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KANSEI EVALUATION WITH ROUGH SETS THEORY FOR NEW PRODUCT DEVELOPMENT

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Abstract- New product development strategy taking into account customer needs has become very important for companies' development and competition in the market. Kansei engineering is a method to help designer for capturing the consumer needs. Kanseiwords help to reflect consumer perception about a product. At the same time, the rough sets theory is effective as a means of knowledge acquisition for designer. This paper proposes Rough Sets Theory with Kansei Engineeringfor the definition of emotional marketability decision rules according to consumer feelings for new baby cot design.

Index Terms-Consumer Feeling (Kansei), New Product Development, Rough Set Theory

I. INTRODUCTION

Understanding and integrating the voice of customer have become an indispensable part in new product development (NPD) process [1]. Nowadays, companies focusing only on functionality and usability may not gain competitive advantages because consumers buy products not only for basic function and usability, but also for product's emotional aspect [2, 3, 4, 5]. In this respect, Kansei Engineering (KE) [2] has been developed to help designers to link between consumers' emotional response and design properties of a product [6]. KE identifies the relational rules between design elements of products and uncertain human sense and feeling [4]. Rough Set Theory (RST) can be used to extract decision rules between consumer feelings (Kansei) and product [7,8]. RST was introduced as a mathematical theory to handle uncertain or conflicting data [9]. This theory has been used to extract the decision rules in many application areas, and its effectiveness has been shown in many problems [10]. The purpose of this paper is to apply RSTfor the definition of emotional marketability decision rules according to consumer feelings for new baby cot design. This emotional marketability rules would enable product designer to design the new products for market.

II. KANSEI ENGINNERING AND GENERAL PROCEDURE

Kansei Engineering Type I [11], capable of relating emotional appeal in the form of Kansei Words to physical design appearance, is used. 15 baby cots were collected from different furniture websites, and 10 young women with the ages between 20-30 years evaluated the cots using a 7 point Semantic Differential Scale (SDS) with respect to five Kansei words (quality, luxurious, classical, elegant and sportive) that were founded at furniture websites and different furniture magazines, books and journals representing various emotional needs of baby cots. Some of the baby cot samples are given Figure I.

The general procedure for Kansei Engineering application and results in these baby cot studies were:

1. Selection of a product domain.
2. Collection of Kansei Words.
3. Collection of product samples.
4. Identification of the most representative Kansei Needs of the Market
5. Evaluation of product samples vs. Kansei Words on SDS scale.
6. Assessment of the significance of attribute of Kansei word using RST.
7. Identification of consumer feeling marketability decision rules for new product development

Figure I : Samples of baby cot used for Kansei survey

III. DEFINITIONS OF ROUGH SETS THEORY

Assume that U is the universe containing all the alternatives which are registered in an information table [11]. A data table is the 4-tuple S = (U,R,V, f) where U is a finite set of objects (universe); $R = C \cup D$ is a set of attributes, subsets C and D are the condition attribute set and the decision attribute set, respectively; Vr is domain of the attribute r,

$V = U_{r \in R} Vr$ and $f : U \times R \to V$ is a total function such that $f(x,r) \in Vr$ for each $r \in R, x \in U$ called information function [12].

To every non-empty subset B of attributes $R(B \subseteq R)$ is associated an indiscernibility relation on U, denoted by $IND(\text{B})$:

$$IND(\text{B}) = \{(x,y)/(x,y) \in UxU, \forall b \in B(b(x) = b(y))\} \quad (1)$$

Clearly, the indiscernibility relation defined is an equivalence relation (reflexive, symmetric and transitive). The family of all the equivalence classes of the relation IND(B) is denoted by $U/IND(B)$.

Definition 1. Entropy H(P) of knowledge P (attributes set) is defined as

$$H(\text{p}) = -\sum_{i=1}^{n} p(\text{X}_i) \log p(\text{X}_i) \quad (2)$$

where $p(X_i) = |X_i|/|U|$ and $p(X_i)$ denotes the probability of X_i when P is on the partition $X = \{X_1, X_2, X_3 \dots . X_n\}$ of universe U, i = 1,2,. . . ,n.

Definition 2.Conditional entropy H(Q/P) which knowledge $Q(U/IND(Q)) = (\{Y_1, Y_2, \dots . Y_n\})$ is relative to knowledge $P(U/IND(P)) = (\{X_1, X_2, X_3 \dots . X_n\})$ is defined as

$$H(\text{Q/ P}) = -\sum_{i=1}^{n} p(\text{X}_i) \sum_{j=1}^{m} p(\text{Y}_j / X_i) \log p(\text{Y}_j / \text{X}_i) \quad (3)$$

where $p(Y_j/X_i)$ is conditional probability, *i*= 1, 2, . . .,n, *j* = 1,2,. . . ,m.

Definition 3.Suppose that decision table $S = (U, R, V, f)$, $\text{R} = \text{C} \cup \text{D}$, subsets C and D are the condition attribute set and the decision attribute set, respectively, attribute subset $A \subset C$. The attribute significance SGF(a,A,D) of attribute $a \in C/A$ is defined as

$$SGF(\text{a, A, D}) = \text{H}(D/A) - H(D/A \cup \{a\}) \quad (4)$$

Given attribute subset A, the greater the value of SGF(a,A,D), the more important attribute a is for decision D.

III. CASE STUDY

RST was used to for the analysis of evaluated Kansei data to determine the decision rules for new baby cot design according to consumer feelings. While the decision table was created, the decision attributes were divided into 3 categories. Those in the first range are low-Kansei designs, those in the second range are medium Kansei designs, those in the third range are high-Kansei design and shown in Table I as 3,2,1, respectively.

We constructed thedata table with 5 Kansei word and 15 different baby cot to categorized response variables, meaning “1 = marketability” and “0 = non-marketability” values in Table I. For example, for easy marketable baby cot design expectation (see Table I), the perception of design feeling would be: high quality, medium luxurious, medium classic, low elegant and sportive.

Alternative (U)	Quality	Luxurious	classic	Elegant	sportive	Marketable(D)
1	2	3	1	2	2	0
2	1	2	2	3	3	1
3	1	3	1	2	2	1
4	2	2	2	3	3	1
5	2	3	3	2	2	0
6	1	3	3	3	2	1
7	3	3	3	3	2	0
8	2	3	3	3	2	1
9	3	2	2	3	3	0
10	3	1	1	1	3	0
11	1	3	3	2	2	1
12	3	3	3	3	2	0
13	2	1	3	3	2	1
14	2	2	1	3	3	0
15	2	3	3	1	2	1

Table I .Decision table about Kansei words

For the decision table of Table I, we can get the significances of “quality”, “luxurious”, “classical”, “elegant” and “sportive” by the following process:

$$\text{U/IND}\{\text{quality”, “luxurious”, “classical”, “elegant”, “sportive}\}$$
$$=\{\{1\},\{2\},\{3\}.......\{12\}\}$$
$$\text{U/IND}\{\text{marketable}\}=\begin{Bmatrix}\{2;4;6;\ 8;\ 11;12,13,15\}, \\ \{1;\ 3;\ 5;\ 7;\ 9;\ 10,14\}\end{Bmatrix}$$
$$=\{\text{D1,D2}\}$$
$$\text{U/IND}\{\text{“luxurious”, “classical”, “elegant”, “sportive}\}$$
$$=\{\{1,3\},\{6,7,8\},\{2,9\},\{5,11\},\{4,12\}\}$$
$$=\{\text{X}_1,\text{X}_2,\text{X}_3,\text{X}_4,\text{X}_5\}$$
$$\text{P}(\text{X}_1)=2/15\text{P}(\text{D}_1/\text{X}_1)=1/2,\text{P}(\text{D}_2/\text{X}_1)=1/2;$$
$$\text{P}(\text{X}_2)=3/15\text{P}(\text{D}_1/\text{X}_2)=1/3,\text{P}(\text{D}_2/\text{X}_2)=2/3;$$
$$\text{P}(\text{X}_3)=2/15\text{P}(\text{D}_1/\text{X}_3)=1/2,\text{P}(\text{D}_2/\text{X}_3)=1/2;$$
$$\text{P}(\text{X}_4)=2/15\text{P}(\text{D}_1/\text{X}_4)=1/2,\text{P}(\text{D}_2/\text{X}_4)=1/2;$$
$$\text{P}(\text{X}_5)=2/15\text{P}(\text{D}_1/\text{X}_5)=1/2,\text{P}(\text{D}_2/\text{X}_5)=1/2;$$
$$\text{SGF}(\text{quality”}, \{\text{“luxurious”, “classical”, “elegant”, “sportive}\},\{\text{D}\})$$
$$=\text{H}(\{\text{D}\}/\{\text{“luxurious”, “classical”, “elegant”, “sportive}\})$$
$$-\text{H}(\{\text{D}\}/\{\text{quality”, “luxurious”, “classical”, “elegant”, “sportive}\})$$
$$=-\frac{2}{15}\left(\frac{1}{2}\log\frac{1}{2}+\frac{1}{2}\log\frac{1}{2}\right)\text{x}4$$
$$-\frac{3}{15}\left(\frac{1}{4}\log\frac{1}{3}+\frac{2}{3}\log\frac{2}{3}\right)=0{,}105$$

We obtain the significance of attribute "quality" as 0.105. By the similar process, we also can get the significance of attribute "classic" as 0.080 and the significance of attribute "luxurious" as 0.055 and the significance of attribute "elegant" as 0.032 and the significance of attribute "sportive" as 0.040, respectively. According to results, feeling of "quality" is the most important than others feeling and affects the purchase deicison. The perception of "classic" also affects the decision and increase the affect of merchantability.

CONCLUSION

Kansei Engineering is open to new models to translate more accurately the uncertain information of consumer feelings of a market to generate new product desings. We use a RST with Kansei words and try to discover the design that could generate emotional satisfaction in the market for baby cot based on physical visual design. RST enables to generate decision rules of according to consumer needs in the market, resulting in different approaches to the design. So, the future product forecasts with the help of RST can be made on the determined emotional theme for the market. We have determined which Kansei words are more important in terms of marketability for the baby cot such as ''quality''.

In the future, the result of this study is needed to validate by designers and marketing team. The selected and produced baby cot prototypes can be tested to understand the impact of the Kansei words in the market with different evaluation group.

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