

Control Interface Design of Aircraft Cockpit by the Kansei Engineering

Jinsheng Ma

School of Mechanical Engineering & Automation,
Beihang University,
Beijing, China
mjs99@126.com

Yujie Sun

School of Mechanical Engineering & Automation,
Beihang University,
Beijing, China
syj0659@163.com

Abstract—The study which focuses on the driving feelings of pilots and quantifies the emotional intention of users based on the Kansei Engineering put forward a new research direction and method of the control interface design of civil aircraft. The study applies the design methods of Kansei Engineering such as semantic differential method and fuzzy math to quantify the feelings of pilots. And then mathematic relationship is set up between design elements and Kansei cognition to guide design work. It can help designer to seize the emotion of users more efficiently and accurately, and apply it into design work.

Keywords—aircraft cockpit; control interface design; kansei engineering.

I. INTRODUCTION

In the field of aviation technology, control interface of aircraft cockpit is the primary medium which pilots and flight system interact with each other. Pilots use the control interface to complete the flight mission. In the early days, people just focus on the plane itself rather than think about the human factors and the cognition and interaction problem of interface information. Then people take the human factors into account and the aircraft cockpit is designed based on ergonomics. However, on this level, the human factors mainly refer to physiological properties and physical indexes. On the other side, emotional requirements and changes of human which have a significant associate with interface design are neglected. Therefore, perceptual factor is an important part of interface design, especially emotions of pilots whose personalities are different from average persons. It's essential to do research on the emotional requirements and changes of pilots. Only in this way, can safe driving be ensured and can pilots complete the flight mission efficiently. Kansei Engineering as a new design concept and method injects fresh energy to control interface design of aircraft cockpit.

II. RESEARCH METHOD & WORKFLOW

A. Research method

Kansei Engineering focuses on the relationship between sensitive responses of users towards products and design elements. It applies rational mathematical methods and engineering knowledge to quantify emotional responses which are qualitative and illogical. And then the mathematic relationship between emotional responses and design elements is analyzed.

This research adopts mathematical methods such as semantic differential method, quantification theory I and fuzzy mathematics judgment.

• Semantic Differential Method

This method mainly consists of three components: the concept of the object of study, semantic vocabulary for evaluation, evaluators. And among them, semantic vocabulary refers to a pair of antonym. In each group of antonym, there are an odd number of evaluation grades ranging from 3 to 11.

• Quantification Theory I

Quantification theory I mainly does the research on the relationship between qualitative variables x (independent variable) and quantitative variables y (dependent variable). The theory tries to found mathematical model of the two elements by multiple linear regression. So that dependent variable y can be predicted.

• Fuzzy Mathematics Judgment

This method considers design element as independent variable x (qualitative variable) and takes emotional value as dependent variable y (quantitative variable). The study supposes there are r design elements, c_j is taken as the class number of the j th design element, $\delta_i(j, k)$ is taken as the response of the j th design element and the k th class in the i th sample group. So

$$\delta_i(j, k) = \begin{cases} 1 \\ 0 \end{cases} \quad (1)$$

(In the i th sample group, when the data of the j th design element is the k th class, $\delta_i(j, k)$ is taken as 1, otherwise 0.)

The study assumes that there is a linear relation between emotional values and responses of design elements. So the linear model can be

$$y_i = \sum_{j=1}^r \sum_{k=1}^{c_j} a_{ik} \cdot \delta_i(j, k) + \varepsilon_i \quad (2)$$

In this type, a_{ik} is the k th class constant which only depends on the j th design element, ε_i is the random error of the i th sampling. Thus n sets of samples and principle of least squares are used to get the least squares estimate \bar{a}_{ik} of the coefficient a_{ik} to make the minimum deviation.

$$Q = \sum_{i=1}^n \varepsilon_i^2 = \sum_{i=1}^n [y_i - \sum_{j=1}^r \sum_{k=1}^{c_j} \bar{a}_{ik} \cdot \delta_i(j, k)]^2 = \sum_{i=1}^n (y_i - \bar{y})^2 \quad (3)$$

And then, the partial derivatives of \bar{a}_{ik} is taken, which is considered as zero.

$$\sum_{j=1}^r \sum_{k=1}^{c_j} f(uv, jk) \bar{a}_{ik} = \sum_{i=1}^n y_i \delta_i(u, v) \quad (4)$$

In this type, $f(uv, jk) = \sum_{i=1}^n \delta_i(u, v) \delta_i(j, k)$ (5)

After solving the equation set, the least squares estimate $\overline{a_{ik}}$ can be obtained. The average perceptual evaluation is

$$\overline{y_i} = \sum_{j=1}^r \sum_{k=1}^{c_j} \overline{a_{ik}} \cdot \delta_i(j, k) \quad (6)$$

B. Research process

Based on the above research methods, the main process of this research are as follows:

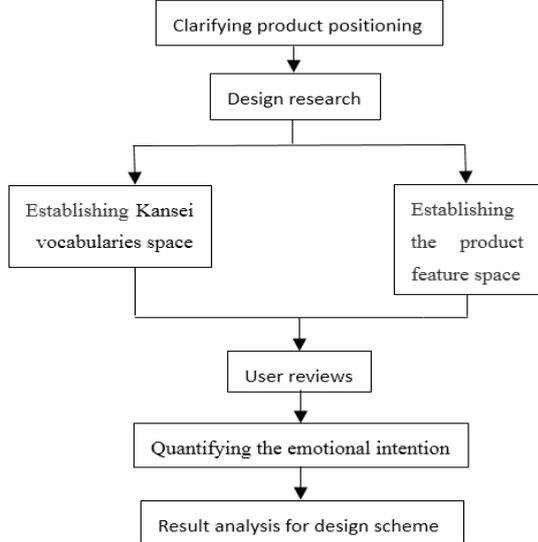


Figure 1. Research Process

- First of all, doing product orientation work. User-centered design is more and more popular used in product development, it focuses on user's need.
- Secondly, establishing the product feature space. The same type of typical product samples are widely collected and studied. Based on the morphological analysis, the design elements of product are deconstructed and the space of designing elements are established.
- At the same time, collecting and filtering Kansei vocabularies which can best describe the perceptual acknowledge of users. Thus the space of Kansei vocabularies are established.
- Then, combining (2) with (3). The pictures of typical products and Kansei vocabularies are put together to let user evaluate. The evaluation is made by semantic difference scale containing grade 5 or 7.
- At last, quantifying the emotional intention. The relationship between emotional appeals of users and design elements is analyzed by the means of fuzzy mathematics and multiple linear regression analysis.

III. CASE STUDY

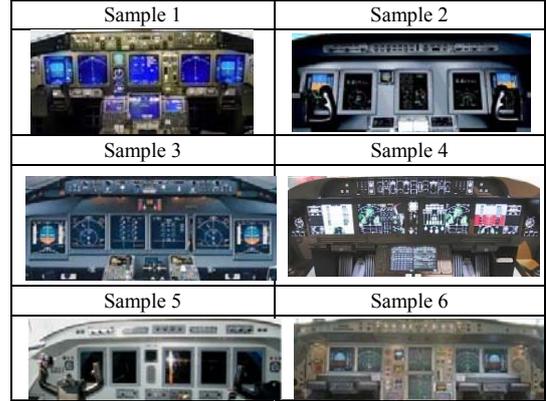
A. Clearing product positioning

The research regards the control interface of cockpit as design case and its target users are the special pilots who have been flight training strictly that they are better than the ordinary people in high-flying not only in physical but also in mental. So the pilots have distinct psychology characteristics and are chosen as our object users.

B. Gathering typical product modeling

In the beginning, our team has gathered 18 image samples of control interface of different civil aircraft focusing on Airbus, Boeing and domestic. In the light of the consistency of photo sharpness and shooting degree and the similarity of product modeling, we select 6 samples that can represent 18 image samples of driving control interface above. (Table 1)

TABLE I. IMAGE SAMPLES OF CONTROL INTERFACE



C. Creating the projects of design elements of control interface

Morphological analysis has been applied to this experiment, the layout of display screen and the color of baseplate are extracted as two primary design elements. Because the two design elements are distinct and can affect the style of cockpit. Pilots would experience negative emotion if they are designed randomly.

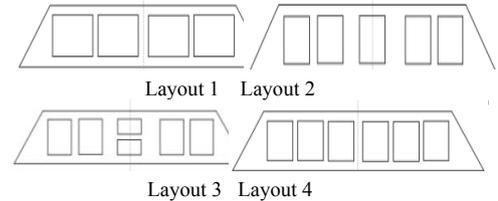


Figure 2. The layout of electronic display

TABLE II. THE COLOR OF CONSOLE

Color 1		Light Gray
Color 2		Dark Gray
Color 3		Light Blue
Color 4		Mazarine
Color 5		Deep Brown

D. Gathering and filtering kansei vocabulary

We collect 125 adjective words in total that can evaluate the cockpit from airline magazines, advertisements, website and the feelings of pilots and engineers. Afterwards, we select 18 pairs of vocabulary that have opposite meaning by deleting the synonym words. At last, we get 6 pairs of adjective words by questionnaire, and they are superior-

inferior, uniform-changing, complicated-brief, tough-rounded, safe-dangerous, stable-dynamic.

E. Quantification of kansei intention

• Firstly, we formulate a rating form for the six pairs of adjective vocabulary on a scale of one to seven on the basis of semantic differential. Then, the testers grade each modeling in the rating form by their own semantic feeling. The testers total 26 pilots, including 3 experienced pilots and 23 fresh pilots. We will acquire the average value of Kansei intention assessments of the six samples after processing data in the questionnaire.

TABLE III. SEMANTIC DIFFERENCE EVALUATION OF SAMPLES

adjective	level							adjective
superior	1	2	3	4	5	6	7	inferior
uniform	1	2	3	4	5	6	7	changing
complicated	1	2	3	4	5	6	7	brief
tough	1	2	3	4	5	6	7	rounded
safe	1	2	3	4	5	6	7	dangerous
stable	1	2	3	4	5	6	7	dynamic

TABLE IV. THE AVERAGE OF PERCEPTUAL EVALUATION

Sample	adjective					
	superior	uniform	complicated	tough	safe	stable
1	1.2	1.6	2.2	1.8	1.2	1.5
2	3.8	1.7	4.6	3.8	2.3	3.3
3	2.4	1.4	1.8	1.2	1.5	1.3
4	1.1	2.1	1.5	4.6	2.1	2.2
5	4.2	3.2	3.6	2.9	2.4	2.9
6	2.1	1.5	2.1	2.1	1.9	1.6
Average	2.467	1.917	2.633	2.733	1.900	2.133

• Secondly, we do define the membership value of design elements of the six samples. We quantify the design elements of the six samples according to formula 1 and transform the data to 0 or 1 as quantitative data.

• Lastly, we use membership value of the design elements as independent variable and the average value of the Kansei assessments of the samples as dependent variable to apply fuzzy mathematics and do multi-variable linear return analysis by SPSS software.

TABLE V. MEMBERSHIP VALUES OF DESIGN ELEMENT

item	category	Quantitative values of samples $\delta_i(j, k)$					
		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
layout	1	0	0	0	1	0	0
	2	0	1	0	0	1	0
	3	1	0	0	0	0	1
	4	0	0	1	0	0	0
color	1	0	0	0	0	1	0
	2	1	0	0	0	0	1
	3	0	1	0	0	0	0
	4	0	0	1	0	0	0
	5	0	0	0	1	0	0

TABLE VI. LINEAR REGRESSION BETWEEN DESIGN ELEMENT AND PERCEPTUAL EVALUATION

Item(i)	category(k)	superior—inferior	
		a_{jk}	coefficient of partial correlation
1(layout)	1	0.013	0.419
	2	-0.010	
	3	0.075	
	4	-0.175	
2(color)	1(light gray)	-0.275	0.616
	2(dark gray)	0.032	
	3(light blue)	0.008	
	4(mazarine)	-0.375	
	5(deep brown)	0.051	

We can get the information from analyzing the data in the table:

- The determination coefficient of this experiment is 0.867, it is a very important parameter that represents feasibility degree of the result. In general, the results of return analysis can be accepted when > 0.7 .
- The category score represents the relevant of each design element of interface and semantic vocabulary.
- Partial correlation coefficient denotes the degree of each project affects the Kansei intention.

IV. CONCLUSION

In this paper, we explore a mathematics law of the Kansei cognition that how the pilots regard the driving control interface focusing on the emotion reaction when pilots are on a flight by the mathematics method of Kansei Engineering. Then, we quantify and analyze it and set up a mathematics relationship between cognition and design elements. At last, we conclude that the law can enable designers to seize the degree of design elements affecting the user emotion more rapidly and accurately.

REFERENCES

- [1] Li Wei, Yao Hailin. Analysis on Factors which Influence the Flight Safety of Civil Aircraft.[J] AVIC The First Aircraft Institute,2007(77).
- [2] Li Yanzu. New Idea of Design: Kansei Engineer[J]. New Arts, 2003,(4):20-25.
- [3] Li Yueshan. Design of Human-Machine Interface[M].Beijing: Science Press,2002,43-81.
- [4] Chen Guoxiang, Deng Yixin, Guan Raosheng. Kansei Engineer—The Perceptual to Rational Technique.[J], Industrial Design,2000,29(1):2-16.
- [5] Su Jianning, Li Heqi. Investigation of Relationship of Form Design Elements to Kansei Image by means of Quantification-Theory[J]. Journal of Lanzhou University of Technology,2005,31:36-39.
- [6] Chen Dehuang. More Intuitive, More Convenient, More Safety—New Trades of Man-Machine Interface Design of Civil Aircraft[J]. International Aviation,2001(09).
- [7] Chen Zhixuan. Application of Aesthetic feeling and Perceptual Technology in the Study of Picture Type of user Interface Evaluation[D].Industrial Design Institute of Successful University,2004.
- [8] Georgive G, Nikov A. Method and Microcomputer Program for Complex Ergonomical Rating of Industrial Products[J]. The Proceedings of the Second International Occupational Ergonomics Symposium, April 1987.
- [9] Mitsuo Nagamachi, Andrew S.Imada. Kansei Engineering: An ergonomic technology for product development. International Journal of Industrial Ergonomics,1995(15):1-74P.
- [10] Huang Ming Chi. Exploring the Style and Viewing angle of brake lamp for driver's safety and visual cognition. National Cheng Kung University Master's thesis.2007.