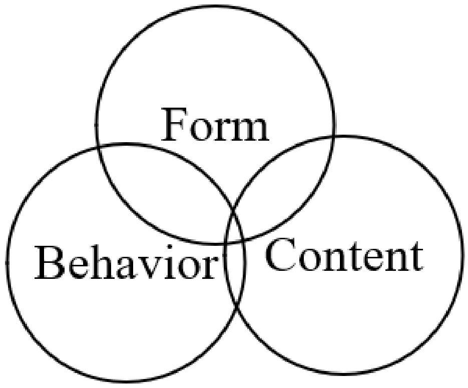

Fig. 1. Three categories of user experience focusing on

3. Establishing a Perceptual Index Evaluation System

The concept of ”Aesthetic Engineering” is to analyze human emotions and transform the vague emotional needs and images of people into quantitative data. The key of Aesthetic Engineering lies in accurately grasping the ”emotional” aspect of people towards products and establishing the connection between ”emotion” and product design elements. The general research steps are as follows: (1) Collect typical samples of interfaces and screen them; (2) Collect emotional imagery words; (3) Screen the emotional imagery words and establish an evaluation system for emotional indicators.

This paper collects typical human-machine interface sample images through channels such as literature, the internet, and on-site photography. To ensure the validity and usability of the samples, the collected samples are screened, and those with lower clarity and higher similarity are removed. Finally, 50 representative interface design samples are selected. Aesthetic imagery analysis is conducted on the samples. The aesthetic imagery of a product refers to the psychological anticipation and perception that people have towards the product, which can be described using aesthetic imagery vocabulary. Regarding the aesthetic imagery of the human-machine interface, it is mainly influenced by potential factors such as balance, proportion, simplicity, and resonance of interface beauty [18,19]. Through the collection of sensory words for the human-machine interface through questionnaires and interviews, and by applying the KJ method to conduct a preliminary screening of the sensory words, those that are not suitable for evaluation or have too high similarity are eliminated. Eventually, 24 sensory words are summarized. Thirty subjects are selected (including 10 designers, 10 design students, and 10 non-design students), and a scale analysis is conducted on the interface samples. Using the principal component analysis method through the SPSS (Statistical Product and Service Sciences) statistical analysis software, the factors influencing users' aesthetic perception are analyzed. Four factors with eigenvalues greater than 1 are selected: balance, proportion, simplicity, and correspondence, as shown in Table 1.

”Balance” refers to the balance and stability of the overall visual information content of the interface, and is an indicator representing the rationality of the area and distribution of interface elements. It can prevent visual fatigue and information omission caused by an unbalanced interface information layout; ”Proportion” refers to

Table 1. Analysis of interface beauty degree factors

Factor	Feature value	Contribution rate/%	Cumulative contribution rate/%
Balance	8.662	43.575	43.575
Proportion	6.468	26.217	69.791
Simplicity	3.735	11.383	81.714
Correspondence	1.289	8.029	89.202

the differentiated layout of interface elements based on visual cognitive laws, so that the interface is designed according to certain visual guidance rules to improve reading efficiency and accuracy; "Simplicity" means reducing the complexity of the interface without affecting the display of necessary information, ensuring the simplicity and clarity of the interface, and avoiding unnecessary cognitive load; "Correspondence" refers to the unity of interface elements, maintaining the overall style of the design, thereby increasing people's familiarity.

The 24 selected emotional words are subjected to cluster analysis, and grouped based on 4 dimensions. The emotional words are scored according to 5 importance levels (not important, marginally important, important, relatively important, and very important), with scores ranging from 0 to 5. The results are analyzed using SPSS statistical analysis software. Finally, based on the average values and commonalities of the emotional words, the most important representative emotional words are selected [20]. Eventually, 4 groups of the most significant representative emotional words are obtained, and the evaluation system for emotional indicators is constructed using the principle of hierarchical analysis method.

4. Multimodal Human-Computer Interface Evaluation Model

The determination of the weights of each indicator is a key step in the comprehensive evaluation process, and it has a significant impact on the evaluation results. The Analytic Hierarchy Process (AHP) performs well in handling multi-attribute decision-making problems that are both quantitative and qualitative [21], and its application in weight determination is becoming increasingly common. The traditional AHP method usually determines the weights of the underlying indicators through the judgment of a single expert. However, the judgment of a single expert often fails to adequately reflect the objective facts. Therefore, it is necessary to integrate the opinions of multiple experts, which leads to the problem of group decision-making. The process of group decision-making is to unify the differences in opinions from various experts and minimize the inconsistency between the group decision result and individual preferences [22]. However, the knowledge backgrounds of the experts involved in the decision-making process vary, and their perspectives on a certain indicator also differ. Additionally, factors such as the experts' own preferences can also have certain influences, leading to significant deviations in the evaluation of the same decision problem.

How to gather the information of the expert group is the key to determining the comprehensive weight of the indicators. The grey correlation analysis method is one of the widely used methods in the grey theory. This method judges the closeness of the relationship based on the degree of proximity between the comparison sequence and the reference sequence, and uses this as the basis for decision-making. It is an objective evaluation method. Considering the grey nature of expert cognition, the grey correlation analysis method is introduced into the group AHP method. By using the grey correlation to process the evaluation information, the weights of each indicator determined by the group AHP method are corrected. The steps are as follows:

(1) Construct the judgment matrix. Suppose there are m experts evaluating n indicators. The judgment matrix A_k of the $k-th$ expert is:

$$A_k = \begin{bmatrix} a_{11}^k & a_{12}^k & \cdots & a_{1n}^k \\ a_{21}^k & a_{22}^k & \cdots & a_{2n}^k \\ a_{n1}^k & a_{n2}^k & \cdots & a_{nn}^k \end{bmatrix} \tag{1}$$

In the formula, a_{ij}^k represents the relative importance degree of the $i-th$ indicator compared to the $j-th$ indicator for the upper-level indicator. The relative importance degree is determined using the 1-9 relative importance scale method: when $i = j$, $a_{ij}^k = 1$; when $i \neq j$, $a_{ij}^k = \frac{1}{a_{ij}^k}$.

(2) Calculate the weights. For any judgment matrix A_k, it is obvious that it has the eigenvalue λ_{kmax} and the corresponding eigenvector I_k, satisfying:

$$A_k \times I_k = \lambda_{kmax} \times I_k. \tag{2}$$

After obtaining the vector I_k, it is normalized. The result after normalization is the relative importance degree of the indicators given by the $k-th$ expert, which is also the weight vector $W = (w_{k1}, w_{k2}, \cdots, w_{kn})^T$. The obtained weight vector needs to undergo consistency testing. When the consistency ratio $CR \leq 0.10$, it is considered that the judgment matrix has satisfactory consistency, indicating that the weight allocation is reasonable; otherwise, the judgment matrix needs to be adjusted until satisfactory consistency is achieved.

(3) Construct the grey correlation evaluation matrix. Suppose there are m evaluation objects and n evaluation indicators, then the grey evaluation matrix can be expressed as:

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix} \tag{3}$$

where $b_{ki} = w_{ki}$

(4) Standardization processing. To ensure the scientificity and comparability of the evaluation matrix, it is necessary to standardize the evaluation indicator information. The mean method (Equation (4)) is adopted to process the evaluation matrix:

$$x_{ki} = \frac{b_{ki}}{\sum_{k=1}^{m} b_{ki}}. \tag{4}$$

(5) Calculate the grey correlation coefficient and correlation degree. To fully reflect the degree of dispersion of the given information of the evaluation object, according to the grey correlation analysis method, the average value of the weights of each indicator is selected as the reference sequence and is denoted as x_{0i}. Then, the grey correlation coefficient between the weight evaluation value of each indicator and the reference value is:

$$\xi_{ki} = \frac{\min_i \min_k |x_{0i} - x_{ki}| + \lambda \max_i \max_k |x_{0i} - x_{ki}|}{|x_{0i} - x_{ki}| + \lambda \max_i \max_k |x_{0i} - x_{ki}|}. \tag{5}$$

Where $i = 1, 2, \cdots, n, k = 1, 2, \cdots, m$. ξ_{ki} represents the correlation coefficient between the $i-th$ indicator information given by the $k-th$ expert and the $i-th$ indicator information of the reference sequence. λ is the discrimination coefficient, which belongs to the range of [0,1]. The introduction of the discrimination coefficient can reduce the influence of extreme values on the calculation of the correlation coefficient. Generally, it is set to 0.5, and then its correlation degree can be expressed as:

$$\alpha_{0k} = \frac{1}{n} \sum_{i=1}^{n} \xi_{ki}. \tag{6}$$

(6) Calculate the expert weight coefficients. The expert weight coefficients reflect the significance of the information provided by the experts during the evaluation process. The calculation formula is as follows:

$$\beta_k = \frac{\alpha_{0k}}{\sum_{k=1}^{m} \alpha_{0k}}. \tag{7}$$

Then the expert weight coefficient matrix is $\beta = (\beta_k)_{1\times m}$.

(7) Calculate the comprehensive weight. By introducing the grey correlation analysis method to construct the expert weight coefficients, the index weights obtained through the analytic hierarchy process are revised. Taking into account the grey nature of the evaluators' cognition and its role in the evaluation process, the scientificity and persuasiveness of the determination of index weights are enhanced. The calculation of the revised comprehensive weight is as follows:

$$W = \beta B. \tag{8}$$

5. Intuitive Fuzzy TOPSIS-based Comprehensive Evaluation

During the process of qualitative evaluation, it is necessary to quantify the qualitative indicators. The traditional engineering quantification methods for qualitative problems mostly adopt the semantic difference method [23]. The semantic difference method rates and quantifies the pairs of semantic words that are antonyms of each other based on the semantic difference table. However, this method ignores the fuzziness of the evaluators' evaluations. Intuitionistic fuzzy sets are an extension of fuzzy sets, taking into account three aspects of information: membership degree, non-membership degree, and hesitation degree. This compensates for the deficiency of traditional fuzzy sets that only consider the membership degree. TOPSIS method is a comprehensive analysis method for multi-objective decision-making. It ranks the degree of closeness of a limited number of evaluation objects to the idealized target. This method makes full use of comparisons on the original data and has small errors and high reliability. The traditional TOPSIS method can only handle quantitative evaluation index values and is unable to quantify the fuzziness of expert's intuitive evaluations. The author transforms the scale to quantify the intuitive e-valuations into intuitionistic fuzzy numbers, quantifies the qualitative indicators, combines with the comprehensive weights of intuitive indicators determined in the previous section, proposes a comprehensive evaluation method combining intuitionistic fuzzy set theory and TOPSIS, and evaluates the human-machine interface.

(1) Constructing intuitionistic fuzzy numbers. The expert's subjective evaluation values of the human-machine interface are divided into 5 levels: very good, good, average, poor, and very poor. Each evaluation level corresponds to an evaluation interval of the subjective score, and the membership degrees of the evaluation criteria for the subjective indicators are assigned. The specific assignment is shown in Table 2.

Table 2. Analysis of interface beauty degree factors

Level	Emotional score	Membership degree	Non-membership degree
very good	90	0.9	0.1
good	70	0.7	0.3
average	50	0.5	0.5
poor	30	0.3	0.7
very poor	10	0.1	0.9

According to the membership and non-membership degrees of the perceptual evaluation shown in Table 2, the calculation formula is as follows. For each scheme, calculate the membership and non-membership degrees of the perceptual indicators' scores.

$$y'_{ij} = z'_1 + \frac{y_{ij} - z_1}{z_k - z_1}. \tag{9}$$

Where y'_{ij} represents the membership degree of the emotional score in Table 2. y_{ij} represents the calculated inductive score to be determined in Table 2. z_1 and z'_1 are respectively the lower limit values and the membership degrees of the evaluation intervals of the inductive score in Table 2. z_k and z'_k are respectively the upper limit values and the membership degrees of the evaluation intervals of the inductive score in Table 2.

(2) Construct the intuitive fuzzy evaluation matrix. Let there be m evaluation schemes and n indicators. Based on the fuzziness of the experts' intuitive evaluation, the evaluation value of the $j-th$ indicator of the $i-th$ scheme is represented by the intuitive fuzzy value $q_{ij} = (\mu_{ij}, v_{ij})$. Thus, the intuitive fuzzy evaluation matrix is as follows:

$$Q = \begin{bmatrix} (\mu_{11}, v_{11}) & (\mu_{12}, v_{12}) & \cdots & (\mu_{1n}, v_{1n}) \\ (\mu_{21}, v_{21}) & (\mu_{22}, v_{22}) & \cdots & (\mu_{2n}, v_{2n}) \\ (\mu_{m1}, v_{m1}) & (\mu_{m2}, v_{m2}) & \cdots & (\mu_{mn}, v_{mn}) \end{bmatrix} \tag{10}$$

(3) Determine the ideal solution. Use the TOPSIS method to determine the positive and negative ideal solutions Q^+ and Q^-.

$$Q^+ = q_1^+, q_2^+, \cdots, q_n^+ = (\max_i \mu_{ij}, \min_i v_{ij}) | j \in [1, n]. \tag{11}$$

$$Q^- = q_1^-, q_2^-, \cdots, q_n^- = (\min_i \mu_{ij}, \max_i v_{ij}) | j \in [1, n]. \tag{12}$$

(4) Calculate the Euclidean distance. Based on the comprehensive weights of the indicators determined in the previous section, the Euclidean distance between the evaluated scheme and the intuitive fuzzy ideal solution is:

$$d_i^+ = \sqrt{0.5 \sum_{j=1}^{n} w_j [(\mu_{ij} - \mu_{ij}^+)^2 + (v_{ij} - v_{ij}^+)^2]}. \tag{13}$$

$$d_i^- = \sqrt{0.5 \sum_{j=1}^{n} w_j [(\mu_{ij} - \mu_{ij}^-)^2 + (v_{ij} - v_{ij}^-)^2]}. \tag{14}$$

(5) Determine the degree of closeness. The degree of closeness δ_i of the $i-th$ scheme to the optimal scheme is:

$$\delta_i = \frac{d_i^-}{d_i^+ + d_i^-}. \tag{15}$$

6. Comprehensive Evaluation

Based on the established perceptual evaluation system for human-computer interfaces, four experts are invited to use the AHP method to establish pairwise judgment matrices for the perceptual indicators, resulting in the following four judgment matrices:

$$A_1 = \begin{bmatrix} 1 & 3 & 4 & 3 \\ 1/3 & 1 & 3 & 1/3 \\ 1/4 & 1/3 & 1 & 1/3 \\ 1/3 & 3 & 3 & 1 \end{bmatrix} \tag{16}$$

$$A_2 = \begin{bmatrix} 1 & 4 & 3 & 2 \\ 1/4 & 1 & 1/3 & 1/3 \\ 1/3 & 3 & 1 & 1/4 \\ 1/2 & 3 & 4 & 1 \end{bmatrix} \tag{17}$$

$$A_3 = \begin{bmatrix} 1 & 3 & 4 & 2 \\ 1/3 & 1 & 3 & 1/3 \\ 1/4 & 1/3 & 1 & 1/4 \\ 1/2 & 3 & 4 & 1 \end{bmatrix} \tag{18}$$

$$A_4 = \begin{bmatrix} 1 & 1/3 & 1/2 & 1/5 \\ 3 & 1 & 3 & 1/3 \\ 2 & 1/3 & 1 & 1/4 \\ 5 & 3 & 4 & 1 \end{bmatrix} \tag{19}$$

From Equation (2), the weight vectors given by each expert can be obtained as:

$$W_1 = (0.494, 0.154, 0.082, 0.270)^T. \tag{20}$$

$$W_2 = (0.441, 0.083, 0.148, 0.328)^T. \tag{21}$$

$$W_1 = (0.494, 0.155, 0.078, 0.318)^T. \tag{22}$$

$$W_1 = (0.082, 0.256, 0.124, 0.563)^T. \tag{23}$$

After the consistency ratio is calculated and found to be $CR \leq 0.10$, it is considered that the judgment matrix has satisfactory consistency, indicating that the weight allocation is reasonable. Then, the grey correlation evaluation matrix is constructed according to Equation (3) and standardized processing is carried out according to Equation (4), resulting in:

$$X = \begin{bmatrix} 0.337 & 0.238 & 0.190 & 0.183 \\ 0.301 & 0.128 & 0.343 & 0.222 \\ 0.306 & 0.239 & 0.181 & 0.215 \\ 0.056 & 0.395 & 0.287 & 0.381 \end{bmatrix} \tag{24}$$

Inviting experts to conduct a qualitative evaluation of the human-machine interface scheme for the CNC machine tools, and processing the qualitative score values through Table 1 and Equation (1), an intuitionistic fuzzy evaluation matrix is constructed:

$$Q = \begin{bmatrix} (0.80, 0.20) & (0.85, 0.15) & (0.75, 0.25) & (0.80, 0.20) \\ (0.85, 0.15) & (0.70, 0.30) & (0.80, 0.20) & (0.80, 0.20) \\ (0.75, 0.25) & (0.80, 0.20) & (0.85, 0.15) & (0.75, 0.25) \\ (0.80, 0.20) & (0.80, 0.20) & (0.85, 0.15) & (0.75, 0.25) \end{bmatrix} \tag{25}$$

According to Equation (13), the degree of closeness of each scheme to the ideal scheme is calculated, and the result is $\delta_1 = 0.595$, $\delta_2 = 0.576$, $\delta_3 = 0.395$, $\delta_4 = 0.546$. It can be seen that if $\delta_1 > \delta_2 > \delta_3 > \delta_4$, then the ranking of the schemes from best to worst is Scheme 1, Scheme 2, Scheme 4 and Scheme 3, that is, Scheme 1 is the optimal scheme.

To analyze this evaluation result, the evaluation method for human-machine interface aesthetics in reference [24] was adopted. The aesthetic index of each scheme interface was calculated, and the correlation values of the aesthetic degree of each scheme were calculated using the grey correlation analysis method (the calculation process is omitted). The correlation values of the aesthetic degrees of the four design schemes were 0.6182, 0.5805, 0.4346, and 0.5180 respectively. The order of superiority was Scheme 1, Scheme 2, Scheme 4, and Scheme 3. This is consistent with the results obtained by the evaluation method in this paper, thereby verifying the feasibility of the method.

7. Conclusion

This research uses human factors engineering as a bridge to shift the digital interface from "usable" to "touching". The experiment shows that when visual temperature, blank space breathing, animation rhythm, and form softness work together, users first feel that the interface is "understanding" them, then develop trust and a sense of familiarity, and complete the transition from usability to empathy. The mapping framework we proposed connects design variables, emotional experiences, and humanistic care into an iterative method chain, providing a paradigm for subsequent emotional interfaces. In the future, we will expand the scenarios and cultural contexts, explore multi-channel integration such as dynamic interaction, sound, and touch, and make technology no longer cold but a warm medium that reflects human hearts.

8. Conflict of Interest

The authors declare that there are no conflict of interests, we do not have any possible conflicts of interest.

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