A PROPOSAL OF THE *KANSEI* STRUCTURE VISUALIZATION TECHNIQUE FOR PRODUCT DESIGN

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ABSTRACT

In the process of product design, understanding just only the impression of a whole design target, but the features of locally existing impressions in the design is an important issue. Considering these impressions at the same time is however difficult using the conventional *Kansei* engineering approaches. This paper proposes a novel visualization technique, called *Kansei* structure visualization technique. The visualization clarifies the distribution and intensity of the impressions existing in a single design. It also illustrates the difference between the impression of a whole design and the impressions of each location in the design. As the first phase of the visualization procedure, *Kansei* evaluation experiments are conducted to investigate the impressions existing in a design target. Based on the results of the evaluation, *Kansei* scores are allocated for each location in the target. The visualization phase illustrates the scores using colours and their density. The visualization results are finally overlaid on a picture of the target design. This paper also introduces two visualization simulations for an automobile design as an example. The simulations demonstrate that the visualization is useful to determine the locations where design elements need to be repaired. The proposed technique will be an effective decision making tool to improve existing design plans.

Keywords: *visualization*, *impression*, *Kansei evaluation*, *product design*

1. INTRODUCTION

Kansei engineering [1] is a technique to translate target psychological responses into perceptual design elements, and vice versa. The technique has been extensively applied in the field of product design, which includes car interior, office chair, and mobile phone designs. In the *Kansei* engineering approaches, design elements are decided such that a whole design target achieves the

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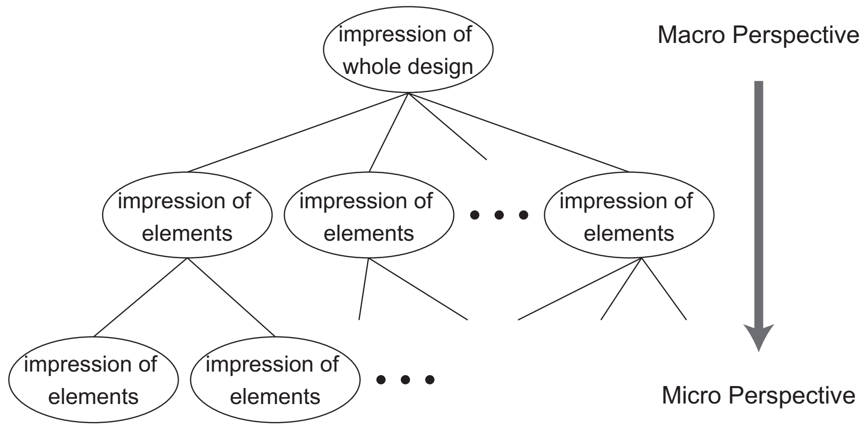

Figure 1: Impression of a whole design (from *macro* perspective) and impressions of its constituting elements (from *micro* perspectives).

desired impression. In this case, the impression of the design target is evaluated from a *macro* perspective. Since small-sized design elements (e.g., door handles in an automobile design) do not affect strong impact to the impression of a whole design, those elements tend to be ignored in this conventional approach. However, the small elements also evoke specific impressions when the elements themselves are focused on. Every constituting design part or element actually has its own impression as shown in Figure 1. When a product is in use, there is no guarantee that users always look at the whole design. The design of the product is usually looked from various perspectives. In a product design process, the impressions from various *micro* perspectives, in addition to the impression from *macro* perspective, therefore need to be considered.

For this problem, the visualization of locally existing impressions will be one of the useful methods to understand the distribution of the impressions existing in a whole design target. Although several studies regarding the visualization of impressions have been reported [2, 3], these visualizations are based on the impressions of multiple targets and visualize the relationship between the targets. In this paper, a novel technique, called *Kansei* structure visualization technique, is proposed to visualize locally existing impressions and their locations in a single design using colours. This paper also applies those techniques to automobile designs as an example.

2. *KANSEI* STRUCTURE VISUALIZATION TECHNIQUE

2.1. Procedure

Figure 2 shows the procedure of the *Kansei* structure visualization technique. First, *Kansei* evaluation experiments are conducted to investigate the impressions existing in a design target. Based on the results of the experiments, *Kansei* scores are allocated for each location in the target. The interpolation phase allocates *Kansei* scores for the locations where the score is not allocated by the results of the experiments. The visualization phase finally assigns a colour to each location based on the *Kansei* scores, one by one.

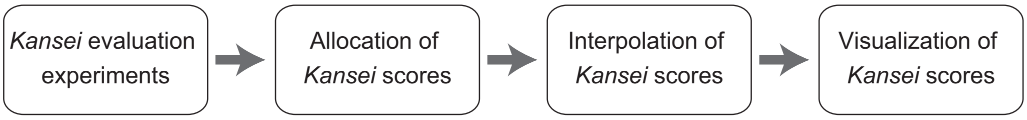

Figure 2: Procedure of the *Kansei* structure visualization technique.

Figure 3: Examples of the evaluation target in *Kansei* evaluation experiments.

2.2. *Kansei* evaluation experiments

As the first phase of the visualization, *Kansei* evaluation experiments using the SD (semantic differential) method [4] are conducted to investigate the impressions of a design target. In the traditional *Kansei* engineering approach, subjects usually evaluate the impression of a whole design target using *Kansei* words. In this approach, subjects also evaluate the impressions of many small design elements constituting a single design target separately. Since this study deals with an automobile design as an example, the subjects evaluate the pictures of car design elements such as a hood, headlights, door handles, wheels, taillights et cetera from various perspectives as shown in Figure 3. Through the evaluation experiments, each picture acquires its own evaluation scores. With respect to each pair of *Kansei* words, the average of the evaluation scores by all subjects is adopted as the *Kansei* score for the picture.

2.3. Allocation of *Kansei* scores

Based on the *Kansei* scores for the pictures, the scores are allocated for each location in the design target. The scores for each sample picture express the evaluation for the elements shown inside the picture. The *Kansei* score with respect to each pair of *Kansei* words is therefore allocated to the locations corresponding to the elements in the picture.

Since the *Kansei* evaluation uses pictures taken from various perspectives, some certain locations may be included in two or more pictures. These pictures could be evaluated with different *Kansei* scores even though the pictures commonly include the same location. This is caused by the location to which the subjects paid attention when the evaluation is made. The fact that a single location has multiple different *Kansei* scores is however not desired to conduct the visualization process easily. It is required to integrate those scores and assign a single *Kansei* score for each location with respect to each pair of *Kansei* words. For this problem, this study defines a parameter of the *degree of confidence* that expresses the probability that a certain location in a picture adopts the *Kansei* score for the picture. The parameter is assigned with the range of [0, 1] for each location. It is considered that subjects pay attention to stand out locations in a picture throughout the *Kansei* evaluation. Thus, it is possible to assign the degree of confidence simply such that locations around the centre of pictures and/or zoomed locations in pictures become higher values.

(a) Picture focusing on headlights (b) Picture focusing on a hood

Figure 4: Two different pictures including the same headlight.

For example, Figure 4(a) is a picture focusing on headlights of a car while Figure 4(b) is focusing on a hood. Figure 4(b) however includes the same headlights included in Figure 4(a). In this case, the *Kansei* scores for the location of the headlights are allocated from both pictures. The degree of confidence for the location of the headlights is assigned to have higher values in Figure 4(a) and lower values in Figure 4(b).

Another possible method to assign the degree of confidence is based on eye tracking. Subjects are supposed to move their eyes and gaze several locations throughout the *Kansei* evaluation. The degree of confidence can be assigned according to the fixation time of the gazing. The gazing locations with longer fixation time take higher values.

Based on the assigned degree of confidence, the *Kansei* score for the location l is finally determined as the weighted average of all the *Kansei* scores for the pictures including the location l. When the location l is included in n pictures, the *Kansei* score of the location l for the *Kansei* word k is expressed as

$$S_{lk} = \frac{\sum_{i=1}^{n} e_{ik}\, p_{il}}{\sum_{i=1}^{n} p_{il}} \tag{1}$$

where e_{ik} and p_{il} represent the *Kansei* score of the picture i for the *Kansei* word k and the degree of confidence for the location l in the picture i, respectively.

2.4. Interpolation of *Kansei* scores

After the allocation phase, the locations included in the sample pictures used in the *Kansei* evaluation have a single *Kansei* score S_{lk} for each pair of *Kansei* words. On the other hand, *Kansei* score is not allocated for the locations that are not included in the pictures. It however can be considered that this kind of location evokes specific impressions as well. This phase therefore allocates *Kansei* scores for those locations by linear interpolating where required.

2.5. Visualization of *Kansei* scores

Through the allocation and interpolation phases, *Kansei* scores S_{lk} $(k = 1, 2, 3, \ldots, m)$ is allocated for each location l constituting the whole design target. The visualization is conducted by assigning a colour to each location l based on the allocated *Kansei* evaluation scores. The assigned colours are finally overlaid on a picture of the target design. This paper describes two

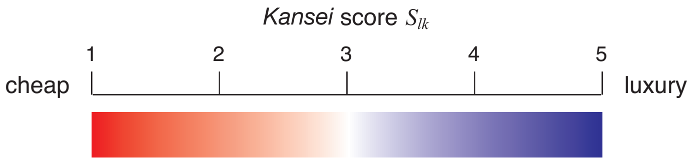

Figure 5: Colour mapping for *Kansei* evaluation scores.

methods for the colour assignment.

2.5.1. Method A: Visualization of the distribution and intensity of impression

The first method represents the distribution and intensity of any single impression using colours and their density. The location l in the design target has m *Kansei* scores when the *Kansei* evaluation is conducted using m pairs of *Kansei* words. From these *Kansei* scores, this method only focuses on the score of a single pair of *Kansei* words. A *Kansei* score allocated for each location is simply mapped to a colour, one by one. Assuming that the five-point SD scale $\{1, 2, 3, 4, 5\}$ is used in the *Kansei* evaluation, red and blue colours are mapped for the location l when the *Kansei* scores S_{lk} are '1' and '5,' respectively. Figure 5 shows the mapping example for the *Kansei* words *cheap—luxury*. Since this method only consider the impression expressed by a single pair of *Kansei* words, the result of the visualization varies depending on the selected pair of *Kansei* words.

2.5.2. Method B: Visualization of the differences between the impression of a whole design and the impressions of each location in the design

The second method considers the *Kansei* scores for all the pairs of *Kansei* words at the same time. The visualization represents the difference between the impression of the whole design and the impressions of each location in the design using a colour and its density. Unlike Method A, this method therefore requires not only the *Kansei* scores of each location in the design but the *Kansei* score of the whole design. When the *Kansei* evaluation is conducted using m pairs of *Kansei* words, the impression of the whole design will be plotted in an m-dimensional space. The impression of the location l in the design is also plotted in the same space. Here, the difference between these two impressions is expressed by the Euclidean distance in the m-dimensional space. The distance is directly mapped to the density of a colour. The difference between the impression of the whole design and the impression of the location l is expressed as

$$D_l = \sqrt{\sum_{k=1}^{m} (S_{lk} - S_{\mathrm{w}k})^2} \tag{2}$$

where $S_{\mathrm{w}k}$ and S_{lk} represent the *Kansei* score of the whole design for the *Kansei* word k and the *Kansei* score of the location l for the *Kansei* word k, respectively. The distance D_l is firstly calculated for all the locations in the design. From those D_l values, the maximal value is defined as $D_{\max}$. For this visualization, red colour is mapped for the distance $D_{\max}$ while transparent colour is mapped for the distance '0' as shown in Figure 6.

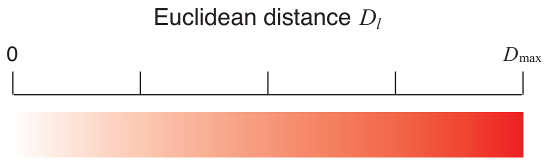

Figure 6: Colour mapping for Euclidean distances in a multi-dimensional *Kansei* space.

Figure 7: Visualization simulation of Method A.

3. RESULTS AND DISCUSSIONS

Figure 7 shows an example of the visualization simulation of Method A. Note that the *Kansei* scores used in this visualization example are virtual scores and are not acquired from actual subjective *Kansei* evaluation. This method focuses on a single impression and illustrates the intensity of the impression using colours. This visualization is suitable for the design modification process with a single concept, and is able to identify the location where design elements need to be repaired. When the concept of the design target is expressed by a *Kansei* word, the locations that have the impression suited for the concept are visualized as dense blue colours (or sometimes dense red colours). In this case, pale colours and colours with different hue indicate the locations where the concept impression is relatively weak and where the impression is different from the concept, respectively.

Figure 8 shows an example of the visualization simulation of Method B. This method illustrates the differences between the impression of a whole design and the impressions of the elements constituting the design. When the concept of the whole design target is expressed by multiple *Kansei* words, the locations that have the impression different from the concept are visualized as dense red colours. In the process of product design, the realization of comprehensive and consistent impression for the entire design is one of the most important issues. It is therefore required to repair the design indicated by dense red colours with the attention to the concept of the whole design. The repair result will eventually achieve a desired design with a consistent concept.

Here, the features of this visualization technique as well as the relation with the conventional *Kansei* engineering approaches [1] are discussed. The design process in *Kansei* engineering is usually based on the analysis of how perceptual design elements affect the impression of a whole design target. This therefore has an advantage for creating a new product based on a specific design concept. Jindo and Hirasago [5] applied *Kansei* engineering to the design of a speedometer for automobiles. The study conducted *Kansei* evaluation of various types of speedometers, and an-

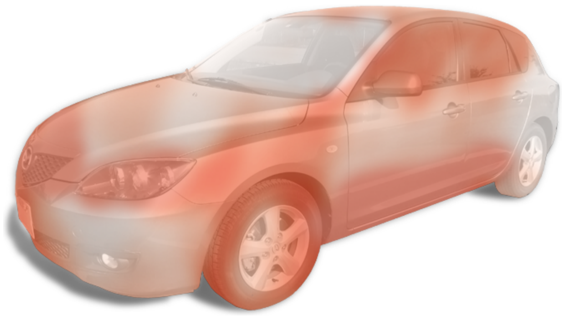

Figure 8: Visualization simulation of Method B.

alyzed the relationship between the impression of a whole speedometer and elements constituting the speedometer, such as a panel, a pointer, lettering et cetera, using the quantification theory [6]. In addition to the speedometers, the application to seat design is also reported [7]. These applications commonly deal with a part of automobile design. When the number of design elements constituting a design target is large (e.g., the case of an entire automobile design), it however is difficult to conduct the quantification analysis using all design elements at the same time. It therefore can be said that the design targets to which *Kansei* engineering can be applied are limited when the scale of design targets is considered.

On the other hand, the approach of the visualization technique proposed in this paper is based on the impressions from *micro* perspectives. This focuses on the impressions of each small element constituting a whole design, as opposed to the impression of a whole design. This technique facilitates the process of understanding the existence of local impressions as well as their distribution (i.e., continuous or discrete), intensity and transformation in a single design target. Unlike the conventional *Kansei* engineering technique, this technique is not intended to create a new design. This visualization is intended to be used for existing designs and to determine the locations where design elements need to be modified. Since this technique directly considers the impression of each element in a design target, it is not required to consider the affect of those elements to the impression of the whole design. The technique can be easily applied to various types of design targets even if the number of design elements in a design is large.

From the different features of the conventional *Kansei* engineering [1] and the proposed visualization technique, the following new design flow can be evolved.

1. Applying the visualization technique to a design target with a large number of design elements.
2. Determining locations where design elements to be modified.
3. Creating a new design for the determined locations from the approaches of *Kansei* engineering.

Since this design flow firstly narrows down the applicable scope of *Kansei* engineering, new modified designs will be efficiently created even for the design target with a large number of constituting elements.

4. CONCLUSIONS

This paper proposed a novel visualization technique, called *Kansei* structure visualization technique, to clarify locally existing impressions and their location in a whole design using colours. The visualization technique consists of the four phases: *Kansei* evaluation experiments, allocation of *Kansei* scores, interpolation of *Kansei* scores and visualization of *Kansei* scores. This paper also introduced two visualization simulations for an automobile design as an example. The first visualization clarified the distribution and intensity of the impressions existing in the design while the second visualization illustrated the difference between the impression of the whole design and the impressions of each location in the design. The simulations demonstrated that the visualization were useful to determine the locations where design elements need to be repaired. In the field of product design, the proposed technique will be an effective decision making tool to improve existing design plans.

In the future works, the present authors will apply this proposed technique to other types of target, and discuss the validity and practicability of this technique in detail.

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REFERENCES

[1] Nagamachi, M., *Kansei* Engineering: A new ergonomic consumer-oriented technology for product development, *International Journal of Industrial Ergonomics*, 15(1): 3–11, 1995.

[2] Ryoke, M. and Nakamori, Y., Kansei visualization system using fuzzy correspondence analysis, *In Proceedings of the 8th International Symposium on Knowledge and Systems Sciences*, 140–147, 2007.

[3] Nakakoji, K., Yamamoto, Y., Sugiyama, K. and Takada, S., Finding the "right" image: Nisualizing relationships among persons, images and impressions, *In Proceedings of the IFIP Conference on Designing Effective and Usable Multimedia Systems*, 91–102, 1998.

[4] Osgood, C. E., Suci, G. J. and Tannenbaum, P. H., *The Measurement of Meaning*, University of Illinois Press, Urbana, IL, 1957.

[5] Jindo, T. and Hirasago, K., Application studies to car interior of Kansei engineering, *International Journal of Industrial Ergonomics*, 19(2): 105–114, 1997.

[6] Hayashi, C., On the prediction of phenomena from qualitative data and the quantification of qualitative data from the mathematico-statistical point of view, *Annals of the Institute of Statistical Mathematics*, 3(2): 69–98, 1952.

[7] Nakada, K., Kansei engineering research on the design of construction machinery, *International Journal of Industrial Ergonomics*, 19(2): 129–146, 1997.