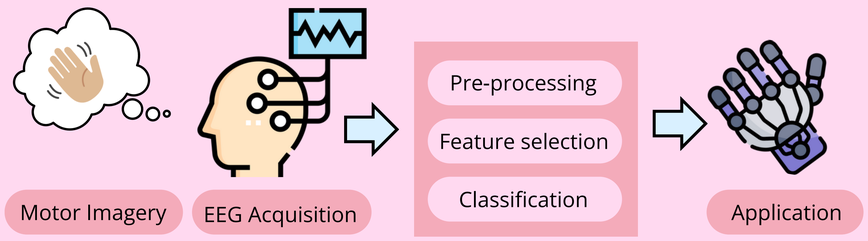
Combination of unsupervised clustering and linear classification to enhance brain-computer interface classifiers

Madeline Wong[1], Nicolas Ivanov[2], Tom Chau[2]

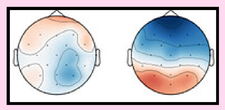
1. University of Waterloo, Department of Systems Design Engineering
2. University of Toronto, Institute of Biomedical Engineering

Background

Brain-computer interfaces (BCIs) enable people to control external devices through their neural activity by performing mental tasks



Different mental tasks produce unique patterns of electrical activity in the brain which can be classified by the BCI and used to **map thoughts to physical actions**



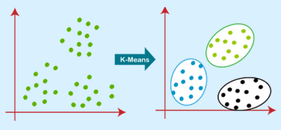
Clinical use of BCIs is limited because **task-irrelevant brain activity occludes task-relevant modulations**, impeding the BCIs ability to accurately classify the true tasks the user is performing.

Research Question

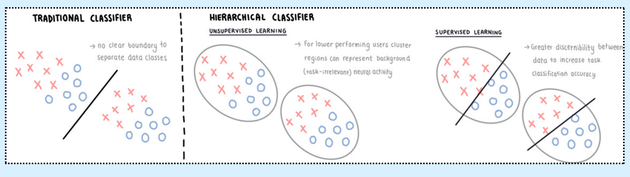
Does combining unsupervised clustering with traditional linear classifiers for BCI task decoding improve prediction accuracy?

Methods

1. **K-means clustering** applied to segment each participant's data into regions of similar neural patterns



2. Within each cluster region, **linear classifier** applied to make task predictions



Improving Brain Computer Interface accessibility by combining machine learning methods.

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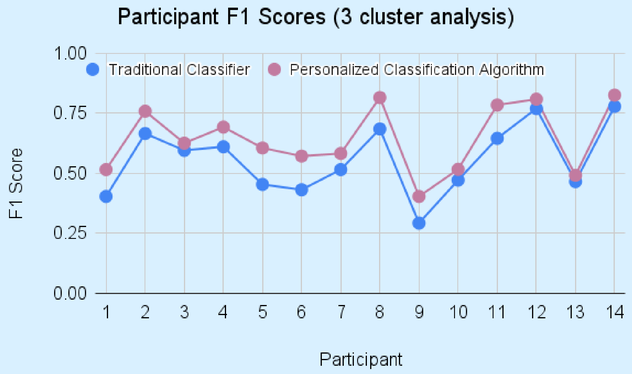
Results



Average F1 scores showed that the proposed algorithm modestly outperformed traditional classifiers

F1 score: performance evaluation metric for ML models that combines precision and recall. F1 score ranges from 0 to 1 (1 is best)

Key Takeaways:

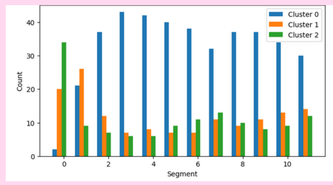
- No degradation in BCI performance for any participant
- Improvement is greater for some participants than others. Further analysis needed to determine reasoning fo this.

Conclusions and Next Steps

This analysis yields insight into the task performance characteristics of low-performing users. These **insights could guide personalized BCI design practices** that would improve their clinical feasibility.

Next Steps: Many participants transition into task-irrelevant pattern states at the beginning of a motor imagery trial. We can refine the algorithm to look at specific time windows during the trial when making classifications

Cluster Probability Over Trial



Relevance to HB Clients

Child autonomy and empowerment
BCIs can enable children with disabilities to interact with their environments using their brain alone.

Increasing BCI accessibility to a wider demographic of children
These hierarchical classification algorithms can enable more people to successfully use BCIs