Inter-session Transfer Learning using Riemannian Geometry for Mental Workload Estimation

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BACKGROUND:

- EEG is highly **non-stationary** and drifts in terms of amplitude and other features over time, even within a day for a particular user.
- So, there is a need for algorithms capable of **inter-session transfer learning** such that the **calibration is minimized or eliminated** for the subsequent sessions.
- **Riemannian Geometry** makes excellent use of Covariance matrices by virtue of the property that they are **Symmetric Positive Definite** matrices.
- Data is projected from the Riemannian manifold to a locally homomorphic **Tangent Space** which is Euclidean - Can then use conventional classifiers on it.
- Transfer Learning is done by using an **adaptive projection** which changes the projection point by learning from the new session data in an unsupervised manner

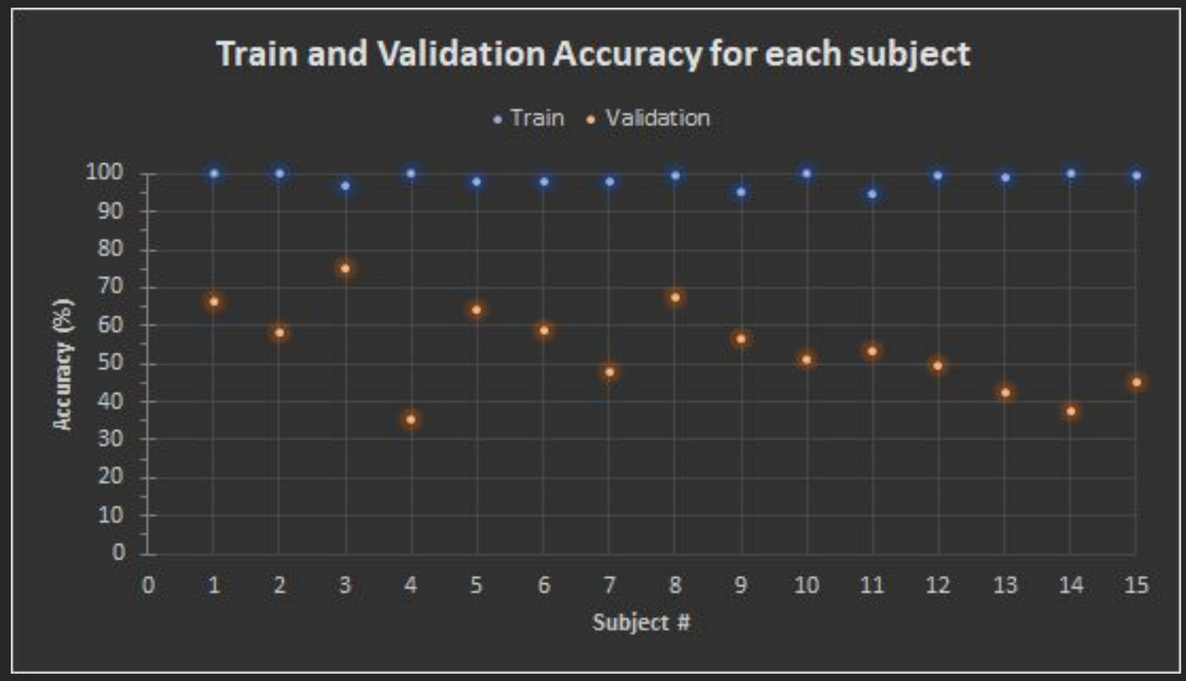
METHODS

1. Data -
   a. 2-second epochs of EEG at 250Hz preprocessed for noise rejection
   b. 15 subjects, 3 sessions with different difficulty levels
2. First 2 sessions available for training, testing on 3rd session.
   a. Training was done in an intra (per) subject manner
3. 3 models were ensembled
   a. Riemannian Minimum Distance to Mean classifier
   b. Tangent Space Projection -> SVM Classifier
   c. Tangent Space Projection -> XGB Classifer

RESULTS

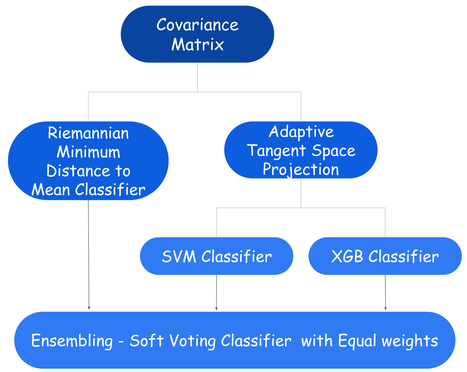
- Overall average validation accuracy by training on session 2 and testing on session 1 was **51.25%**

Ensembling of techniques using the fundamental properties of covariance matrices through Riemannian geometry combined with unsupervised transfer learning using an adaptive kernel for tangent space projection shows a promising result for inter-session generalization



Train on Session 2 and Validation on Session 1

Architecture Flowchart



Visualisation for the Techniques

Fig 1 - MDM Classifier and Tangent Space Projection [1]

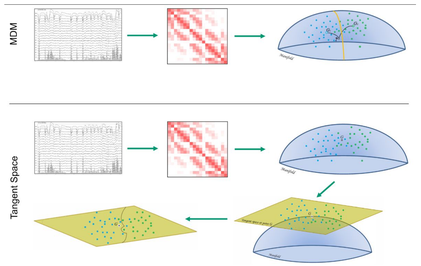
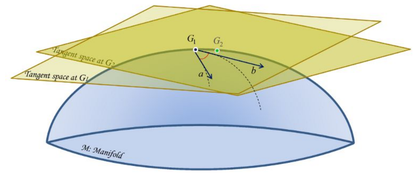


Fig 2 - Adaptive Tangent Space Projection by learning the new projection point from the next session data [1]



Reference

[1] 2021 BCI Society Workshop Slides - Marco Congedo

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