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CSP-TSM: Optimizing the performance of Riemannian Tangent Space Mapping using Common Spatial Pattern for MI-BCI

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***Abstract - Background*: Classification of electroencephalography (EEG) signals for motor imagery based brain computer interface (MI-BCI) is an exigent task and common spatial pattern (CSP) has been extensively explored for this purpose. In this work, we focused on developing a new framework for classification of EEG signals for MI-BCI.**

***Method*: We propose a single band CSP framework for MI-BCI that utilizes the concept of tangent space mapping (TSM) in the manifold of covariance matrices. The proposed method is named CSP-TSM. Spatial filtering is performed on the bandpass filtered MI EEG signal. Riemannian tangent space is utilized for extracting features from the spatial filtered signal. The TSM features are then fused with the CSP variance based features and feature selection is performed using Lasso. Linear discriminant analysis (LDA) is then applied to the selected features and finally classification is done using support vector machine (SVM) classifier.**

***Results*: The proposed framework gives improved performance for MI EEG signal classification in comparison with several competing methods. Experiments conducted shows that the proposed framework reduces the overall classification error rate for MI-BCI by 3.16%, 5.10% and 1.70% (for BCI Competition III dataset IVa, BCI Competition IV Dataset I and BCI Competition IV Dataset IIb, respectively) compared to the conventional CSP method under the same experimental settings.**

***Conclusion:* The proposed CSP-TSM method produces promising results when compared with several competing methods in this paper. In addition, the computational complexity is less compared to that of TSM method. Our proposed CSP-TSM framework can be potentially used for developing improved MI-BCI systems.**

***Index Terms*—Brain Computer Interface (BCI); Common Spatial Pattern (CSP); Electroencephalography (EEG); Motor Imagery (MI); Riemannian Distance, Tangent Space Mapping (TSM).**

I. Introduction

IN a brain computer interface (BCI) system, direct communication takes place between the brain and the external devices without the involvement of peripheral nerves and muscles in order to allow humans to interact with their surroundings [1]. The electrical control signals generated by the brain activity are