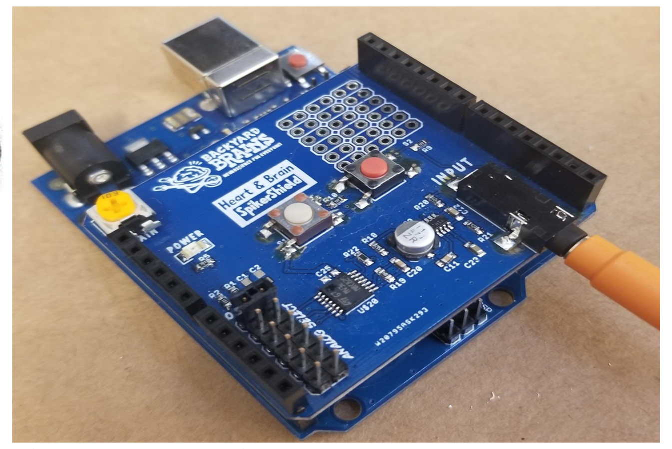
# Neural/Optical Control of Quadcopter Improves Accessibility for Disabled Pilots

## Introduction

We designed a control system for a quadcopter that allows the pilot to control the vehicle with their brain and eyes by using Heart and Brain SpikerBox from Backyard Brain to measure Electroencapholograph (EEG) and Electrooculograph (EOG) data. The drone and Arduino boards we used are illustrated in the figures.



## Problem Statement

Neural signals present a novel method of control which have yet to be used extensively for aircraft flight. We chose to further investigate the feasibility of this system using consumer grade electronics and an off-the-shelf drone to demonstrate the possibility of making this technology more accessible and affordable.

## Motivation

- Improves accessibility for disabled pilots
- Direct aerospace applications in the controls field
- Medical applications for the treatment of neurodegenerative diseases such as Alzheimer's due to the mental exercise for the pilot

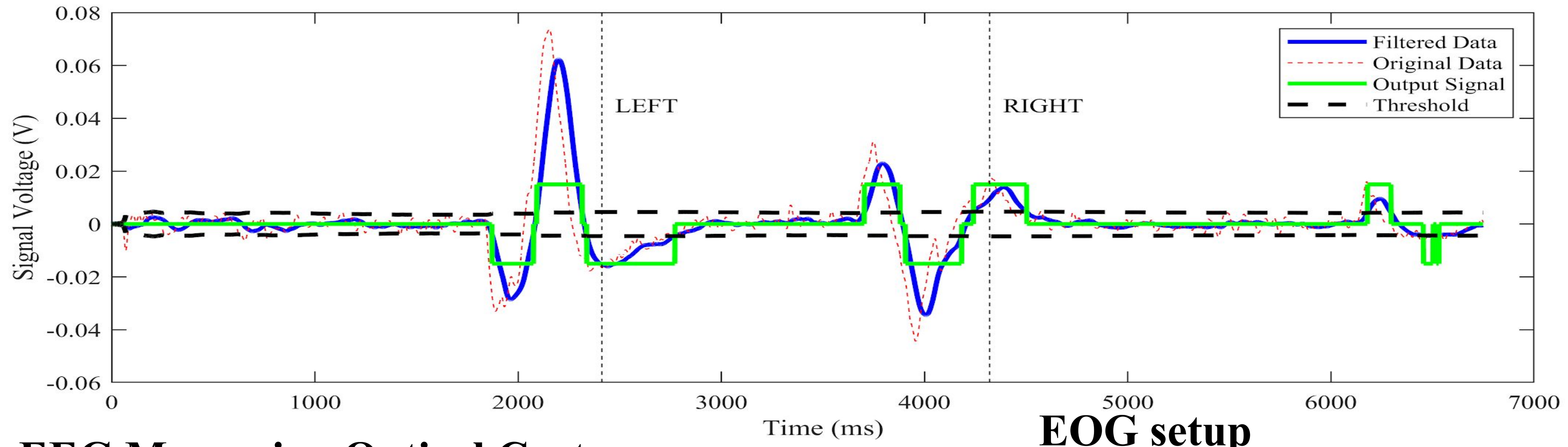
## Project Scope and Objectives

- Develop signal processing algorithm that transforms EEG and EOG data to controls for quadcopter
- Establish control of quadcopter via laptop WiFi commands
- Establish live-stream of data and connection between algorithm and quadcopter

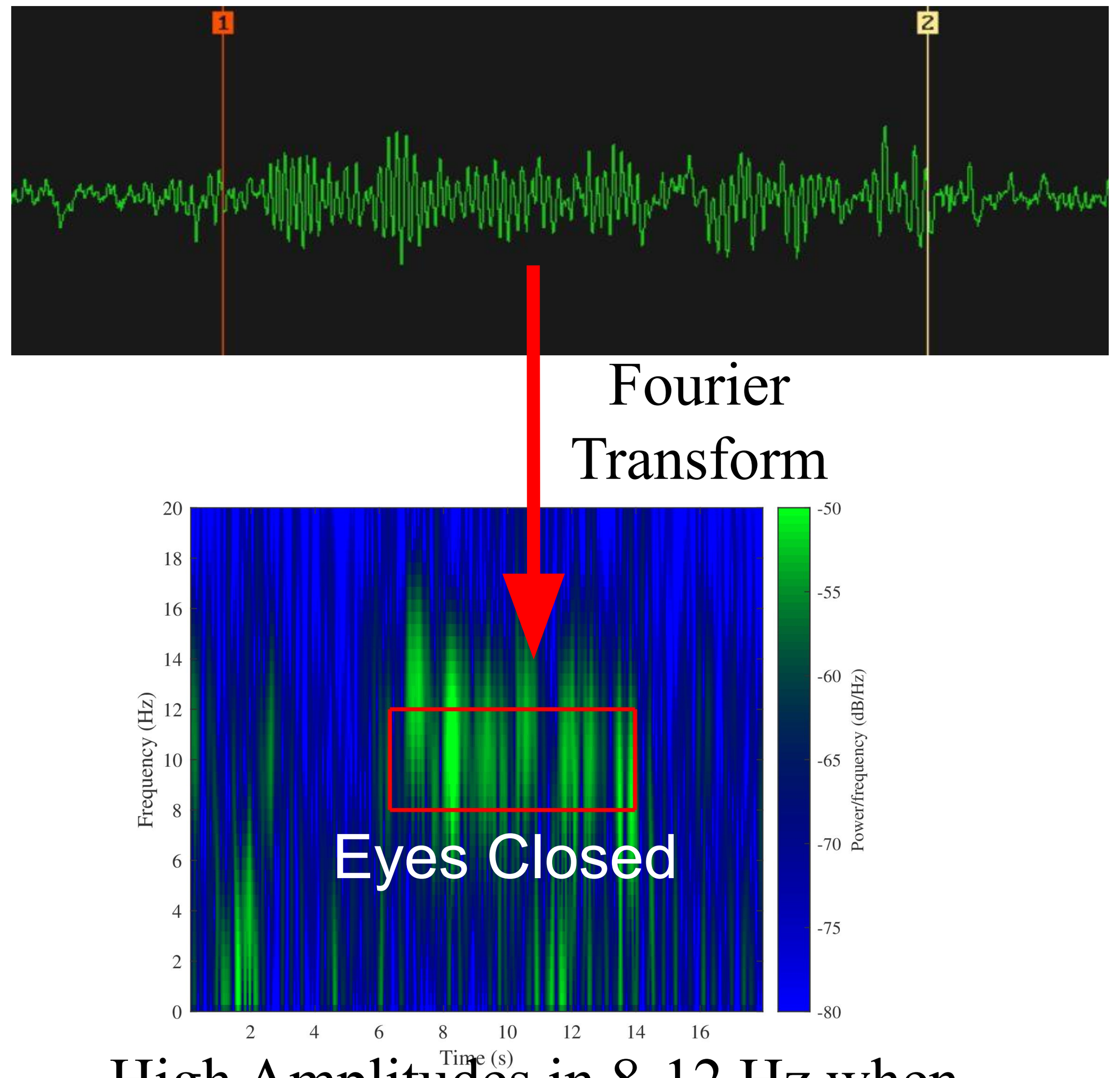
## Methodology

- Used electrodes connected to SpikerBox with Arduino Uno to collect brain EEG and EOG signals
- Used MATLAB to filter input signals
- Calculated the mean amplitude of input EOG signals to set it as threshold determining eye movements
- Conducted Fourier Transform on input EOG signals and integrated over the magnitude in the 8 - 12 Hz frequency band to detect when the pilot opens or closes eyes
- Built real-time data livestream through MATLAB

## Signal Processing




### EEG Measuring Optical Cortex




High Amplitudes in 8-12 Hz when eyes are closed

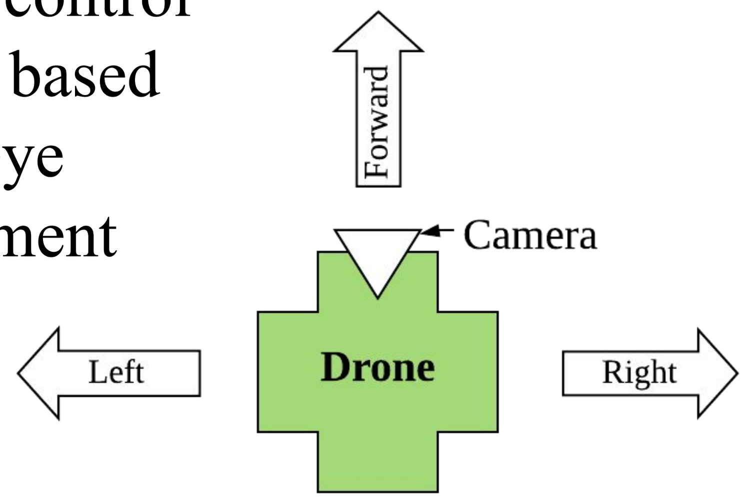
### EOG setup

EEG (optical cortex) setup

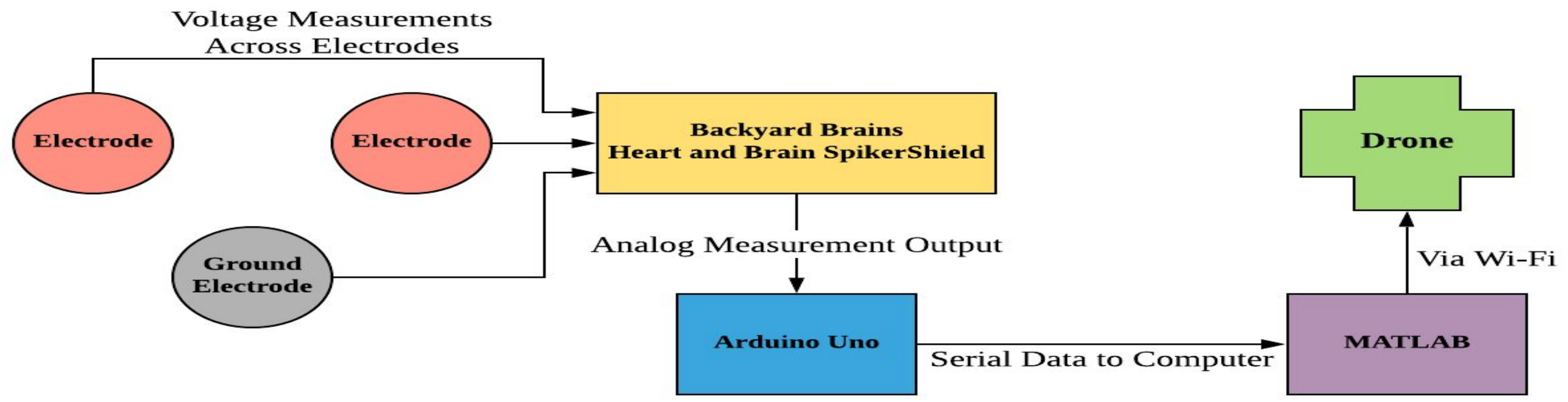
### Control Schemes

| Input | Output |
|---|---|
| Look Left | Move Left |
| Look Right | Move Right |
| Look Down | Stop Moving |
| Look Up | Go Forward |
| Open Eyes | Take Off |
| Close Eyes | Land |

Intuitive control scheme based on eye movement




## Data Flow Through Control Process




## Results

- Signal processing algorithm identifies input command with consistent accuracy:
  - 91.2% accuracy for live left-right EOG data
  - 100% accuracy for recorded EOG data for both left-right and up-down signals
  - Consistent detection of EEG events in previously recorded data
- Live up-down EOG signals affected by periodic extreme data points; some more work needed to account for this in the processing algorithm
- Inconsistent results using live EEG data

## Conclusions

- Demonstrated feasibility of the left-right component of the proposed BCI control system
- Evidence suggests functionally of up-down, and takeoff-land components of proposed BCI control system, with some current minor issues
- Proved that low-cost, consumer-grade BCI equipment is adequate for certain applications and provided fundamental results for future research

## Omissions and Future Developments

- Currently fixing some issues with live EEG and up/down EOG data, so will develop more results and conclusions shortly
- BCI processing code may be optimized by using a more lightweight framework than MATLAB
- The Parrot AR Drone platform has been discontinued, meaning that support for enhanced features is limited
- Highly complex EEG signals that require numerous electrodes to measure cannot be processed due to limited number of electrodes that we can hook up to the pilot

**Daniel Ferriero, Nathan Minsk, Dario Potter, Yichen Zhou**

# First Test Flight - successful!