Kansei Engineering Analysis on Mobile Phone Design

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1. Introduction

The mobile phone is one of the most growing and developing products. Its functionality is rapidly expanding to the web browser, e-mail and receiving broadcasting, beyond speech communication. The design of mobile phone is ever changing along such evolution.

This paper shows Kansei evaluation experiments and how various analysis methods are applied to Kansei evaluation data.

Kansei engineering is a method to convert a customer's ambiguous image of product into a detailed design. To obtain relations between Kansei and design details, several analyses must be made to determine which types of external appearances and functionality produce what type of feelings.

2. Kansei data analysis

At first step, we counted design elements of mobile phone on all models sold in Japan at that time. Design variables (also called design items) are at least 18 (i.e. body color, number of speaker hole). Each item has several variations. Sum of variations is up to 81. If design items and variations are not so many, we usually use the linear multiple regression model for analyzing relations between design and Kansei. When too many variables are entered to regression model, analyzing result becomes meaningless and not reliable. This is the case.

Obviously, some design items have associations with Kansei, but many others do not have. We decided to use other multivariate analysis techniques for finding "definitive" design items. Then identified a reduced set of important design items are entered to multiple regression model.

At first, we use clustering analysis by our neural network. As a result, noteworthy design items are identified. Next, we use principal component analysis for analyze Kansei structure and representative Kansei words. At last, we use the linear regression model on reduced design variable. Since significant design items are identified by prior analyses, obtained model is accurate.

3. Kansei evaluation and data analyses on mobile phone

3.1 Kansei evaluation experiment

We conducted an experiment for evaluating mobile phone samples on a 5-points SD scale. Sixty-one mobile phone sample pictures were collected, and were used for evaluation experiment using questionnaire. These sample pictures covered around 70 % of mobile phones that are selling at spring of 2000.

Fourteen subjects participated who were women students of college, and at age 19 or 20. Eighty-three adjective words (Kansei words) were used for evaluation with the SD scale. The words proper to mobile phone are chosen from frequently appeared words on phone catalogues. Other words are our standard Kansei words for doing experiments.

Each subject has seen the sample on color adjusted computer display, marked her impression on SD-scale pair of Kansei words.

3.2 Clustering of mobile phone by arboART

At the first stage of Kansei data analysis, we use cluster analysis for understand overall characteristics of evaluation samples and Kansei words.

(1) arboART

In this research, we use our neural network based clustering algorithm arboART (Ishihara et al., 1995) as a hierarchical clustering algorithm. ArboART consists ART1.5-SSS, our modified version of ART1.5 for small sample size clustering. In Ishihara et al. (1995), we have shown this modification enables right classification.

Basic idea of arboART is using the prototype formed in an ART network as an input to other ART that has looser distance criteria. By sending prototype vectors made by ART to one after another, many small categories are combined into larger and more generalized categories.

We can draw dendrogram using classification records of sample and categories. A Cluster prototype of ART1.5-SSS provides features of cluster. On Kansei evaluation data, it provides specific relations between product and Kansei. Ishihara et al. (1999) compared clustering ability of arboART with several clustering algorithms. As a result, we confirmed that clustering ability of ArboART is better than conventional algorithms. The detail of
ART1.5-SSS and arboART is shown in our another paper in this proceedings (Ishihara et al., 2001).

(2) Analysis of Kansei evaluation data by arboART

Averages of evaluations between subjects were used as an input vector on a sample. Each element of the input vector corresponds to an evaluation of each adjective word, so the input vector has 83 elements, and there are 61 input vectors. We used arboART consisted of 4 layers of ART1.5-SSSs.

Various samples are hierarchically grouped by its pattern of subjects' response to products. At the third ART1.5-SSS, 3 large clusters, 3 small clusters and 20 singleton (one member) clusters are made.

When analyze Kansei evaluation data with cluster analysis type method, we can see common design features between samples in a cluster. The design features are definitive for higher rated Kansei of the cluster.

At first large cluster, classified samples have large sized LCD (longer height than width) or medium sized LCD (around square). Large valued evaluation Kansei word from the cluster's prototype vector is, easily viewable. High-rated Kansei words in sub clusters are also shown. Right side cluster has high on easily viewable, simple, calm. Left side cluster is easily viewable, bright, calm.

At second large cluster, many samples have small to medium sized LCD. In this cluster, sub-cluster located upper side should be regarded. They correspond to plain, simple, formal.
In another large cluster, members are colored in silver pink, silver orange, silver purple. They are bright, feminine, tender.

In a small cluster, they have large value on durable, curvy, sporty. They have shaped stick body which is wider in LCD panel part. There are many singleton clusters and some examples are shown in below. An example is water-proofed body and has metal ring around LCD panel which reminds diver's watch. Another example has metallic light blue body. Unique features of singleton cluster-ed phones seem idiosyncratic to each model.

3.3 Kansei structure analysis by Principal Component Analysis
After measurement by SD scales of many Kansei words, principal component analysis or factor analysis is used for compressing information into a smaller number of synthesized variables and for finding axes of semantic space. This procedure is called analyzing Kansei structure.

Then, Kansei words are mapped in the Kansei structure based on their principal component loadings (or factor loadings). Similar Kansei words are grouped together. As a result, we obtain a basic structure of Kansei and word groups.

In this analysis, we used principal component analysis. We decide 3 major principal components (PC) by “Knee method” (finding abrupt change of eigenvalue) and rotated PC loadings. Rotated PC loading of each Kansei word is shown in figure 5.

On the first principal component (PC1), Kansei words that have positive large loadings are feminine, bright, soft, pretty, cute and so on. The right side of the figure is corresponding to such Kansei words. Words that have negative large loadings are masculine, square, dark, stiff. We can call PC1 as an axis of softness in both physical and gender image.

On the second principal component (PC2), words that have positive large loadings are varied, individual, creative, unique and so on. Negative loading words are plain, basic and simple. PC2 is an axis of impressive-ness.

On the third principal component (PC3), positive loading words are good sense, refined, cool, urban and so on. Negative loading words are inelegance, uncool and coarse. PC3 is an axis of refine-ness. We found Kansei structure on mobile phone has 3 components, soft-hard, impression and refine. Blending and balancing between these 3 factors may determinant of mobile phone design.

3.4 Analysis of relations between design elements and Kansei by Quantification Theory I
At the final stage of analyses, we use quantification theory I. Chikio Hayashi’s Quantification Theory type I is a computing procedure of multiple regression analysis with categorical variables. Evaluation value on a Kansei word is assigned to Y variations of design elements are assigned to Xi.

Most of variations of design items have categorical value (i.e., Shape and colors of body shell). To express categorical variable in linear regression model, each variation of a variable is assigned to one dummy variable. (More properly, the number of dummy variable
is number of variation –1 at each design item. This is to avoid failure of computing caused by complete interdependency of dummy variables.)

The shortcoming of this method is involvement of many dummy variables to express categorical value. In our initial study, mobile phone has 81 categories, which is total number of design categories of categorical variables. Now we can reduce the number of design variables those have significant relations. Design items incorporated in QT 1 are; Size of LCD panel, Body color and Body Shape.

On Kanssei words from clustering result;

- Easily viewable is associated only on LCD panel size. Larger panel has positive effect, smaller has negative effect to the rating. Simple is associated on smaller LCD panel. Durable is carved stick shape.
- These results are compatible with clustering by arboART.

On Kanssei words from Kanssei structure;

- Feminine, Bright and soft associate with colors of Silver Blue, Pink, Light Gold, Silver Orange and Silver purple. These are also compatible with clustering. Masculine associates with small LCD, silver, black and blue.
- Varied associates with colors of Black, Silver Orange, Dark Blue and Shaped stick type body. Creative associates with colors of Silver Blue, Black, Silver Purple and Slide lid.
- Good sense associates with Full flip type body (two fold) or Slide lid.

4. Conclusion

In this research we have developed methodology to analyzing overabound numbers of design elements in linear model. Cluster analysis by arboART helps finding definitive design elements and Kanssei words. Principal component analysis reveals Kanssei analysis and implications to Kanssei structure. Using the results of these analyses, we had multiple regression analysis on reduced essential set of design elements and set of Kanssei words.

Meanwhile, variable selection methods of regression analysis are developed and used in practical field. Such automated methods could not easily applied to Kanssei data. In this mobile phone case, there are many outliers which has unique colors. In regression analysis,