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On the use of augmented autocorrelation matrix for the classification of BCI-EEG

Igor Carrara, Theodore Papadopoulo

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Electroencephalogram (EEG) signals is recorded as a multidimensional dataset, which can be interpreted using autoregressive (AR) models. These models are based on the hypothesis that the signal can be explained by its past values and an additional random component called innovation. In this way, it is possible to extract relevant information about the signal, which can be used for a BCI classification.

From the AR equation can be derived the Yule-Walker equations, which show the emergence of a symmetric positive definite matrices (SPD) matrix i.e. the autocorrelation matrix with lags. The state-of the art for classifying SPD matrices is based on Riemann Geometry, so a fairly natural idea is therefore to extend the standard approach using these autocorrelation matrices with lags. In order to validate the results, we test our approach both with a classification on the Riemann surface using the Minimum Distance to Mean and also with a classification on the Tangent Space using Support Vector Machine. To compute the hyper-parameters of the model, we use a Grid Search algorithm.

The problem can also be formulated from another point of view: since the AR Yule-Walker matrix is a matrix of delayed correlations, we can obtain the same result by creating an embedding of the original system in a high dimensional space. Hence, it is natural to connect our approach with the delay embedding theorem proposed by Takens in the context of dynamical systems. Such an embedding method is based on the knowledge of two parameters: the delay parameter and the embedding dimension, respectively the lag and the order in the context of the AR model. This approach can be used as a new method to compute the hyper-parameters.

We will test our approach on several dataset and on several subjects using the MOABB framework, using both within-session and cross-session evaluation.