Hypernetwork for self-calibrating brain computer interface

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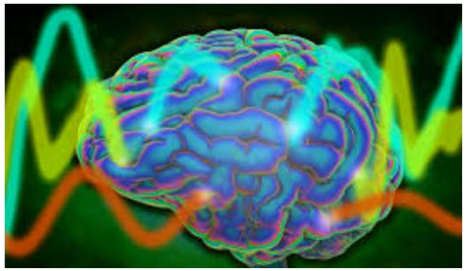
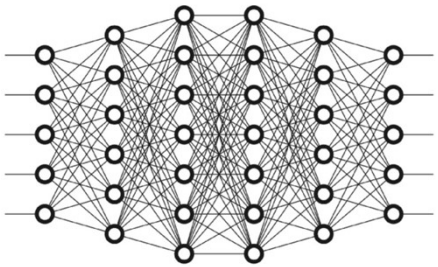
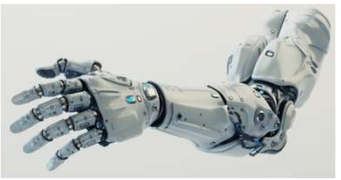
Introduction: Brain Computer Interface







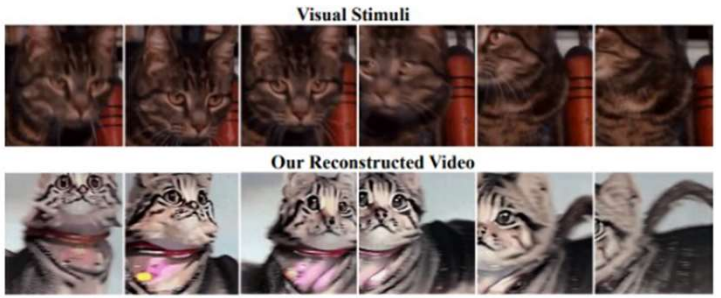
Ongoing brain Activity

Real-time data streaming

Brain computer interface

Processing

Human interpretable concepts



Deo et.al 2023 Translating deep learning to neuroprosthetic control
Willett et.al 2023 A high-performance speech neuroprosthesis

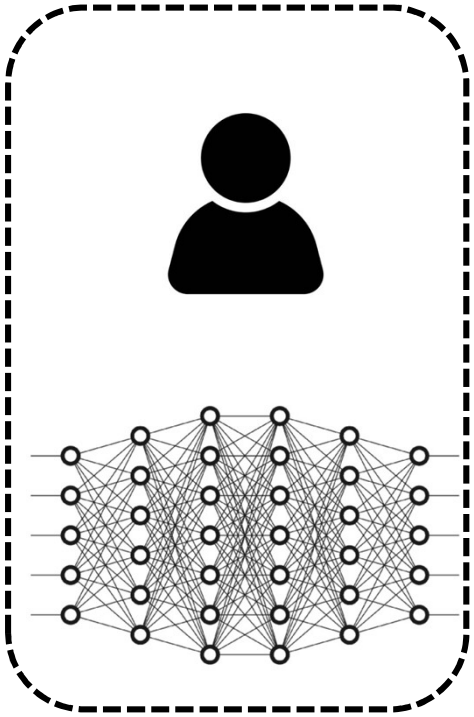
Introduction: BCI calibration for new user

Differences of brain activity and hardware between individuals

Existing users

Model calibration

New user



Krumpe et.al 2017; Kamrud et.al 2021

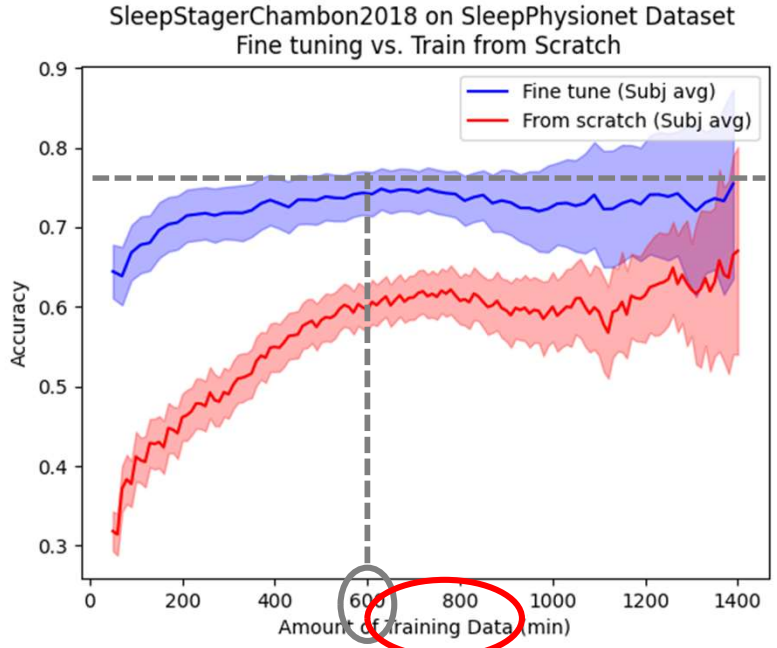
Challenge in *supervised* calibration

Supervised calibration requires labeled data. Accessing data labels from new user is impractical for real-time BCI applications.

Unlabeled brain data

Human labeling

Labeled data



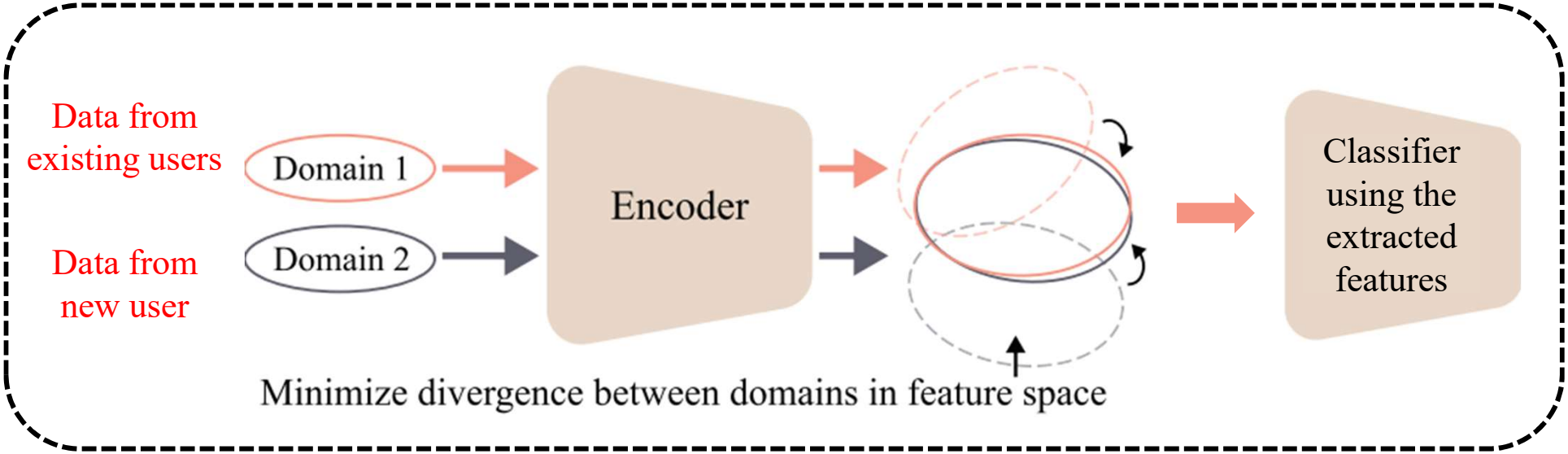
labeled

Sleep stage classification

Challenge in *unsupervised* calibration

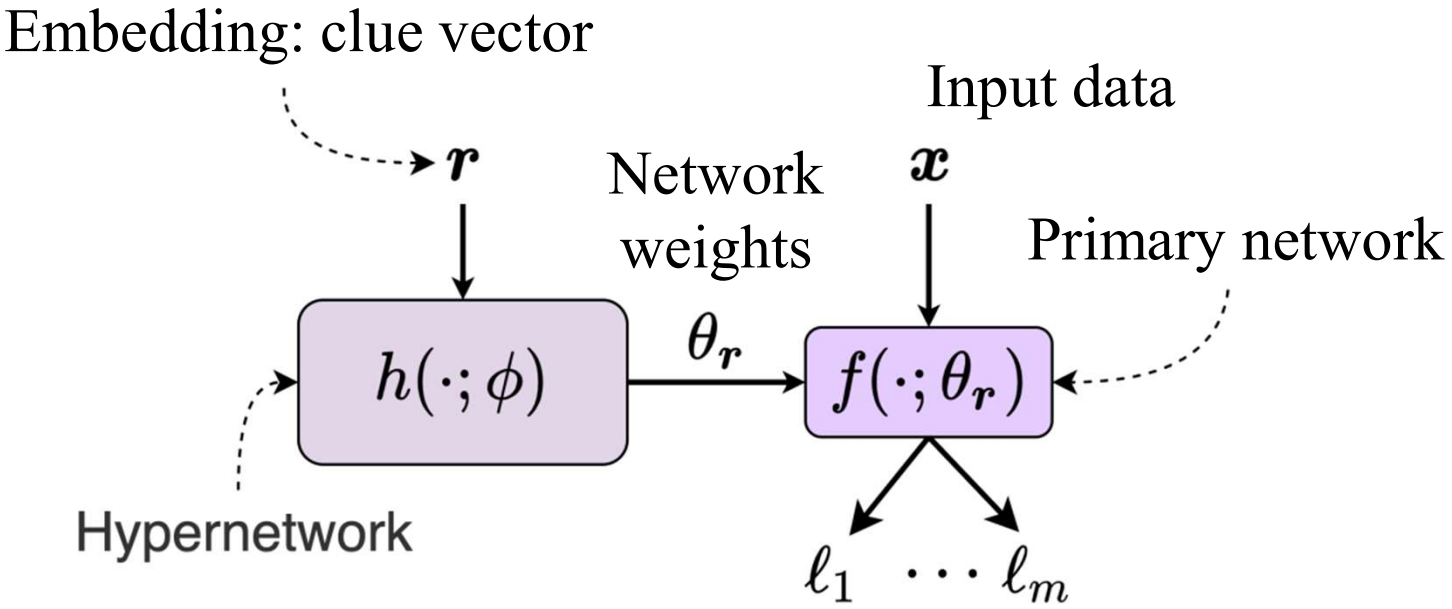
Unsupervised calibration typically involves feature space alignment, which usually requires brain data from existing users.

May be challenging to access due to privacy or sheer quantity.



Schematic reproduced from: Ko et.al 2021

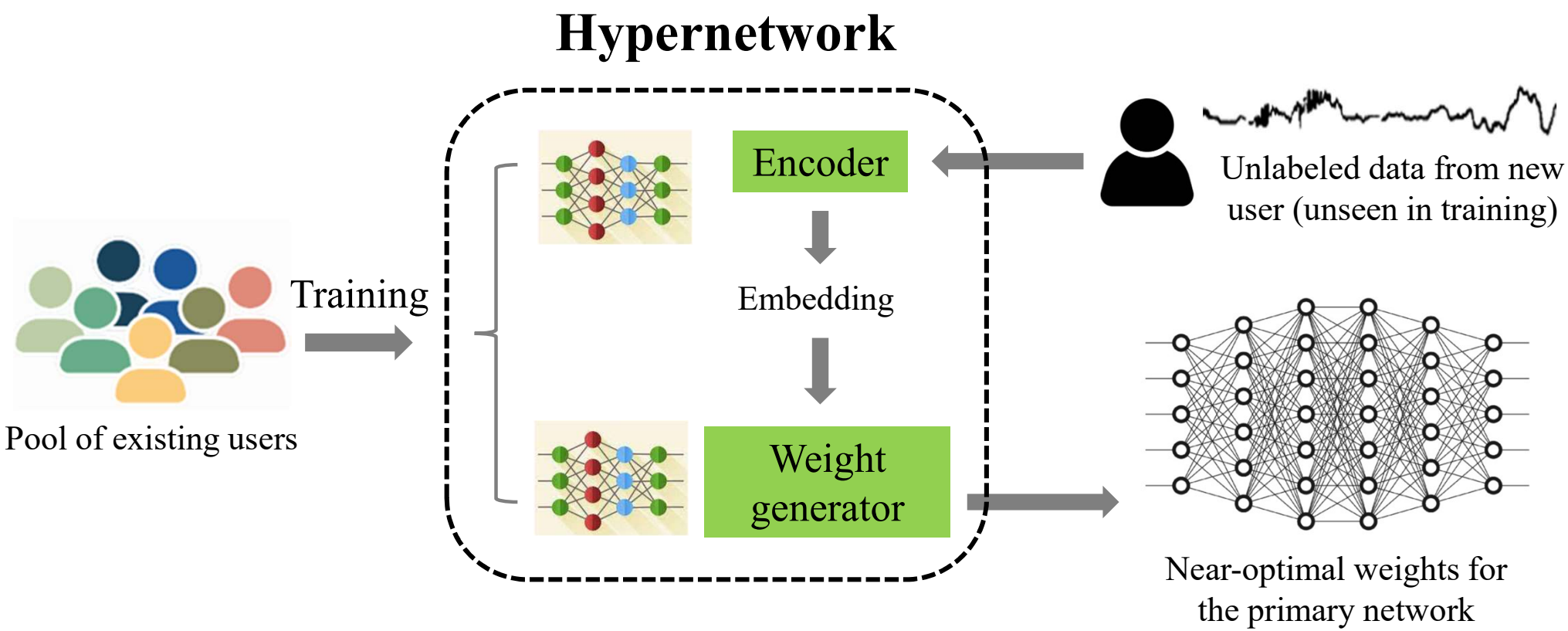
Method: Hypernetwork



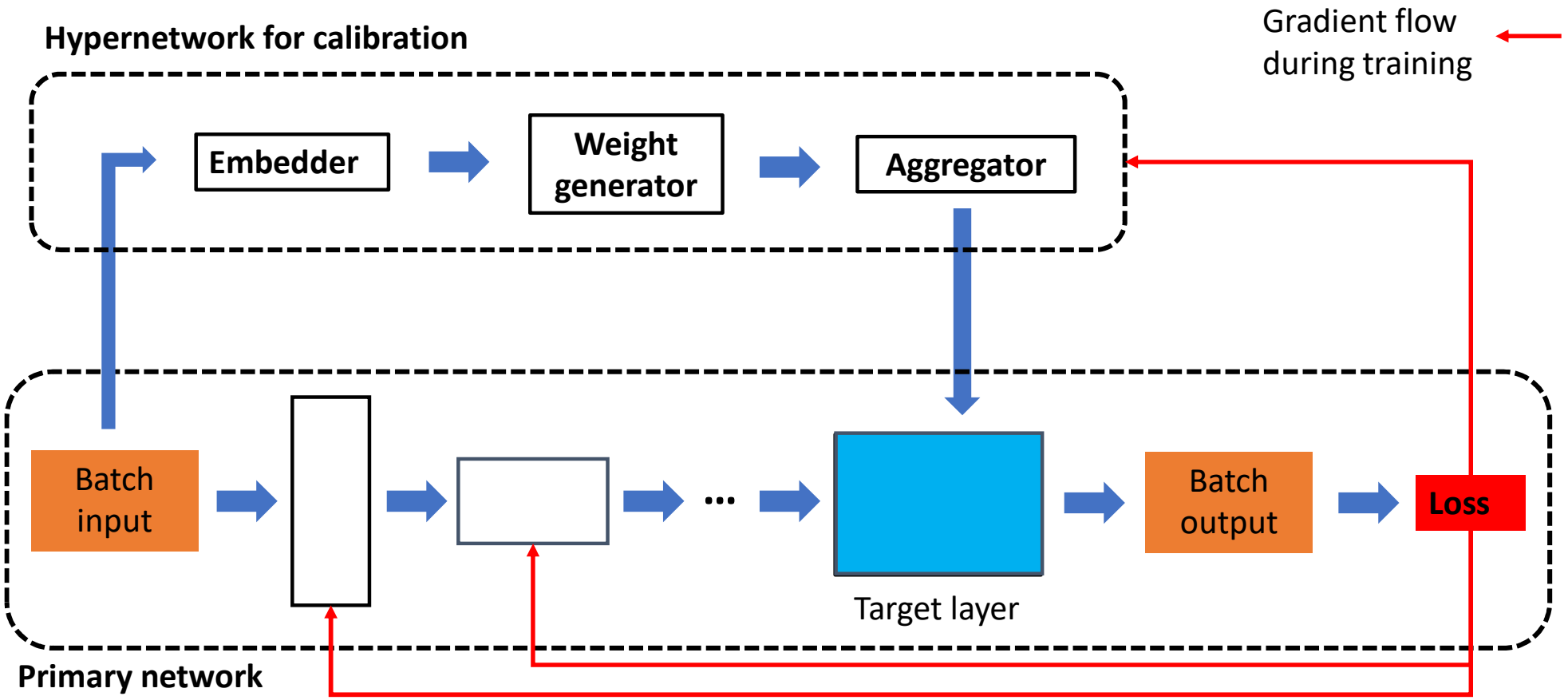
If given proper clue, hypernetworks can **generate** near-optimal weights, which are usually acquired through iterative, time-consuming optimization process.

Schematic reproduced from: Navon et.al 2021 (ICLR '21); Reference: Zhang et.al 2020, Ben-David et.al 2022

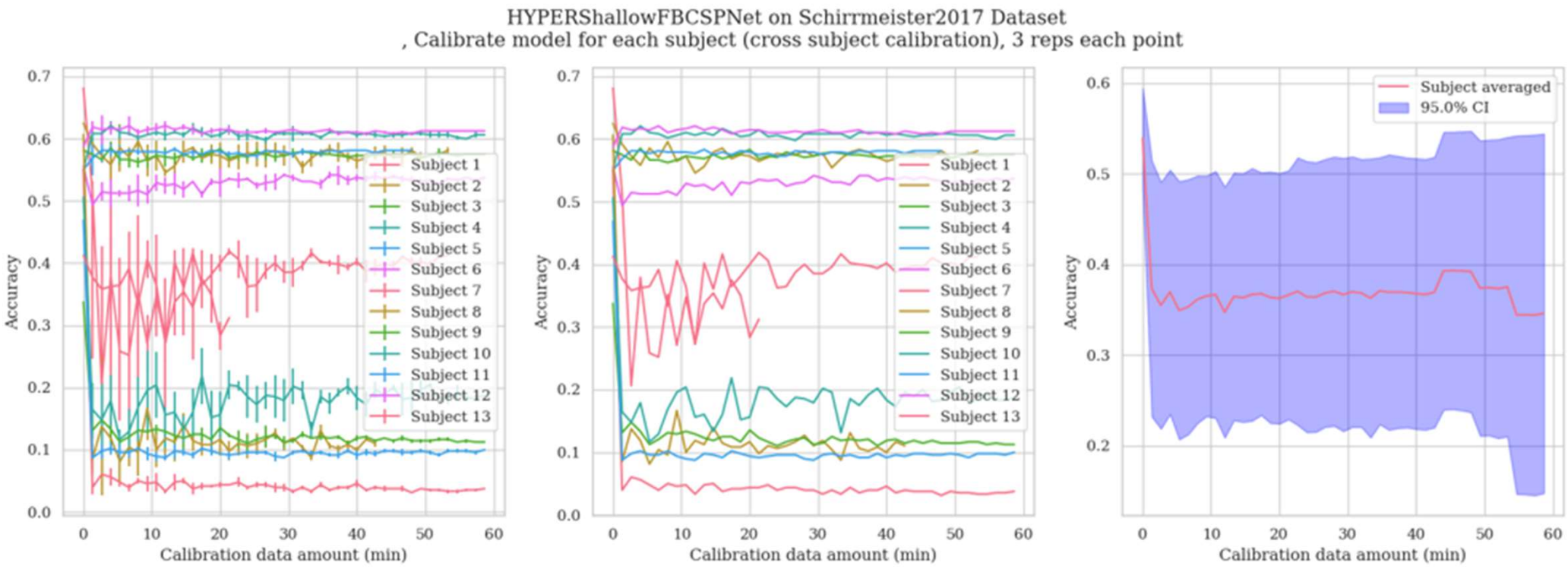
Method: Hypernetwork for unsupervised, real-time calibration



Method: HypernetBCI architecture

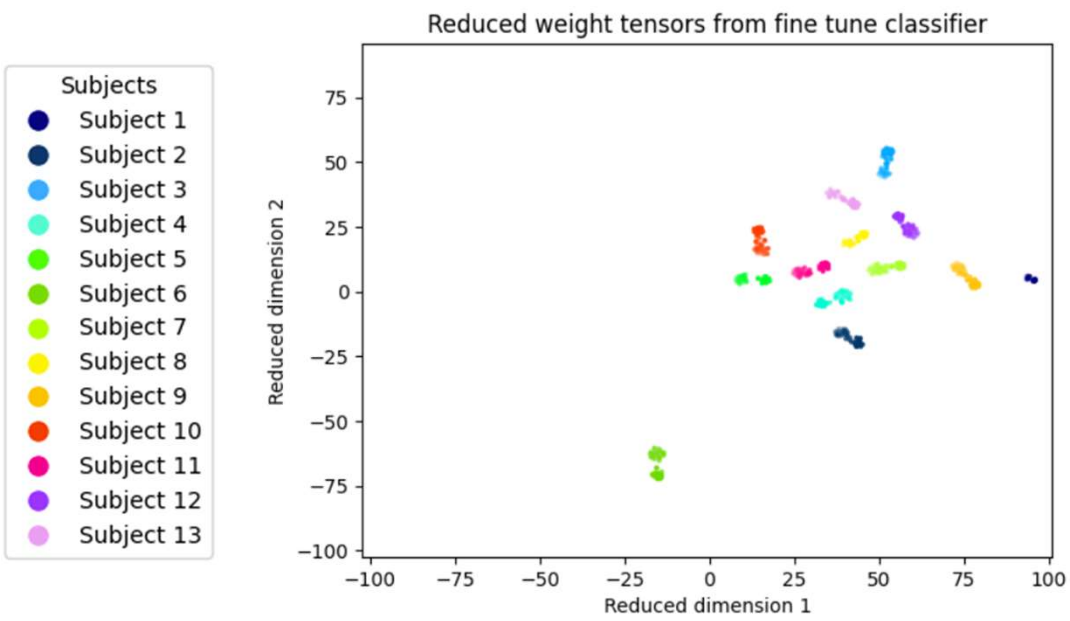


Result: test accuracy vs. amount of calibration data

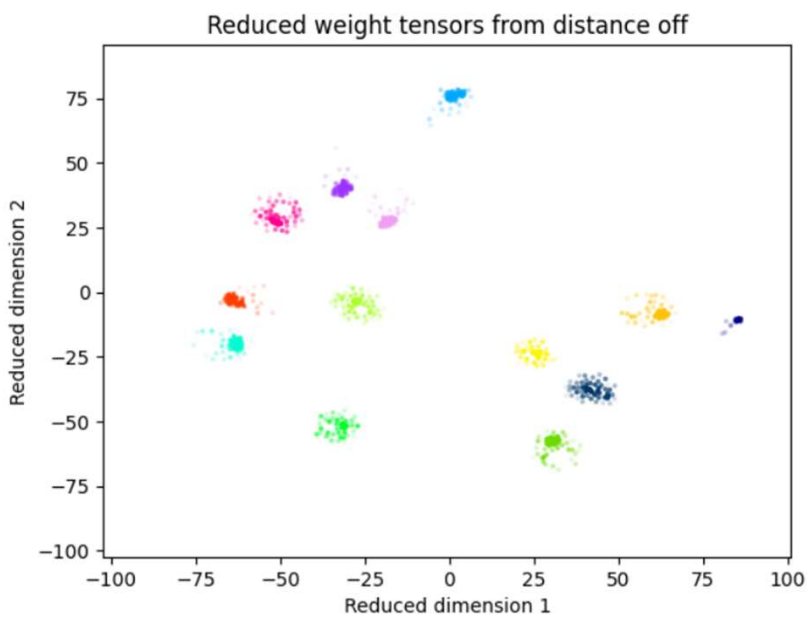


Result: visualizing weights to understand calibration efficacy

Weight tensors produced by fine tuning



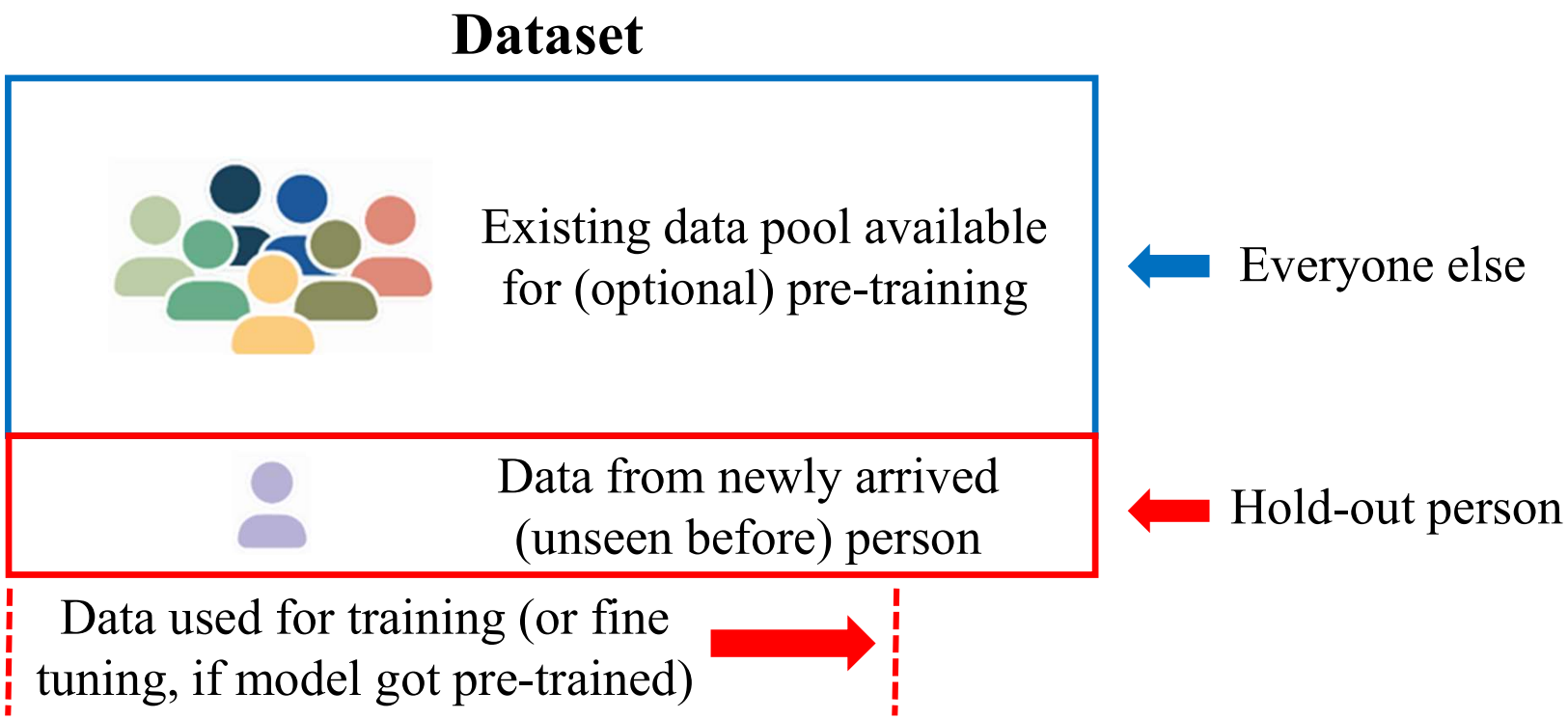
Weight tensors produced by hypernetBCI



Contributions

- First to apply hypernetwork for **unsupervised domain adaptation**
- Calibration takes one forward pass, repeatable and good for **real-time** adjustment
- **Data efficient**, good for edge deployment (brain implants)

Appendix I: Experiment setup



Appendix II: motor imagery classification dataset

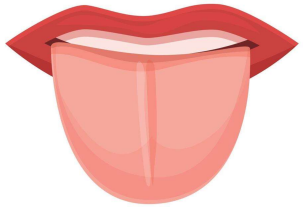
Brain activity (EEG)

Imagined movements

Class 1

Class 2

Class 3

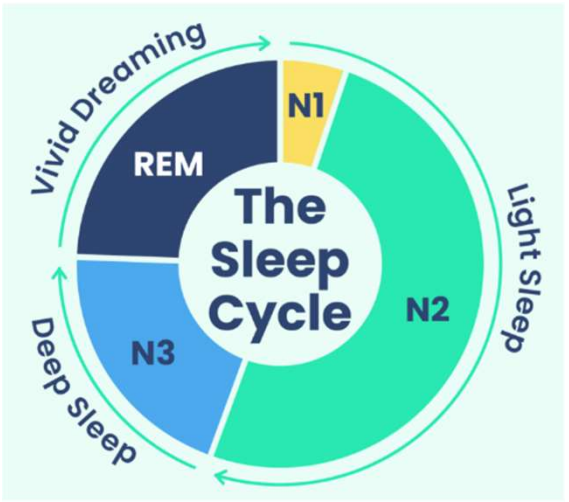


Class 4

Appendix II: sleep stage classification dataset

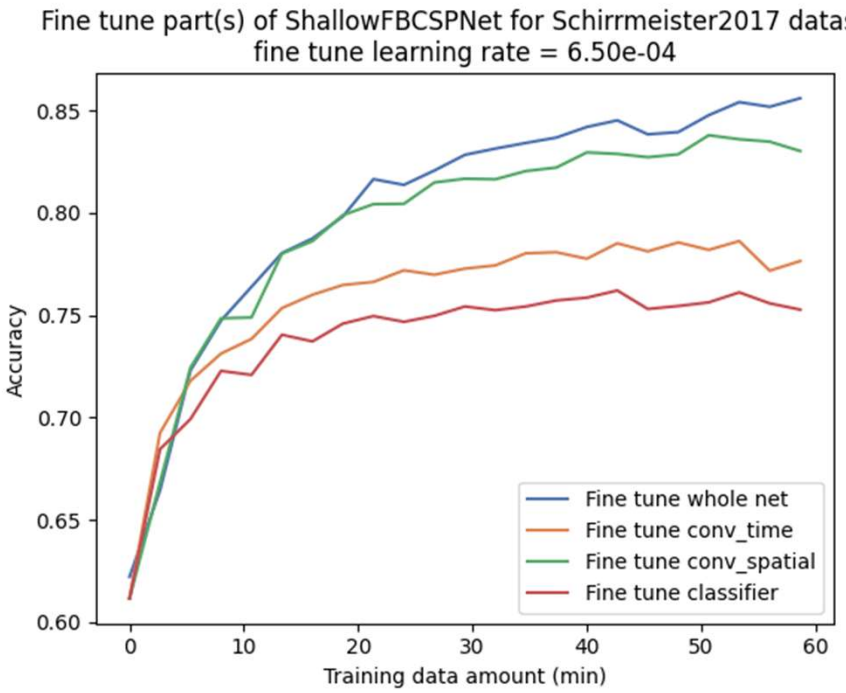
Brain activity (EEG)

Sleep stages (or awake)



Appendix III: fine tuning part(s) of the model while freezing others

Motor Imagery Classification



Sleep Stage Classification