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Analysis the effect of PCA for feature reduction in non-stationary EEG based motor imagery of BCI system

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ABSTRACT

Many brain computer–interface (BCI) systems depend on imagined movement to control external devices. But how to extract the imagination feature and classify them to control systems is an important problem. To simplify the complexity of the classification, the power band and a small number of electrodes have been used, but there is still a loss in classification accuracy in the state-of-art approaches. The critical problem is the machine learning art that when the signal into source has property of non-stationary causing the estimation of the population parameter to change over time. In this paper, we analyzed the performance of feature extraction method using several spatial filter such as common average reference (CAR), Laplacian (LAP), common spatial pattern analysis (CSP) and no-spatial filter techniques and feature reduction method using principle component analysis (PCA) based 90% rule variance and leave-one-out correct classification accuracy selection method; where support vector machine is the classifier. The simulation with non-stationary data set from BCI competition III-Iva shows that CAR best performance CSP method in non-stationary data and PCA with leave-one-out CCA could maintain CCA performance and reduced the trading off between training and testing 13.96% compared to not using PCA and 0.46% compared PCA with 90% variance.

1. Introduction

A brain–computer interface, or BCI, is a communication and control system that creates a non-muscular output channel for the brain [1]. The language of this communication is in part imposed on the brain that by the use of distinct brain signal features that the BCI system extracts and uses for device control and in part negotiated by the continuous and mutual adaptations of both the user and the system. The University of all over the world is committed to the development of the BCI system. Application of new sensors and EEG signals is to be used for exploiting motor imagery in order to produce more and more signal to control complicated BCI system. BCI systems have measured specific features of brain activity and translate them into command for the device control. For example, movement of arbitrary limbs changes the brain activity in the related cortex. In fact, already the preparation of movement or the imagination of movement also changed the so-called sensory rhythms. α rhythm activity is recorded from the sensorimotor areas, also called μ rhythm activity.

The EEG has numerous regular rhythm. The most famous are the occipital α rhythm, the central mu and beta rhythm. People can desynchronize the α rhythm and more increase activity by moror imangiry. This desynchronization reflects a decrease of oscillatory activity related to an internally or externally-paced event and is known as Event-Related Deynchronization (ERD). The opposite, namely the increase of rhythmic activity, was termed Event-Related Synchronization (ERS). ERD and ERS are characterized by fairly localized topographic and frequency specificity. The ERD/ERS patterns can be volitionally produced by motor imagery, which is the imagination of movement of limbs without actual movement [2]. In general, the EEGs are recorded over primary sensorimotor cortical areas often displays 8–10 Hz (μ rhythm) and 18–26 Hz (β rhythm) activity. Some published paper had shown that people can learn to control the amplitude of μ/β rhythm in the absence of actual movement or sensation. Because μ/β rhythms are included in the ERD and ERS of the brain signals. It can be as part of spatial features for motor imagery

In order to improve the classification accuracy, in this paper, spatial filter and principal component analysis method have been proposed for the feature extraction and reduction, and SVM is introduced for the classifier.

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