2013 Conference
June 23-27, 2013
TORINO, ITALY
EFITA WCCA CIGR
Sustainable Agriculture through ICT innovation

Building of Computer Vision System to Extract *Kansei* Information from Facial Expressions

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ABSTRACT

Kansei engineering is one field of engineering where the feelings of humans are applied to manufacturing. If *Kansei* can be extracted, the design, development, and evaluation of various things are possible. This study aims to build an automatic design and evaluation system for agricultural products and landscapes and then utilize the system for the evaluation and improvement of educational effects. In this presentation, we built a low price and near real-time system to extract *Kansei* information from the facial expressions of users and obtained knowledge about *Kansei*. Additionally, we created an algorithm to discriminate *Kansei*. We built a system to obtain facial expression information of a user from a camera image as our experimental equipment. The characteristic values calculated from them were the variation (or the normalized polygon area change ratio) of the four items; the inner ends of the eyebrows, upper parts of the eyes, lower parts of the eyes, and the corners of the mouth. The target *Kansei* was three items: positive *Kansei* (liking, fun, and happy) and negative *Kansei* (unpleasantness and hatred). The results are as follows:First, for the target three *Kansei*, changes could be captured through the four specified normalized polygon area change rates. As for the positive *Kansei*, the changes in the corners of the mouth were greater than those of the others in particular. As for the negative *Kansei*, the changes in the lower parts of the eyes were slightly greater than those of the others and, as for the *Kansei* of surprise, the changes in the corners of the mouth were slightly greater. The direction of the change showed a tendency where the positive *Kansei* increased at the corners of the mouth in particular. The negative *Kansei* showed a strong tendency to decrease at the inner ends of the eyebrows and the lower parts of the eyes in particular. The *Kansei* of surprise showed a tendency where the normalized polygon area change rates increased as a whole. Next, we selected one subject because the relationship between the facial expressions and *Kansei* varies among individuals, and then we built an algorithm to discriminate the three *Kansei* features. As for the *Kansei* of positive – negative and negative – surprise, it became possible to discriminate at a rate of nearly 100% from the information of the corners of the mouth. It became possible to discriminate the positive-surprise at a rate of about 80% from the information of the upper parts of the eyes. As described above, although it is necessary to prepare the template image of the seven points of the target person and adjust the parameters after measuring the *Kansei* facial expression in advance, a low price and near real-time computer vision system to extract facial expression *Kansei* could be built.

Keywords: *Kansei*, computer vision, automatic evaluation and design, decision support system, Open CV, Japan

1. INTRODUCTION

We aim to apply *Kansei* engineering, in which *Kansei* and image of human are translated into physical design elements to design products, environments and the likes compatible with *Kansei*, to the food and environmental fields. By utilizing *Kansei* information, we believe that the following things will become possible; design/development/evaluation of new agricultural products and foods with color, shape, scent, etc., of high consumer rating; development of marketing methods; design/evaluation of office/living space using green amenity (Asaumi et al. 1995); landscape creation/evaluation of city/farming village/garden with comfort and healing effect; development of agricultural machines with appearance, comfort, etc., of high consumer rating; development of Agri-robot capable of *Kansei* communication (Sasaki 2011); welfare/nursing support using animals and plants and/or artificial life. Two specific application examples we assume are as follows (Fig. 1). The first example is related to the disaster reconstruction program in Fukushima Prefecture, and Tokyo University of Agriculture is building the Cyber field simulation system for the restoration of farming and mountain villages in the disaster areas. This consists of building a base simulation system by adding map information and 3D space information obtained using the MMS (Mobile Mapping System) to the GIS for the restoration of farming and mountain villages and building a regional model simulator with consideration for disaster prevention and landscape after reconstruction, which will lead to an important decision for support of a landscape simulator if *Kansei* information can be utilized. The second example is the development of an educational application for tablet PCs for foods and environment. Education effects could only be evaluated through questionnaires and the like until now. However, when the *Kansei* information, such as if the students feel interested, if they feel dull or if they are concentrated in can be obtained, it can be used for the evaluation of educational application and software and/or the improvement of education. As described above, in this study, we built a low price and near real-time system to extract *Kansei* information from the facial expressions of a user by using a computer vision and obtained knowledge about *Kansei*. We also created an algorithm to discriminate *Kansei* using them. The purposes are the following two points.

1. Building of a system to investigate the relationship between facial expression and *Kansei* and acquisition of knowledge about *Kansei* of multiple persons
2. Development of a computer vision system to discriminate *Kansei* from facial expressions

The reasons why we are focusing on facial expression information are that it has an important role that it is said 55% of emotion, which is a part of *Kansei*, is expressed by facial expression (Mehirabian 1986), and the system can be realized with a camera and image processing without requiring special sensors. Additionally, facial expressions can be measured without contact/loading and are easy to be used as feedback information.

By evolving the system further, we believe that *Kansei* information at the unconscious level, which cannot be captured through questionnaires, can be obtained.

Figure 1. Image of *Kansei* application

2. DEVELOPMENT SYSTEM AND *KANSEI* EXTRACTION METHOD

According to the related investigative studies and our study (Sasaki et al. 2007), it was shown that *Kansei* of a person tends to appear on the eyes and mouth. By referring to the face graph by Ayinde and Yang (2002), in order to grasp *Kansei* in a near real-time manner, a total of seven face nodes —the inner ends of the eyebrows, inner corners of the eyes, outer corners of the eyes, upper eyelids, lower eyelids, and both corners of the mouth—are traced by using the template matching technique (Fig. 2). The template matching technique is processing to identify the position of a target by searching a partial image signal (target) that corresponds to a known template signal from the input image signal. The position of an object is detected by storing a region of the object to be traced in each image of a video as a template image in advance and detecting the region that has a high degree of similarity to the template image in the images input in a time-series manner. The template image used was an image of 19 x 19 pixels. The seven face nodes placed as above were connected and four polygons corresponding to the inner ends of the eyebrows, upper parts of the eyes, lower parts of the eyes and corners of the mouth were created as shown in Fig. 3. The areas of the polygons were calculated and extraction of *Kansei* from the change ratios was attempted. In this paper, $N(i)$ is defined as a face node. Therefore, in this study, $N(1)$: indicates the inner ends of the eyebrows, $N(2)$: the upper eyelids, $N(3)$: the lower eyelids, $N(4)$: the inner corners of the eyes, $N(5)$: the outer corners of the eyes, $N(6)$: the left corner of the mouth and $N(7)$: the right corner of the mouth. The parameters calculated for facial expression analysis were normalized polygon area change ratios $\Delta A(i,j,k)$ and they were calculated using the following equation.

$$\Delta A(i,j,k) = 100\,\frac{A_{t+\Delta t}(i,j,k)/scale^2 - A_t(i,j,k)}{A_t(i,j,k)} \quad (1)$$

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Y.Sasaki, M.Emmi and H.Negishi. “Building of Computer Vision System to Extract *Kansei* Information from Facial Expressions”. EFITA-WCCA-CIGR Conference “Sustainable Agriculture through ICT Innovation”, Turin, Italy, 24-27 June 2013.

Also, the scale was expressed by Eq. (2) and $A_t(i,j,k)$ was expressed by Eq. (3), By normalizing the scale, the back and forth movements of head in the direction toward the camera (zoom in/out) are dealt with.

$$scale = L_{t+\Delta t}(4,5)/L_t(4,5) \quad (2)$$

$$A_t(i,j,k) = \frac{1}{2} \cdot \left| \begin{array}{l} \{x_t(i) \cdot y_t(j) - x_t(j) \cdot y_t(i)\} \\ + \{x_t(j) \cdot y_t(k) - x_t(k) \cdot y_t(j)\} \\ + \{x_t(k) \cdot y_t(i) - x_t(i) \cdot y_t(k)\} \end{array} \right| \quad (3)$$

Where, t: time, i, j and k: node numbers, $x_t(i)$ and $y_t(i)$: x and y coordinates of $N(i)$ at time t, $L_t(i,j)$: distance between $N(i)$ and $N(j)$ at time t, *scale*: scale ratio for normalization at time t and $t + \Delta t$, and $A_t(i,j,k)$: area of polygon (triangle) in $N(i)$- $N(j)$ - $N(k)$ at time t. The normalized polygon area change ratios were calculated for the changes of the four polygons at the inner ends of the eyebrows, upper parts of the eyes, lower parts of the eyes and corners of the mouth as described above. The target *Kansei*s were three types: positive *Kansei* (liking, fun and happy), negative *Kansei* (unpleasantness and hatred) and surprise *Kansei*. The experiment method was as follows. After the test subjects were told the purpose of the experiment, they filled their ages and genders and were told the flow of the experiment and the precautions. They were told the contents of the target *Kansei* expressions and instructed to practice the expressions using a mirror. And then the experiment to obtain the *Kansei* expressions was conducted. The test subjects made the *Kansei* expressions intentionally but they tried to make them natural as much as possible. The test subjects were 12 men (age: 18 - 22). In addition to their facial expressions at the normal state, 50 samples of the *Kansei* expressions or a total of 2,400 images were obtained.

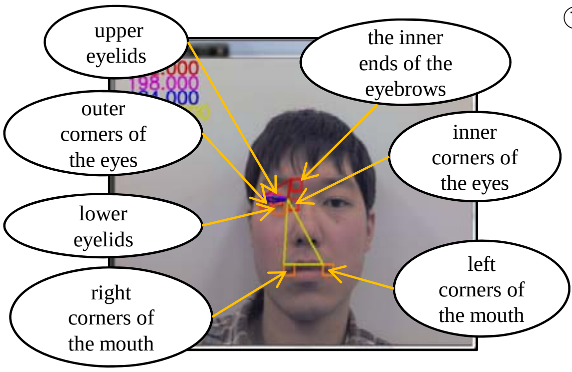


Figure 2. Face nodes

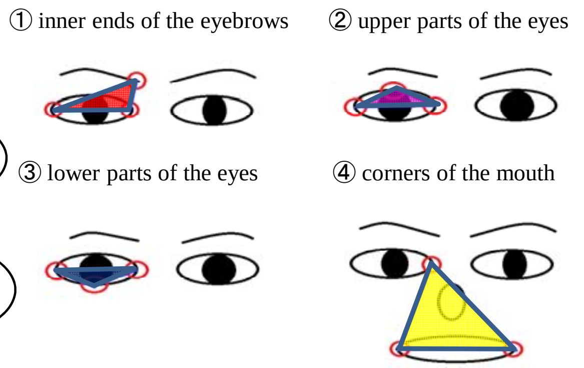
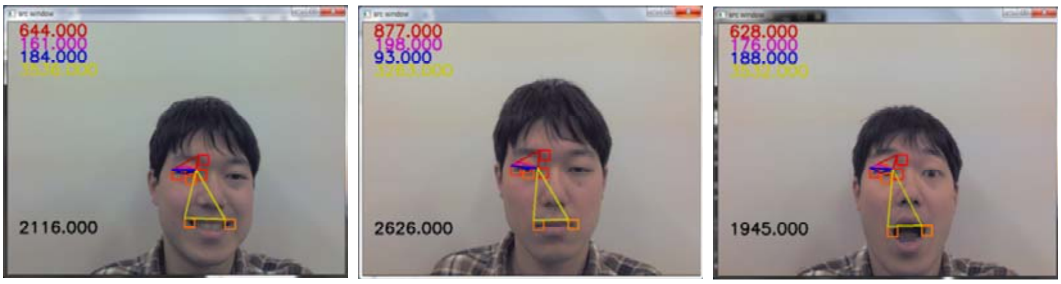


Figure 3. Four polygons made into the amount of the characteristics

3. RESULT AND DISCUSSION

3.1 Knowledge about *Kansei* Obtained from Multiple Persons

Fig. 4 shows the obtained positive *Kansei*, negative *Kansei* and surprise *Kansei* expressions and one example of the execution result of the program. This indicates the output result of the four polygons created by connecting the face nodes with rectangles and by connecting the polygons with lines. Table 1 shows the changes in the absolute values of the normalized polygon area change ratios. As for the positive *Kansei*, the changes in the normalized polygon area change ratios were about 15 – 29% and the change at the corners of the mouth was about 29% and higher than those of the others in particular. As for the negative *Kansei*, the changes were about 11 – 16% and the change at the lower parts of the eyes was about 16 % and slightly higher than those of the others. As for the surprise *Kansei*, the changes were about 15 – 18% and the change at the corners of the mouth was slightly higher than those of the others. Next, a result was indicated as plus when the normalized polygon area change ratio increased and minus when the ratio decreased, and then the ratios of the corresponding test subjects were checked. The results are shown in Tables 2 – 4. As a general trend, for the positive *Kansei*, the normalized polygon area change ratios of the inner ends of the eyebrows and upper parts of the eyes increased or decreased depending on the subjects, that of the lower parts of the eyes decreased and that of the corners of the mouth increased. For the negative *Kansei*, all the normalized polygon area change ratios showed a decreasing trend and the trend was stronger at the inner ends of the eyebrows and lower parts of the eyes in particular. For the surprise *Kansei*, the normalized polygon area change ratios showed an increasing trend as a whole and the trend was stronger at the inner ends of the eyebrows in particular. According to the results above, since the direction and amount of the change in the normalized polygon area change ratio depends on individuals, a general trend can be speculated but it is thought that the *Kansei* change information must be learned individually. Based on the results from multiple test subjects in this study, when discriminating the three *Kansei*s, it is thought that focusing on the directions of change (positive *Kansei*: minus at the lower parts of the eyes and plus at the corners of the mouth, negative *Kansei*: minus at both the inner ends of the eyebrows and the corners of the mouth, and surprise *Kansei*: plus at both the inner ends of the eyebrows and l the corners of the mouth) and the amounts of change is informative.



(a) positive *Kansei* (b) negative *Kansei* (c) surprise *Kansei*

Figure 4. Example of the acquired image

Table 1. Absolute value changes(%)

	positive *Kansei*	negative *Kansei*	surprise *Kansei*
the inner ends of the eyebrows	15.3±11.7	12.9±7.8	14.6±11.8
upper parts of the eyes	18.4±13.9	13.7±9.9	15.1±9.9
lower parts of the eyes	18.4±19.3	15.7±10.4	14.6±12.3
corners of the mouth	28.8±15.7	11.8±5.7	17.9±12.8

Table 2. Subject percentage about the alteration orientation(positive *Kansei*)

	Plus (%)	Minus (%)
the inner ends of the eyebrows	50.0	50.0
upper parts of the eyes	41.7	58.3
lower parts of the eyes	25.0	75.0
corners of the mouth	83.3	16.7

Table 3. Subject percentage about the alteration orientation(negative *Kansei*)

	Plus (%)	Minus (%)
the inner ends of the eyebrows	16.7	83.3
upper parts of the eyes	25.0	75.0
lower parts of the eyes	8.3	91.7
corners of the mouth	33.3	66.7

Table 4. Subject percentage about the alteration orientation (surprise *Kansei*)

	Plus (%)	Minus (%)
the inner ends of the eyebrows	91.7	8.3
upper parts of the eyes	58.3	41.7
lower parts of the eyes	58.3	41.7
corners of the mouth	75.0	25.0

3.2 Building and Evaluation of *Kansei* Discrimination Algorithm

Since the directions and amounts of the change in *Kansei*s depends on individuals as described above, we selected one test subject and built an algorithm to discriminate the *Kansei*s from the facial expression. The average values and standard deviations of the normalized polygon area change ratios of the selected test subject are shown in Table 5. The amounts of the changes of this subject were small as a whole. Here, in order to study which index is suitable from the four characteristic quantities, *D.I.* was calculated (Table 6). *D.I.* is a simplified index in consideration of the variance between categories (Eq. (4)).

$$D.I. = \frac{\left|\mu_{\omega_1,x} - \mu_{\omega_2,x}\right|}{\sqrt{\sigma^2_{\omega_1,x} + \sigma^2_{\omega_2,x}}} \tag{4}$$

Where, $\mu_{\omega_i,x}$ and $\sigma^2_{\omega_i,x}$ are the average and variance in each category.
In general, it is easy to discriminate when *D.I.* is high. According to the result shown in Table 6, it was found that the information about the corners of the mouth is suitable for

discrimination between the positive—negative *Kansei*, that about the upper parts of the eyes for discrimination between the positive—surprise *Kansei* and that about the corners of the mouth for discrimination between the negative—surprise *Kansei*. The H-method is a cross-calibrated division learning method used to determine an error rate by interchanging the learning sample and test sample. The samples were divided into the learning sample and test sample randomly and they were evaluated. This operation was repeated 1,000 times to calculate the average value and the value was considered as the error rate. The result is shown in Table 7. The discriminations between the positive—negative and negative—surprise were possible at a rate of nearly 100% from the information of the corners of the mouth. For the discrimination between the positive-surprise, they could be discriminated at a rate of about 80% from the information of the upper parts of the eyes. The optimal threshold values for the discriminations were obtained statistically and the three *Kansei*s of the target test subject could be grasped using the algorithm shown.

Table 5. Normalization polygon area change ratios (%)

	positive *Kansei*	negative *Kansei*	surprise *Kansei*
the inner ends of the eyebrows	0.05±2.47	-18.80±2.70	0.75±2.92
upper parts of the eyes	6.07±4.27	-15.08±6.65	-0.42±3.75
lower parts of the eyes	3.35±3.36	-21.71±8.96	2.28±3.57
corners of the mouth	2.69±1.34	-10.81±1.03	1.76±1.26

Table 6. *D.I.* compare

D.I.	the inner ends of the eyebrows	upper parts of the eyes	lower parts of the eyes
positive－negative	5.15	2.68	2.62
positive－surprise	0.18	1.14	0.22
negative－surprise	4.91	1.92	2.49

Table 7. H-method identification result compare

Kansei	information	The H-method misconception percentage (%)	optimal threshold
positive－negative	corners of the mouth	0.2±2.6	-4.95%
positive－surprise	upper parts of the eyes	21.1±13.5	2.6%
negative－surprise	corners of the mouth	0.0±0.0	-5.2%

4. CONCLUDING REMARKS

A system to obtain facial expression using a computer vision was built. As a result of the investigation on multiple subjects, the following knowledge were obtained. First of all, for the target three *Kansei*s, their changes could be grasped through the four specified normalized polygon area change ratios. For the positive *Kansei*, the change at the corners of the mouth was greater than those at the others, in particular. For the negative *Kansei*, the change at the lower parts of the eyes was slightly greater than those at the others and, for the surprise *Kansei*, the change at the corners of the mouth were slightly greater than those at the others. As for the directions of the changes as a general trend, for the positive *Kansei*, the normalized polygon area change ratios of the inner ends of the eyebrows and upper parts of the eyes increased or decreased depending on the subjects, that of the lower parts of the eyes decreased and that of the corners of the mouth increased. For the negative *Kansei*, all the normalized polygon area change ratios showed a decreasing trend and the trend was stronger at the inner ends of the eyebrows and lower parts of the eyes in particular. For the surprise *Kansei*, the normalized polygon area change ratios showed an increasing trend as a whole and the trend was stronger at the inner ends of the eyebrows in particular. Next, since the relationship between the facial expressions and *Kansei*s depends on individuals, we selected one test subject based on the knowledge obtained and built an algorithm to discriminate the three *Kansei*s. For the positive—negative *Kansei*s and the negative—surprise *Kansei*s, the discriminations were made possible at a rate of nearly 100% from the information of the corners of the mouth. For the discrimination between the positive-surprise *Kansei*s, they could be discriminated at a rate of about 80% from the information of the upper parts of the eyes. Thus, although it is necessary to prepare the template image of the seven points of a target person and adjust the parameters after measuring the Kansei facial expressions in advance, a low price and near real-time computer vision system to extract facial expression-*Kansei* could be built. We believe that this system can be applied to automatic evaluation/design through decision support using the *Kansei* information. The future challenge includes reduction of processed required for the learning of prepared template images etc. and building of a *Kansei* grasping system, which is closer to a real-time system.

5. ACKNOWLEDGMENT

Part of this work was supported by Grant-in-Aid for scientific research (KAKENHI A, 23248043)

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