CogniSync: Training EEG Brain Wave Data with Machine Learning to Output Directional Controls

Justin Haysbert[1,2], Gabe Sagrera[1,3] , Shayne Shelton[1,3], Ryan Stevens[1,4], Saad Hassan[1]

1. Department of Computer Science, Tulane University -New Orleans, LA
2. Department of Psychology, Tulane University – New Orleans, LA
3. Department of Biomedical Engineering, Tulane University – New Orleans, LA
4. A.B. School of Business, Tulane University – New Orleans, LA

COGNISYNC

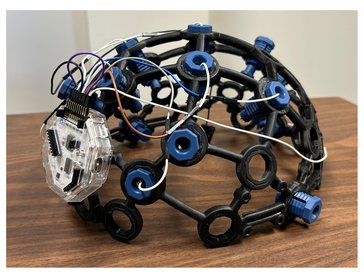
Motivation

- Millions of people in the United States have paralysis
- Electroencephalogram (EEG) headsets measure electrical activity in the brain like motor imagery related brain waves
- Machine learning (ML) approaches can categorize a user's brain state into directional controls for wheelchair navigation
- *However*, first-time user training is **long** and **user specific** and EEG's headsets experience a **low signal-to-noise ratio**

Objective

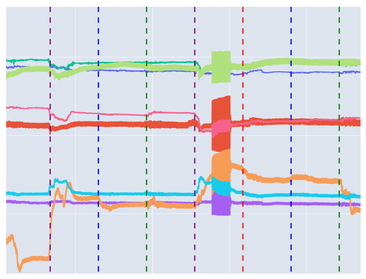
This project aims to **reduce user training time** for first-time users and increase user accessibility to EEG-based devices by (1) decreasing the number of movements users perform during training (2) building a comprehensive graphical user interface (GUI) to streamline the recording, modeling, and prediction processes

Product Architecture



Prompting

4 movement types
Auto-prompting with rest time

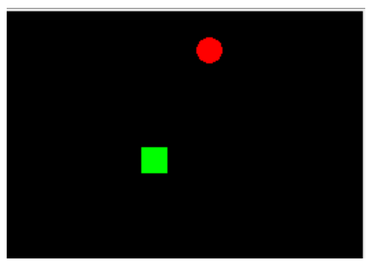


Recording

Live stream of EEG data stored in .csv format

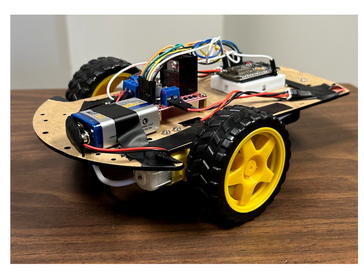
ML Modeling

SciKit-Learn (LDA, DTC, & RFC) and PyTorch



Computer Game

"Snake Game" for preliminary model validation

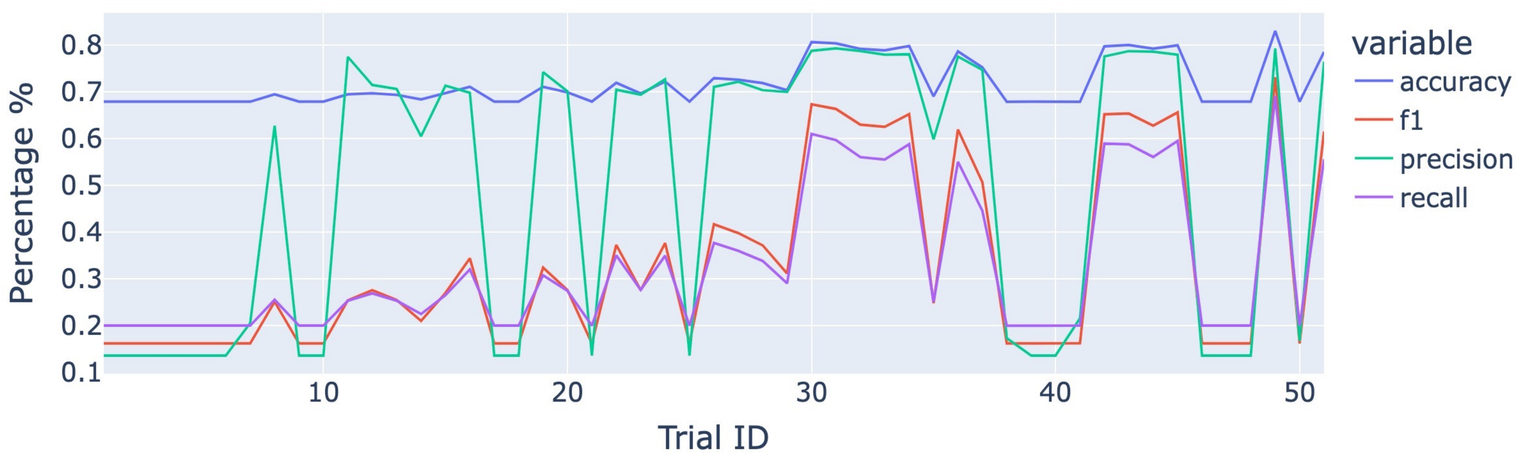


Mechanical Device

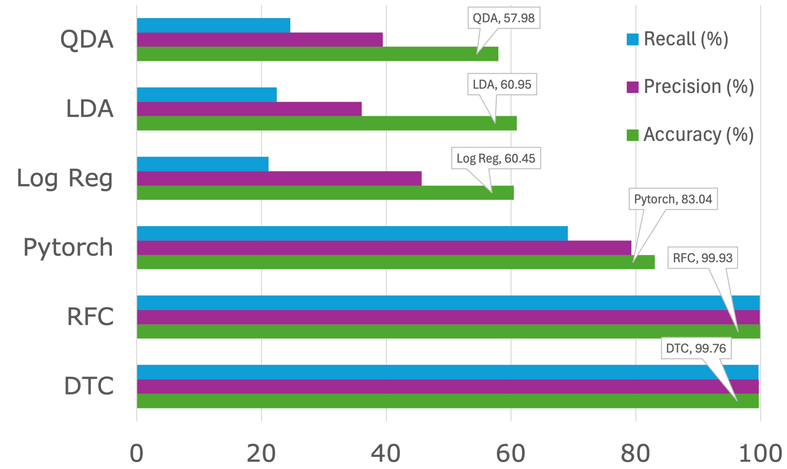
2-wheel RC car for verification of concept

Results

PyTorch Trial Metrics



Hyperparameter Optimization



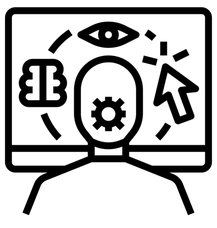
Target Movements

Left Arm
Right Arm
Legs
Jaw

Please view a video of a demo of our working prototype

Please visit our GitHub to interact with our open-source data, models and GUI

Discussion



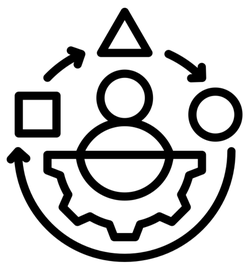
GUI Development

- ***Streamline, adaptable, and accessible***
- ✓ Seamless and automated user experience
- ✓ Easily alter movement types and durations

Source of generalizable EEG datasets

- Capabilities of EEG made available to many audiences

Future Development



Maximize Accuracy

- GUI allows users to easily change training parameters (model, movements, times, etc.) which is critical for model optimization
- *Online learning* by using the snake game

Acknowledgements

The authors thank Professor Saad Hassan and the Tulane University Department of Computer Science for funding the OpenBCI headset and robotic model wheelchair.