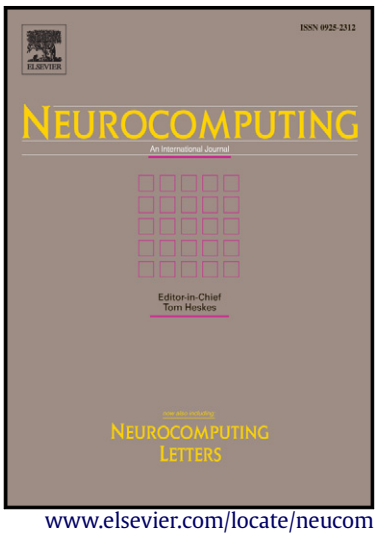

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Adaptive semi-supervised classification to reduce intersession non-stationarity in multiclass motor imagery-based brain computer interfaces

Luis F Nicolas-Alonso[1], Rebeca Corralejo[1], Javier Gomez-Pilar[1], Daniel Álvarez[1] and Roberto Hornero[1]

[1]Biomedical Engineering Group, E.T.S. Ingenieros de Telecomunicación, Universidad de Valladolid, Valladolid, Spain

Email addresses:
Luis F. Nicolas-Alonso[1]: lnicalo@ribera.tel.uva.es
Rebeca Corralejo[1]: rebeca.corralejo@gib.tel.uva.es
Javier Gomez-Pilar[1]: javier.gomez@gib.tel.uva.es
Daniel Álvarez[1]: dalvgon@ribera.tel.uva.es
Roberto Hornero[1]: robhor@tel.uva.es

CORRESPONDING AUTHOR:
Luis F. Nicolas-Alonso
E.T.S. Ingenieros de Telecomunicación
Universidad de Valladolid
Paseo de Belén, 15
47011 - Valladolid (Spain)
Phone: +34 983 423000, ext. 3708
Fax: +34 983 423667
E-mail: lnicalo@ribera.tel.uva.es

Abstract
The intersession non-stationarity in electroencephalogram (EEG) data is a major issue to robust operation of brain–computer interfaces (BCIs). The aim of this paper is to propose a semi-supervised classification algorithm whereby the model is gradually enhanced with unlabelled data collected online. Additionally, a processing stage is introduced before classification to adaptively reduce the small fluctuations between the features from training and evaluation sessions. The key element of the classification algorithm is an optimized version of kernel discriminant analysis called spectral regression kernel discriminant analysis (SRKDA) in order to meet the low computational cost requirement for online BCI applications. Four different approaches, SRKDA and sequential updating semi-supervised SRKDA (SUSS-SRKDA) with or without adaptive processing stage are considered to quantify the advantages of semi-supervised learning and adaptive stage. The session-to-session performance for each of them is evaluated on the multiclass problem (four motor imagery tasks: the imagination of movement of the left hand, right hand, both feet, and tongue) posed in the BCI Competition IV dataset 2a. The results agree with previous studies reporting semi-supervised learning enhances the adaptability of BCIs to non-stationary EEG data. Moreover, we show that reducing the inter-session non-stationarity before classification further boosts its performance. The classification method combining adaptive processing and semi-supervised learning is found to yield the highest session-to session transfer results presented so far for this multiclass dataset: accuracy (77%) and Cohen's kappa coefficient (0.70). Thus, the proposed methodology could be of great interest for real-life BCIs.

Keywords
Adaptive classification; Brain Computer Interfaces; Electroencephalography; Non-stationarity; Semi-supervised classification;