

# Supplementary Information for: MontageFL: Privacy-Preserving Federated Learning across Heterogeneous EEG Montages

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## ABSTRACT

This document contains supplementary information for the main manuscript.

## S1. Definition of the 56 covariance features (Stream B)

Stream B summarizes the within-epoch channel covariance structure. For each 4-second epoch the signal is divided into 1-second windows with 50% overlap; within each window every channel is z-scored and a covariance matrix  $\Sigma$  is formed and shrinkage-regularized as  $\Sigma' = (1-\lambda)\Sigma + \lambda I$  with  $\lambda=0.10$ , which keeps  $\Sigma'$  full rank at any channel count. This yields a sequence of regularized covariance matrices per epoch. For each of the four regions, 14 features are computed from this sequence (Table 1), where the diagonal series for a region is the set of channel variances over windows and the off-diagonal series is the set of within-region channel pairs ( $a < b$ ) over windows. Total:  $14 \times 4$  regions = 56 features. Regions with at least two channels (all regions under both montages) yield defined off-diagonal statistics.

**Table 1.** The 14 covariance features computed per region ( $\times 4$  regions = 56). All quantities are computed on the shrinkage-regularized covariance sequence described above.

#	Feature	Definition
1	Diagonal mean	Mean of channel variances across channels and windows
2	Diagonal SD	Standard deviation of the diagonal series
3	Diagonal median	Median of the diagonal series
4	Diagonal IQR	75th – 25th percentile of the diagonal series
5	Temporal instability	Mean absolute first difference of the diagonal series across windows
6	Off-diagonal mean	Mean of within-region channel-pair covariances
7	Off-diagonal SD	Standard deviation of the within-region pair covariances
8	Off-diagonal  mean	Mean absolute within-region pair covariance
9	Off-diagonal instability	Mean absolute first difference of the pair series across windows
10	Cross-region  coupling	Mean absolute covariance between region channels and all other channels
11	Coupling ratio	Within-region  mean  (feature 8) divided by cross-region  coupling  (feature 10)
12	Eigenvalue ratio	$\lambda_1/\lambda_2$ of the region’s mean (over windows) covariance submatrix
13	Diagonal kurtosis	Fisher kurtosis of the diagonal series
14	Diagonal maximum	Maximum value of the diagonal series