User-specific frequency band and time segment selection with high class distinctiveness for Riemannian BCIs

Maria Sayu Yamamoto, Fabien Lotte, Florian Yger, Sylvain Chevallier

User-specific frequency band and time segment selection with high class distinctiveness for Riemannian BCIs

Maria Sayu Yamamoto*†[1], Fabien Lotte[2], Florian Yger[3], and Sylvain Chevallier[4]

[1]Laboratoire d'Ingénierie des Systèmes de Versailles (LISV, Université Paris-Saclay) – Laboratoire d'Ingénierie des Systèmes de Versailles (LISV), University paris saclay – 10-12 Avenue de l'Europe, France

[2]Inria Bordeaux Sud-Ouest / LaBRI (Inria Bordeaux Sud-Ouest / LaBRI (Univ. Bordeaux / CNRS / Bordeaux INP)) – Inria Bordeaux Sud-Ouest, LaBRI – 200 Av. de la Vieille Tour, Talence, France

[3]LAMSADE, PSL-Université Paris-Dauphine (LAMSADE) – LAMSADE, Université Paris-Dauphine, PSL – Place du Maréchal de Lattre de Tassigny, Paris, France

[4]Laboratoire d'Ingénierie des Systèmes de Versailles, Université de Versailles Saint-Quentin-en-Yvelines, Université Paris-Saclay (LISV, UVSQ, Université Paris-Saclay) – Laboratoire d'Ingénierie des Systèmes de Versailles (LISV), Université de Versailles Saint-Quentin-en-Yvelines (UVSQ), University Paris-Saclay – 10-12 avenue de l'Europe, France

Abstract

User-specific settings are known to enhance Brain-Computer Interface (BCI) performances [1]. In particular, the optimal frequency band and time segment for oscillatory activity classification are highly user-dependent and many selection methods have been developed in the past two decades. However, it has not been studied well whether those conventional methods can provide optimal settings for the Riemannian BCIs, a recent family of BCI systems that utilize different data representation, based on covariance matrices, compared to conventional BCI pipelines. In this work, we proposed a novel frequency band and time segment selection method considering class distinctiveness on the Riemannian manifold. The class distinctiveness of each combination of frequency band and time segment is quantified based on inter-class distance and intra-class variance on the Riemannian manifold [2]. An advantage of this method is the user-specific settings can be adjusted without computationally heavy optimization steps. To the best of our knowledge, this is the first optimization method for selecting both the frequency band and the time segment on the Riemannian manifold. We evaluated the contributions of the 3 different selection models (frequency band, time or frequency band+time), comparing classification accuracy with a baseline (a fixed frequency band of 8-30 Hz and a fixed 2s time window) and a conventional popular method for non-Riemannian BCIs [1], on the BCI competition IV dataset 2a (2-class motor imagery). Our method showed higher average accuracy than baseline and a conventional method in all three models, and especially the frequency band selection model showed the highest performance. This preliminary result suggests the importance of developing new selection algorithms considering the properties of the manifold, rather than directly applying methods developed prior to the rise of Riemannian BCIs as they are.

Blankertz B & al., IEEE Sig Proc Mag, 2007; [2] Lotte F & Jeunet., JNE, 2018

*Speaker

†Corresponding author: maria-sayu.yamamoto@universite-paris-saclay.fr

Keywords: Riemannian geometry, oscillatory activity based BCIs, frequency band and time segment selection