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BASIC STUDY OF FACIAL EXPRESSION DUE TO POSITIVE FEELINGS USING VISIBLE AND NEAR INFRARED IMAGES

Tsuyoshi Takahashi†, Yoichi Kageyama†, Masaki Ishii††, Makoto Nishida†,
Akira Miyasawa†, and Yu Long Zhang†
†Akita University, Japan ††Akita Prefectural University, Japan

ABSTRACT

Japan has an aging population, and improving the quality of life (QOL) for individuals is necessary to maintain social vitality. Therefore, the demand for life–support systems such as life environment and health monitoring system are particularly increasing. The support system must recognize human feelings to maintain a comfortable life for users. A particularly important issue of such systems is recognizing a little happiness. Recognition of facial expressions is necessary to enable emotional communication with machines. However, it is difficult to recognize and distinguish slightly varying facial expressions such as happiness using information in the visible spectrum only.

In this paper, we investigate the features of change in facial expressions arising from amusement and happiness. We consider visible information acquired by a CCD video camera and near infrared (NIR) information acquired by an NIR camera. Experimental results for five subjects showed some suggestion for recognizing and distinguishing target emotions.

1. INTRODUCTION

Japan is the leading nation for population aging, and social security payments are on the rise. Therefore, maintaining and improving health of the elderly is necessary to reduce social payment. One action for solving this issue is improving the quality of life for individuals. It has also been discovered that a feeling of amusement or happiness (well-being) has a positive effect on human health. Improving the quality of life (QOL) for individuals tends to increase social vitality. To realize this goal of improving and maintaining QOL for individuals, the demand for life–support systems using information technology such as QOL monitoring systems is especially increasing. The supporting system must recognize human feelings to judge whether the user is comfortable or not. A great deal of research has been conducted to recognize facial expressions from images of faces captured in the visible range, which has revealed the usefulness of emotional recognition [1-4]. However, it is particularly difficult to recognize emotions such as happiness with only minor changes in expression. To solve this issue, multiple sensing is useful: visible information, face temperature with thermal vision [5-7] and near infrared information.

In this paper, we investigate the features of change in a facial expression arising from amusement and happiness. We consider visible information acquired by a CCD video camera and near infrared (NIR) information acquired by an NIR camera. We acquired facial changes due to emotional expression from visible and NIR images. NIR is widely used in security or medical fields such as vein authentication system [8] or an intravenous injection support system [9]. Therefore, we tried to investigate a particular information relating to hemodynamic change of venous blood from NIR images. We then attempt to analyze the difference in facial expression features of visible and NIR images.

2. TARGET EMOTION

2.1. Definition of target emotion

In this paper, two kinds of pleasing or comforting emotions were considered as targets: “amusement” and “happiness.” These emotions are good feeling for human. The definition of “amusement” is the same as that in reference [10]. On the other hand, “happiness” has various meanings connoting comfortable emotions. It needs to be evoked the same kind of emotion frequently to evaluate the target emotion quantitatively. For this reason, we limited the “happiness” to two reprehensive emotion units used in psychology field based on reference [11]. Concretely, we subdivided happiness into two kinds of emotion “heart-warming (a sweet feeling)” and “peacefulness (a calm feeling)” in this study. Heart-warming and peacefulness are positive feelings, and can be evoked for subjects passively by showing an image material.

2.2. Emotion eliciting stimuli

To select movies that evoke heart-warming and peacefulness, a survey with 19 people was conducted through questionnaires (Japanese males and females in their 20s). Each subject evaluated the intensity of the two target emotions for nineteen movies based on natural scenery, pretty animals, and children. Two points were assigned to the movie if they felt a strong emotion, one point if they felt a weak emotion, and zero points if they felt no emotion. The results of the questionnaire are

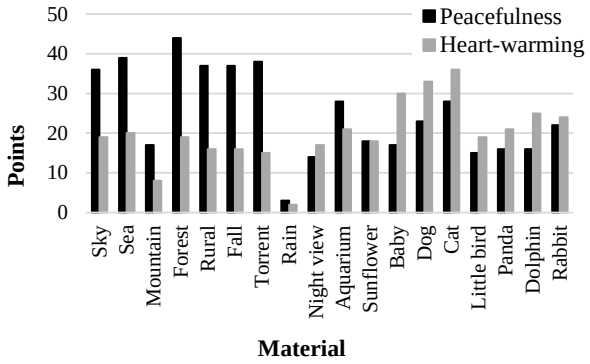


Figure 1. Results of emotion–eliciting questionnaire.

shown in Figure 1. Scenes from nature easily evoke peacefulness but are not as effective in evoking heart-warming. On the other hand, pictures of animals and children effectively evoke heart-warming.

According to those results, we selected five kinds of movies on topics like the "sky," "sea,'' "forest," "cats," and "dogs" to evoke a target emotion with the assumption that they are applicable to almost all subjects in emotion arousal experiments. Moreover, we used these movies to suit each subject's taste based on their answers to the questionnaire.

2.3. Evaluating subjects' feelings

In this study, we used the Affect Grid [12] to measure and evaluate the subjects' feelings. The Affect Grid is a single-item scale with two dimensions as shown in Figure 2. The vertical dimension represents the degree of arousal with half the vertical dimension of the map representing baseline feeling. The horizontal dimension represents the degree of pleasantness with half the dimension of the map representing the baseline pleasant level similar to the vertical dimension.

Subjects intuitively marked their present feeling on the Affect Grid. In this study, subjects marked their feeling before and after they watched the emotion eliciting movies. We calculated the average points of arousal (A-Score) and pleasantness level (P-Score) for every subject to investigate the temporal transition of that subject's feeling.

3. DATA USED

3.1. Data acquisition

Figure 3 shows the data acquisition environment and acquisition timeline. We recorded the facial expressions of thirteen subjects (subjects A–M; Japanese males and females in their 20s) watching a few short movies [13-17] as emotion eliciting stimuli. The subjects' facial data were acquired by a CCD camera (Point Grey Research: Grasshopper) and an NIR camera (Ximea: XiQ). We prepared three short movies; one movie was 5 min-long funny television program for eliciting amusement and the other two movies involved scenes from nature or pretty animals. After watching these movies, each

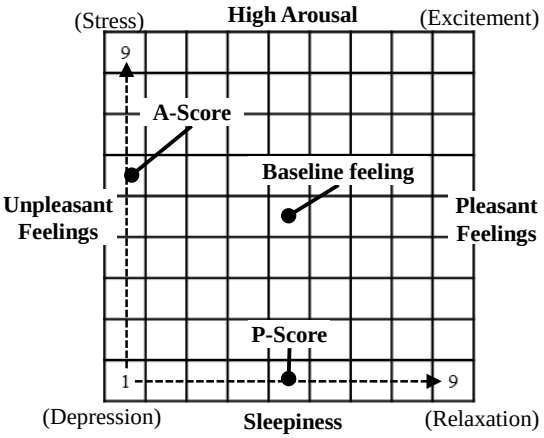


Figure 2. Affect Grid [10].

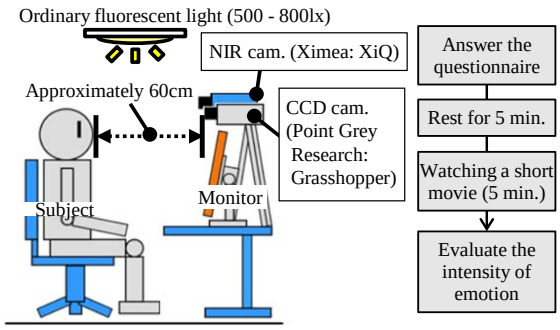


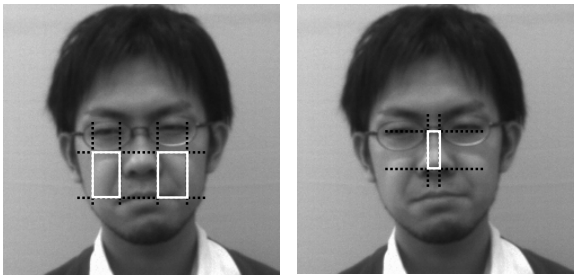
Figure 3. Data acquisition environment.

subject intuitively evaluated them with a grade (0–3) of the intensity of the evoked emotion using an Affect Grid. Furthermore, in the experiment, to evoke a feeling of amusement, subjects evaluated the intensity of this feeling for every such section. The evaluation of the detailed feeling is not carried out for happiness because the expression and disappearance of happiness-related emotions are difficult to judge. Data acquisition was performed for three days. Each day the subject watched a different stimulus. The data used in this paper were acquired with the approval of the ethical regulations regarding studies in humans at Akita University, Japan.

3.2. Preprocessing

3.2.1. Extraction of sections displaying target emotion

The videos were converted to static images (60 frame/s; 320 × 240 pixels). The visible images were then converted to 8-bit grayscale images for comparison with NIR images. Next, the section displaying the target emotions were manually extracted from each subjects' data. We extracted a 24-frame segment of the hardest laughter segment from each acquired video to evaluate feelings of amusement. From happiness data, we extracted two sections: "data before emotion evoked" and "data after emotion evoked" from the same video. Each extracted section was 24 frames long. The first section was extracted right at the start of watching the short movie, and another section was extracted two



(a) Cheeks (b) Nose

Figure 4. Definition of target regions (Subject A).

minutes and thirty seconds later.

3.2.2. Extraction of analysis regions

In this study, we focused on the three object regions: the right and left cheeks, and the bridge of the nose based on references [7]. Figure 4 shows these three object regions. The regions of either cheek were defined by rectangles (solid white outline) enclosed by four lines (dotted black). Of these four lines, the upper horizontal line runs along the inferior border of the eyes, and the lower, along the center of the lip; the perpendicular lines run along the right and left ends of each eye. The nasal region was defined by a rectangle (solid white) enclosed by a horizontal line running along the inferior border of the eyes and apex of nose, and perpendicular lines along the right and left ends of the bridge of the nose.

4. DATA ANALYSIS METHOD

To consider the change in target regions when amusing and peaceful feeling arose, the following procedures were performed:

First, the gradation value of the target regions of the gray scale visible and NIR images was calculated. Next, a histogram of this gradation value was created. Third, the kurtosis and skewness of each histogram were computed. Finally, the distribution of the visible and near-infrared image histogram was compared, followed by investigation of the tendency of transition of the kurtosis and skewness.

5. RESULT AND DISCUSSION

5.1. Transition of subjects feelings

Figure 5 shows the evaluation results using an Affect Grid. Both scores increase when the subjects watched comedy programs on the television. This result suggests that the subjects' feelings have been altered to excitement. On the other hand, subjects who had watched natural scenery show an increase in the P-score and a decrease in the A-score. This result suggests that the subjects' feelings have altered to relaxation. These results suggest that the amusement feeling associated with laugh belongs to the excitement emotion, and the peacefulness belongs to the relaxation emotion.

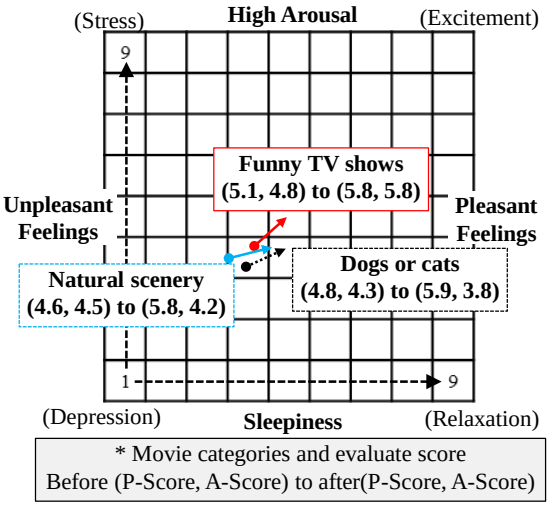


Figure 5. Evaluation result using Affect Grid.

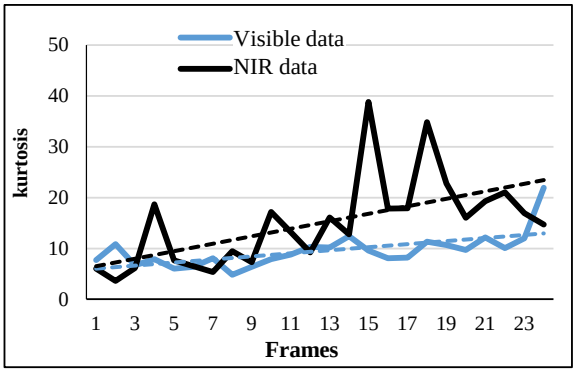


Figure 6. An example of kurtosis transition in visible and NIR data (Subject A: left cheek; amusement).

Moreover, these results show that the emotion-eliciting materials used in this experiment were effective in evoking the target emotion.

5.2. The feature transition result

Figure 6 shows an example of the feature transition result of visible and NIR image data of the left cheek in a state of amusement. These results indicate an upward tendency of the time series movement of kurtosis of visible and NIR images. The tendency was observed in the result of skewness as same as the kurtosis result. Moreover, the magnitude of change in kurtosis and skewness of NIR data has the tendency to be greater than that of visible data. On the other hand, a tendency to increase does not clearly appear when a peaceful feeling arises. The differences between normal and peaceful expressions appear at the nasal region.

Figure 7 shows an example of the feature transition result of the NIR image data of the right cheek region in a state of heart-warming. Variation of the transition becomes larger when subjects are shown short movies based on animals. In contrast, a particular tendency of the feature transition does not clearly appear when a peaceful feeling arises as shown in Figure 8. In the nasal region, we couldn't find a clear difference between

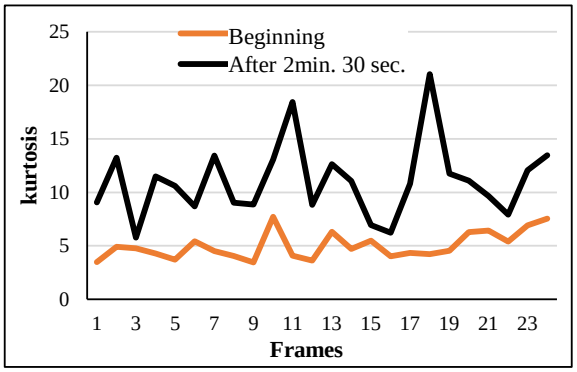


Figure 7. An example of kurtosis transition in NIR data (Subject A: right cheek; heart-warming).

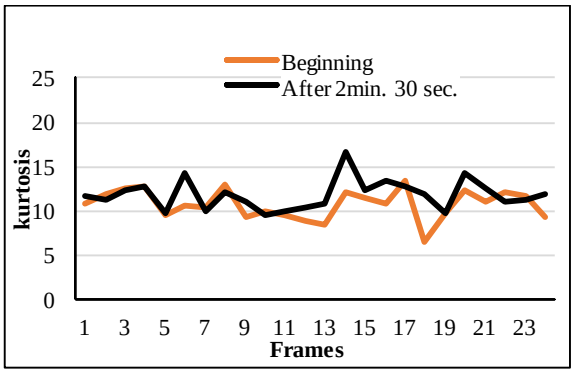


Figure 8. An example of kurtosis transition in NIR data (Subject A: right cheek; peacefulness).

beginning state and after 2 minutes 30 second state in the states of peacefulness and heart-warming. We have to more research about useful features in the nasal region.

Based on these results, we think that the transition of kurtosis and skewness of image histograms of the cheek and nose may become useful features to detect the occurrence of "amusement" and "heart-warming". However, we could not find any tendencies in transitions of kurtosis and skewness when "peacefulness" occurred. Therefore, it requires further investigation for finding the useful features to detect the occurring peacefulness.

We plan to further analyze the relationship between the target emotion and the acquired data. Additionally, we plan to increase the number of subjects.

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