상상 움직임에 대한 실시간 뇌전도 뇌 컴퓨터 상호작용, 큐 없는 상상 움직임에서의 뇌 신호 분류

Real-time BCI for imagery movement and Classification for uncued EEG signal

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Abstract Brain Computer Interface (BCI) is a communication pathway between devices (computers) and human brain. It treats brain signals in real-time basis and discriminates some information of what human brain is doing. In this work, we develop a EEG BCI system using a feature extraction such as common spatial pattern (CSP) and a classifier using Fisher linear discriminant analysis (FLDA). Two-class EEG motor imagery movement datasets with both cued and uncued are tested to verify its feasibility.

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1. Introduction

Brain Computer Interface (BCI) is a systematic way to communicate between digital devices and human brain. It has been initiated with intention to provide severely paralyzed people with some controlled convenience. Mostly EEG (electroencephalography) based BCI system has been developed since EEG is fully noninvasive and cheap to get real-time data. In general, BCI system consists of a feature extraction and classification. Feature extraction is a way to extract some understandable or discriminable information from real-time EEG data. Classification is to figure out which brain activities (left or right movement) extracted feature tells.

In this work, we try to implement real-time EEG based BCI system extracting special feature by common spatial pattern analysis and classifying two class brain activities by Fisher linear discriminant analysis.

2. Methods

2.1 Data description

We collected two different datasets for the real-time imagery movement from healthy subjects. For one dataset, we used 32-channel EEG system (Neuromedic WEEG-32 system), and acquired real-time EEG dataset at 256 Hz. The other dataset was got from Berlin-BCI (BBCI) group. It is a EEG dataset (dataset1 : motor imagery, uncued classifier application) among four different datasets used for BCI competition IV [4]. It consists of normal data(1a, 1b, 1f, and 1g) and artificial data(1c, 1d, and 1e).

Detailed experimental paradigms for both datasets are explained in Section 3.

2.2 Common Spatial Pattern (CSP)

Among many methods of feature extraction, CSP method is applied. CSP is a kind of spatial filter which generates common spatial patterns from two different class spatial covariance matrices. It requires to solve generalized eigenvalue problems to get spatial filters and spatial patterns [1-2]. It is very useful feature extraction to discriminate two classes.

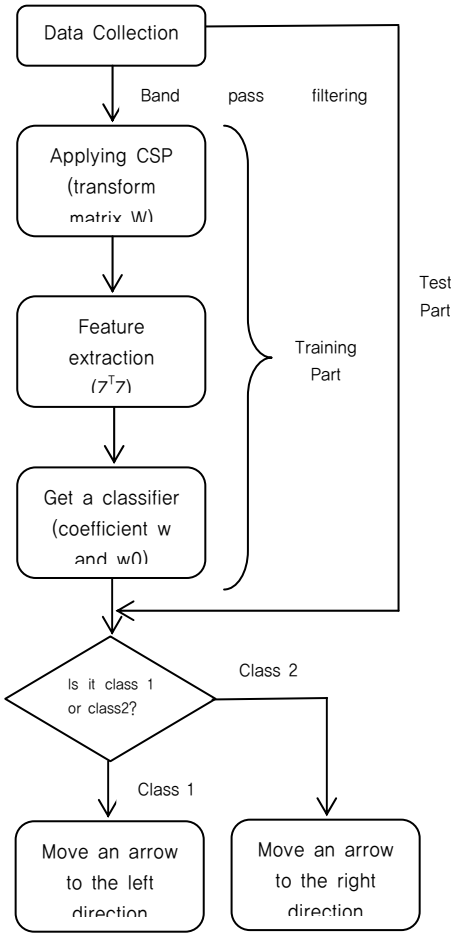
2.3 Fisher Linear Discriminant Analysis (FLDA)

Fisher Linear Discriminant Analysis (FLDA) is classifying easily classes through maximization of ratio of the variance between the classes to the variance within the classes. We applied FLDA to classify CSP transformed features into two classes [3].

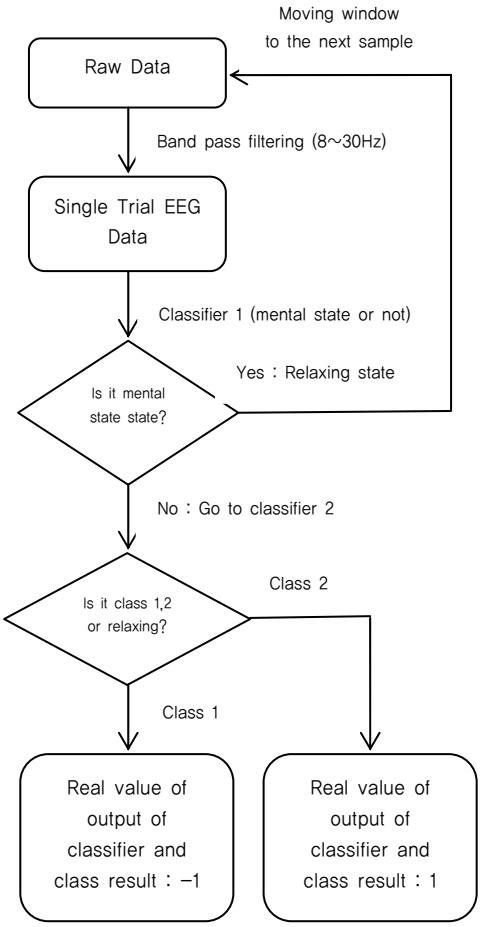
3. Experiment

1 Experiment 1

We implemented real-time EEG based BCI for imagery movement (left/right hand). Firstly, we collected the EEG data during 5 sessions. For each session, we collected 40 EEG spatiotemporal data, whose class is generated randomly (left: 20 / right: 20). At initial stage blank screen is displayed and arrow (arrow gives an instruction which hand subject should imagine to move)



〈Fig.1 Flow chart of data processing for experiment 1〉



〈Fig.2 Flow chart of data processing for experiment 2〉

shows up from 1s to 5s. On arrow direction shows up, spatiotemporal EEG signal is recorded as text format (ascii type). Cue (time when arrow starts to show up) is recorded. This process is repeated until 40 times are tried for each session. Between sessions, a couple of minutes rest is given. After acquiring total of 200 data, band-pass (8Hz 50Hz) filtering is done, and then CSP features are extracted. As a training data, 160 data among them were used to generate a classifier. Remaining 40 datasets were used to test how well the classifier is working.

3.2 Experiment 2

Another left/right hand imagery movement 59-channel EEG datasets were obtained from BCI competition Ⅳ. It is called 'Dataset 1 <motor imagery, uncued classifier application>'. During runs, arrows pointing left, right were presented as visual cues on a computer screen. Cues were displayed for a period of 4 seconds during which the subject was instructed to perform the cued motor imagery task. These periods were interleaved with 2 seconds of blank screen and 2 seconds with a fixation cross shown in the center of the screen. The fixation cross was superimposed on the cues, i.e. it was shown for 6 seconds. These data sets are provided with complete marker information.

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