TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 59, Issue II, June, 2016

KANSEI ENGINEERING - A NEW TECHNIQUE IN DEVELOPMENT OF SUCCESS PRODUCTS

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Abstract: *Kansei Engineering is built on existing theories and methods. Traditional Kansei Engineering has three data dimension: products, consumers and emotions. The new aspect with Kansei Engineering is the composition and usage of tools from different areas within engineering, psychology and mathematics. This paper presents some of the most important aspect, tools and techniques that can be successfully applicate if performance analysis and definition of a new product, to increase chances of survival in the market.*

Key words: *Kansei Data, Kansei Engineering, Semantic, Quantification.*

1. INTRODUCTION

In the first half of the 20^{th} century several researchers aimed to analyze the connection between words as such and their meaning and underlying ideas, which in this context can be called Kansei. It became apparent that such studies needed powerful instruments for quantification and measurement.

Several researchers conducted studies on this problem and proposed different models. Thorndike and Lorge [1], Cason and Cason [2] and Zipf [3] (Zipf's law) made similar frequency-of-usage counts in order to detect laws and relations to its meaning. The underlying theory is that associations on the semantic level appear to be organized in such a way that "few words and expressions have a higher probability of occurrence whereas many have low probabilities of occurrence" (Osgood 1952).

Harada in 1998 described Kansei as a mental function, and more precisely as being a higher function of the brain , and therefore it is implicit.

2. CONTENT

2.1. Semantic differentials. The process of Kansei begins with gathering the sensory related functions such as feelings, emotions and intuition, by means of the five senses (i.e. vision, hearing, smell, taste and skin sensation).

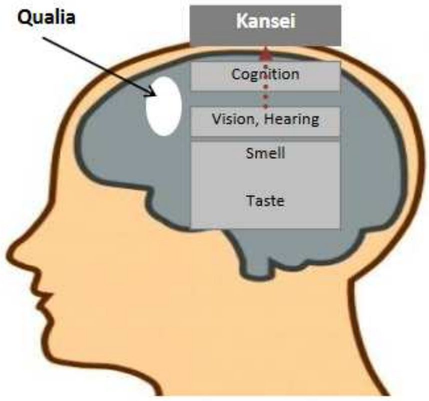

Figure 1. The Process of Kansei (Lokman & Nagamachi, 2009).

When these senses are triggered, psychological cognition concerned with perception, judgment and memory will surface. In the scenario of going into an unfamiliar restaurant, your vision, smell, taste and cognition would judge whether the restaurant is "very friendly "and or provide "good service". These are "Kansei". The Kansei emerges through cognition with several contributing sensations in place.

As being implicit, Kansei process cannot be measured directly. What can be observed are actually not Kansei but the causes and the consequences of the Kansei process (Nagasawa 2004). Therefore, Kansei can be measured only indirectly and partially, by measuring sense activities, internal factors, and psycho - physiological and behavioral responses.

The term "Kansei" used in KE refers to an organized state of mind which has emotions and images held in the mind towards physical objects such as products or environment. For example, "luxury", "elegant", "flashy", "young" and alike as in the "that dress looks luxury and elegant", or "that car looks flashy and for youth" are all Kansei words describing feelings to certain product. Although in most cases [2,6,3].

Among the Kansei terms used in KE, there are Kansei that reflect the era and change occasionally such as trend-related Kansei, and ones that practically do not change such as fundamental Kansei (colors, etc.). Furthermore, differences of culture and social behavior between individual and countries may cause difference in the Kansei itself [4] and there are Kansei that are almost similar, but differ end in terms of the expressed Kansei words. Therefore, issues such as culture and timeliness are some of the delicate matter need to be considered when applying KE internationally. Kansei is used the form of adjective, nouns as well as short sentences can also be employed [6].

Kansei Engineering is built on existing theories and methods. The new aspect with Kansei Engineering is the composition and usage of tools from different areas within engineering, psychology and mathematics.

Inspired by the different political ideologies, which became evident in World War II and the following Cold War Osgood developed a method to measure the emotional content of a word more objectively. He called this method "semantic differential technique", which more than 30 years later became one of the foundations of modern Kansei Engineering.

His assumption was to divide any expression into two parts:

- The object, "which is a pattern of stimulation which evokes reactions on the part of an organism", and
- The sign, "which is any pattern of stimulation which is not the object but yet evokes reactions relevant to "object"-conditions under which this holds lying the problem for theory"

For example, the spoken word "hammer" is not the same stimulus as the object hammer. The former is a pattern of sound waves and the latter a combination of visual, olfactorical and tactual sensations. The word hammer elicits a type of behavior, which is in some manner relevant to the object hammer. This means that the spoken or read word "hammer" is the sign for the object "hammer". Osgood's approach is expressed in simplest terms by the question**: Under what conditions does something which is not an object become a sign of that object?**"[4]

To answer the question above, Osgood and his colleagues [5] conducted surveys by means of questionnaires. His subjects were supposed to rate signs (words) of objects like Pacifist, Russian, Germans, Dictator or Neutrality (remember that the experiments were conducted during World War II) on bipolar scales. These scales were defined with a number of contrasting adjectives at each end on which the participants checked that position which best represented the direction and intensity according their point of view.

The data collected can be stacked in a three dimensional raw store data matrix, as it can be seen in Figure 2.

Raw store data matrix is obtained when a group of subjects (x-axle) judges a sample of concepts (y-axle) against a set of semantic scales (z-axle). Each cell contains a number from 1 to 7, representing the judgment of a particular concept on a particular scale by a single subject.[6]

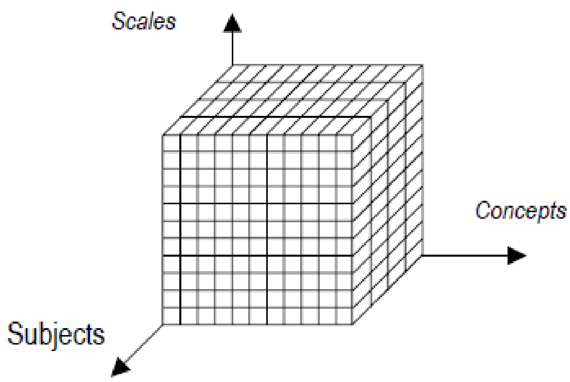

Figure 2. Raw store data matrix

In a following step the 3 dimensional matrix from Figure 1 is converted to a matrix of inter-correlations by summing together both subjects and concepts.

This allows an easy comparison of every scale with every other scale to which the total data contribute and also avoid spuriously low variability of judgments on single concepts. In addition a factor analysis can easily be run with the data conditioned in that way .

Together with the interrelation matrix, the factor analyses answer questions of how the different word pairs are related to each other, in which way they affect the understanding of a meaning of a certain word, and how to facilitate upcoming experiments. Furthermore, comparing the rotated matrix of the factor analysis from many different experiments led to the discovery of the existence of a common pattern [7]. It could clearly be seen that all examined word pairs span a three dimensional orthogonal vector space. Osgood called this space the semantic space.

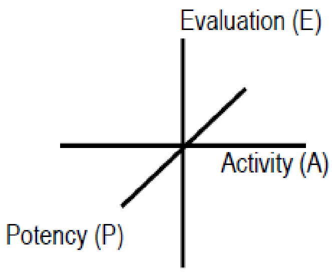

Figure 3. The Semantic Space

Considering the word pairs in the individual factors it was possible to identify a pattern and name these factors.

- Evaluation (E) usually contains word-pairs like: good-bad, timely-untimely, kind-cruel, beautiful-ugly, successful-unsuccessful, important-unimportant, true-false, wise-foolish, etc. All these word-pairs have in common a possibility to evolve into a better or worse stage.
- Potency (P) usually contains word-pairs like: large-small, hard-soft, masculine-feminine, strong-weak, etc. These pairs characterize a potential, a capacity for change.
- Activity (A) is characterized by word pairs like: active-passive, fast-slow, hot-cold, sharp-dull, angular-rounded, etc. This factor indicates the grade and speed of change.

Applying these factors into the semantic space, as is seen in Figure 2 these factor-names become the names of the axis.

Now it is possible to project every concept in the semantic space and give it an individual position. E.g. a dictator would score high on the potency axis (hard, strong, etc.), low on the evaluation axis (bad, cruel, ugly, etc.) and receives low positive values on the activity axis (active, fast…)

2.2. Statistical methods and tools used in Kansei engineering; Quantification theory type 1 (QT1)

The quantification of the relationship between Kansei words and design elements can be performed using Hayashi's Quantification Theory Type I. It is a variant of the linear multiple regression analysis, which allows inclusion of independent variables that are categorical and qualitative in nature, such as design elements within Kansei Engineering [8].

Introducing dummy variables in Kansei Engineering requires special attention, since design elements are classified into two levels: each element (e.g. the colour of a beer can) corresponds to an item and each variation of an item (e.g. blue, silver, black) corresponds to a category. Table 1, partly taken from a study of Nagamachi [9], helps to understand this context

Table1. Corresponds to a category

	Item	1			2			3			…	R	Evaluation value
		Can Colour			Can Illustration			Label Shape					
	Category	1	2	3	1	2	3	1	2	3	…	C_j	
	Sample	Blue	Silve	Black	Anim	Symb	Other	Oval	Other	None			
	1	1	0	0	0	1	0	0	0	1			3,2
	2	0	1	0	1	0	0	1	0	0			4,1
	3	0	0	1	0	0	1	1	1	0	0		2,6
	⋮												
	n												

To include the classified design elements in the regression analysis, dummy variables are introduced as in the following:

$$\delta_{i(jk)} \begin{cases} 1\text{: when sample i corresponds to item j in category k} \\ 0\text{: Oterwise} \end{cases} \quad (1)$$

i =1, ..., n (n = number of samples)
j = 1, ..., R (R = number of items)
k = 1, ..., C_j (C_j = number of catogory for item j)

Consequently, for the item “can colour” in Table the coding would equal:

SAMPLE 1: “100”;
SAMPLE 2: “010”;
SAMPLE 3: “001”

This coding was only done for ease of demonstration. Considering the item color, a third category for cans being black would be redundant, since every can which is neither blue, nor silver has to be black (at least in the above table). Consequently, the correct coding for item color is “10” for the first sample [10].

This means if a category variable has k categories, k-1 dummy variables are needed to represent that variable. Otherwise a situation of perfect multi-collinearity would be created, as the dummy variables would be linear combinations of each other. The kth category is treated as the base level or reference category.

This reference category should be clearly defined and contain a sufficient number of cases to allow a reasonably precise estimation of its mean. With dummy variables, coefficients are not interpreted in isolation, but in connection to the reference category [11].

Taking these points into account, the resulting linear regression model for the category variable is:

$$\sum_{j=1}^{R}\sum_{k=1}^{C_j} b_{jk} \cdot \delta_{i(jk)} \quad (2)$$

Y_i is the observed value of the dependent variable. It stands for the semantic differential evaluation value on a Kansei word, which was explained above. The column on the right in Table 2, named “Evaluation value”, indicates the scores of the Kansei word “bitter”, taken from a hypothetical semantic differential analysis.

b_{jk} is called the coefficient of the dummy variable δ, indicating the relation of the dummy variable (design element) and the rated Kansei word Y_i, when all other variables are held constant.

As within all other linear multiple regression models, now, the task is to find a value for b_{jk} such that the difference between actual observation Y_i and prediction Y* is at a minimum. Or, to express it in the terms of Kansei Engineering, to accurately predict the influence of the items as well as of the categories on the customer feelings, expressed in Kansei words. This is achieved with the help of the least square method, which minimizes the squared prediction error ε [12]. Therefore, the following equations have to be solved:

Equation 1:

$$L = \sum_{i=1}^{n} \varepsilon_i^2 = \sum_{i=1}^{n} (Y_i^* - Y_i)^2 = \sum_{i=1}^{n} \left(\sum_{j=1}^{R}\sum_{k=1}^{C_i} b_{jk} * \delta_{i(jk)} - \sum_{j=1}^{R}\sum_{k=1}^{C_i} b_{jk}\delta_{i(jk)}\right)^2 \rightarrow min \quad (3)$$

and consequently $\frac{\delta L}{\delta b_{jk}} = 0$

This partial differentiation has to be solved for each b_{jk} and for each Kansei word separately. These calculations are performed with the help of standard computer software, hence the details of computing will not be given here. For further details see Matsubara et al. [13].

A sample of what is received as an output can be seen in Table 2

Table2. Hypothetical Output of a Conducted Quantification Theory Type I.

Item	Category	PCC	*not bitter* ← → bitter (-2, -1, 1, 2)
Can Colour	1. Blue 2. Silver 3. Black	0.302	1.1 -1.4 1.9

It is, on the one hand, the partial correlation coefficient (PCC) that indicates how much an item, for example the item colour, affects y, the Kansei word. In his beer can study [14] detected that the item colour has the largest PCC. This means that, in this context, the colour has the strongest relation to the Kansei word “bitter”. On the other hand, the category score corresponds to the coefficient of each category. This figure describes the influence of the categories within the item. A result might be that category black has the largest positive value, indicating a positive relation to the Kansei word “bitter” [15].

The third output of importance is the multiple correlation coefficient (MCC). It measures the overall accuracy of the equation. It can take values between zero and one. At zero there is no correspondence at all between the predicted and actual variable while at unity the coefficient indicates a perfect correspondence. MCC is written as R^2 and calculated by dividing the explained variation with the total variation. For applications in this context a R^2 value lower than 0.5 was considered as not reliable [16].

2.3. Non-linear models

The previously introduced mathematical models deliver a linear prediction model for the connection between the user's Kansei and the product properties. Consequently a linear correlation is presumed. However, these methods work well in many cases, but often human senses do not work linear, which can disturb the result. Figure 4 displays the sensitivity of the human skin over the actual temperature exemplarily, where full line actual human sensation, dashed line regression line.

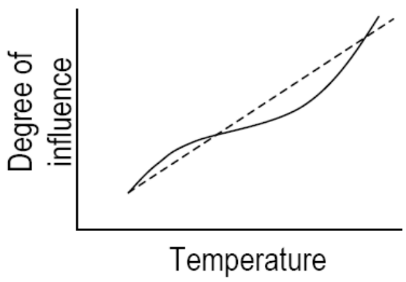

Figure 4: Example of non-linearity of human sensation. (adapted from Shimizu and Jindo, 1995).

The dashed line shows a linear regression line deflecting in many points significantly from the actual human sensation. Using e.g. QT 1 based on multiple linear regression analysis leads in this case with strongly varying human sensation to wrong results. It is, therefore, desirable to provide a procedure adapting better to these curves. Currently a number of different tools are developed adapting bended curves in a better way:

- Neural Networks (Ishihara et al. 1996)
- Fuzzy Logics (Shimizu and Jindo 1995)
- Genetic Algorithm (Nishino et al. 1999)
- Rough set analysis (Nishino et al. 2001)

3. CONCLUSIONS

Kansei data collection and analysis is often complex and connected with statistical analysis. Depending on which synthesis method is used, different computer software is used.

Kansei Engineering Software (KESo) uses QT1 for linear analysis. The concept of Kansei Engineering Software (KESo) Linköping University in (www.kanseiengineering.net) Sweden. The software generates online questionnaires for collection of Kansei raw-data Another Software package (Kn6) was devleoped at the Politechnical University of Valencia in Spain. Both software packages improve the collection and evalutation of Kansei data. In this way even users with no specialist compentence in advanced statistics can use Kansei Engineering

The process of refinement is difficult due to the shortage of methods. This shows the need of new tools to be integrated.

Software Tools for Kansei Engineering Kansei Engineering has always been a statically and mathematically advanced methodology. Most types require good expert knowledge and a reasonable amount of experience to carry out the studies sufficiently. This has also been the major obstacle for a widespread application of Kansei Engineering.

There are two different types of software packages available: User consoles and data collection and analysis tools. User consoles are software programs that calculate and propose a product design based on the users' subjective preferences (Kanseis). However, such software requires a database that quantifies the connections between Kanseis and the combination of product attributes. For building such databases, data collection and analysis tools can be used.

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Kansei engineering – o noua tehnica in dezvoltarea produselor de succes

Filozofia ingineriei Kansei are la bază teorii ştiinţifice si metode existente. Aspectle recente ale Ingineriei Kansei sunt axate pe compozitia si utilizarea instrumentelor din diferitele arii stiintifice ale ingineriei, psihologiei si matematicii. Lucrarea de faţa prezinta cateva din cele mai importante aspect, precum şi instrumente si tehnici ce pot fi applicate cu success in cazul analizei şi definirii performanţelor unui nou produs pentru creşterea şanselor de supravieţuire pe piaţă.

Cuvinte cheie:, *Kansei, Ingineria Kansei, Semantică, Quantificare.*

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