

A Visualization Method of Kansei Texture and Its Individual Difference

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Abstract: A visualization method of Kansei Texture is proposed, and its individual difference is analyzed by a t-test in statistical method. By introducing the proposed visualization method to online shopping site screen, buyers recognize goods as in the same manner as that in real shopping, where individual difference analysis of Kansei Texture provides advices about merchandise strategy for both buyers and sellers. A questionnaire experiment is done for 17 subjects by showing the conventional online shopping web site and the proposal site using Kansei Texture visualization, and 18.7% applicability of the proposal in online shopping rather than conventional is confirmed. A subjective evaluation experiment is also done for 17 subjects and 20 goods, and the result of parametric t-test is $P < 0.05$. The proposals are planning to be extended to visualize higher order individual difference by applying fuzzy sets.

Keywords: Kansei/Affective-engineering, online shopping, visualization, t-test

I. Introduction

In online shopping, buyers can easily purchase various kinds of products anytime and anywhere but they have to guess the sensation of the product from photos, price, specification, user reviews, and so on. On the other hand, when buyers purchase a product in a real shop, they actually may see, take it in their hands, and they will select suitable one based on their own feeling. In order to decrease these information gaps, Kansei Texture which adds new information on the conventional online shopping is proposed [1]. To understand Kansei Texture information easily by general people, visualization of Kansei Texture and its verification is important but not much investigated. And existence of individual difference of Kansei Texture is also shown [2], but it has not been studied enough, too.

The Kansei Texture is represented in 3-dimensional $[-1,1]^3$ space compressed from 5-dimensional $[-1,1]^5$ space, i.e., roughness, hardness, dryness, warmth, and glossiness, and

Kansei Texture of a product is shown by the combination of values on 3 axes, i.e., "PuruPuru - GotsuGotsu", "KachiKachi - FuwaFuwa", and "ButsuButsu - PikaPika". It is expected to get the texture information of products easily like touching them in real shops. As a solution of this demand, a Kansei Texture of the visualization method is established by assigning an appropriate geometric element to each axis by considering the property of each axis and its illustration program is provided. By the program, Kansei Texture illustration is generated based on 3-dimensional input vector information in $[-1,1]^3$. The Kansei Texture illustration is added to the online shopping web site in order to help buyers to guess tactile sensation of the product. By evaluating buyers' feeling about the proposed Kansei Texture illustration, it is verified whether Kansei Texture of the proposed online shopping site is recognized as in the same manner as that in real shopping rather than that in the conventional site. Furthermore, existence of individual difference for Kansei Texture appeared in individual feeling is confirmed by the result of the subjective evaluation experiment. The distribution of individual difference for Kansei Texture is analyzed and it is concluded that Kansei Texture has a possibility to be expressed by property of normality for the sake of simplicity.

Buyers easily obtain Kansei Texture information by the illustration added to conventional information, and recognize Kansei Texture feeling which is obtained at the real shopping, and such information may be useful for buyers to search or to select suitable products. When the individual difference of Kansei Texture is shown to buyers, they may request sample sending to confirm fitness of the good, and sellers may make a strategy for return-goods. If the degree of individual difference is small, then buyers may make a decision smoothly and sellers may concentrate on other goods. The information of individual difference is utilized to operate online shopping effectively.

Subjective evaluation experiment is done for 17 subjects and 20 goods by showing conventional virtual online shopping

website, proposal, and real shopping by touching real object. The degree of Kansei Texture feeling by subjective evaluation using these virtual shopping sites is compared to that of real shopping, the effect of the proposed method is confirmed. Analysis of distribution of individual difference for Kansei Texture is done by using t-test for the statistical data of the subjective evaluation appeared in individual feelings. In II, the definition of Kansei Texture is detailed. A visualization method of Kansei Texture is presented in III. In IV, subjective evaluation of Kansei Texture illustration, where application to online shopping added Kansei Texture illustration is given. In V, the importance and treatment of individual difference in Kansei Texture is discussed.

II. Definition of Kansei Texture

When buyers purchase a product in the shop, they actually can observe and take it in their hand, and they can select suitable one based on their sensation about the value, the tactile sensation, the textures, and so on. In online shopping, however, they have to guess its sensation from some photos, a price, a specification, a review, and so on. It means that they can check and select one using a lot of information that they can actually feel in the real shop than in online shop. That indicates the existence of information gap between real shop and online shop. In the future online shopping, the technology which decreases the information gap between the real shopping and the online shopping becomes important for checking or selection of the suitable products for buyer's individual feeling.

In order to decrease the gap of this information, Kansei Texture which adds new information on the present online shopping screen is proposed [1]. The Kansei Texture is defined as the quality index of the feeling information on the tactile or vision sense when people see the photo of a product or a real object. The Kansei Texture is represented in 3-dimensional [-1,1]³ space condensed from 5-dimensional [-1,1]⁵ space.

At first, many kinds of expression terms are collected from the photos of the products. They are mainly concerned with the feeling felt when seeing or touching a product is carried out, are mostly onomatopoeia in Japanese language, and are called Kansei Texture expression terms. For example, a Kansei Texture expression term where the surface is elastic, smooth, and soft is "PuruPuru", and hard/ rough touch is expressed by "GotsuGotsu". The Kansei Texture expression terms are language dependent and the original study [1] has been done in Japanese language, where total 120 Kansei Texture expression terms are collected. Each of 120 Kansei Texture expression terms contains the amount of feelings which are extracted from the photos by individuals (Figure 1).

[Sensitivity]

- Completely Yes : 1.0
- Yes : 0.5
- Don't Know : 0.0
- No : -0.5
- Completely No : -1.0

[Confidence]

- Surely : 1.0
- About : 0.5
- Irresponsible : 0.0

By investigating various texture studies [3]-[8], the amount of feelings are characterized by 5 tactile sensations in [-1, 1] scale, i.e., roughness, hardness, dryness, warmth, and glossiness. A subjectivity evaluation questionnaire is done by using the sheet shown in Figure 2, where the sensitivity in 5 grades and the confidence in 3 grades are represented in [-1,1] and [0,1], respectively. The Kansei Texture expression terms are expressed in 5-dimensional [-1,1]⁵ through the questionnaire. The questionnaire is carried out by 50 subjects.



Figure 1. Extraction of Kansei Texture expression terms

KANJI TEXTURE expression terms	Tactile sensation	Sensitivity			Confidence			
		Completely No	Don't Know No	Yes	Completely Yes	Irresponsible	About	Surely
PuruPuru	Roughness	Smooth				Rough		
	Hardness	Soft				Hard		
	Dryness	Wet				Dry		
	Warmness	Cold				Warm		
	Glossiness	No Gloss				Strong Gloss		

Figure 2. Acquisition of tactile sensation for Kansei Texture expression terms

By applying PCA (Principal Component Analysis) it is confirmed that cumulative contribution ratio attains 0.914 by using 3 principal components. For the easiness of visibility a 3-dimensional cubic [-1,1]³, called Kansei Texture space, is finally accepted to represent the Kansei Texture, where the names of 3 axes are "PuruPuru - GotsuGotsu", "KachiKachi - FuwaFuwa", and "ButsuButsu - PikaPika" in this order. The 120 Kansei Texture expression terms are plotted in the Kansei Texture space as shown in Figure 3.

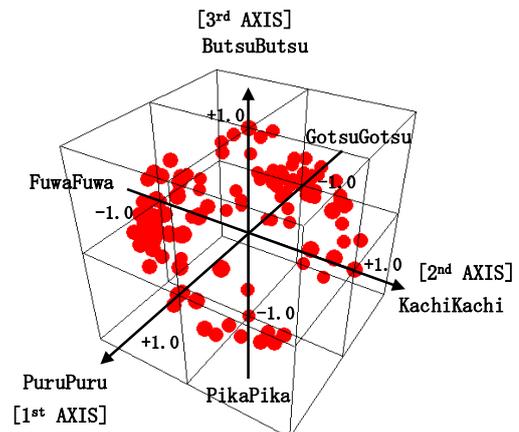


Figure 3. Kansei Texture space [-1,1]³

III. A Visualization Method of Kansei Texture

In widely accepted online shopping, a photo of a product with a few text information including price, size, weight, specification, review, and others is shown to buyers through the internet. It is not very easy, however, for buyers to imagine the texture of the product, and accordingly sometimes failed to buy an expected product. On the contrary it is easy to get the texture information of products by touching them in the real shop. In the online shopping there exist advantages such as no need to visit the shop, possible to buy even in midnight, wide selection of products, and so on, and the market size of the online shopping becomes doubled in the last 10 years. The Kansei Texture has been introduced to compensate the information gap about the texture of products. The problem is how to provide the Kansei Texture information easily to buyers. It may be a great help for buyers if simply understandable illustrated information of Kansei Texture is presented. Hence it is worthwhile investigating visualization method of Kansei Texture. A visualization method is widely studied and attracted as an expression method of invisible information [8].

A visualization method of Kansei Texture is established by assigning an appropriate geometric element to each axis considering the property of each axis.

A. The 1st AXIS (PuruPuru - GotsuGotsu)

Through the questionnaire experiment of tactile sensation for 120 Kansei Texture expression terms, it is confirmed as shown in Figure 4 that “PuruPuru” has a property of Smooth, Soft, Wet, Slightly Cold, and Slightly Gloss, whereas “GotsuGotsu” has a property of Rough, Hard, Dry, a little Cold, and No Gloss. By thinking about such properties of “PuruPuru” and “GotsuGotsu”, someone may hit upon pudding and crag, respectively, i.e., “PuruPuru” and “GotsuGotsu” may correspond to the shape of surface. Hence smooth and zigzag boundaries are accepted as the geometric element to express “PuruPuru” (= 1.0) and “GotsuGotsu” (= -1.0). The value in between 1.0 and -1.0 corresponds to the zigzag degree linearly as shown in Table 1.

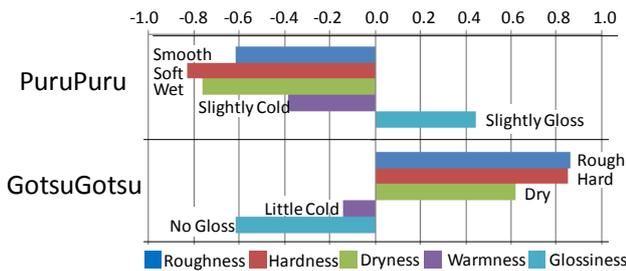


Figure 4. The 1st axis property

	Figure Part	Form Change of [-1,1]
1 st AXIS	Outline	(-1)GotsuGotsu ←→ (+1)PuruPuru 

Table 1. A visualization method of the 1st axis.

B. The 2nd AXIS (KachiKachi - FuwaFuwa)

In the same way in the case of 1st axis, shape is accepted as the geometric element of 2nd axis, where “KachiKachi” has a property of a little Rough, Hard, Dry, Cold, and Slightly Gloss and “FuwaFuwa” Soft, Slightly Dry, Slightly warm, and No

Gloss (cf. Figure 5). The feeling to touch an aluminum material and cotton may be imagined for “KachiKachi” and “FuwaFuwa”, respectively. The diamond shape is assigned for “KachiKachi” (=1.0), cloud like shape indicates “FuwaFuwa” (= -1.0), and the intermediate value corresponds to continuously deformed shape as shown in Table 2.

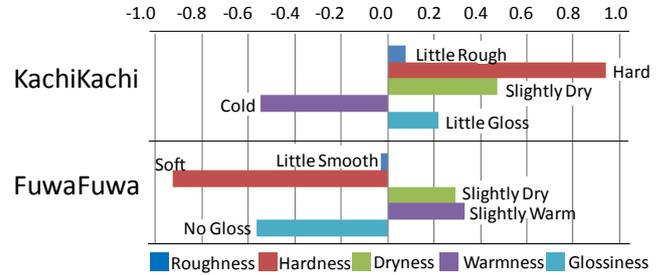


Figure 5. The 2nd axis property

	Figure Part	Form Change of [-1,1]
2 nd AXIS	Shape	(-1) FuwaFuwa ←→ (+1) KachiKachi 

Table 2. A visualization method of the 2nd axis.

C. The 3rd AXIS (ButsuButsu - PikaPika)

In the 3rd axis (cf. Figure 6), “ButsuButsu” has a property of Smooth, Soft, Wet, Slightly Cold, and Slightly Gloss, and cotton tofu may be guessed, whereas “PikaPika” Rough, Hard, Dry, a little Cold, and No Gloss and thought of sashimi (= raw fish). As shown in Table 3, gradation tint of granules is employed as the geometric element for the 3rd axis.

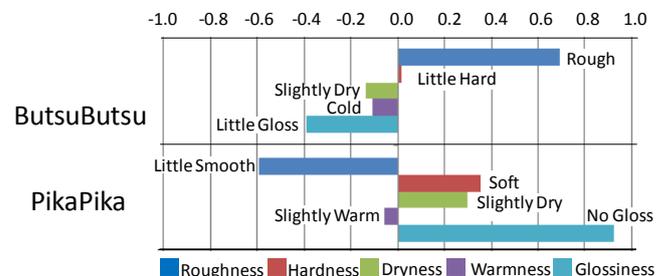


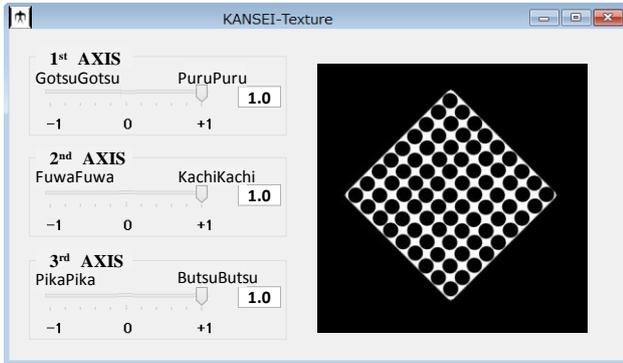
Figure 6. The 3rd axis property

	Figure Part	Form Change of [-1,1]
3 rd AXIS	gradation tint of granules	(-1) PikaPika ←→ (+1) ButsuButsu 

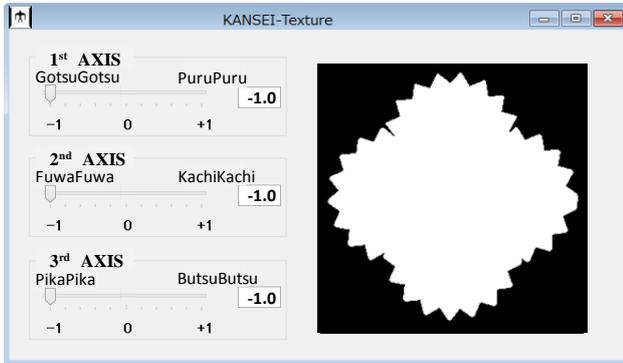
Table 3. A visualization method of the 3rd axis.

Based on axis-wise investigations of geometric element, a visualization method of Kansei Texture is proposed and its illustration program is provided. Each user is requested to input the Kansei Texture information, i.e., 3-dimensional vector in [-1,1]³, by moving the points on 3 slide bars using a pointing device, then the program generates a corresponding Kansei Texture illustration. A few examples of illustration are shown in Figure 7, where (a)-(d) indicate the cases of (1,1,1) = (PuruPuru, KachiKachi, ButsuButsu), (-1,-1,-1) = (GotsuGotsu, FuwaFuwa, PikaPika), (0,0,0) = origin, (0.7,-0.9,-0.8) = (a typical example of general cases), respectively. In Figure7(a), user inputs (1,1,1) by moving 3

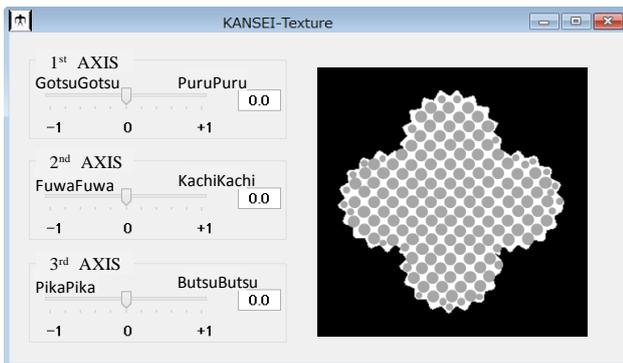
slide bars to the right end and the program generates the illustration as having smooth boundary (PuruPuru), diamond shape (KachiKachi), and black granules (ButsuButsu). The program illustrates a zigzag boundary (GotsuGotsu), cloud like (FuwaFuwa), and white (PikaPika) drawing for the input (-1,-1,-1) by a user in Figure 7(b). A neutral Kansei Texture (0,0,0) is shown in Figure 7(c) by a half zigzag, mid cloud shaped, and half gray tone granule illustration. A general case (0.7,-0.9,-0.8) is illustrated in Figure 7(d) in the same way.



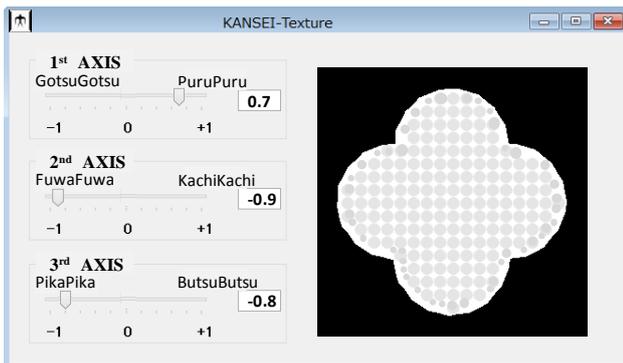
(a) (1, 1, 1) = (PuruPuru,KachiKachi,ButsuButsu)



(b) (-1,-1,-1) = (GotsuGotsu, FuwaFuwa, PikaPika)



(c) (0, 0, 0) = origin



(d) (0.7,-0.9,-0.8)

Figure 7. A few examples of Kansei Texture illustration

IV. Subjective Evaluation of Kansei Texture Illustration

A. Application to Online Shopping

The tactile sensation of a product is shown by using Kansei Texture illustration which is generated by inputting 3-dimensional vector information in $[-1,1]^3$. By adding 3 values to the conventional information of the product, Kansei Texture is transferred into the place far away. Further Kansei Texture is indicated by using the proposed visualization method which generates a corresponding illustration. The Kansei Texture is aimed to be applied to online shopping, robot vision, telemedicine, and e-learning, which need to provide the information of quality to a remote place. The program generated Kansei Texture illustration is added to the online shopping web site to help inferring tactile sensation of the product for buyers.

An example application of Kansei Texture in online shopping is shown in Figure 8. In the conventional online shopping, some information of the product, e.g., some photos, price, specification, and review, are shown, and buyers select products by guessing tactile sensation of the product from the information. In Figure 8, an example of the merchandise information of a handbag in online shopping is shown, where Kansei Texture illustration is added to the conventional information. The Kansei Texture in Figure 8 illustrates slightly zigzag boundary (feeling a slightly GotsuGotsu), cloud shape (feeling FuwaFuwa), and a little bit gray tone granule (feeling a little ButsuButsu). Buyers may understand tactile sensation like these feeling by looking such a Kansei Texture illustration shown in Figure 8.

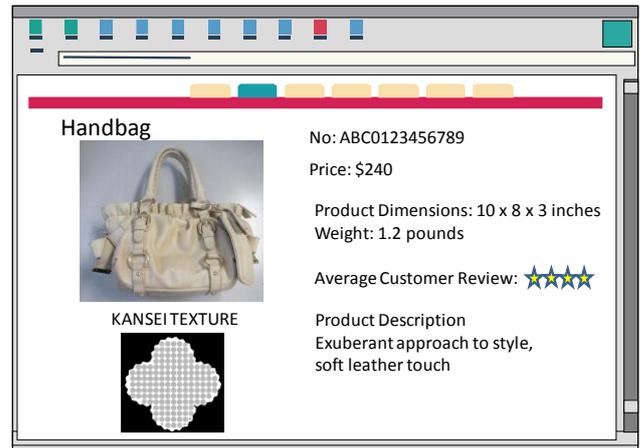


Figure 8. Example of Kansei Texture application to online shopping

B. Subjective Evaluation Experiment of Kansei Texture Illustration

A set of 20 goods which requested to touch strongly at the time of the purchase is selected for subjective evaluation experiment through local discussion. The feelings of these products are touched and evaluated by buyer's hands when these are used, for example a handbag, a grip of the golf club, a cover of the smartphone, and so on in Figure 9. The subjective

C. Gap of Kansei Texture with Real Shopping

It is investigated that which is closer to the degree of Kansei Texture in each axis on real shopping between that of proposal and that of conventional. The degree of Kansei Texture to the same good on real shopping and on conventional shopping site are related and are plotted in a graph. In the same way, The degree of Kansei Texture to the same good on real shopping and on proposed shopping site are related and are plotted in the graph in Figure 13. By calculating correlation coefficient from conventional online shopping site and that from proposed shopping site, the degree of similarity feeling to real shopping is investigated. The correlation coefficient in each axis is shown in TABLE IV. An average of the correlation coefficient by conventional online shopping is 0.80 and that of proposal is 0.95, the proposed method provides closer feeling to real shopping at 18.7% rather than the conventional method.

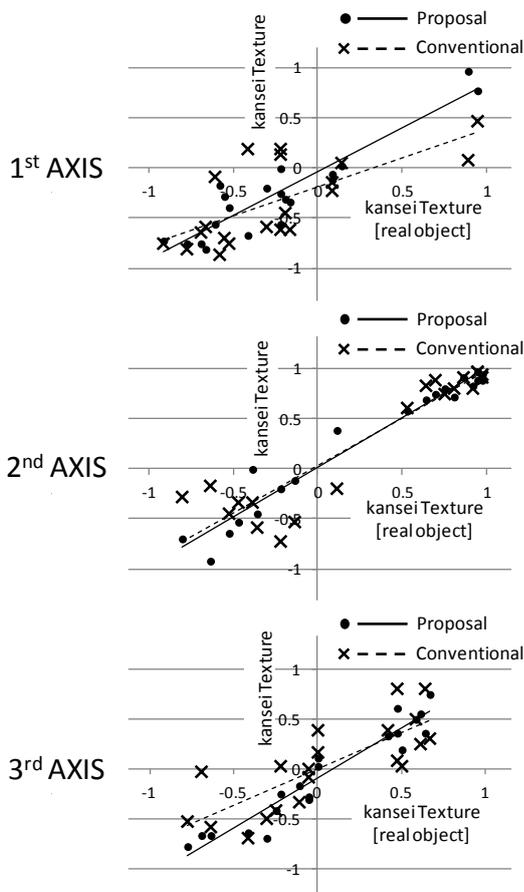


Figure 13. Subjectivity evaluation of Conventional and proposal online shopping site for real shopping

Relation to Kansei Texture of real object in hands	1 st AXIS	2 nd AXIS	3 rd AXIS
Conventional	0.69	0.93	0.79
Proposal	0.92	0.98	0.96

Table 4. Correlation coefficient of real object in hands.

V. Individual difference of Kansei Texture

A. Existence of Individual Difference in Kansei Texture

It is well known that individual difference exists in tactile-sensing/tactile-feeling [9]-[13], and it is expected that there also exists individual difference in Kansei Texture [1] because it is related to vision and tactile sensing information. A degree of Kansei Texture is expressed by a 3 dimensional vector in $[-1,1]^3$ [1], i.e., "PuruPuru – GotsuGotsu (1st AXIS)", "KachiKachi - FuwaFuwa (2nd AXIS)", and "ButsuButsu - PikaPika (3rd AXIS)". To show the individual difference of Kansei Texture, a collection of 50 vectors for the same online shopping good by 50 subjects is shown in Figure 14, where it is confirmed that 50 vectors are almost the same but there are impalpable differences, i.e., individual difference.

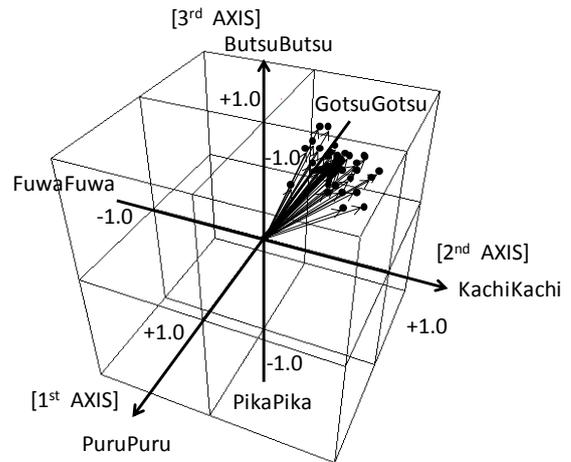


Figure 14. Kansei Texture of 50 subjects for the same shopping good

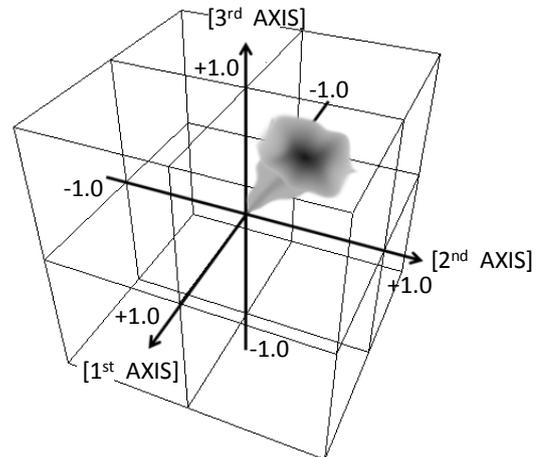


Figure 15. Cloud of gathering Kansei Texture vector

If the number of subjects becomes tremendously big, then a set of Kansei Texture vectors may constitutes a flower like cloud in $[-1, 1]^3$ as shown in Figure 15, where a part of the condensation of Kansei Texture vectors is expressed by black color and a part of the rarefaction is expressed by white color, gradation is used according to the density. A representative Kansei Texture vector may exist in the central area in deep dark part, and the area size of scattering cloud indicates the degree of individual difference.

B. Subjective Evaluation Experiment of Kansei Texture Expression Terms

In Figure 16, each variation in five elements, i.e., roughness, hardness, dryness, warmth, glossiness, which construct each axis is shown, where the amount of feelings. The maximum variation of 35.3% from 7.1% in each element and average variation of 20.9% are shown by individual difference of 50 subjects. The distribution of individual difference of Kansei Texture by individual feelings is taken into consideration.

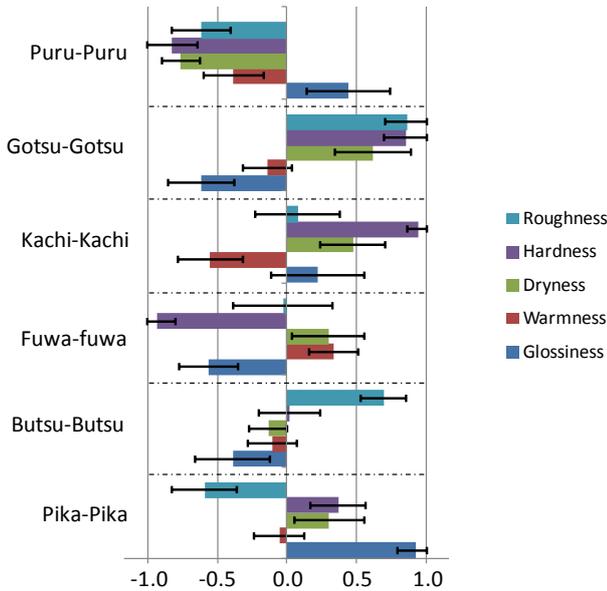


Figure 16. Individual difference of subjectivity evaluation of 5 elements consisted of each axis

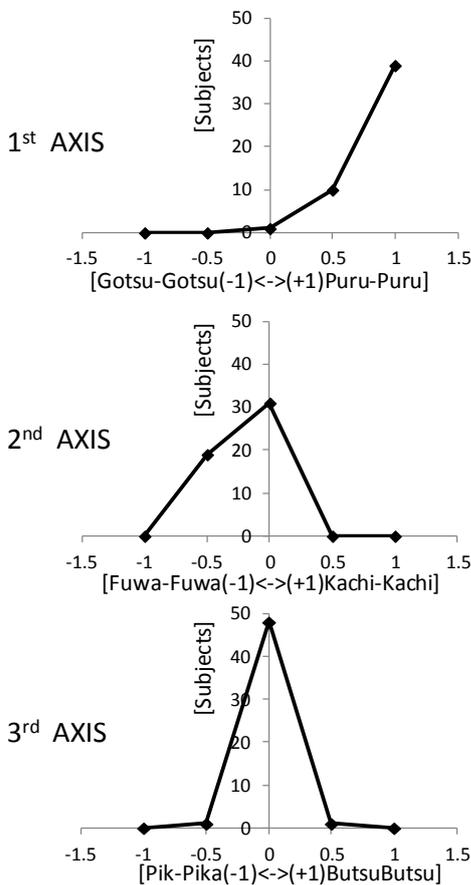


Figure 17. Distribution of subjectivity evaluation of each axis

The distribution of each axis of Kansei Texture space for each of Kansei Texture expression (120 terms) by 50 subjects is investigated. Figure 17 shows the relationship between the degree of feelings and the number of its subjects when Kansei Texture Expression term “PuruPuru” is given, where its form is confirmed like normal distribution as central on Kansei Texture value (1,0,0) according to the difference of individual feelings. In addition, the similar forms are confirmed also about the other Kansei Texture expression words of each axis, i.e., “GotsuGotsu”, “KachiKachi”, “FuwaFuwa”, “ButsuButsu”, and “PikaPika”. Thereby, the state of individual difference of Kansei Texture may be handled with normal distribution simply. Although individual difference of Kansei Texture expression term may be able to be expressed in the same manner as this way, it is necessary to investigate about the individual difference of Kansei Texture for a good because Kansei Texture for the good includes some Kansei Texture terms and it is usually a complex feeling.

C. Subjective Evaluation Experiment of Kansei Texture for Real Goods

A set of 20 goods with different kinds is selected by discussion that they are taken in one’s hands and are requested a feeling of its availability in Figure 9. Distribution of individual difference in each axis on subjective evaluation experiment is shown in Figure 17. Conditions of these distributions are investigated for each of 20 goods to confirm that its distribution has normality.

If individual difference of Kansei Texture follows normal distribution, T_{Hi} of statistic follows t-distribution where

$$T_{Hi} = \frac{\overline{X_{Oj}} - \mu_{HiOj}}{\frac{S_{Oj}}{\sqrt{N-1}}}, \tag{1}$$

Oj is the j th object, Hi is the i th subject and X_{OjHi} is a value of subjective evaluation of Hi for Oj , its average is

$$\overline{X_{Oj}} = \frac{1}{N} \sum_{i=1}^N X_{OjHi}, \tag{2}$$

then $\overline{X_{Oj}} \in [-1, 1]$, and μ_{HiOj} is comparison value, standard deviation S_{Oj} of subjective evaluation for object Oj is

$$S_{Oj} = \sqrt{\frac{1}{N} \sum_{i=1}^N (X_{Oj} - \overline{X_{Oj}})^2}, \tag{3}$$

then $S_{Oj} \in [0, 1]$.

The probability (P) is estimated by using t-test according to t distribution, and it is less than 0.05 standard significance level, and is confirmed that its result is meaningful as the parent population which assumed the normal distribution. Whether each Kansei Texture axis’s distribution has normality is investigated with 20 goods by 17 subjects. In TABLE V, in the case of the rate of $P < 0.05$ by t-test is 1.0, variation of the individual difference of Kansei Texture is indicated by normal distribution with high probability, in the case of low rate of $P < 0.05$ by t-test, individual difference of Kansei Texture is difficult to be represented by normal distribution.

From the average of these results, it is confirmed that distribution of the individual difference of Kansei Texture is expressed as normal distribution with probability 0.63. It is a result of 17 subjects, and also if the number of subjects increases, its normality becomes high. By expressing the individual difference of Kansei Texture on normal distribution by a simple standard deviation, it is expected to be applied to not only online shopping but also other fields requested to transmit vision/tactile sensation information with remote, e.g., medical education and robot vision.

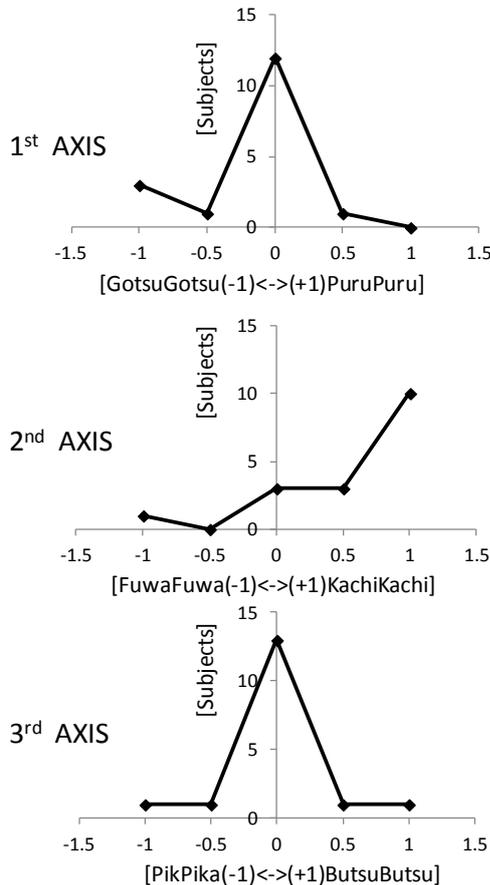


Figure 18. Subjective evaluation on a real object by 17 subjects

#	Goods	1 st AXIS: Rate of $P<0.05$ by t-test	2 nd AXIS: Rate of $P<0.05$ by t-test	3 rd AXIS: Rate of $P<0.05$ by t-test
1	Pestle plate	1.00	0.18	1.00
2	Toy	0.12	1.00	1.00
3	Beer glass	0.24	0.12	0.47
4	Teacup	0.53	0.18	0.59
5	Mug cup	0.76	0.53	0.76
6	Smart phone case	0.18	0.12	0.82
7	Handbag 1	1.00	0.65	0.47
8	Glass dish	0.65	1.00	0.24
9	Cordless handset	0.35	0.65	0.41
10	Running shoes	1.00	0.53	0.82
11	Coffee mill	0.88	1.00	0.94
12	Business bag	0.88	0.06	1.00
13	Moisturing cream	1.00	0.53	0.47
14	Jeans	0.29	0.82	0.24
15	Suitcase	0.94	0.06	1.00
16	Golf club (SW)	0.12	0.71	0.53
17	Handbag 2	0.82	0.82	0.59
18	Handbag 3	1.00	0.82	0.41

19	Golf club (driver)	1.00	0.24	0.88
20	Stroller	0.41	1.00	0.82

Table 5. Rate of $P<0.05$ by t-test each Axis.

VI. Conclusion

Results of subjective evaluation experiment by 17 subjects for 20 goods are summarized as;

- 1) Proposed method shows familiar feelings with real shopping by 18.7% superior to that of conventional method.
- 2) Individual difference of Kansei Texture is expressed in terms of standard deviation because significance level ($P < 0.05$) by 63% in subjective evaluation is fulfilled when normality is assumed.

Representation method of Kansei Texture is expected to investigate based on fuzzy set using its individual difference. The visualization of individual difference for Kansei Texture is planned to evaluate through the subjectivity evaluation experiment in online shopping. In advancing verification of the requirement specification for which individual difference information is asked, the following two issues are considered on the online shopping in the real world.

- for a buyer, the judgment index of the sample product demand before purchase,
- for a seller, the judgment index of the making strategy for possibility of returned goods.

Fuzzy set representation of Kansei Texture for the sake of simplicity is under developing, and individual difference of Kansei Texture as fuzzy set is expressed and its visualization is also under investigated.

Furthermore, the individual difference of Kansei Texture is planning to be applied to medical education fields, and it is expected to be effective as one of the information paying attention to the difficulty at intern doctor's education process. If Kansei Texture of medical operation of an intern doctor by individual feeling is different from a lot of matured doctor's feelings, then the intern doctor is able to recognize the degree and to learn, and patients has also an advantage which can receive the medical treatment in the same level as that of matured doctor.

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