EEG-Based Photo Pickup

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Abstract

In this paper, a technique of photo pickup using human brain activities is presented. The non-invasive electroencephalogram (EEG) recording was applied to have event-related P300 evoked potentials during the photo retrieval tasks in oddball paradigm. Three subjects tried to select the photo images among nine that they want to pickup according to their mental states. The P300 components were successfully extracted in temporal average EEG signals. It was found that the average performances of target photo selections could reach 80% using three-channel EEG activities with four-time average. Furthermore, the reproducibility of the EEG waveforms and the photo pickup performance over two days was investigated with the additional experiments involving another set of photo images. This concept would be applicable in future to achieve intuitive retrieval and indexing for life log with large quantities of data.

1. Introduction

Life log technology has lately attracted considerable attention. People can collect and record the data (images, sounds, timestamp, positions etc.) of their entire experiences using mobile, wearable or ubiquitous devices. With such technology, we might be blessed with a variety of useful applications such as 'MyLifeBits' [1].

One of the problems of the life log technology is concerning the data retrieval. In most cases, the data retriever has to operate the computer devices such as mouse and keyboard in order to seek one specific data that the user wants among large quantities of data archives. Furthermore, the automatic indexing to the life log in which people are interested and find the specific emotions has not been established in the present stage.

Recently, a new interaction technique which directly connects human brain and machine has been emerging; the Brain-Computer Interface (BCI). The BCI is a communication channel that enables us to send commands to external devices only by using brain activities [2]. A variety of BCI systems have been studied using visual, stimuli and imagery tasks [3-5]. Among them, the advantage of the BCI system based on P300 evoked potentials [6-7] is that it requires no subject training, and the feasibility has been established; for instance, the P300 speller [8]. Furthermore, it has a compatibility with multi-modal stimuli. The presented stimuli are not restricted to visual one. Therefore, the P300 evoked potentials are thought to be appropriate for life log retrieval and indexing paradigm.

In this paper, the BCI technology will be applied to the life log retrieval paradigm. The event-related P300 evoked potentials was recorded during the photo retrieval tasks in a simple condition. The purpose of this paper is to evaluate the performance of the photo pickup and to confirm the reproducibility of the brain states during the relevant tasks.

2. Experimental method

2.1. Subjects

Three normal volunteers (s1-s3) with normal vision participated in the experiments as subjects (males, 23, 25 and 36 yr, respectively). The subjects were naïve for the EEG measurement and comfortably sitting on an arm-chair facing a screen.

2.2. EEG recordings

To address the performance of the photo pickup, a modular EEG cap system was applied in scalp recordings. Three-channel EEG signals were recorded from the electrode locations of Cz, CPz, and Pz according to the extended international 10/20 system. The analogue EEG signals were amplified at a multi-channel bio-signal amplifier (MEG-6116, NIHON KOHDEN INC. Japan). The amplified signals were band-pass filtered between 0.5 and 30 Hz and sampled at 128 Hz by using a standard A/D converter. The digitized EEG data was stored in a personal computer.

2.3. Experimental tasks

Now, the experimental task sequence is explained. Nine photo images were randomly projected one after the other

from backside every 0.5 sec on the screen. Earlier 2.0 sec was for eye-fixation and the following 4.5 sec included one-time presentation of each photo. The 20-time repetitions were performed to construct 1 session (for 130 sec = 6.5 sec x 20 times). The session was repeated in order to collect the EEG datasets.

The task was to focus attention on one or more specific photos in which the subject was interested and silently counted the number of times that the target photos were presented. These interested photos were selected before the experiments by subjects themselves. For other photo images, the users were instructed to ignore them (oddball task). The photo image sets were sampled by the author from a public photo archive of the web site.

For each subject, the experiments were performed over two days with different photo image sets.

3. Photo pickup algorithm

The recorded EEG datasets were categorized into two according to the number of the brain states (target and non-target photo retrieval). There were totally 1300 single-trial target datasets involving all three subjects over two photo image sets. These datasets were divided into N segments in the order of EEG-recording timestamp to have N-times averaging datasets. In this study, N was taken to be 1, 2, or 4, where 1 denotes the Single-Trial (ST) or non-average case.

For future applications, only three-channel EEG was investigated in the binary classification (between target and non-target). From three electrode sites, the N-times average EEG potential values were considered to have 192-dimensional feature vectors (3ch x 0.5sec x 128Hz). The number of the feature dimension was reduced to 24 by applying Principal Component Analysis (PCA). After that, Linear Discriminant Analysis (LDA) was used for the discrimination of two brain states. Using the N-time average EEG datasets, a leave-one-out method was adopted to simulate the performance of the photo pickup, where only one data is used for the testing and the others are for the training.

4. Results

The target (silently counted) and non-target (not counted) photo images were identified after the experiments by sending the subject a brief questionnaire. Fig.1 shows the results of average waveforms for three electrode locations of Cz, CPz, and Pz. Note that the P300 evoked potentials were observed for target retrieval over three electrodes typically beyond 0.3sec.

The waveforms with photo image set 2 were very similar to those with photo image set 1, which showed the reproducibility of the EEG measurements over two days. That indicated the robustness in our scheme. Note that the waveforms were to some extent unique between the subjects, and thus it is responsible for the personal identification using the photo retrieval tasks discussed in our previous work [9].

It was found that the photo pickup performances were successfully improved with several-time average data (Fig.2). For example, with two-time (four-time) average

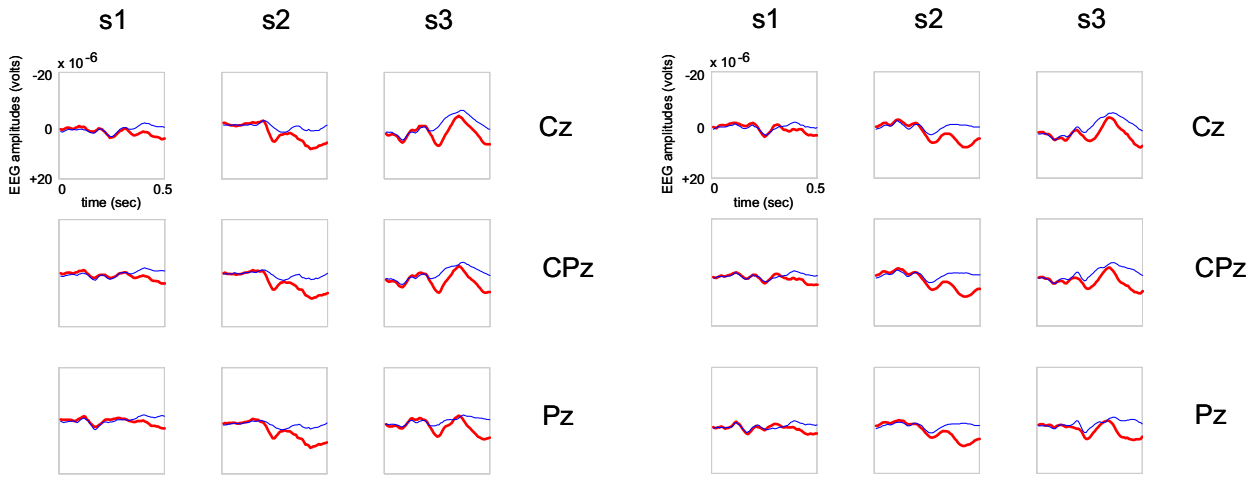

Figure 1: Average EEG waveforms for photo image set 1 (upper 3 x 3) and 2 (lower 3 x 3). Thick line and thin line denotes target and non-target photo retrieval, respectively. From left to right, the waveforms for subject s1-s3, and from upper to lower, the waveforms for the electrode location Cz, CPz, Pz, respectively.

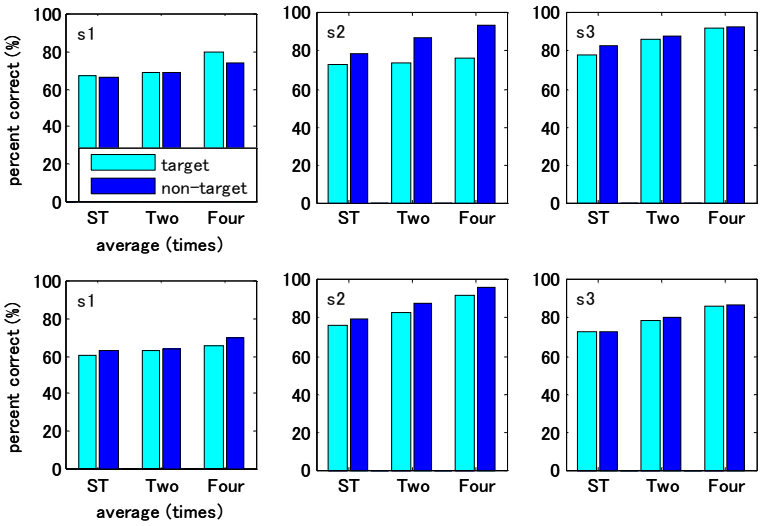

Figure 2: The performances of EEG-based photo pickup. The correct rates are illustrated for both target and non-target photo pickup. From left to right, the percent corrects for the subject s1-s3, respectively. From upper to lower, the performances using photo image data set 1 and 2, respectively.

EEG involving three electrodes, the photo pickup performances using photo image set 1 were 68.7, 74.0 and 86.0% (80.0, 76.0 and 92.0%) of the target stimuli and gave 68.7, 86.7 and 88.0% (74.0, 93.3 and 92.6%) for the non-target stimuli for the subject s1-s3, respectively. For the image set 2, the performances were similar to those of the image set 1. With four-time photo presentation, the performance of target retrieval also reached 92.0%. The user-average of target retrieval was 82.7 and 81.1% with four-time average EEG for image set 1 and 2, respectively. Note that it was about 72.7 and 69.7% using non-average EEG.

5. Discussions

In this study, the average performance of photo pickup reached 80% using four-time average EEG involving three subjects. Note that it was about 70% using non-average EEG. This result also showed the possibility to make EEG-based photo retrieval and also indexing in the context of life log application. The advantage of the P300 evoked potentials is concerning no subjects' training and easiness to obtain the reproducibility. In fact, the subjects had not been trained and the reproducible waveforms as well as photo pickup performances were confirmed. Note that these results were obtained using only three-channel EEG activities applying PCA/LDA algorithm.

In our study, the required time to obtain four-time averaging of target EEG activities was at least 18 sec (4.5sec x 4) for one photo image. For practical use, it would be required to have higher pickup performances improving the feature extraction method and the photo pickup algorithm with single trial or non-average EEG signals. Furthermore, the number of photo (of the order of 100) and the possibility of rapid presentation (less than 0.5sec for one photo) are to be studied in the further research, because these two factors might influence on the waveforms (in particular, the amplitude and the latency) of the P300 evoked potentials. The significant feature of the P300 evoked potentials were beyond 0.3 sec as shown in Fig.1, thus the rapid presentation (presentation frequency more than 2Hz) would result in no significant EEG features. However, the rapid presentation is still in our research scope with the total system-designing, because it has not been studied extensively.

It is expected that the P300 evoked potentials can be obtained using multi-modal stimuli such as auditory, tactile and other possible stimuli. The life log includes the multi-modal data mainly involving visual and auditory one. It would be also in our research scope.

In this study, the results of pilot test of photo pickup using human brain activities were presented. This technique is expected to be applicable in future to achieve intuitive retrieval and indexing for life log, while mentioned improvements would be required.

Acknowledgment

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