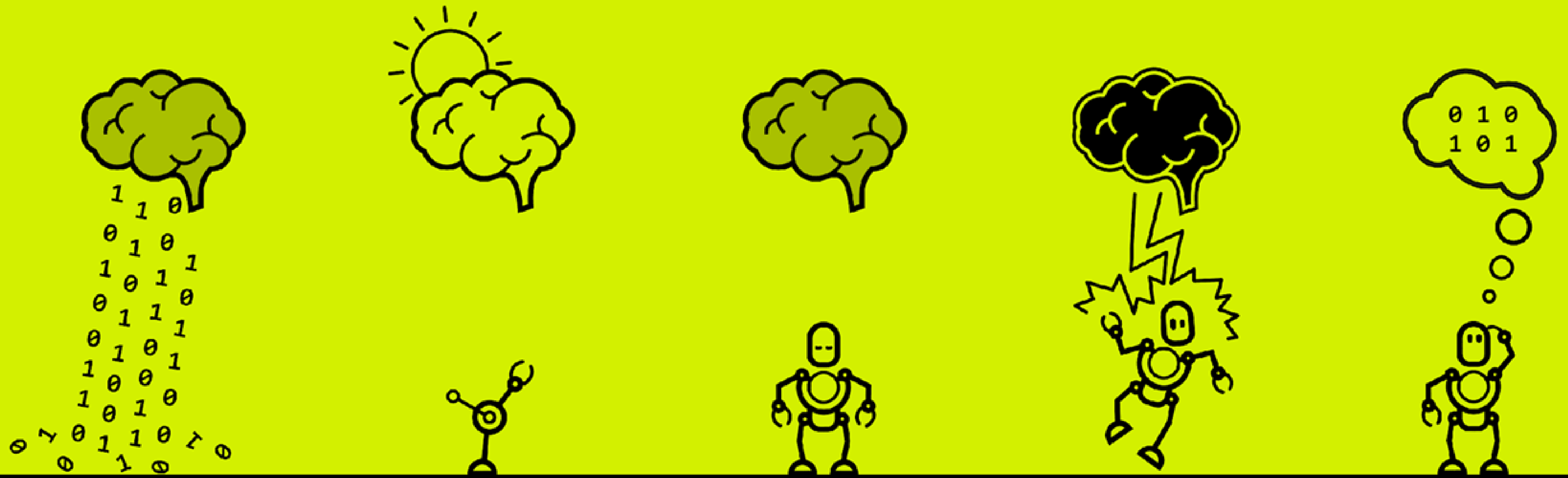

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THE BRAIN-COMPUTER INTERFACE DESIGNERS HACKATHON

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BCI-Stroke Rehabil Data Analysis – G23

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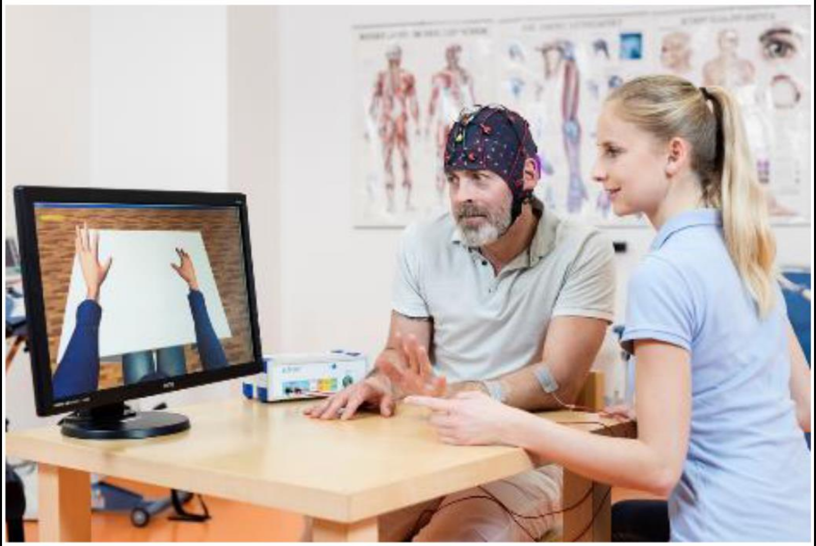
INITIAL SITUATION INTRODUCTION...

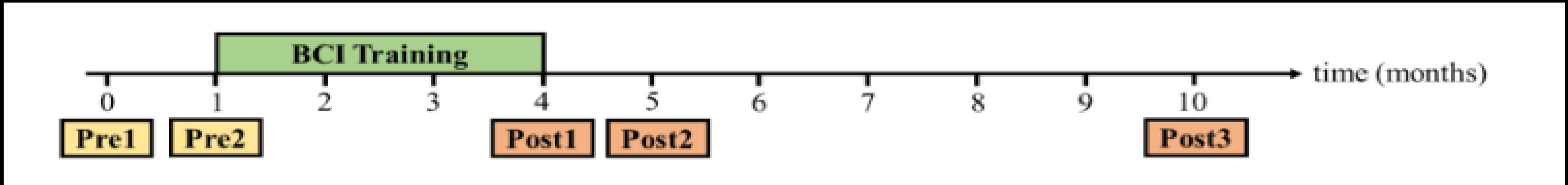
BCI systems used as rehabilitation tools to help subacute and chronic stroke patients recover upper extremity movement.

Functional Electrical Stimulation (FES)
and
Virtual Reality (VR)



From Brain Computer Interface treatment for motor rehabilitation of upper extremity of stroke patients – A feasibility study [1]

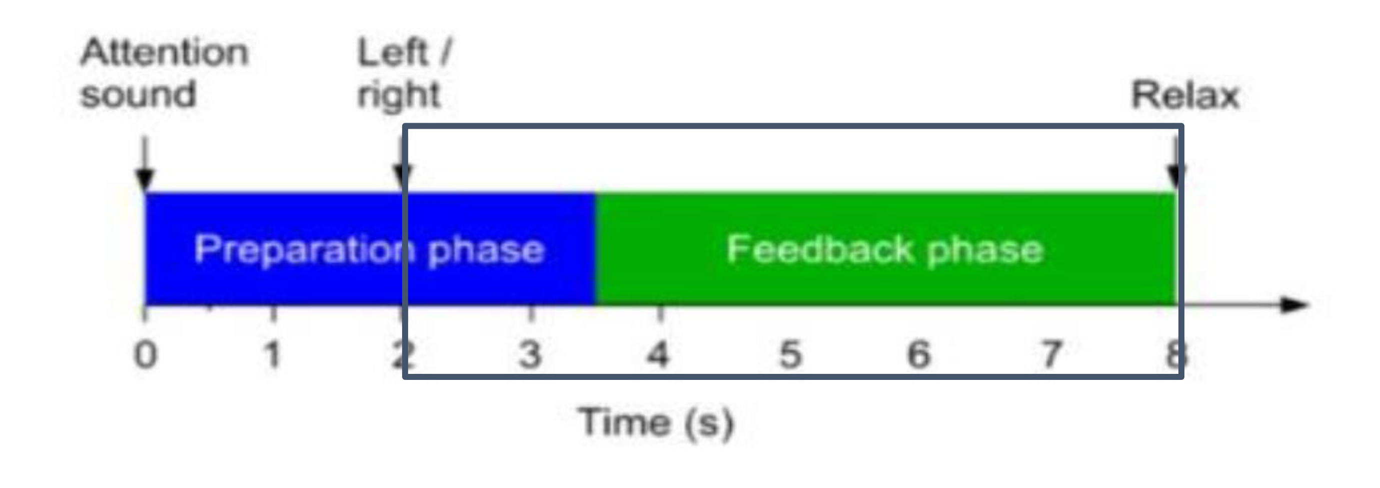
INITIAL SITUATION INTRODUCTION…



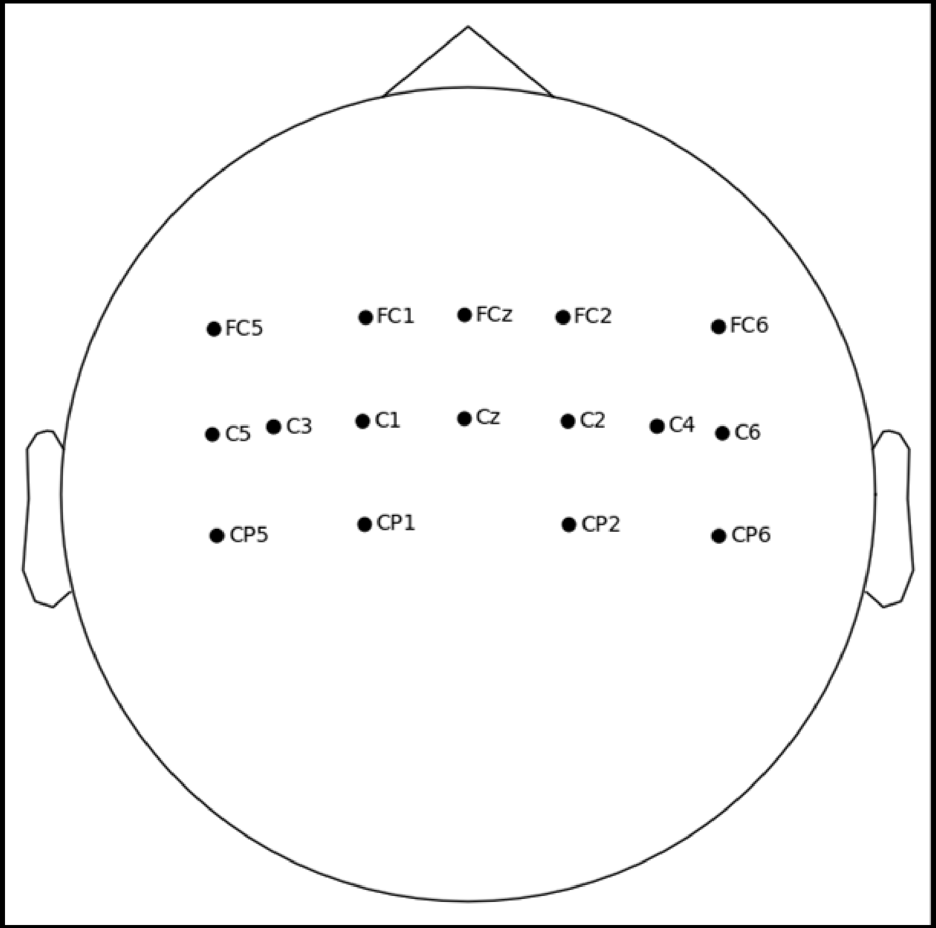
From [1]

51 stroke patients

3 subjects for our experiments



Traditional Methods



16 electrodes used for records

1) Common Spatial Patterns (CSP)
   Linear Discriminant Analysis (LDA)

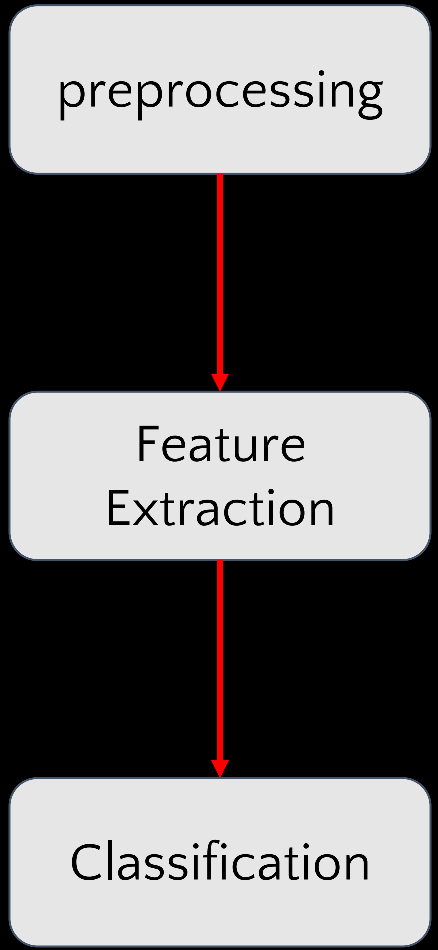
1) Principal Component Analysis (PCA)
   with Time-Variant LDA (TV-LDA)

Our idea

- Which frequency band contains more motor imagery features?
- What is the best method to extract effective features from EEG data?
- How do spatial and temporal features in EEG data show the improvement comparing pre and post session?

Methods

- preprocessing
  - Re-referencing:
  - Line Noise Removal
  - Bandpass Filtering
  - Epoching
  - Noise Removal:
- **feature extraction**
  - **Common Spatial Pattern**
  - **Riemannian geometry-based method**
- classification
  - Support Vector Machine



Riemannian Geometry

What is Riemannian Geometry?

Riemannian geometry is a branch of mathematics focusing on **curved spaces** or **manifolds**.

Covariance matrices of EEG signals lie on a **Riemannian manifold**, which is a curved space.

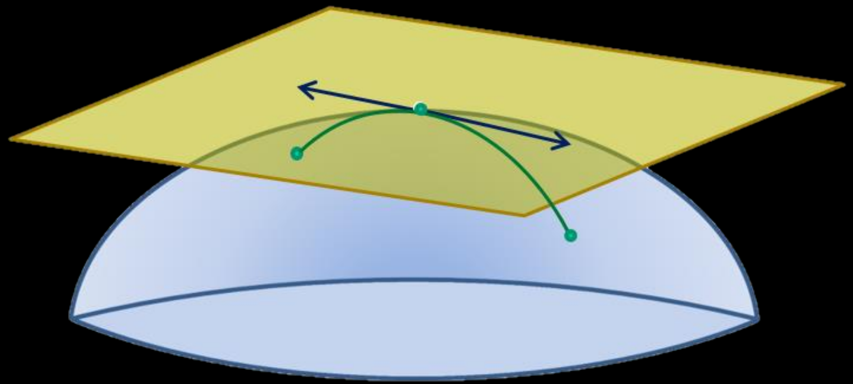
Why Use It for EEG?

Riemannian geometry respects the **non-linear relationships** between EEG channels, preserving the true spatial and temporal interactions in the data.

Tangent Space Mapping

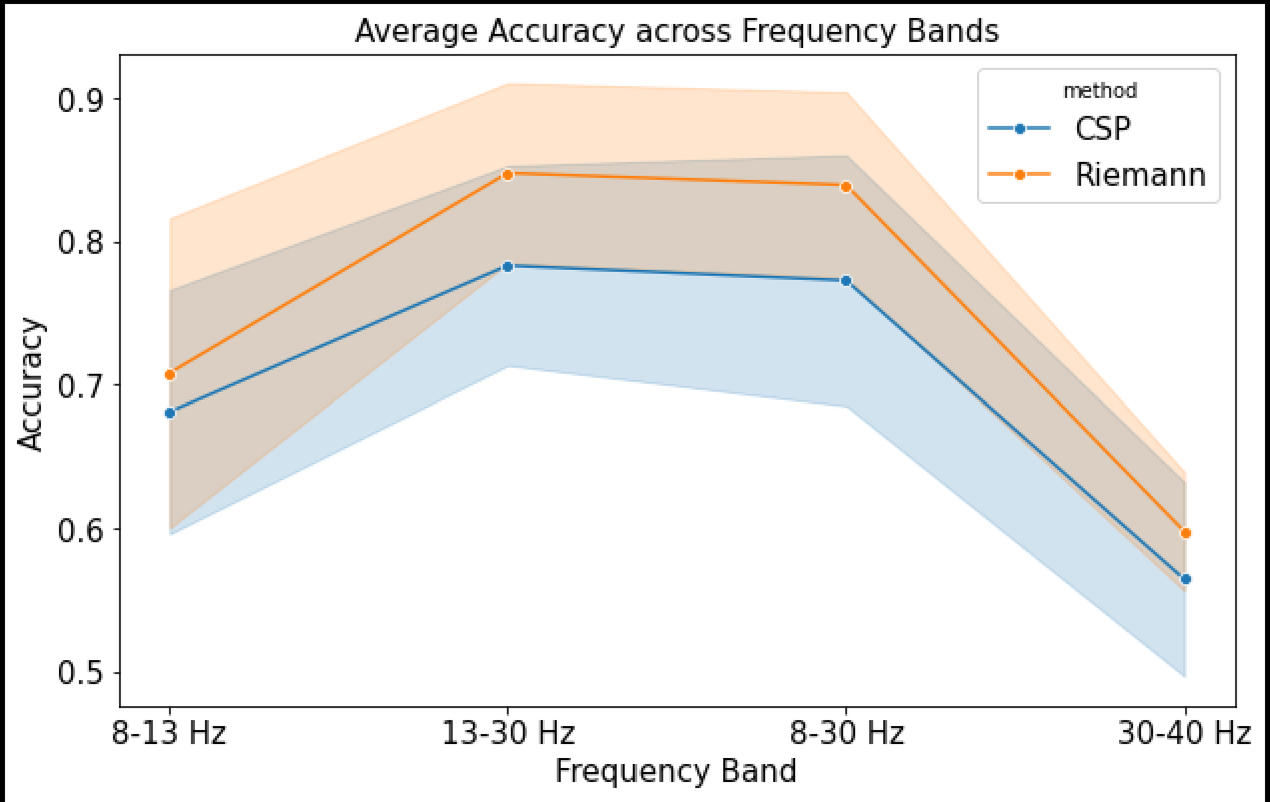
To make these features usable for classification, they are projected onto a **tangent space** at the Riemannian mean.

This allows standard machine learning models, like SVM, to effectively utilize the extracted features while maintaining their meaningful relationships.



RESULTS

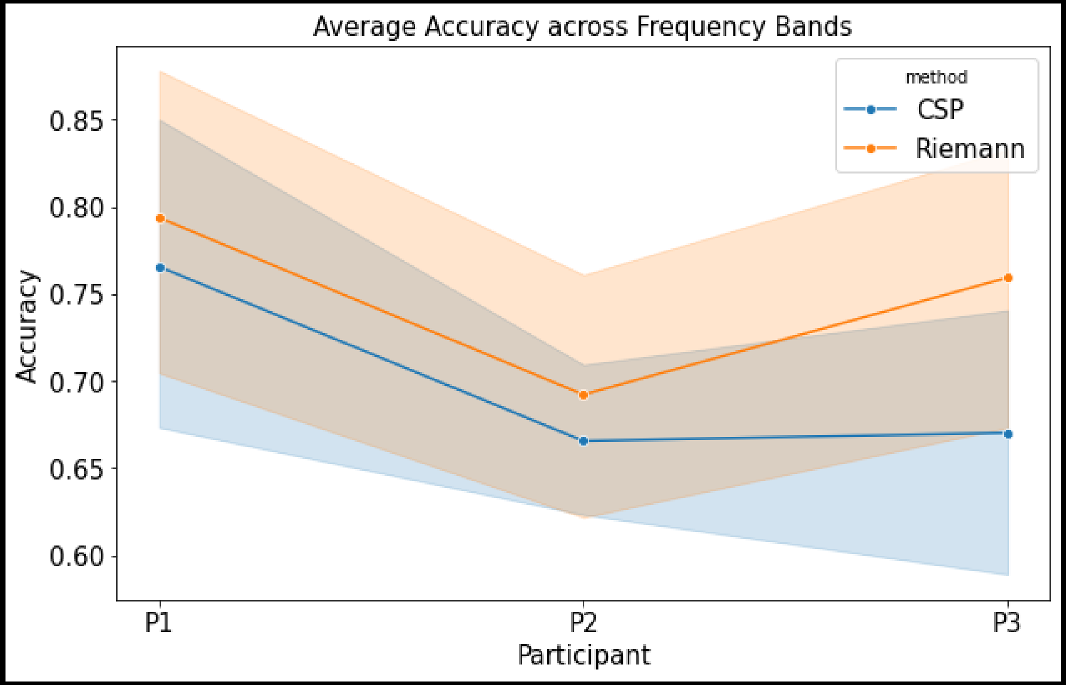
Q1: Which frequency band?



- data in beta band provides a better accuracy
- associated with active cognitive processes and sensorimotor activities

RESULTS

Q2: What is the best method for features extraction?

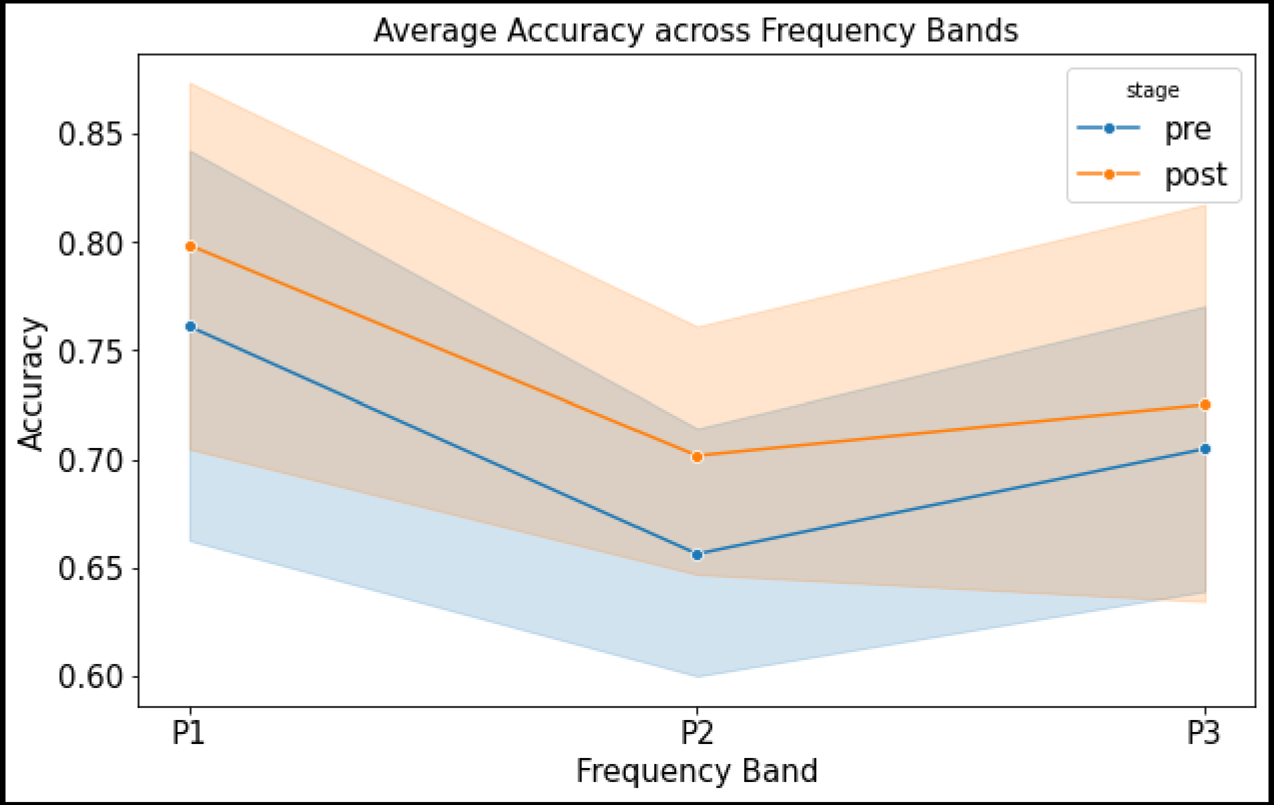


- Riemannian geometry-based method perform better than CSP
- effectively capturing the geometric properties of the EEG data

Sub	Stage	Fre band	Accuracy
P1	pre	13-30 Hz	0.913
P1	post	13-30 Hz	0.888
P2	pre	13-30 Hz	0.750
P2	post	13-30 Hz	0.813
P3	pre	13-30 Hz	0.825
P3	post	13-30 Hz	0.900

RESULTS

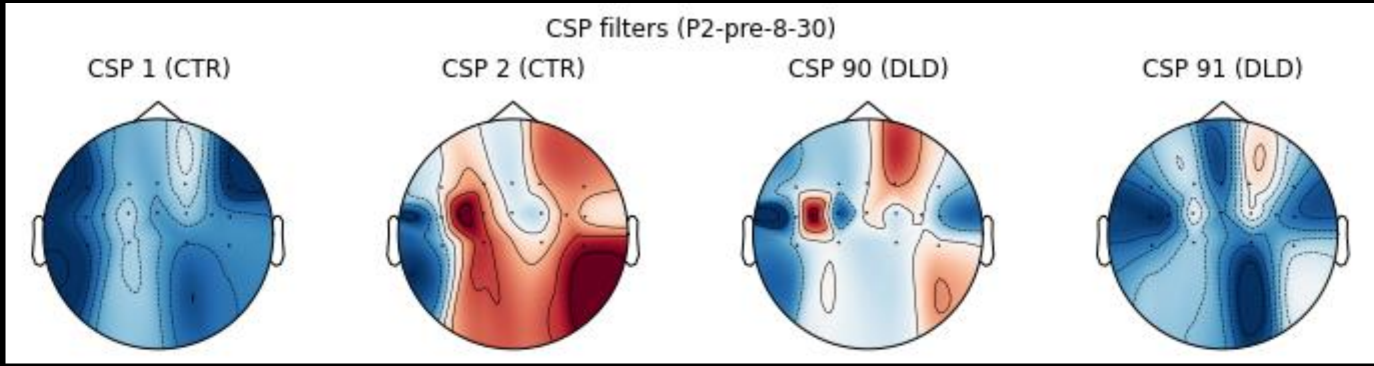
Q3: How the improvement been shown?

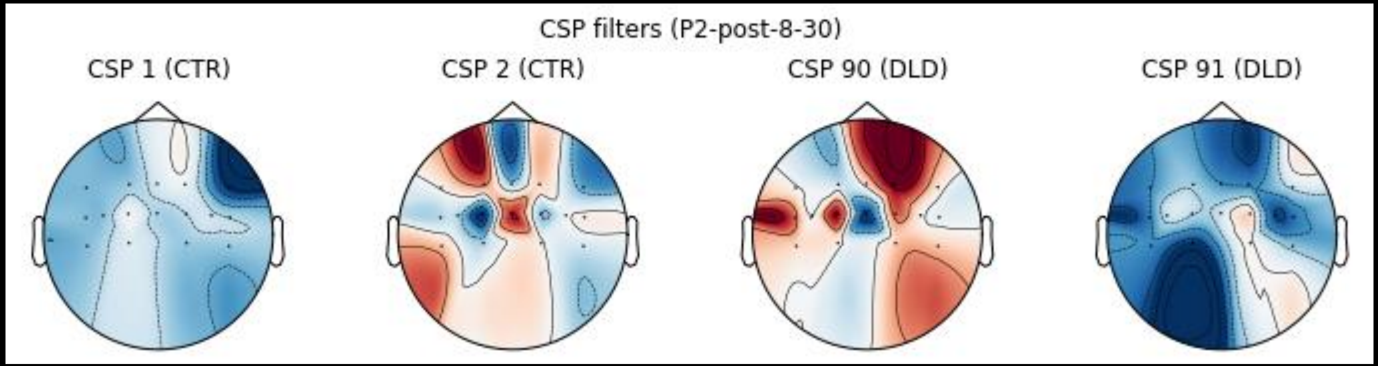


- accuracy went higher

RESULTS

Q3: How the improvement been shown?





- accuracy went higher
- more clear spatial neural pattern

REFLECTION

- Preprocessing: Currently, we employ a band-pass filter and a notch filter. We could also implement manual artifact rejection to eliminate specific muscle artifacts.

- Classification: We currently use Support Vector Machine (SVM) for classification. However, integrating state-of-the-art machine learning methods could enhance accuracy.

Github link: https://github.com/CoSineZxc/G23_stroke_rehab.git

REFERENCES

[1] Sebastián-Romagosa, M., Cho, W., Ortner, R., Murovec, N., Von Oertzen, T., Kamada, K., ... & Guger, C. (2020). Brain computer interface treatment for motor rehabilitation of upper extremity of stroke patients—a feasibility study. Frontiers in Neuroscience, 14, 591435.

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