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Evaluation of Interface Beauty of Microwave Oven Control Panel Based on Aesthetic Calculation

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ABSTRACT

In the process of human-computer interaction of people using microwave ovens, the interaction interface is the control panel of the microwave oven. The aesthetics of the interface layout directly affect the interaction experience, and also indirectly affects the interaction efficiency. In order to evaluate the aesthetics of the control panel interface layout, this study selects six aesthetics indicators from the interface aesthetics calculation: balance degree, symmetry degree, simplicity degree, economy degree, density degree, and integrity degree, and then quantifies them respectively by mathematical methods and uses hierarchical analysis to calculate the weights of each indicator, using a combination of subjective and objective methods to explore the quantitative calculation method of aesthetics, while evaluating the overall interface aesthetics. Finally, I use five different interface layouts of five microwave ovens as examples to verify the validity of the above findings in evaluating the aesthetics of the control panel.

Keywords: Aesthetic calculation, Human-computer interaction, Interface beauty, Interface evaluation

INTRODUCTION

Interface is the "surface" of interaction between human and machine. All information exchange between human and machine occurs on the interface, which is a pivotal part of the human-computer interaction system. Interface design is the design of each element in the interface and that of element layout (Bauerly and Liu 2008), so that the system or device can have good input and output functions and achieve smooth and efficient communication between human and the system or device to accomplish specific goals and functions. In the context of the increasing number of professional designers and the increasing aesthetic level of users, excellent interface design not only improves the efficiency of the system, but also enables users to have a good user experience when using it, so it needs to be designed in a way that integrates functionality and aesthetics. In the layout design principles of the display control device, the degree of importance as the priority principle, the use of the operation order, functional order and operation layout principles. This shows that the layout design of the interface is extremely important for manipulating the display and control device.

As people pay more and more attention to the standard of living, the requirements of life gradually increase, the use of microwave ovens home cooking demand is also gradually increasing, but the use of electrical appliances should be from a safety point of view to the user operation of certain guidance, which requires the operation and display of information interaction in a way more in line with the subjective wishes of people, and to provide more convenient services for users. In this regard, the design of the microwave oven control panel is particularly important: on the input side of the consideration, the layout of the panel should be designed to better set the time, set the operation of various functions and emergency pause, etc., on the output side to facilitate the user to obtain the required information at a glance, such as the remaining time, temperature, heating mode, etc. For electrical appliances, on the basis of complete functions, a beautiful and easy-to-read layout of the operation panel provides a better service role for its operation and use process, and a good visual experience helps to improve the efficiency and use experience.

In the study of Chen Xiaojiao et al. (2017), in the design of interface layout, it is necessary to consider six aspects of interface basic elements, the number of interface information, interface layout, the average time of gaze, the correct rate of operation and the amount of cognitive resources invested in the design of the interface layout to obtain an excellent user experience, and in this study, we focus on the influence of the interface layout of the microwave oven control panel on meeting its aesthetic experience. Ngo (2003) found that based on the calculating aesthetics in screen layout, 13 aesthetics metrics were proposed and expressed as mathematical formulas, using graphic blocks instead of area and position of elements to assess the aesthetics in the interface in an objective and measurable way. Zhou Lei et al. (2013) further elaborated on the application of aesthetic calculation formulae to the layout of elements in the interface. Ren and Xue (2018) applied these metrics to the aesthetic calculations of other interfaces, such as those of mobile applications.

In this study, since the above 13 indicators are not entirely related to the interface layout design of the control panel, six of the 13 evaluation indicators were selected to assess and improve the aesthetics of the microwave oven control panel layout, and the six selected indicators were: balance, symmetry, simplicity, economy, density, and wholeness.

Since multiple indicators are to be evaluated comprehensively, it is necessary to assign certain weights to each indicator. The objective weighting method has a strong mathematical basis, however, in practice, the most important indicators derived from the objective weighting method do not necessarily meet the subjective desires of users. Some of the beauty indicators do not correlate with the indicators that determine how users make decisions and do not have consistency. To ensure that the results are closer to the actual results, this study uses the subjective weighting method to obtain the weight of each indicator in the social software, derive the beauty formula and optimize the interface layout to provide a design suggestion for the interface layout of the microwave oven control panel.

BEAUTY INDEX SELECTION

According to the selection of professional designers and the subjective choice of users, on the basis of the beauty index proposed by Ngo and others, six quantifiable indexes which are relatively consistent with the layout design of microwave oven control panel are selected: balance, symmetry, simplicity, economy, density and integrity.

Degree of Balance

By calculating the difference of the total weight of the elements on both sides of the horizontal and vertical axis of symmetry, we can determine whether all the elements in the interface are evenly distributed, so as to check whether the visual perception is stable and the readability is good.

$$\mathrm{BM} = 1 - \frac{\left|\mathrm{BM}_{\mathrm{vertical}}\right| + \left|\mathrm{BM}_{\mathrm{horizontal}}\right|}{2} \in [0,1] \tag{1}$$

$$\mathrm{BM}_{\mathrm{vertical}} = \frac{w_{\mathrm{L}} - w_{\mathrm{R}}}{\max\left(\left|w_{\mathrm{L}}\right|, \left|w_{\mathrm{R}}\right|\right)} \tag{2}$$

$$\mathrm{BM}_{\mathrm{horizontal}} = \frac{w_{\mathrm{T}} - w_{\mathrm{B}}}{\max\left(\left|w_{\mathrm{T}}\right|, \left|w_{\mathrm{B}}\right|\right)} \tag{3}$$

$$w_j = \sum_{i}^{n_j} a_{ij} d_{ij} \quad j = \mathrm{L},\ \mathrm{R},\ \mathrm{T},\ \mathrm{B} \tag{4}$$

L, R, T, and B represent the left, right, upper, and lower parts of the interface space respectively; a_{ij} represents the area of object i in area j; d_{ij} represent the distance between the object center line and the interface center line, and n_j represent the number of objects in this area. D_{BM} is the characteristic index of balance degree in comprehensive beauty degree.

Degree of Symmetry

By calculating the degree of symmetry in horizontal, vertical and diagonal directions, users can form an overall perception of the weight of elements on both sides of the axis. The higher the degree of symmetry, the faster the recognition and recognition.

$$\mathrm{SYM} = 1 - \frac{\left|\mathrm{SYM}_{\mathrm{vertical}}\right| + \left|\mathrm{SYM}_{\mathrm{horizontal}}\right| + \left|\mathrm{SYM}_{\mathrm{radial}}\right|}{3} \in [0,1] \tag{5}$$

$\mathrm{SYM}_{\mathrm{vertical}}$, $\mathrm{SYM}_{\mathrm{horizontal}}$, and $\mathrm{SYM}_{\mathrm{radial}}$ are, respectively, the vertical, horizontal, and radial symmetries with

$$\mathrm{SYM}_{\mathrm{vertical}} = \frac{\begin{array}{c}\left|X'_{\mathrm{UL}} - X'_{\mathrm{UR}}\right| + \left|X'_{\mathrm{LL}} - X'_{\mathrm{LR}}\right| + \left|Y'_{\mathrm{UL}} - Y'_{\mathrm{UR}}\right| + \left|Y'_{\mathrm{LL}} - Y'_{\mathrm{LR}}\right| + \\ \left|H'_{\mathrm{UL}} - H'_{\mathrm{UR}}\right| + \left|H'_{\mathrm{LL}} - H'_{\mathrm{LR}}\right| + \left|B'_{\mathrm{UL}} - B'_{\mathrm{UR}}\right| + \left|B'_{\mathrm{LL}} - B'_{\mathrm{LR}}\right| + \\ \left|\Theta'_{\mathrm{UL}} - \Theta'_{\mathrm{UR}}\right| + \left|\Theta'_{\mathrm{LL}} - \Theta'_{\mathrm{LR}}\right| + \left|R'_{\mathrm{UL}} - R'_{\mathrm{UR}}\right| + \left|R'_{\mathrm{LL}} - R'_{\mathrm{LR}}\right|\end{array}}{12} \tag{6}$$

$$\mathrm{SYM}_{\mathrm{horizontal}} = \frac{\begin{array}{c}\left|X'_{\mathrm{UL}} - X'_{\mathrm{LL}}\right| + \left|X'_{\mathrm{LL}} - X'_{\mathrm{LR}}\right| + \left|Y'_{\mathrm{UL}} - Y'_{\mathrm{UR}}\right| + \left|Y'_{\mathrm{LL}} - Y'_{\mathrm{LR}}\right| + \\ \left|H'_{\mathrm{UL}} - H'_{\mathrm{UR}}\right| + \left|H'_{\mathrm{LL}} - H'_{\mathrm{LR}}\right| + \left|B'_{\mathrm{UL}} - B'_{\mathrm{UR}}\right| + \left|B'_{\mathrm{LL}} - B'_{\mathrm{LR}}\right| + \\ \left|\Theta'_{\mathrm{UL}} - \Theta'_{\mathrm{UR}}\right| + \left|\Theta'_{\mathrm{LL}} - \Theta'_{\mathrm{LR}}\right| + \left|R'_{\mathrm{UL}} - R'_{\mathrm{UR}}\right| + \left|R'_{\mathrm{LL}} - R'_{\mathrm{LR}}\right| +\end{array}}{12} \quad (7)$$

$$\mathrm{SYM}_{\mathrm{radial}} = \frac{\begin{array}{c}\left|X'_{\mathrm{UL}} - X'_{\mathrm{LL}}\right| + \left|X'_{\mathrm{UR}} - X'_{\mathrm{LL}}\right| + \left|Y'_{\mathrm{UL}} - Y'_{\mathrm{LR}}\right| + \left|Y'_{\mathrm{UR}} - Y'_{\mathrm{LL}}\right| + \\ \left|H'_{\mathrm{UL}} - H'_{\mathrm{LR}}\right| + \left|H'_{\mathrm{UR}} - H'_{\mathrm{LL}}\right| + \left|B'_{\mathrm{UL}} - B'_{\mathrm{LR}}\right| + \left|B'_{\mathrm{UR}} - B'_{\mathrm{LL}}\right| + \\ \left|\Theta'_{\mathrm{UL}} - \Theta'_{\mathrm{LR}}\right| + \left|\Theta'_{\mathrm{UR}} - \Theta'_{\mathrm{LL}}\right| + \left|R'_{\mathrm{UL}} - R'_{\mathrm{LR}}\right| + \left|R'_{\mathrm{UR}} - R'_{\mathrm{LL}}\right|\end{array}}{12} \quad (8)$$

They are respectively, the normalized values of

$$X_j = \sum_i^{n_j} \left|x_{ij} - x_c\right| \quad j = \mathrm{UL},\ \mathrm{UR},\ \mathrm{LL},\ \mathrm{LR} \quad (9)$$

$$Y_j = \sum_i^{n_j} \left|y_{ij} - y_c\right| \quad j = \mathrm{UL},\ \mathrm{UR},\ \mathrm{LL},\ \mathrm{LR} \quad (10)$$

$$H_j = \sum_i^{n_j} h_{ij} \quad j = \mathrm{UL},\ \mathrm{UR},\ \mathrm{LL},\ \mathrm{LR} \quad (11)$$

$$B_j = \sum_i^{n_j} b_{ij} \quad j = \mathrm{UL},\ \mathrm{UR},\ \mathrm{LL},\ \mathrm{LR} \quad (12)$$

$$\Theta_j = \sum_i^{n_j} \left|\frac{y_{ij} - y_c}{x_{ij} - x_c}\right| \quad j = \mathrm{UL},\ \mathrm{UR},\ \mathrm{LL},\ \mathrm{LR} \quad (13)$$

$$R_j = \sum_i^{n_j} \sqrt{\left(x_{ij} - x_c\right)^2 + \left(y_{ij} - y_c\right)} \quad j = \mathrm{UL},\ \mathrm{UR},\ \mathrm{LL},\ \mathrm{LR} \quad (14)$$

D_{SYM} is the characteristic index of balance degree in comprehensive beauty degree.

Degree of Simplicity

It indicates the simplicity of the arrangement and combination of elements and the alignment of multi-element blocks in the interface layout, which plays an important role in reducing the cognitive load of users.

$$\mathrm{SMM} = \frac{3}{n_{\mathrm{vap}} + n_{\mathrm{hap}} + n} \in [0, 1] \quad (15)$$

where, n_{vap} and n_{hap} represent the number of vertical and horizontal alignment points, and n represents the number of all elements in the interface. D_{SMM} is the characteristic index of simplicity in comprehensive beauty.

Degree of Economy

It means to use fewer elements and smaller size as much as possible to reduce the recognition difficulty of users and the pressure of interface.

$$\mathrm{ECM} = \frac{1}{n_{\mathrm{size}}} \in [0,1] \tag{16}$$

where, n_{size} is the number of element sizes, and n is the number of elements in the interface. D_{ECM} is the characteristic index of economy in comprehensive beauty.

Degree of Density

According to the research of Zhou Lei and others, the density of about 50 percent is a more appropriate value, which is neither too crowded nor too loose.

$$\mathrm{DM} = 1 - 2\left|0.5 - \frac{\sum_i^n a_i}{a_{frame}}\right| \in [0,1] \tag{17}$$

Among them, a_i and a_{frame} is the area of the element and the interface respectively, n is the number of elements in the interface. So D_{DM} is the characteristic index of density in comprehensive beauty degree.

Degree of Integrity

The degree to which each element in the interface belongs to the same whole, each element in the interface will form a sense of wholeness because of the arrangement and combination, thus affecting the compactness of the distribution of interface elements. Therefore, whether the overall interface layout has a sense of order can be determined.

$$\mathrm{UM} = \frac{\left|UM_{form}\right| + \left|UM_{space}\right|}{2} \in [0,1] \tag{18}$$

Among them, UM_{form} is related to element size, while UM_{space} is related to the free area of the interface.

$$UM_{form} = 1 - \frac{n_{size} - 1}{n} \tag{19}$$

$$UM_{space} = 1 - \frac{a_{layout} - \sum_i^n a_i}{a_{frame} - \sum_i^n a_i} \tag{20}$$

where a_{layout} and a_{frame} represent the area of the largest rectangle and the area of the outer contour of all the elements in the whole interface, n_{size} represents the number of interface elements, a_i is the area of each element in the interface. Therefore D_{UM} is the characteristic index of integrity in comprehensive beauty.

INTERFACE AESTHETICS EVALUATION MODEL

Determination of Beauty Weights

According to the Analytic Hierarchy Process, the subjective evaluation results of professional designers are obtained by means of subjective evaluation,

	Criterion	Comment	Weights	+/-
1	BM	Balance	23.4%	4.3%
2	SYM	Symmetry	18.7%	4.7%
3	SMM	Simplicity	15.6%	3.9%
4	EECM	Economy	8.3%	1.4%
5	DM	Density	7.1%	1.1%
6	UM	Integrity	26.9%	4.3%

Figure 1: Weight distribution of each beauty index.

and the weights of six beauty indexes are analyzed and calculated, so as to establish the calculation model of comprehensive beauty index of interface element layout. Based on subjective evaluation of the dashboard, twelve professional designers assigned 1–9 values to the six beauty indicators respectively, and gave relative values to the importance of each indicator through layer by layer comparison and pairwise comparison.

To a certain extent, the weight obtained by this method has room to float up and down due to subjective factors, so on the basis of ensuring its consistency, the average value of six indicators is taken, and the corresponding weights of each indicator are obtained, which are W_{SYM}, W_{SMM}, W_{DM}, W_{UM}, W_{BM}, W_{ECM}. Considering the convenience and intuitiveness of numerical calculation, the weight of each index is normalized to make it more convenient, $W_{SYM} + W_{SMM} + W_{DM} + W_{UM} + W_{BM} + W_{ECM} = 1$. Finally, the overall numerical model of interface beauty of microwave oven electrical appliances is as follows:

$$A = \Sigma_i^{\text{DSYM, DSMM, DDM, DUM, DBM, DECM W*D}}. \tag{21}$$

In this study, the weight of each index in the interface layout design of microwave oven control panel is (as shown in Figure 1):

$W_{BM} = 0.23$, $W_{SYM} = 0.19$, $W_{SMM} = 0.16$, $W_{ECM} = 0.08$, $W_{DM} = 0.07$, $W_{UM} = 0.27$.

Microwave Oven Control Panel Beauty Calculation

In order to verify the effectiveness and accuracy of the research method, five popular types of microwave ovens are selected in this study to calculate the overall beauty (as shown in Figure 2). Firstly, the control panel of the microwave oven is treated as a cell. On the basis of removing the color feature, the interface of the control panel is decolored. Then, according to its functional structure, it is divided into blocks of different sizes, and all regular or irregular patterns and graphics are unified and integrated into rectangles for calculation (as shown in Figure 3).

After the graphic processing, according to the above six calculation index formula of beauty degree, the balance degree, symmetry degree, simplicity degree, economy degree, density degree and integrity degree of the five samples are calculated respectively (as shown in Table 1).

Calculation Results and Analysis

Based on the five beauty index values and their respective weights of the microwave oven control panel, the overall beauty values of the five samples are A1 = 0.5589, A2 = 1.0536, A3 = 0.7313, A4 = 0.5668, A5 = 1.08997. According to the score, the positive order of interface beauty is: interface

Figure 2: Prototype of five kinds of microwave oven control panel.

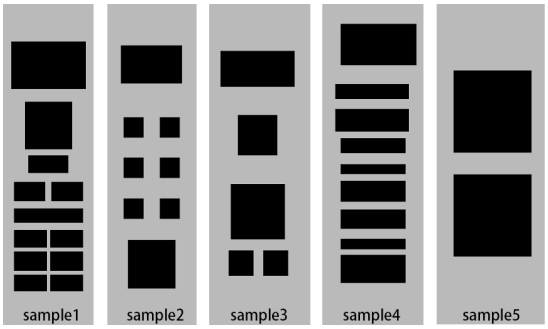

Figure 3: Layout sample of five kinds of control panel.

Table 1. The beauty value of the interface layout sample.

	BM	SYM	SMM	ECM	DM	UM
SAMPLE 1	0.83	0.71	0.21	0.25	0.52	0.53
SAMPLE 2	0.75	0.70	0.15	0.11	0.78	0.34
SAMPLE 3	0.91	0.75	0.60	0.50	0.74	0.71
SAMPLE 4	0.97	0.67	0.12	0.11	0.84	0.48
SAMPLE 5	0.96	0.71	0.18	0.33	0.49	0.70

5 > interface 2 > interface 3 > interface 4 > interface 1. Among the five groups of samples, the comprehensive scores of the second and fifth groups are similar, and the scores of the first and fourth groups are also similar.

The paper selects the actual purchasing users and potential consumers' subjective voting on the five samples, cast the layout they think is the most beautiful, and finally get the voting number of the five samples, which is ranked as interface 5 > interface 2 > interface 3 > interface 4 > interface 1. Compared with the results of data processing after the analysis of this study, the voting result of interface 5 is much higher than that of other samples, which is highly consistent with the calculation results; interface 1 with low number of votes has the lowest score in the calculation; at the same time, the results of the two methods are consistent in the order of arrangement, which shows that the method and calculation model used in this study can basically

meet the requirements of elimination The preference and aesthetic experience of consumers and potential consumers. The control panel design of electrical appliances needs to consider the convenience of use and the clear touch of functions, so the overall design and the balance degree of up, down, left and right are important factors in the panel layout design, which is the same as the balance degree and integrity degree with higher weight obtained from the analytic hierarchy process.

In the interface 5 with high popularity and the highest score, the beauty indexes with high weight measured by AHP are balance, symmetry and integrity. The layout is relatively close, but it will not cause visual confusion or maloperation. The appropriate number also has great advantages in the overall degree. All these provide certain reference value for future panel design. In the interface 4 and interface 1 that get low votes and scores, there are too many elements in interface 4, which affect the visual focus and the choice of operation, thus affecting the function and user experience. Therefore, the low degree of integrity leads to low votes of subjective evaluation, but its balance is high, so it can be used for reference.

CONCLUSION

The purpose of this study is to explore the excellent control panel layout on the microwave oven, and then explore the panel design layout of the display and control device on the electrical appliances. Based on this, a calculation model of overall beauty is proposed, so as to optimize the user's visual experience and use experience, so as to ensure the convenience and safety of the use process. The feasibility of this method is verified in the analysis and calculation of several actual microwave oven control panel. It can be used in the layout design of microwave oven control panel in the future, and provide a guidance method to optimize the beauty and user experience. However, there are still some shortcomings in this study, such as the influence of color on different functions is not included in the scope of consideration, and the influence of different shapes of elements in the interface and the distribution and combination of elements on its beauty is not considered. These two characteristic indicators will be further explored in the future research.

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