Kansei Engineering: A new ergonomic consumer-oriented technology for product development

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Abstract

Kansei Engineering was developed as a consumer-oriented technology for new product development. It is defined as “translating technology of a consumer’s feeling and image for a product into design elements”. Kansei Engineering (KE) technology is classified into three types, KE Type I, II, and III. KE Type I is a category classification on the new product toward the design elements. Type II utilizes the current computer technologies such as Expert System, Neural Network Model and Genetic Algorithm. Type III is a model using a mathematical structure.

Kansei Engineering has permeated Japanese industries, including automotive, electrical appliance, construction, clothing and so forth. The successful companies using Kansei Engineering benefited from good sales regarding the new consumer-oriented products.

Relevance to industry

Kansei Engineering is utilized in the automotive, electrical appliance, construction, clothing and other industries. This paper provides help to potential product designers in these industries.

Keywords: Consumer-oriented technology; Product development; Kansei of psychological feeling; Expert system; Database; Computer graphics

1. Introduction

An industrial age is changing from a product-out concept to a market-in concept regarding new product development. In the 1970’s, manufacturers produced a volume of products and people bought them. At that time, the manufacturers designed the products through their own concept. However, the consumers had to buy them regardless of personal preference. At present, they have many things in their houses which they do not want anymore. The sophisticated consumers desire that products match their own feelings of design, function and price.

The product-out strategy means a production by a manufacturer based on its own design strategy regardless of the consumer’s demand and preference. On the other hand, the market-in strategy implies a production based on the consumer’s desire and preference. Nowadays, the consumers are stringent in choosing the products in terms of their demand and preference. The
Concerning the second point, we conducted a survey or an experiment to look at the relations between the Kansei words and the design elements. In regard to the third point, we utilized advanced computer technology to build a systematic framework of the technology on Kansei Engineering. Artificial Intelligence, Neural Network Model and Genetic Algorithm as well as Fuzzy Logic are utilized in the Kansei Engineering System to construct the concerned databases and computerized inference system. Finally, we were able to adjust the databases of Kansei Engineering to the consumer's new Kansei trend by inputting the new Kansei data of the consumer every three or four years.

2. Procedures of Kansei Engineering

There are three styles of Kansei Engineering procedure; Type I, II and III. Type I Kansei Engineering means Category Classification from zero- to nth-category. Type II uses the computer system and Type III utilizes a mathematical model to reason the appropriate ergonomic design.

2.1. Type I: A Category Classification

The Category Classification is a method in which a Kansei category of a product is broken down in the tree structure to get the design details. Following is a good example of the application of Kansei Engineering Type I. A Japanese automotive manufacturer, Mazda, has developed a new sports car named "Miyata" which was derived from Kansei Engineering. Nagamachi taught Kansei Engineering to Mazda. The chairman, Mr. Kenichi Yamamoto has much interest in this new ergonomic technology (Yamamoto, 1986). Since then, in Mazda, Kansei Engineering has become a fundamental technology for new product development.

Mr. Hirai, a manager for a brand new car, decided to implement Kansei Engineering in "Miyata" development and settled the zero-level category of the new car “Human–Machine Unity (Jinba-Ittai in Japanese)” after discussions with his project team. This concept implies that a
driver feels a unification between himself or herself and the car when driving. The driver feels that his or her body might be the car and controls the machine with his or her own intention freely. Human–Machine Unity is just the concept of a new car and tells nothing about the car design such as engine characteristics, car size and so forth. In Kansei Engineering Type I, the zero level concept should be broken down into clearly meaningful subconcepts to get the design details.

The members of the project team started to classify the zero level concept to the subconcepts, that is, 1st, 2nd, ..., and nth subconcept until they obtained the car design specifications. The procedure of Type I is shown in Fig. 2.

Regarding “Miyata”, the zero Kansei level was classified into four subconcepts in the 1st level; “Tight-feeling”, “Direct-feeling”, “Speedy-feeling” and “Communication”. “Tight-feeling” implies “fitting closely to the machine” and “not large nor small”. With this subconcept, the team decided that the car length would be around 4 meters. It became 3.98 m after discussing its chassis length. When they mounted four sheets inside the car, the consumer’s feeling was “narrow” and this subconcept did not match “Tight-feeling”. So, the team designed the car mounted with two sheets.

This explains how the Type I procedure of transferring the subconcepts to the design details, as shown in Fig. 3 illustrates a part of flow in regard to “Tight-feeling”. If the team could not get the design details, it should continue the classification to 2nd, 3rd, ..., nth level. When the team did realize the specs of the car design, it examined the design details minutely in terms of the automotive engineering. In this stage, the team created a great deal of new patents.

Through the procedure of Kansei Engineering Type I, Mazda has succeeded in developing the new sports car, “Miyata”, which is called “Eunos Roadster” in Japan and has been a good seller in the U.S. as well as in Japan. After this success, Mazda and its subcontractors have been utilizing Kansei Engineering Type I as the fundamental technology for the car development.

2.2. Type II: Kansei Engineering Computer System

Kansei Engineering Type II is a computer-assisted Kansei Engineering System. Kansei Engineering System (KES) is a computerized system with the Expert System to transfer the consumer’s feeling and image to the design details. The computerized Kansei Engineering System architecture basically has four databases, as shown in Fig. 4.

(i) Kansei database

Kansei words which are representatives of the consumer’s feelings on a product are collected from the dialogue with the salesman in the shop or from the industry magazine. More than 600 words were collected and then reduced in number to about 100 words, which seemed to be enough to represent the consumer’s feelings for the product. After constructing SD scales and evaluating the number of the product in the SD scales, the evaluated data are analyzed by Factor Analysis. The results from the Factor Analysis suggest the Kansei word meaning space, from which the Kansei word database is constructed into the system.
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consumer wanted something “gorgeous”, this Kansei word corresponds to some design details in the system. These data construct the image database and the rule-base.

(iii) Knowledge-base

Knowledge-base consists of the rules needed to decide the highly correlated items of the design details with the Kansei words. Some rules resulted from the calculation of the Quantification Theory and some from color conditioning principles and so forth.

(iv) Design and color database

The design details in the system are implemented in the form design database and the color database, separately. All design details consist of the aspects of design which are correlated as a total shape with each Kansei word. The color database consists of full colors which are also correlated to the Kansei words. The combined parts of the design and color are pulled out by the specific inference system and displayed in graphics on the screen.

(v) Kansei Engineering System procedure

A consumer inputs his or her image words concerning the desired product into KES. The KES receives these words firstly through the Kan-
sei word database and checks whether it can recognize them or not. If it can recognize them, the words are transferred to the knowledge-base. The inference engine works in this stage by matching the rule-base and the image database. Then, the inference engine decides the aspects of design details and the controller of KES pulls out and displays the appropriate parts and color on the screen (see Fig. 5).

(vi) How to construct the KES

First of all, a KES engineer decides a specific product domain. If a company wants to make a new automotive model and his or her role is concerned with an interior design, the engineer has to decide whether his or her research is a dashboard design or a steering design and so forth. The KES engineer collects the Kansei words and constructs the SD scale of the words. He or she collects the number of steering designs, 20 to 30 for instance, and asks his or her colleagues to estimate them by the SD scales. After analyzing the evaluated data by Factor Analysis and the Quantification Theory Type I, the KES engineer makes the aforementioned four databases, the inference engine and the control system, based on the Expert System procedure.

Application aspects of KES

There are two ways of applying the KES. One supports the consumer's decision for a choice of the products, and another supports the designer's decision for the product development.

(i) The consumer-supporting KES

Suppose a consumer wants to buy a costume or a house. He or she has a Kansei or feeling concerning his or her desire for the product. For instance, she wants to buy an elegant and/or sexy costume at some price, and he wants to construct his luxurious house at some price. They sit in front of a KES computer and input their desired Kansei words into the KES. It understands their desire through the inference engine and produces the final decisions from the computer which matches their desire for the products. The KES is able to help the consumer's decision for a choice about a product. The consumer-supporting KES for a college girl costume is called FAIMS (Fashion Image System) and the KES for a house is called HULIS (Human Living System) (Nagamachi, 1991a).

(ii) Designer-supporting KES

Another KES application is for help in designing a new product. When a designer is creating a new product, he or she starts with his or her product image or concept. Then, he or she consults with the KES by inputting the designer's image words. The KES outputs the result of calculation in Kansei Engineering on the display. If the displayed graphics are different from the designer's image, it can be changed in the shape design and color by the KES change procedure (see Fig. 4).

2.3. Type III: Kansei Engineering Modeling

In Kansei Engineering Type III, a mathematical model is constructed in spite of the rule-base to obtain the ergonomic outcome from Kansei words. In this procedure, a mathematical model implies a kind of logic which plays a similar role to the rule-base.

An example of this type is the Sanyo Co., which is described in another paper in this special issue. Fukushima and his colleagues in Sanyo attempted to apply Kansei Engineering to a color printer (Fukushima et al., 1995). They succeeded in constructing an intelligent color printer which allows a change of the original color to be more beautiful and more preferred face skin color using Fuzzy Kansei Logic.

3. Applications of Kansei engineering

3.1. Application of Type I

Several years ago, Japanese automotive companies attempted to introduce Kansei Engineering in the automotive vehicle design development. Nissan, Mazda and Mitsubishi were eager to implement Kansei Engineering and they began to produce many kinds of newly designed passenger cars. Nissan has applied the new ergonomic
technology to all new brands since the production of “CIMA”. Mazda first introduced Kansei Engineering for developing “Persona” and later for “Miyata”, which continues to be a good seller. Mitsubishi studied Kansei Engineering earlier than any other automotive companies and tried to implement it in “Diamante”, which has been a good seller. The other Japanese car makers, Toyota and Honda, were also eager to study Kansei Engineering Type I and introduced this technique to design the products. It is safe to say that all Japanese car makers are interested in introducing Kansei Engineering in vehicle designing.

In the U.S.A., Ford Motor Co., former CEO, D. Petersen said in his book (Petersen, 1992) that Ford learned Kansei Engineering from Mazda and implemented it in designing “Taurus”. Fiat in Italy and even Porsche in Germany are interested in Kansei Engineering. Kansei Engineering Type I is used through the world, since it seems easy to introduce in the product development.

3.2. Application of Type II

The KES, the computer-assisted Kansei Engineering is most well known in Japan among the Kansei Engineering procedures. Kansei Engineering Type II has been applied to costume design for a college girl (Nagamachi et al., 1988), house design (Nagamachi et al., 1986), entrance door design in Tateyama Co. (Kashiwagi et al., 1992), car interior design in Nissan (Jindo et al., 1991), office chair design in Itoki Co. (Jindo et al., 1995), the color planning system in Sharp Co. (Nagamachi, 1989b), interior design in a construction machine in Komatsu Co. (Nakata et al., 1994), and automatic door design in NABCO Co. Following are two case study examples of the KES.

(i) Application of KES to a steering wheel design

The Kansei words concerning the steering wheel design were collected from a variety of cars and they were pictured to make slides. These slides were shown to twenty-seven male students and twenty-three female students. Then, the subjects evaluated these slides on the SD scales.

These fifty-nine steering wheel designs were also analyzed by the Kansei Engineering procedure. They were classified as to 13 design items such as the number of spokes, pad face type, pad area and so forth. Each item was again classified to smaller categories such as (2, 3, 4) spokes and (small, medium, large) pad area, and so forth. The evaluated data in the SD scales and the items/categories design details were calculated by the Multivariate Analysis or Quantification Theory Type I. As a result, we obtained the statistical relations between the Kansei words and the design details of the steering wheel. By utilizing these outcomes, we constructed four databases and a computer-assisted KES for the steering wheel design (KESW) similar to Fig. 4.

This research aimed at constructing the designer-supporting KES in an automotive company. Therefore, the evaluated data by the student as well as by the company designers were implemented in the databases for supporting the designer’s decision.

Suppose a car designer is designing a steering wheel. He wants to design a steering wheel with “a safe feeling”. Then, he inputs the word “a safe feeling” in KESW and gets three graphics as shown in Fig. 5. The graphic on the right side in the figure shows the first candidate design for a female consumer and the central graph is for a male consumer. The left graphic illustrates a combined male/female design for the first candidate design.

We tested the estimation of the resulted displays by the experienced designers engaging in the car design. They evaluated very highly the artificial designs of the steering wheel decided by KESW.

Another example of Kansei Engineering Type II is a unique application to an interpretation of the design language. Sharp Co. asked Nagamachi to make an interpretation system on color between the designers and the technical engineers. When developing a new product, a designer asks
the engineers to manufacture it according to the designer's concept. For instance, he or she orders the engineers to paint with the "natural" color on the outer surface of a pot. However, the engineers have difficulty understanding what color "natural" is.

We conducted an experiment for evaluating colors in the Kansei SD scales and succeeded in obtaining the color-Kansei word interpretation map. We implemented the color map in the CAD system and then the engineers easily obtained the color specification on the map by retrieving KES, which a designer ordered them. This system is named "Color Planning System (CPS)" (see Fig. 6).

In the color planning system, an engineer draws a shape of a pot in CAD and inputs the designer's Kansei word of "natural" in CAD. Then, a solid graph of the pot is painted with a metallic color decided by the KES instantly.

3.3. Application of Type III

As mentioned above, Kansei Engineering Type III is a mathematical modeling of Kansei Engineering. A case of Type III is described in detail in Fukushima and his colleagues' paper in this special issue (Fukushima et al., 1995). They attempted to design intelligence in a color printer to produce a better color picture. They conducted an experiment in which the subjects evaluated various girl's face skin colors in the Kansei SD scales. The SD scales consisted of the Kansei words of "beautiful", "good looking face color" and others. The evaluated colors were classified into hue, value and chroma separately, and these were expressed in a triangle fuzzy membership function. The results of the membership function were implemented in the CPU in the intelligent color printer, and then the more beautiful colored picture was obtained through the sophisticated color process.

4. Hybrid Kansei Engineering

Our next attempt is a combination of a consumer-supporting and a designer-supporting Kansei Engineering which is named "Hybrid Kansei Engineering" (Nagamachi, 1993) as shown in Fig. 7. Hybrid Kansei Engineering consists of Forward Kansei Engineering as shown in Fig. 4 and Backward Kansei Engineering as shown in Fig. 8. The former is the Kansei Engineering System in which a designer obtains the demanded design through an input of the Kansei words. In the Backward Kansei Engineering, the designer is able to draw a rough sketch in the computer and the computer system recognizes the pattern of the design inputted by the designer. Then, the system estimates the Kansei or the image of the design inputted through the backward inference engine and shows the estimated level of Kansei about the design.

We conducted research on the recognition system of an entrance door design (Miyazaki et al., 1993) and continued the research of it utilizing a "Neocognitron Model" (Fukushima, 1975; Kashiwagi et al., 1994). In Miyazaki's research, the computer understands the door framework first.
and then other design details. In Kashiwagi's research, Fukushima's Neocognitron was revised and it is able to learn the relations between the Kansei words and the door design details through the selected attention model of multi-layer networks as shown in Fig. 9. This research will be continued until a more intelligent system is built.

5. Conclusions

Kansei Engineering is a consumer-oriented technology for product development based on Ergonomics and Computer Science. It has been utilized in a variety of industries and it was highly evaluated as an effective development method incorporating the consumer's demand.

This ergonomic technology was born at Hiroshima University and Nagamachi and his colleagues endeavored to develop a variety of Kansei Engineering techniques, but they have just three types at present. Many problems still remain to be solved; (1) how to treat the individual differences of Kansei, (2) how to estimate the consumer's and/or the designer's satisfaction with the outcome from the KES, and (3) how to improve the system by incorporating artificial intelligence.

Concerning item (3), Nagamachi and his colleagues started to use virtual reality technology to abstract the consumers' satisfaction in a system-kitchen decided by the KES (Enomoto et al., 1993). In this new system, a consumer provides his or her body height and the information about his or her life-style. The KES produces a kitchen with computer graphics matching the consumer's feeling and then it is transferred to the virtual reality system. The consumer is able to go through the virtual reality to estimate the level matching his or her feeling with the experience of walking through the virtual treatment of the kitchen.

Kansei Engineering is the most recent ergonomic technology and is not mature at present. We hope to produce benefits for human beings through this advanced technology.

References


