A New Concept of Brain-Computer Interface with Environmental Event Sensing

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Abstract

In this paper, a new concept of Brain-Computer Interface (BCI) based on the environmental event sensing is presented. The new BCI system has a variety of sensing devices to extract the important events for the users.

Based on the electroencephalogram (EEG) in the event retrieval paradigm, the event related potentials are extracted being combined with the obtained timing of the environmental events.

This concept will encourage the study on the BCI systems to obtain the specific and interested events for the users in the real environments or to make the indexing to the life log using the brain signals.

1. Introduction

Recently, a new interaction technique which directly connects human brain and machine has been emerging; the BCI [1]. A variety of BCI systems have been studied. Among them, the advantage of the BCI system based on P300 evoked potentials [2] is that it requires no subjects' training, and the feasibility has been established in the retrieval paradigm. The presented stimuli are not restricted to visual one. Therefore, the P300 evoked potentials are thought to be appropriate for retrieval of environmental events.

In the previous BCI systems based on P300 evoked potentials, the target and non-target stimuli were artificial ones. For instance, the P300 speller has the visual stimuli (flushing letters) on the computer monitor [3]. The system had the clear timings of the stimuli and controlled them. However, there is a problem if we consider the EEG-based retrieval of a specific event in the real environments or realistic applications. There is no clear information of timings of the stimuli in EEG signals.

The purpose of this paper is to suggest the BCI system with the environmental event sensing to extract the important events for the users. This concept will enables us to analyze the event related potentials with the timings of the specific events.

2. Overview the analogy in molecular biology

In molecular biology, 'translation' is the first stage of protein biosynthesis. In translation, messenger RNA is decoded to produce a specific polypeptide according to the rules specified by the genetic code. Ribosomes surround the messenger RNA and amino acids are brought to ribosomes and assembled into proteins. (Note that a part of the scenario has been modified in recent studies.)

In this scenario, which is the central dogma in molecular biology, the translation starts with the start codon (AUG), where A, U, and G denote the nucleotide. Termination of the polypeptide happens when the ribosome faces a stop codon (UAA, UAG, or UGA). In this way, the system has start and stop cues in the messenger RNA sequences.

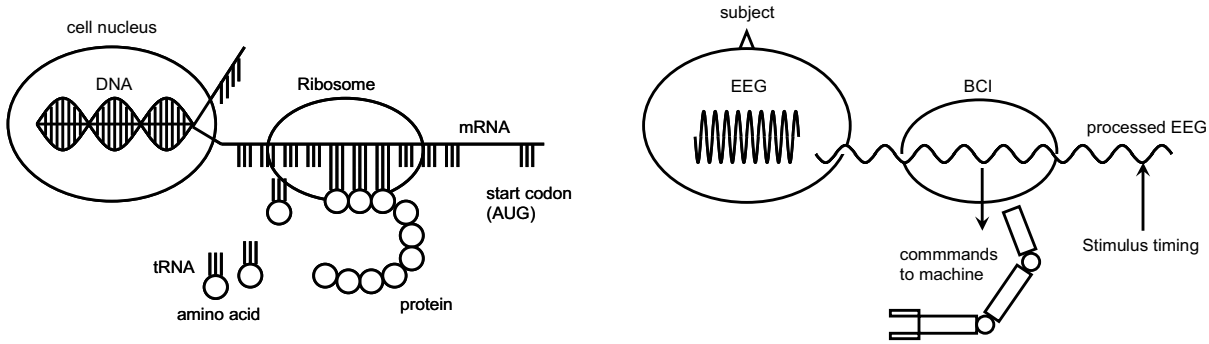

Figure 1: (left) A brief sketch of the central dogma in the molecular biology. (right) The brain-computer interface.

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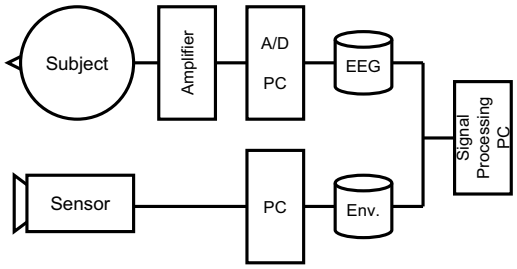

Figure 2: The BCI system with environmental event sensing.

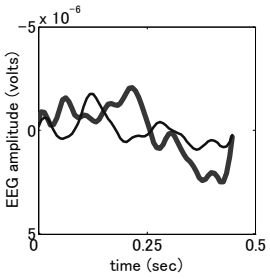

Figure 3: Average EEG waveforms for target (thick line) and non-target (thin line) event retrieval. The electrode position is Cz in international 10/20 system.

In the system of BCI, there is an analogy with the molecular biology as shown in Fig.1. Raw EEG signals and the preprocessed signals correspond to DNA and messenger RNA, respectively. Ribosomes correspond to the BCI systems. A pair of start and stop codon defines the analyzing time in the BCI. Note that start codon is the timing of the specific stimulus. In the usual BCI systems such as P300 speller, the system has the 'start codon' (the timing of the specific stimulus). However, there is no 'start codon' if we consider the specific event in the real environments.

3. BCI systems with environmental event sensing

To extract the specific event in the real world, the BCI system with the environmental event sensing is required as shown in Fig.2.

The EEG signals during retrieval are recorded using the multi-channel biosignal amplifier. The analogue signals are digitized at the A/D converter and the digitized data are stored in the standard computer. The system has a variety of sensing devices such as computer vision, microphone, and so on. The environmental information is simultaneously recorded with EEG activities.

After the data acquisition, the EEG data and the environmental data are processed being combined together. In this process, the timing of the presented stimulus can be obtained from the environmental data.

4. A Preliminary Experiment and the Result

In a preliminary experiment, we studied on a movement of a human hand. The subject focused on the hand of another person and the specific direction of the hand movement was the target stimulus in the oddball paradigm. The opposite direction of the hand movement was the non-target stimulus. The moving hand was optically recorded by the computer vision and the position of the hand was monitored and recognized in real time.

Fig.3 shows the preliminary result on the average EEG waveforms for target and non-target stimulus. The P300 component of the potential was obtained in the target retrieval task.

5. Summary

In this paper, we suggested the possibility of the BCI system with environmental event sensing. In future works, a variety of environmental events are to be investigated using multimodal stimuli. This concept will encourage the study on the BCI systems to make the indexing to the life log using the brain signals.

Acknowledgments

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