A Novel Protocol for Multi-Commands System

Bin Xia\textsuperscript{ab}, Dianyun Xiao\textsuperscript{a}, Jie Li\textsuperscript{b}, Hong Yang\textsuperscript{a}, Cong Wang\textsuperscript{a}

\textsuperscript{a}Department of Electronic Engineering, Shanghai Maritime University, Shanghai, China
\textsuperscript{b}College of Electronic and Information Engineering, Tongji University, Shanghai, China

Correspondence: Bin Xia, Department of Electronic Engineering, Shanghai Maritime University, Shanghai, China.
E-mail: binxia@shmtu.edu.cn, phone +86 21 38282871

Abstract. In general, motor imagery based BCI can provide three or four commands which limit the application of this type BCI system. In this paper, we present a novel protocol to obtain 8 commands based left hand, right hand and foot motor imagery. We apply this multi-commands protocol to control robot arm. In experiments, we verify that the protocol is effective.

Keysor: Motor Imagery, Multi-command, Protocol

1. Introduction

Recently, brain computer interfaces (BCI) has attracted considerable attention in multiple disciplines. The main purpose of BCI is to build a direct communication channel from brain to computer which does not depend on nerves and muscles [Wolpaw et al., 2002]. Using BCI system, disabled people can control output device, such as robot arm or neuroprosthesis.

Motor Imagery (MI) based BCI is commonly used in this field. In general, MI-based BCI system only can provide three or four commands which limit the application area. Researchers try to break through this limitation by building multi-class BCI [Geng et al., 2008]. However, when we increase the number of mental task, the accuracy of the system will decrease. Considering trade-off between accuracy and multi-class, three-class is the best choice in MI-based BCI system [Obermaier et al., 2001].

In order to extend the application area for MI-based BCI system, we propose a novel protocol which applies three motor imagery (left, right and foot motor imagery) tasks to achieve eight commands. To verify this protocol, we apply it to control robot arm which has five degrees of freedom (DoF).

2. Methods

For five DoF robot arm, the movement control is complicated. For any movement of arm, it will involve multiple joint’s movement. To simplicity, we control the end-effector movement in six directions: left and right, up and down, forward and backward. For example, when moving forward in one centimeter, the system will automatically calculate the amount of movement each joint. And considering finger's hold and put command, eight commands are necessary to be able to effectively control the movement of the arm.

2.1. Protocol

Eight commands are divided into four groups in which every group stay in same line. The group structure is shown in Figure.1. In order to control eight commands, we need one switch command and two executive commands. In this protocol, we specify foot imagery as switch command whose role is to switch the command line every once and then highlight the available command line from up to down. In the highlighted command line, we apply left and right hand motor imagery as the executive commands. As shown in Figure.1 (a), the target command is “HOLD”. Subject should use switch command (foot motor imagery) to move highlight bar to the last command line. Figure.1 (b) shows last command line is available. And then subject can use left hand motor imagery to output target command “HOLD”. The score is changed to 3 that means the target command is executed.
2.2. Signal processing and classification

In this work, we choose nine channels (FC3 FCZ FC4 C3 CZ C4 CP3 CPZ CP4) with respect to the international 10-20 systems. The recording was made with a 16-channel g.tec USBamp. The EEG signal was sampled at 256 Hz and filtered by 8-30 Hz band pass filter.

To evaluate the new protocol, we apply common spatial pattern and support vector machine as feature extraction algorithm and classification algorithm respectively.

3. Results

We tested presented protocol with 5 healthy young subjects (codes s1, s2, s3, s4, s5). Subject s1 has some experiences in MI BCI and other subjects are newer in this field. In verification experiments, every subject was requested to perform three motor imagery tasks (right hand, left hand, both feet) first. When the accuracy is greater than 90%, the subject was request to play eight-commands tasks. In experimental paradigm, every subject should finish five sessions. In each session, eight commands were played in five times and total trials are 40 for eight commands. Because subject s2 and s3 failed in three motor imagery tasks, they are not requested to play eight-commands task. Other three subjects finished five sessions eight-commands task. The results are shown in table 1.

Table 1 Average accuracy for eight-command tasks

<table>
<thead>
<tr>
<th>Subject</th>
<th>S1</th>
<th>S4</th>
<th>S5</th>
</tr>
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<tbody>
<tr>
<td>Average Accu</td>
<td>92.5 ± 6.9%</td>
<td>84.5 ± 9.3%</td>
<td>83.8 ± 9.0%</td>
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4. Conclusions

In this paper, we present a novel protocol which applies three motor imagery to drive eight-commands system. We design an experiment to verify this protocol. Three subjects achieve good performance after 10 hours training. Experiment results show proposed protocol is validity.

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References


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