J-034

A Measurement and Classification of Multiple Subjects' P300 for Image Retrieval

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1. Introduction

P300 is a kind of event related potential (ERP). It is evoked by paying attention and we can use P300 to detect the attention. This technique was applied to brain-machine interface (BMI) for information retrieval, such as letters and images for single user [1,2]. However, the classification rate of detecting attention by using the single-shot electroencephalogram (EEG) signal is not reached the application level. In recent years, the hyper-scanned EEG as a method to improve the classification performance of ERP has been proposed [3]. In this paper, we proposed a new retrieval method for computer-generated (CG) images of facial expression by using collaborative P300 from multiple subjects. We focused on a high classification accuracy of the retrieval results.

2. Method

2.1 Experimental Design

Twenty-eight healthy subjects (males, females, age (21-33) years old) participated in the experiment. This experiment was approved by ethics committee in Toyama prefectural university and each subject gave written informed consent.

Eight CG images of facial expression with gray background were used as visual stimuli in our experiment (Fig. 1). Four types of facial expression (non-emotional, angry, fear, and smiley.) in male and female were created with FaceGen (A software to create realistic faces, Singular Inversions, Canada).

EEG and electrooculogram (EOG) signals were recorded by g.USBamp (an EEG measuring instrument, Guger Technologies, Austria) with a sampling rate of 512 Hz. A bandpass filter of 0.1 to 200 Hz for both EEG and EOG was selected. And the notch filter of 60 Hz was applied for reducing the noise from the power supply. Four EEG electrodes were placed at Fz, Cz, Pz, and Oz, based on the extended 10-20 system (Fig. 2). The recording reference and ground were left ear lobe and AFz, respectively.

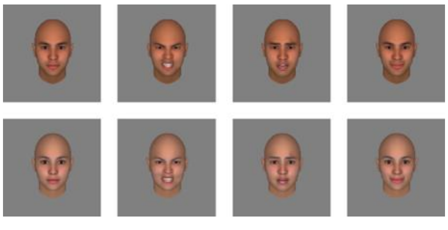

Fig. 1 Stimulus Images

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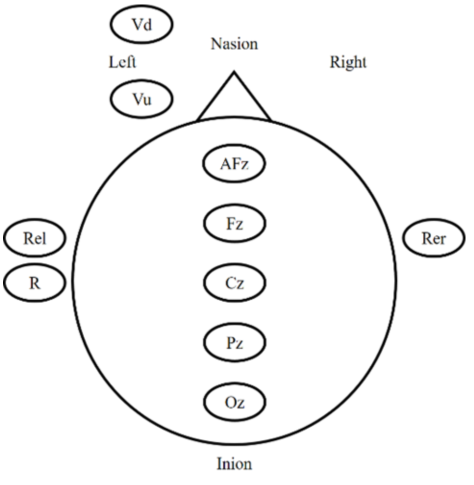

Fig. 2 Electrode Position

Two electrodes were attached to the preauricular points (left: Rel; right: Rer) for re-reference. For removing eye blink and vertical eye movement artifacts, we recorded the vertical EOG. Two EOG electrodes were placed above (Vu) and below (Vd) the left eye.

Subjects were wearing the EEG caps and seated on the standard chairs at 3.5 m in front of a 150-inch screen. The task of subjects was only paying attention to the smiley face images of both sexes. The smiley face images were target stimuli, and other facial images were non-target stimuli. Each subject was performed 10 sessions experiments, after the previewing sessions. One session experiment consisted of 1 min 50 sec. The experimental protocol is shown in Fig. 3. The visual stimuli were presented with Psychtoolbox under Simulink (MathWorks, Inc. American). Each session began with a central fixation point which was presented for 1 sec. And then, the facial expression images were presented with the duration time of 1 sec, randomly. After the facial image was presented four times, there was 3 sec rest for subjects. All of the facial images were presented 5 times in each session, respectively.

2.2 Data Analysis Method

The EEG and EOG data signals were normalized with re-reference method. The average potential value of the two electrodes from Rel and Rer as a new reference was used. And then, the baseline processing was performed with 0.2 sec data before the stimuli onset. The bandpass filter of 0.1 to 10 Hz was used to remove high-frequency artifacts. Moreover, we applied Fast ICA to remove the artifacts which were caused by eye blink and vertical eye movement [4]. After the above pre-processing, the averaging waveforms of P300 and non-P300 were obtained from the EEG signals of Target and Non-Target, respectively.

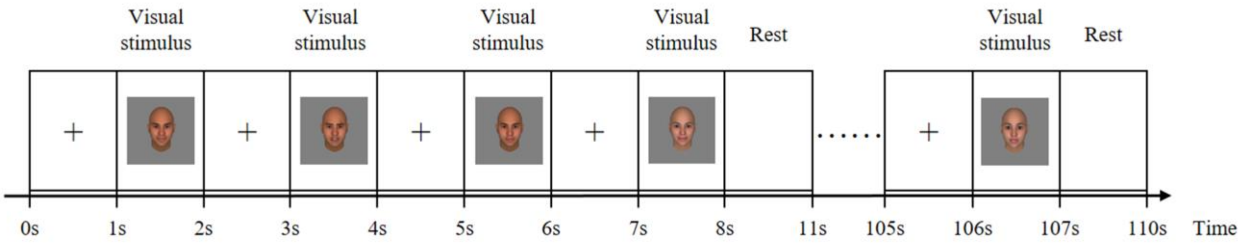

Fig. 3　Experimental Protocol

In order to obtain a high classification accuracy of P300, we performed the EEG features extraction. Spatial and Temporal Principal Component Analysis (STPCA) was applied. In this study, the classifier was Linear Discriminant Analysis (LDA). The classification rate was derived by using leave-one-out cross-validation method.

3. Results

The averaging waveform results of twenty-eight subjects are shown in Fig. 4. The data number of collaborative target and non-target were 100 and 300, respectively. The P300 signal appeared only in the target condition. The amplitude and latency were 12.02 microvolts and 535.16 msec, respectively.

The mean F-measure value of P300 was 89.5% in the multiple subjects condition. However, it was only 62.8% in the single condition. In these analyses, the number of the principal components which was the dimension of the feature vector in the machine learning did not exceed 10. Using those features, we could obtain a high classification result in a short signal processing time. Moreover, we set the multiple subjects condition to seven level with different number subjects. The classification results of those were shown in Fig. 5. The mean value of F-measure was improved by increasing the number of subjects.

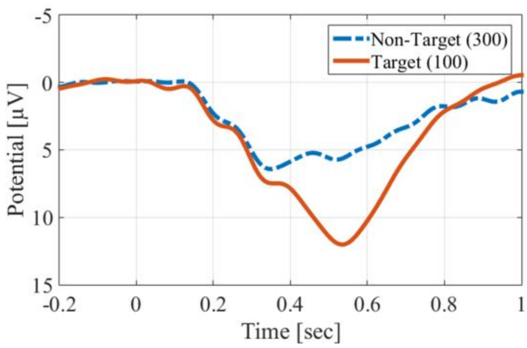

Fig. 4　The Averaging Waveform Results (Pz)

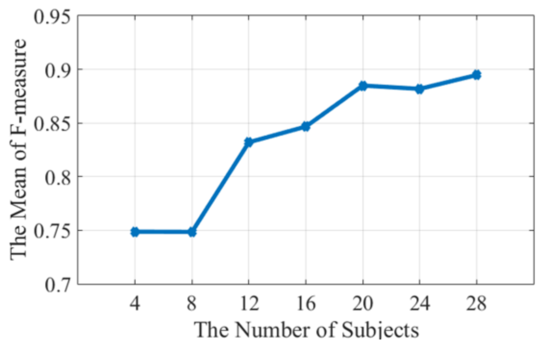

Fig. 5　The Classification Results

4. Discussion

The P300 latency of twenty-eight subjects was later than 300 msec. In our experimental design, smiley faces were similar to the non-emotional faces. It was difficult for subjects to identify the facial images. On the other hand, the P300 latency might be caused by stimuli projection method. We will add a photocell to the experiment for obtaining accurately detecting stimulus onset, in the future.

Moreover, the classification performance could be improved by using the multiple subjects collaborative P300. When the number of subjects was increased, the data quality of collaborative P300 could be improved since the signal-to-noise ratio was raised with the square root of the number of the averaging times.

Our technique may be used for detecting the events with collaborative P300. As we known, there are so many tourist spots in the world. When we want to go a trip, it is necessary to choose a tourist spot. The valuable reference information might be obtained by multiple travelers' thought.

5. Conclusion

In this paper, we performed an experiment which was the facial expression retrieval of the CG images by using collaborative P300. As the results, a high classification performance was obtained. The mean F-measure value was 89.5%. We suggested that the proposed technique may be applicable to BMI for detecting events in future.

Reference

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