

DIMENSIONALITY REDUCTION & FREQUENCY BIN OPTIMIZATION TO IMPROVE A RIEMANNIAN-BASED CLASSIFICATION PIPELINE

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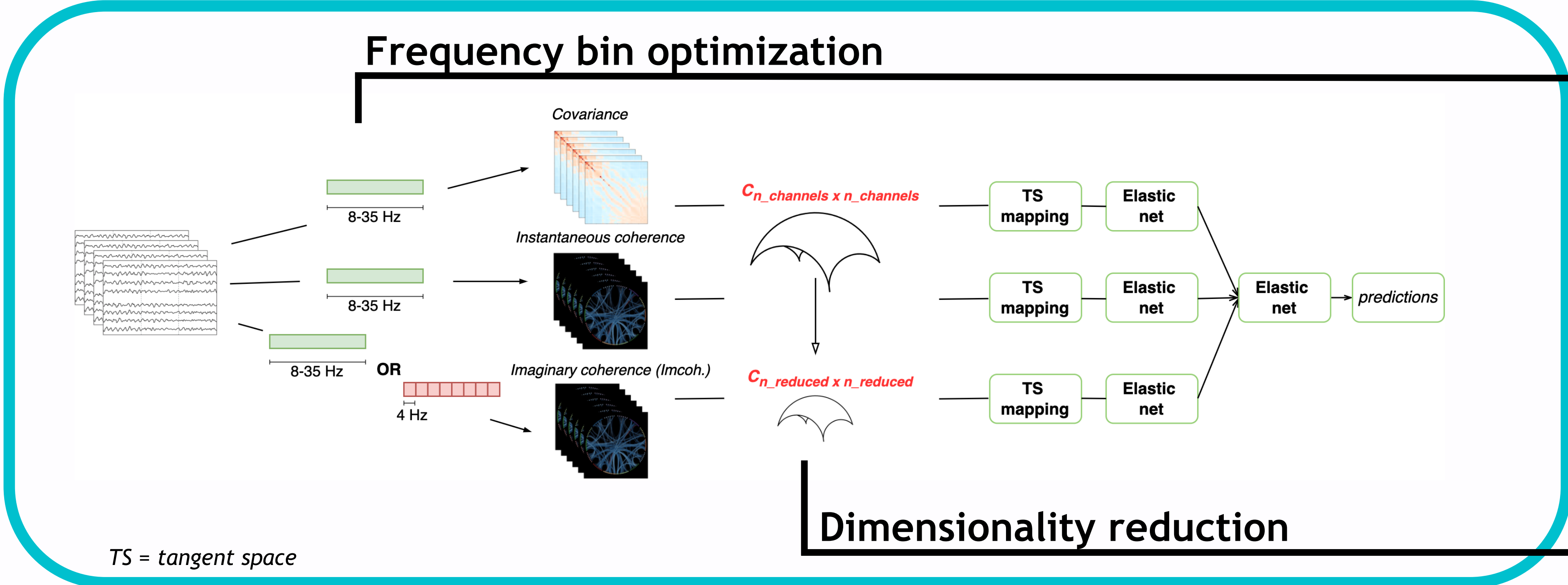
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Subject variability and **BCI illiteracy** pose a challenge to the BCI domain. To tackle this, the field has taken a turn towards **Riemannian geometry**, which has been shown to reach state-of-the-art performance. This promising mathematical concept is applicable in this field as the **covariance matrices** lay on a Riemannian manifold. This idea is exploited by combining Riemannian geometry with **functional connectivity** in a 'Functional Connectivity Ensemble' (FUCONE) in [1] with the aim to improve the performance of motor imagery (MI) BCI. FUCONE showed promising results, but this multi-step classification process also holds room for improvement. In this work, we focus on two aspects of the pipeline: **the choice of frequency band** and **dimensionality reduction** of the feature space.

RIEMANNIAN GEOMETRY

This promising mathematical concept is applicable in the field of BCI as the **covariance matrices** lay on a Riemannian manifold, a curved space. This manifold enables to extract **structural information** that is embedded in the matrices. By mapping the matrices onto the **tangent space** (an Euclidean space), traditional classification methods can be applied, such as LDA and SVM.

THE UPDATED 'FUCONE' PIPELINE



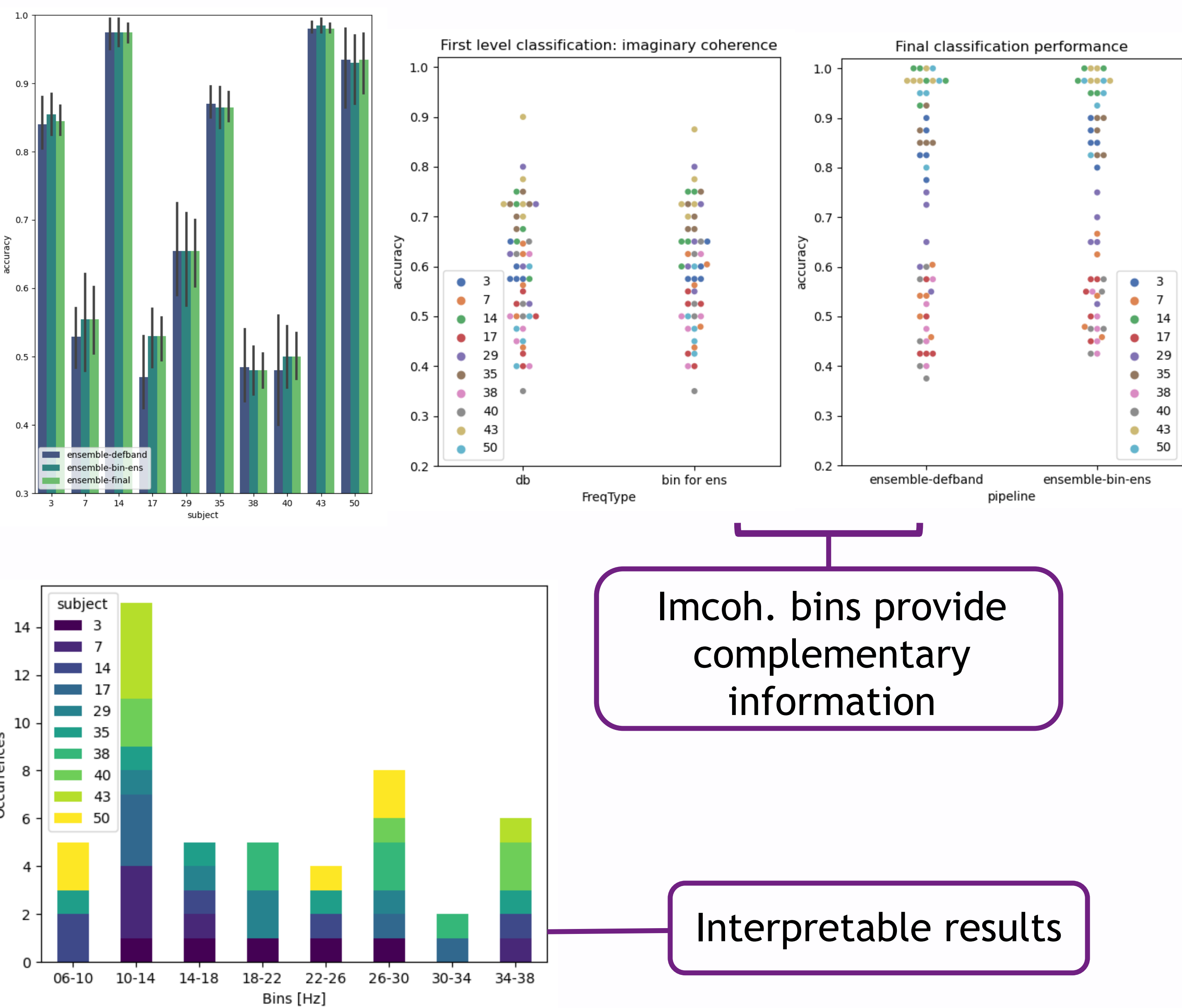
HYPOTHESIS I:

The frequency bin preference is subject- and feature-dependent. Optimizing this choice can partly account for **subject-variability**.

HYPOTHESIS II:

The matrices possess redundant information. Using a sub-manifold can decrease the **computation time** and improve the **performance**.

I - Frequency bin optimization



II - Dimensionality reduction



NEXT STEPS

- Introduce multi-modal data
- Take feature/subject bin-preferences into account
- More extensive bin/metric combinations

- Further hyperparameter tuning (focus on Riemannian PCA)
- Improve interpretability by analyzing the projection matrix

REFERENCES

[1] M.-C. Corsi et al. "Functional Connectivity Ensemble Method to Enhance BCI Performance (FUCONE)". In: IEEE Trans. Biomed. Eng. 69.9 (2022), pp. 2826-2838. doi: 10.1109/TBME.2022.3154885.