Title:
A Method for Supporting Aesthetic Design based on the Analysis of the Relationships between Customer Kansei and Aesthetic Element

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Introduction:
Due to maturation of science and technology, it becomes increasingly difficult to differentiate products in terms of performance, functional feature or price and companies are required to differentiate their products in terms of subjective and abstract qualities such as aesthetic and comfort that are evaluated by customer feeling i.e. kansei.

In the field of emotional engineering or kansei engineering, the methods for measuring customer kansei or customer's kansei evaluation have been developed and applied to many case studies. In these methods, an impression of a product is evaluated using adjectives named "Kansei words" on a scale of 1 to 5. In addition to measurement, Methods for supporting aesthetic design have been developed since evaluation of product aesthetics heavily depends on customer kansei. Design support methods using interactive reduct evolutionary computation or interactive genetic algorithm are such examples [3],[5]. These methods generate the aesthetic design which a customer prefers the best by analyzing the relationships between the results of customer's kansei evaluation and aesthetic elements of existing products. Design support method using rough set theory has also been developed [4]. In the field of CG or CAD, formulation and application of aesthetic curves and surfaces have been studied [2].

In this research, we develop a new aesthetic design support method using customer's kansei evaluation. The feature of the proposed method is to construct a tri-level model that represents the relationships between customer's kansei and product aesthetics. The model consists of two-level of customer kansei and aesthetic elements. Some researches classify kansei words into lower, middle and upper level from the standpoint of level of abstraction. A lower level kansei word is concrete and closely connected with human perception while an upper level kansei word is abstract and integrative. A middle level kansei words is between them. It is said that an upper level kansei words is highly individual. The proposed method use upper and middle level kansei words. To construct a tri-level model, in addition to evaluation of product aesthetics using middle level kansei words, evaluation of upper level kansei words using middle level kansei words is also conducted. After two types of evaluations, the model is constructed using self-organization map (SOM) [1] and traditional artificial neural network (ANN). Another feature is to visualize the similarity of upper level kansei words by analyzing the relationships between upper and middle level kansei words using SOM. The visualized relationships are named "Kansei space". Kansei space helps a customer understand the similarity of upper level kansei words and express customer needs by indicating only one point on the kansei space. Finally, the proposed method explores the optimum aesthetic elements that best fit to customer needs using GA. In the case study, the proposed method is applied to office chair design to confirm its

effectiveness.

Proposed method:
Fig. 1 shows the overview of the proposed method.

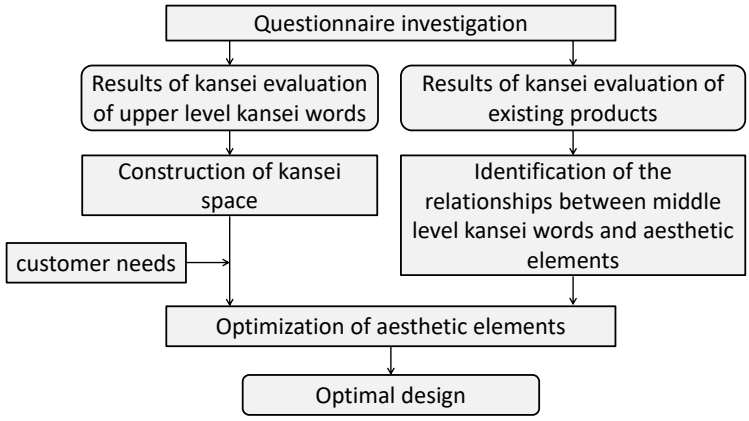

Fig. 1: Flowchart of the proposed method.

Preparation of the proposed method
A user of the proposed method prepares photos of existing products for questionnaire and selects upper and middle level kansei words and aesthetic elements suited for the targeted product. Parameters of aesthetic elements of selected products are measured. The proposed method can consider both discrete (selective) and continuous parameters.
Step1: Questionnaire investigation
A customer evaluates his / her impression of presented products by using middle level kansei words on a scale of 1 to 7. A customer also evaluates his / her impression of upper level kansei words in the same manner.
Step2: Construction of a tri-level model
Based on the questionnaire results, a tri-level model is constructed.

As for the relationships between upper and middle level kansei words, similarity of upper level kansei words is analyzed and visualized from the questionnaire results (the evaluation results of upper level kansei words) by using SOM. The visualized map is named "Kansei space". Fig. 2 shows an example of a kansei space.

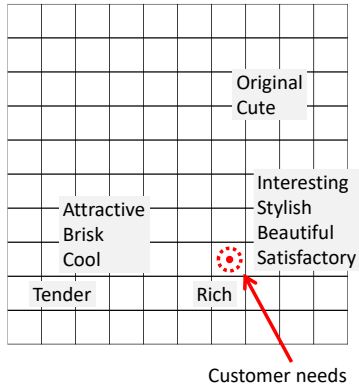

Fig. 2: Example of a kansei space.

As for the relationships between middle level kansei words and aesthetic elements, they are identified from the questionnaire results (the evaluation results of existing products) by using traditional ANN. A network consists of three layers. Nodes of input layer correspond to parameters of aesthetic elements while nodes of output layer correspond to values of middle level kansei words. The questionnaire results are used as training data.

Step3: Input of customer needs

A customer indicates the point on the kansei space that represents the impression which he / she hopes to receive from a new product, as shown in Fig. 2. Since each point on the kansei space have the values of middle level kansei words, the customer need is translated to the values of middle level kansei words.

Step4: Optimization of aesthetic elements

The optimum parameters of aesthetic elements are explored by using GA. Fitness function of GA is formulated as follows.

$$f(p) = Minimize \sum_{k=1}^{K} (C_k - c_k(p))^2$$

Where, p is parameters of aesthetic elements of a design proposal. C_k is the target value of middle level kansei word k. c_k (p) is the value of middle level kansei word k estimated from p by using the constructed network. K is the number of middle level kansei words.

Case study:

To test the effectiveness of the proposed method, the proposed method is applied to office chair design. 8 undergraduate students participate as subjects.

Details of the case study

Outer shape and thickness of a back and a seat and type of a leg and an armrest are considered as aesthetic elements of a chair. Outer shape of a back and a seat is represented by B-spline curve. Coordinates of their control points are used as parameters of aesthetic elements. As for a leg, 4-leged or 5-leged can be selected. As for an armrest, a chair with an armrest or without an armrest can be selected. To wrap up, 28 parameters of coordinates of control points, 2 parameters of thickness of a back and a seat, 2 parameters of types of a leg and an armrest are defined. 11 words (brisk, tender, cool, cute, stylish, attractive, beautiful, rich, original, satisfactory, interesting) are selected as upper level kansei words, while 9 words (easy to sit down, formal, simple, steady, sharp, fancy, masculine, mature, sophisticated) are selected as middle level kansei words. 30 office chairs are prepared for questionnaire. These are virtual model designed by using the above parameters.

Results

8 subjects individually participate in the experiments and 8 office chairs are generated. Fig. 3 shows their examples. After the experiment, they evaluate their own chairs on a scale of 1 to 5. Fig. 4 shows their evaluation results, which indicate the effectiveness of the proposed method.

Fig. 3: Examples of generated office chairs.

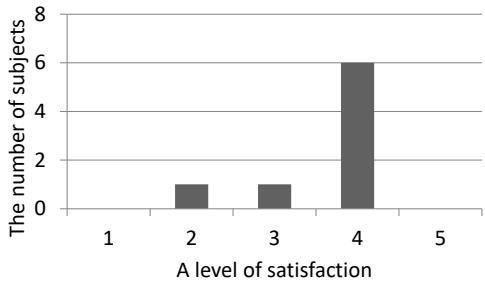

Fig. 4: Evaluation of generated office chairs.

Conclusion:

To support aesthetic design, a new aesthetic design support method using a tri-level model and a kansei space. A tri-level model consists of upper and middle level kansei words and aesthetic elements and shows their relationships. The model is constructed by analyzing questionnaire results (evaluation of existing products using middle level kansei words and evaluation of upper level kansei words using middle level kansei words) using SOM and ANN. A kanse space shows the similarity of upper level kansei words and helps a customer express his / her needs. The space is also constructed by analyzing questionnaire results. A new design that best fits to the customer need is explored by using GA. In the case study, the proposed method is applied to office chair design and its effectiveness is confirmed.

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