EEG-Based Biometric Authentication for Brain Computer Interfaces

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Problem Statement

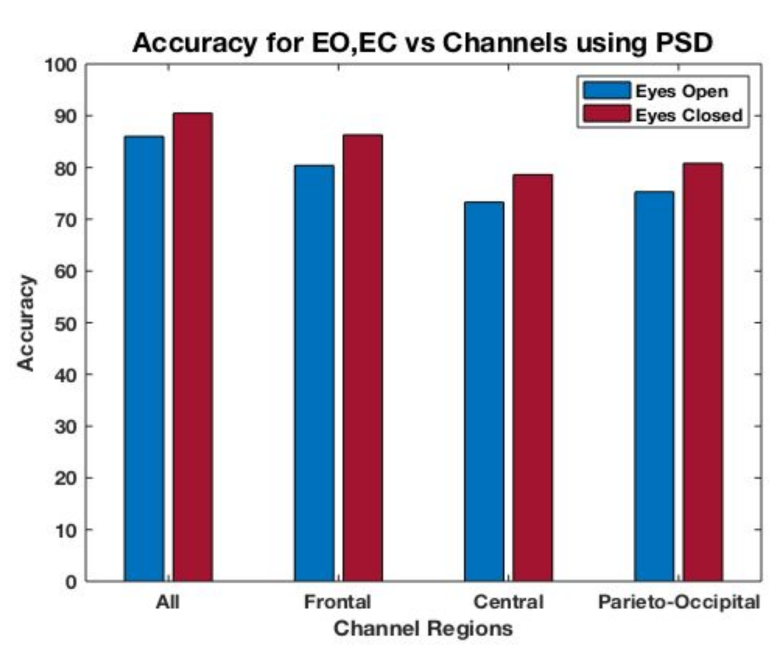
Authenticating users has always been an integral part of security systems. Despite the fact that **Biometric Authentication has long been the gold standard for security**, with advancing technology, even the biometric authentication techniques are not safe from forgery and deception. **A significant step would be Biometric Authentication using the few channels of Electroencephalogram (EEG) data available in brain computer interfaces (BCIs).** Authentication could be done quickly and effortlessly capturing a predefined brain state which is impossible to evoke by insistence or coercion nor can be replicated by a non-living brain, because **every human brain has a distinctive neural signature.**

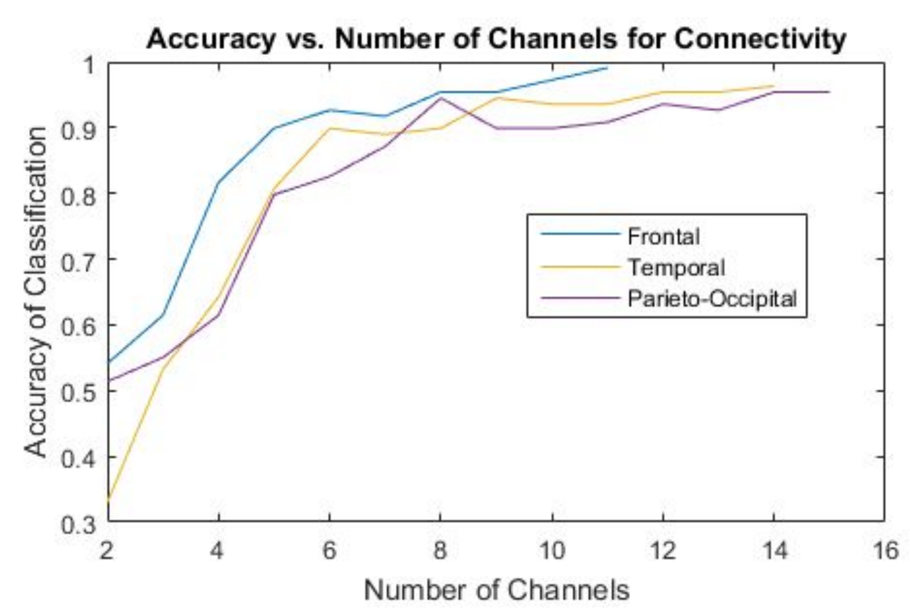
Dataset

Physionet's EEG Motor Movement/Imagery Dataset was used for the implementation with EEG data for two baselines - Eyes Open and Eyes Closed, for 109 subjects over 64 EEG-channels.

The data was segmented into 6 epochs (5 - training, 1 - testing) of 10s on which PSD and Spectral Coherence were used to extract features (N_{feat}^{PSD}=64, N_{feat}^{COH}=1540).

Spectral Distance vs. Channel Connectivity

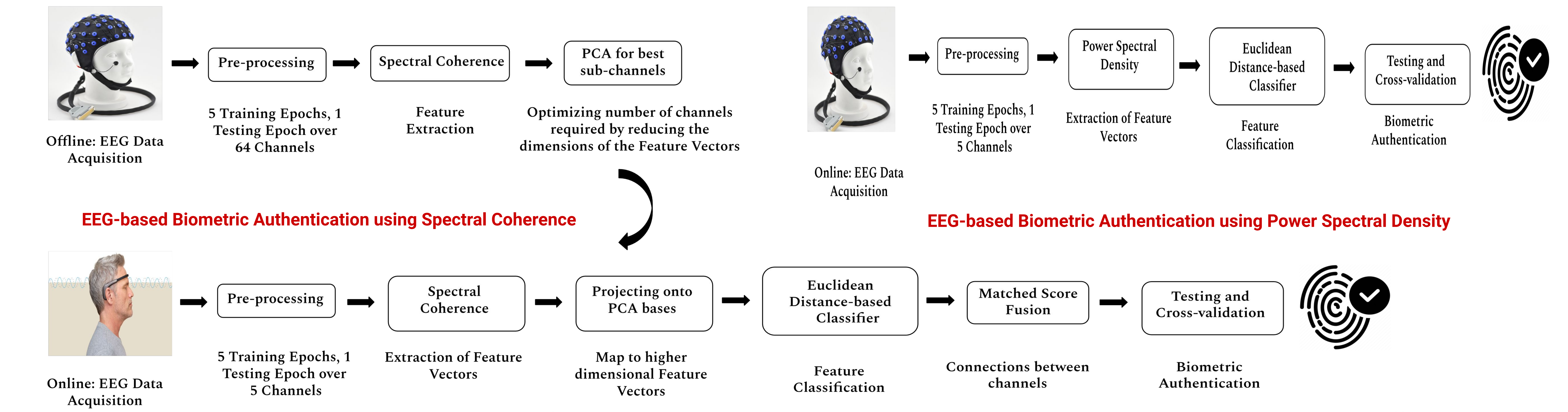




Accuracy for eyes closed is better than eyes open, as eyes closed resting states interrupt the visual processing while enhancing endogenous and autonomic related brain activity.

Spectral Coherence performs much better than Spectral Density, both at low and high channel numbers. Coherence quantifies how regions of the brain connect, characterizing brain structure, and performs better even with the same number of features.

Previous studies have shown that the frontal region provides the best authenticating ability. We were able to verify this for low numbers of channels, and improve performance using the offline feature map.



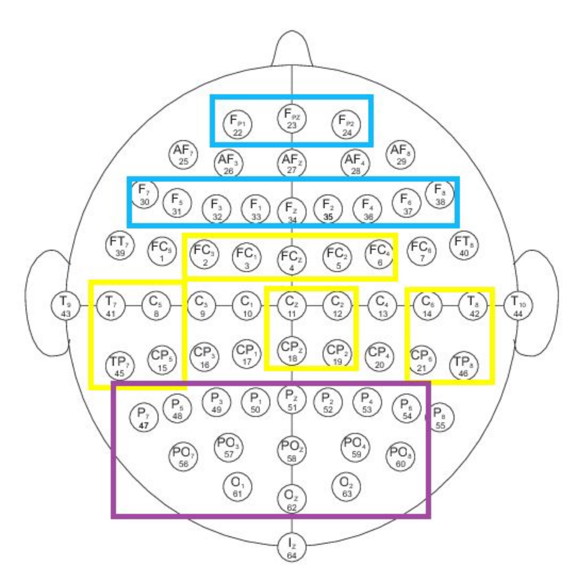
The above block diagrams model the systems for Biometric Authentication using EEG, where a 64-channel EEG is used offline to train the Spectral Coherence model. Training uses PCA to find feature vectors which vary most between classes. During online authentication, the MUSE Headband data is projected onto these higher dimension features. This achieved better authentication compared to the unprojected features, with accuracies of 99% and 95% respectively. Spectral Coherence also performs better than a PSD approach using the same classifier, hence chosen for the online model for identifying the user based on the "brain waves".

Reducing the Number of Channels

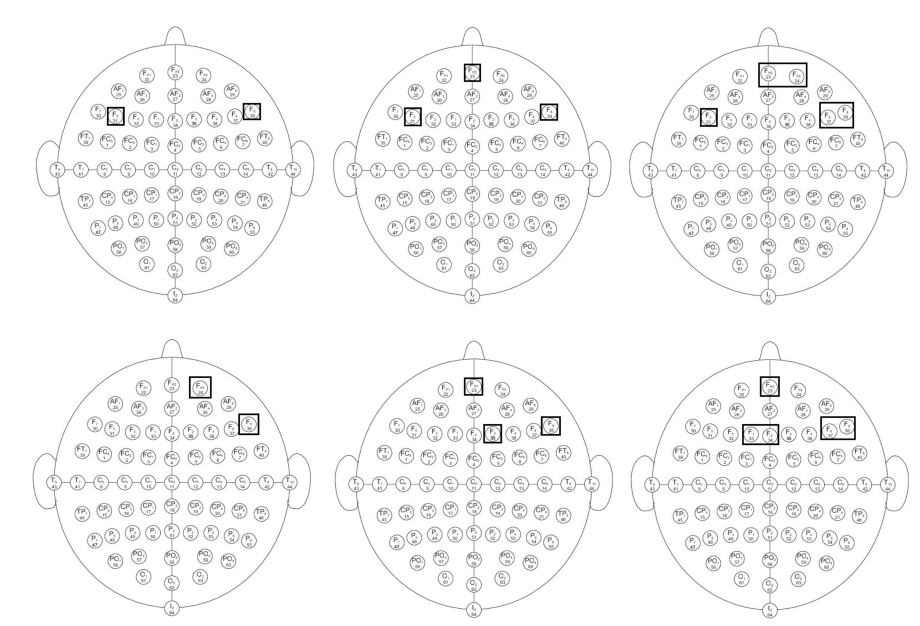
After identifying the principle components of the feature vectors offline, we could find the best subset of channels to estimate these components. A best-subspace search on the channels found the best channels to use in lightweight authentication.

Most of the variance is captured by two channels at the temples and three at the forehead. This provided up to 95% accuracy and could be implemented in a commercial EEG device. In addition, this requires only minimal computing power due to the 100x reduction in number of features.

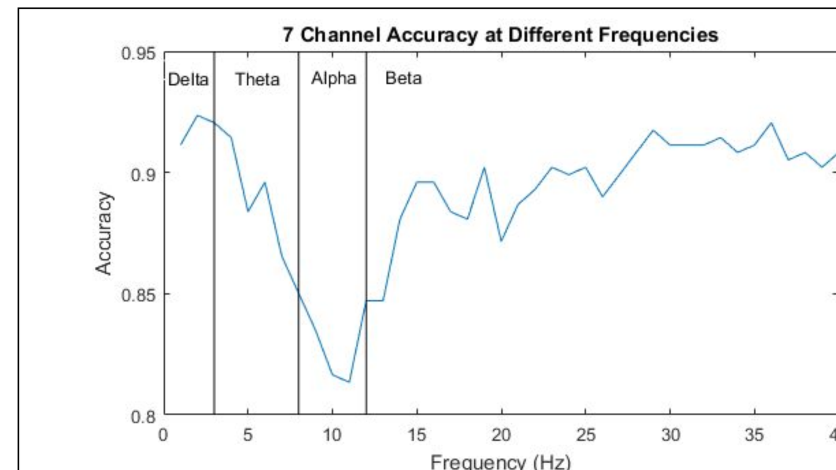
The best channels changed for high and low frequencies, indicating potential improvements by using separate classifiers at Delta and Beta waves.

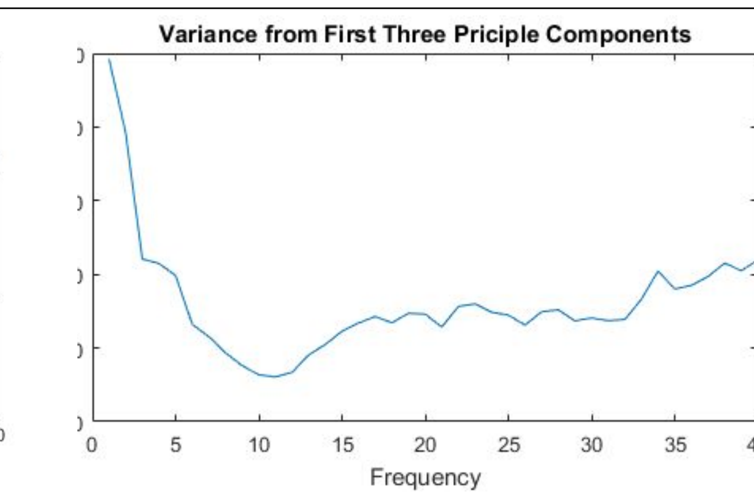


Frontal, Temporal, and Parieto-Occipital shown in blue, yellow, and purple



Best channel subsets at high frequency (top) and low frequency (bottom).





Future Work

We will implement the authentication scheme online in a MUSE headset using the offline features. This will validate the ability of the learned features to provide authentication in lightweight settings with low computation.

Potential improvements could be made by rejecting frequencies of low authenticating ability in different regions of the brain.

Different frequencies provided different accuracies when used in training the features. Namely, the Delta and high-Beta bands provided much better authentication than the Alpha and Theta bands.

References

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[2] M. V. Ruiz-Blondet, Z. Jin, and S. Laszlo, "CEREBRE: A novel method for very high accuracy event-related potential biometric identification," IEEE Trans. on Information Forensics and Security, 2016.