# Closed-Loop Heart Brain Machine Interface

Naiqing Zhou, Yiting Wang & Hao Wu, <u>Advisors:</u> Prof. Bruce Land & Yu Hao

School of Electrical and Computer Engineering, Cornell University

We know how you feel

- We propose an affective Brain-Heart Computer Interface (BHCI) system for monitoring stress and detecting changes in emotion with the collected data of heart. We build the heart machine interface in this phase and plan to implement with brain data in the next phase, by making simple modification on the second channel of our heart interface

- The system can support two channels (up to 4), provide real-time data visualization and perform feature extraction for analysis

- The system can be easily operated by any non-professional users thanks to its straightforward, specially-designed user interface

- Our battery-powered, compact and portable design will extend its application to office setting

User Data & Log
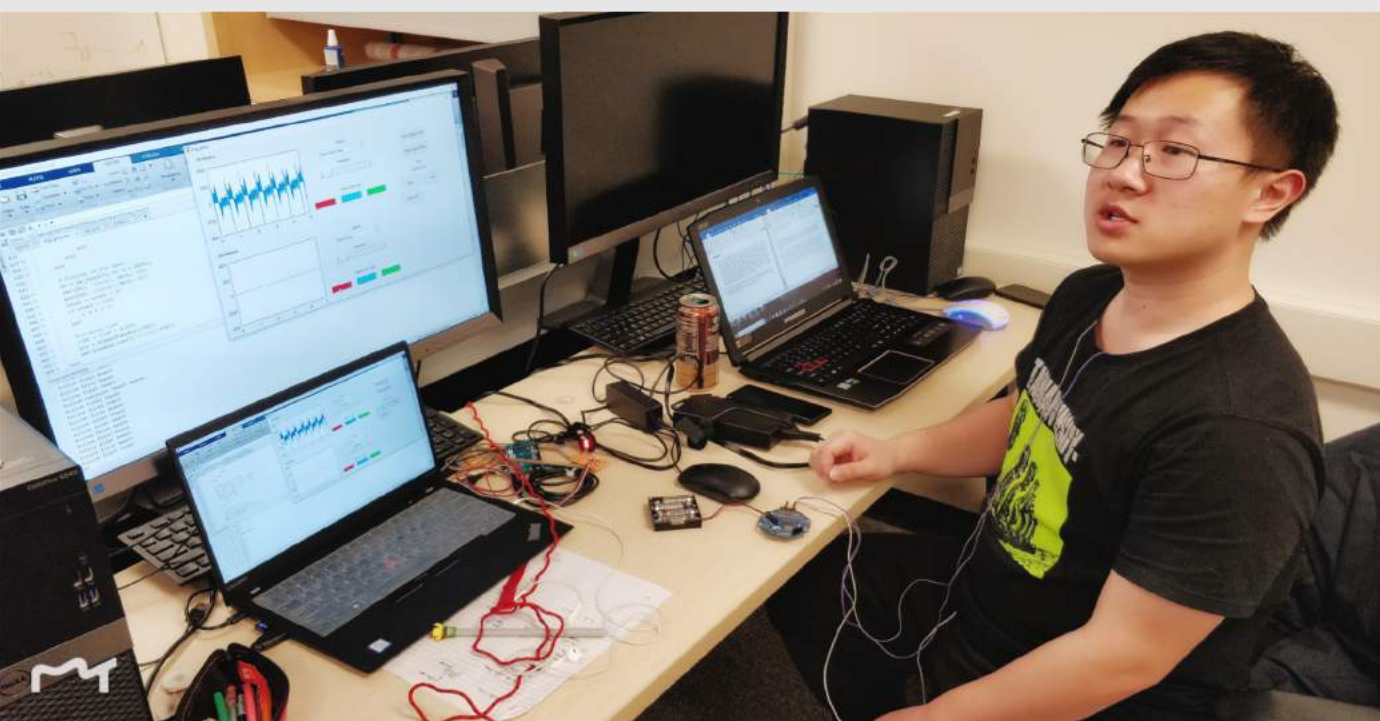
✓ Real-time data analysis

✓ Log data to file for future use

✓ Colored display of cardiac waveform
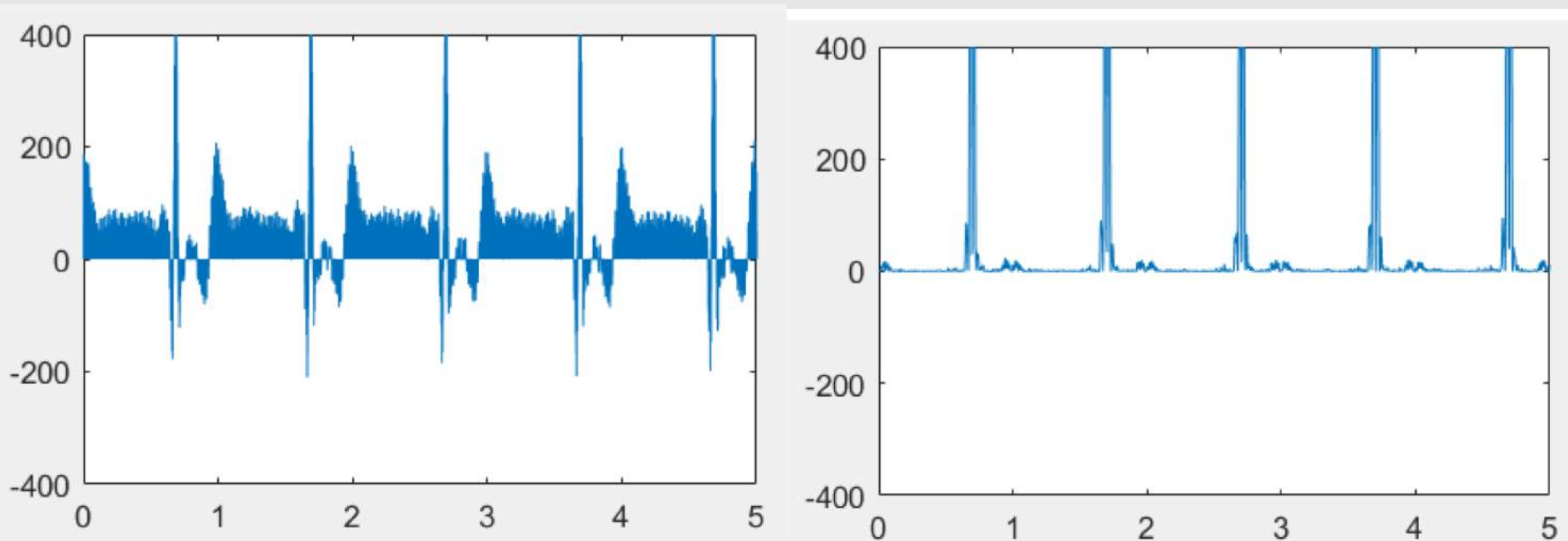
✓ GUI-controlled LED frequency and color

| timestamp	0	0.0025	0.005	0.0075	0.01	0.0125	0.015	0.0175	0.02	0.0225	0.025	0.0275	0.03	0.0325	0.035	0.0375	0.04
value	59.111	4.8843	11.753	11.532	-22.456	12.906	38.985	6.283	35.6	8.9365	-38.465	13.456	24.984	8.7439	69.757	11.259	-27.855

Optimization

- **Figure display speed-up :**

We use Matlab handles to refresh the figure with our real-time data. When figure object created, its attributes can be accessed by figure's handle. And we set the display data attributes without using plot, which saves time in avoid of creating new figure objects.

- **Multi control:**

We use Matlab timer objects to schedule different LEDs blinking. Originally we control our LEDs using serial communication between Matlab and Arduino, but the time consumed in serial reading and writing affected LED blinking. Using timer objects, Matlab will open different threads controlling LED frequency and we can separate LED control and heart following better.
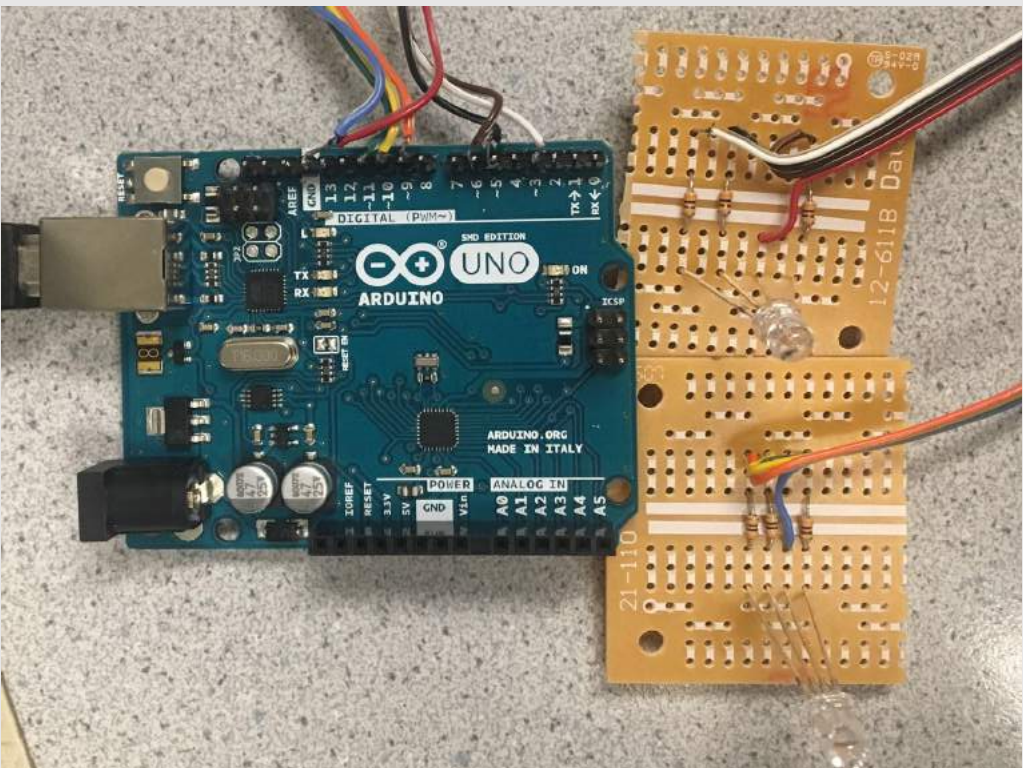
- **Algorithm performance lift up :**

We combine Pan-Tompkins algorithm with moving average and moving maximum to make sure the detection of exact peak without miss
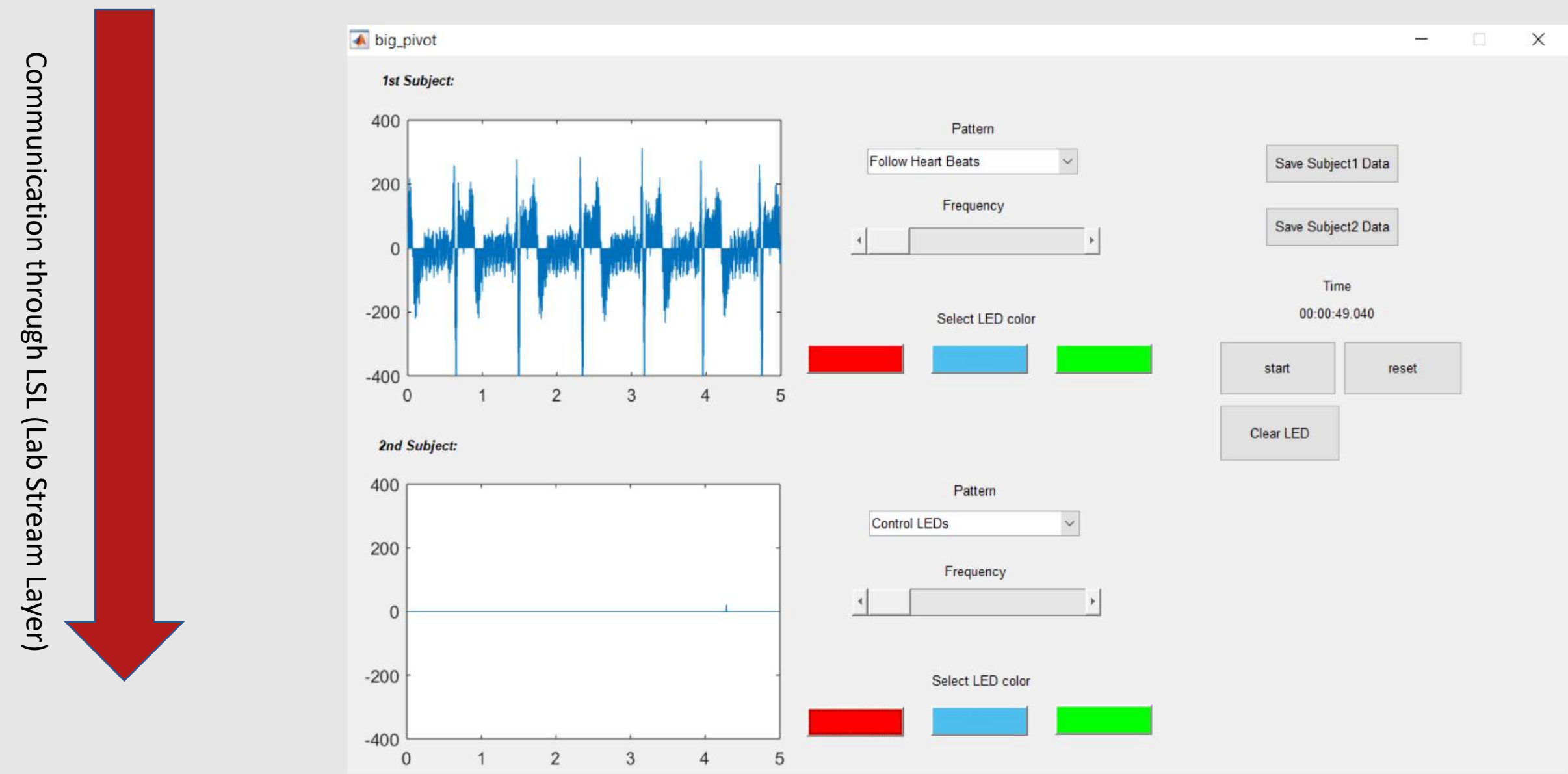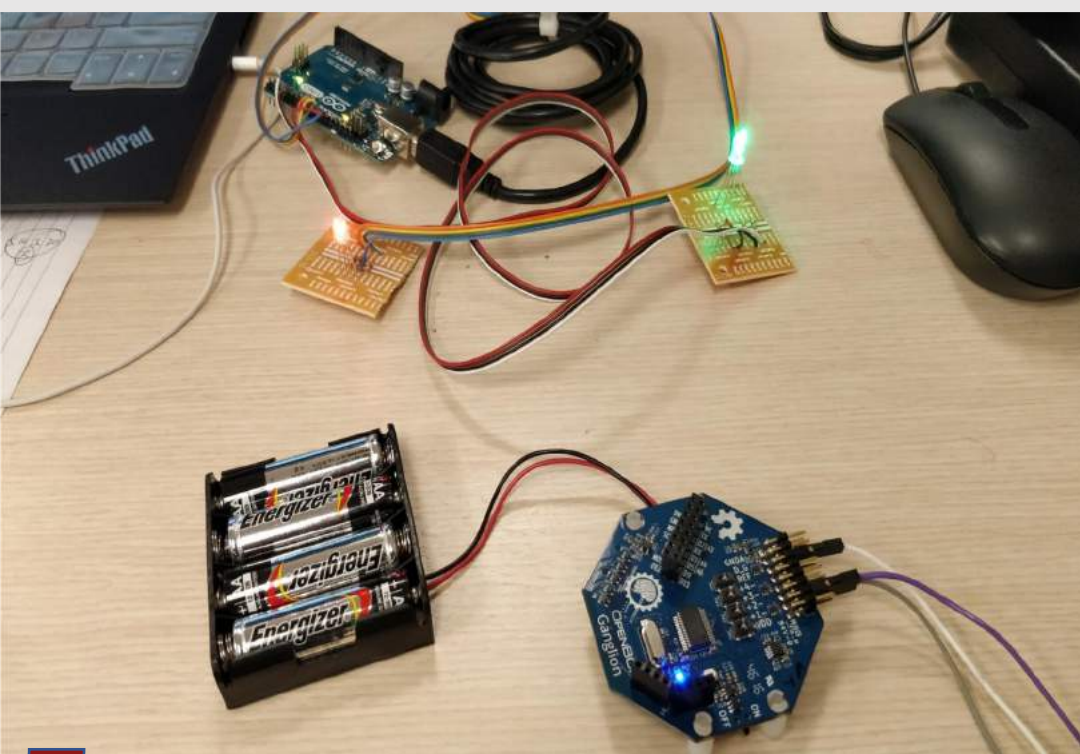

[Before and After optimization]

Under the hood of Heart Machine
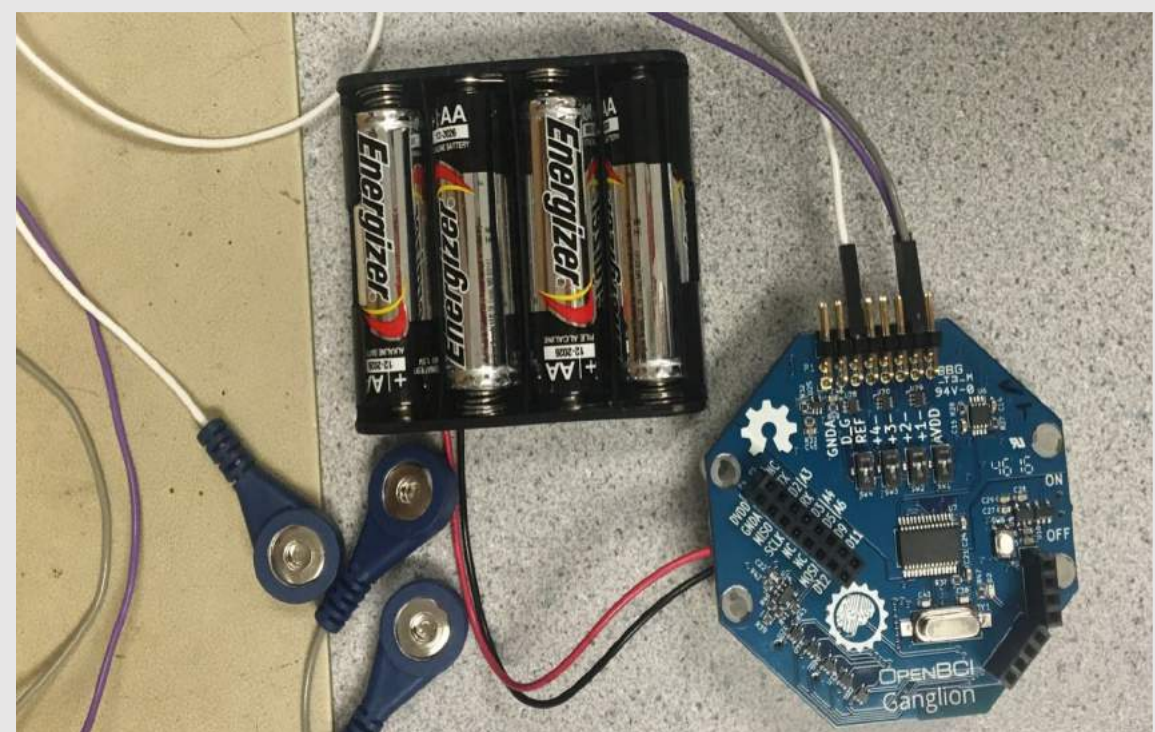
[Battery powered, portable bio-sensing Devices: OpenBCI Ganglion Board]
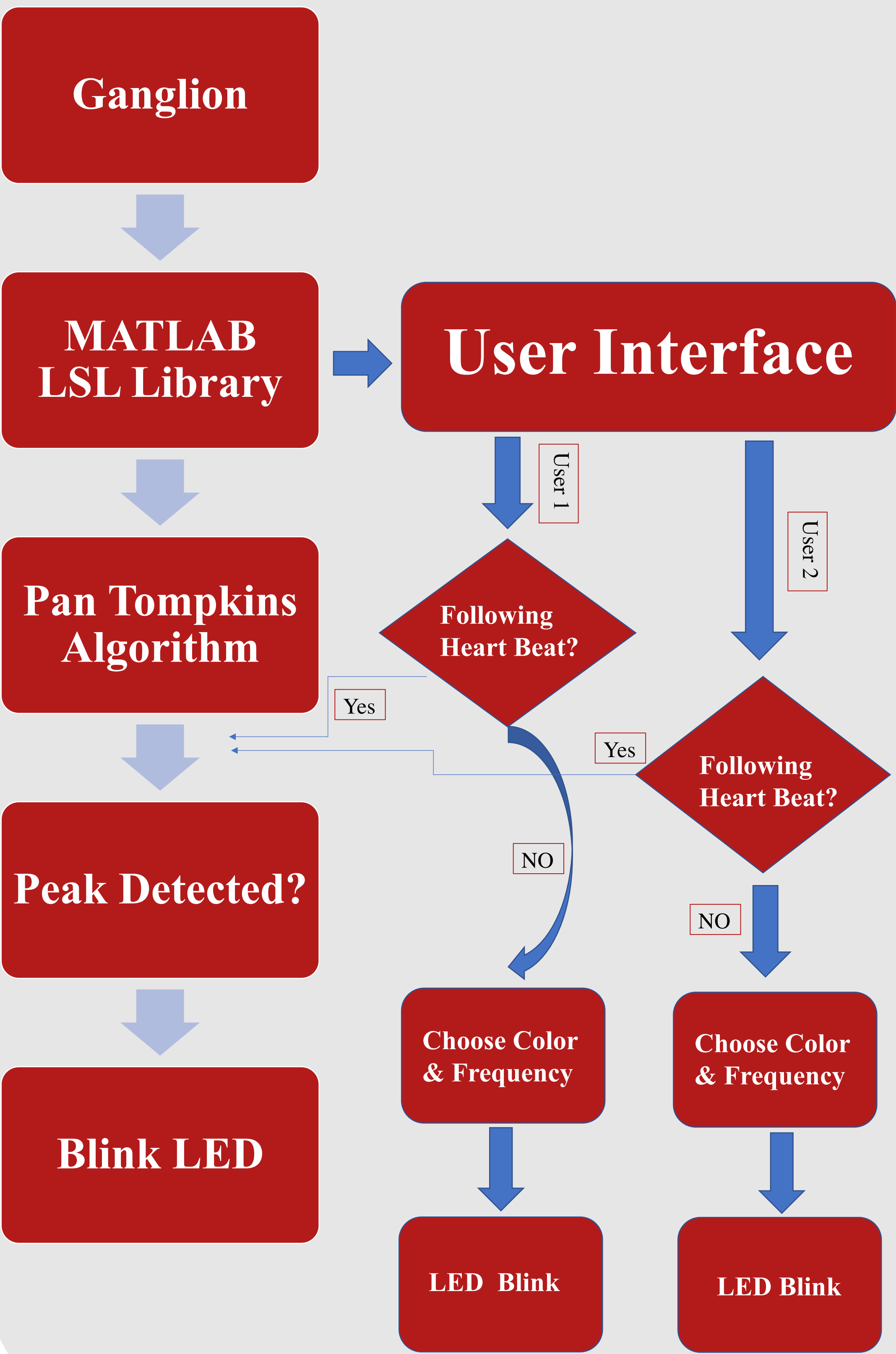
[Arduino handles the frequency and color of LED lights]

Communication through LSL (Lab Stream Layer)

MATLAB GUI control arduino

[Multiple Channels LED lights available]

78.8 uVrms

LEDs influence human heart beat

System Flowchart

Ganglion

↓

MATLAB LSL Library → User Interface

↓

Pan Tompkins Algorithm

Following Heart Beat?

User 1 / User 2

Yes

Following Heart Beat?

Yes

↓

Peak Detected?

NO

NO

↓

Blink LED

Choose Color & Frequency

Choose Color & Frequency

↓

↓

LED Blink

LED Blink

Future Work

- Integration of EEG devices (Brain data)
- Machine learning algorithm
- Emotion detection, intervention and control

Acknowledgements