

Low Cost Electroencephalogram (EEG) Devices

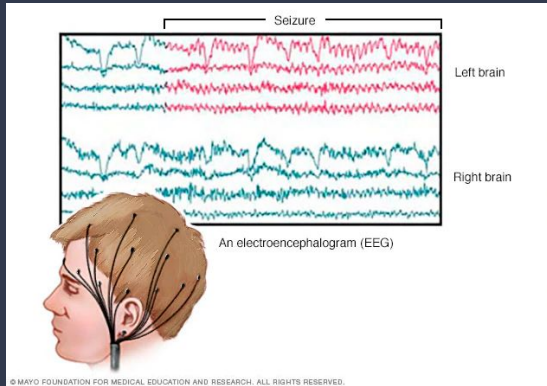
Engineers Expecting Greatness (EEG):

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What is an Electroencephalogram (EEG)?



- A Device that measure electrical signals in the brain
- Uses electrodes to read the small electrical signals
- A software converts those electrical signals into graphs

Objective of this project

Human edition: To develop a cheap, easy to use EEG device that will get high school students interested in STEM fields.

Rat edition: To develop an EEG device that doesn't require surgery and can accurately record brain signals.

Value Proposition: Human Edition

High school students today can be unaware of the breadth of fields in STEM. One such example is the inaccessibility of neurobiology devices.

Electroencephalogram (EEG) devices are too expensive for the average high school student. Due to this, there is a need for a cheap device that students can easily build themselves and learn about the activity and functions of their own brains. To this end, this project seeks to create a low cost, accessible, and easy to use EEG device that will get high school students interested in STEM related fields. The design of this device will be under 100\$ to produce, ready to build, and include an easy to use software that will get students interested in STEM fields.

Value Proposition: Rat Edition

Devices that record signals from rat brains often require intensive surgery and a then immobilized rat. Thus, there is a need for an inexpensive, external electroencephalogram (EEG) device that can accurately record signals from the rat brain. In order to fill this gap, this project seeks to create an EEG device that can be easily attached to a rat without the need for surgery, while still being able accurately record the brain signals. This project will fill this role by creating a device that doesn't require surgery to attach to the rat, while still being able to record accurate signals from the rat brain and leaving the rat free to roam.

Background

The first part of this project stems from the need for more affordable resources for high school student. The average cost for an EEG is upwards of \$800, which is much too expensive to be utilized in most high schools. This is where we come in, we are trying to create an EEG device that can be made for under \$100 that is able to collect accurate data, and aid the learning of students. The second part of this project comes from there not being a way to read a rat's brain waves without being incredibly invasive to the rat as well as endangering its life. We are out to create an EEG that is small enough and accurate enough to read a rat's brain waves without being overly invasive.

Requirements

Human:

- Lightweight
- Flexible
- Under \$100

Rat:

- Lightweight
- Non-Invasive
- Movable

Design 1: Wig cap

- Pros:
- Flexible
 - One size fits all
 - Secure to head
 - Reduces noise
 - Comfortable



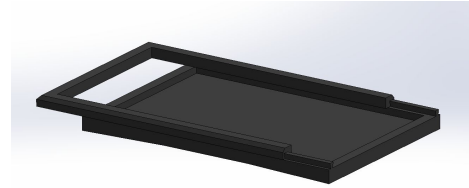
Concept

Actual



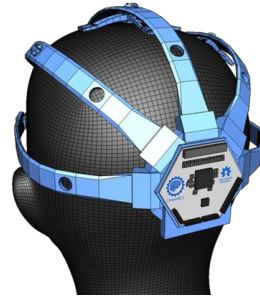
- Cons:
- Nodes are not removable

Circuit Card Positioned on Back of Wig Cap.



Pros: Shorter wires
could be used.

Can be transitioned to
bluetooth.



Cons: Slightly
increase the weight
of the headset.

Design 2: Hydrogel



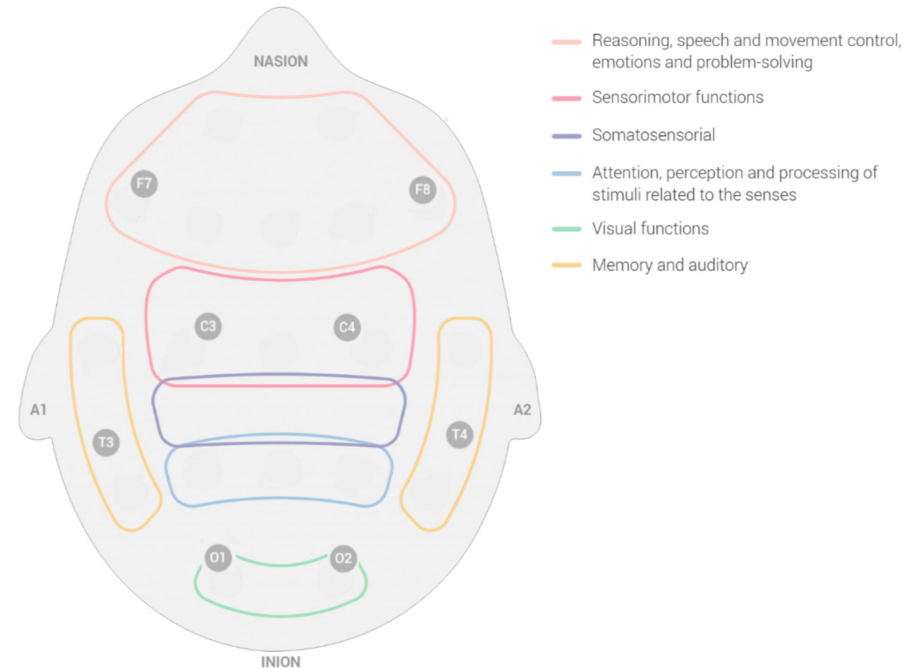
Inserting the circuit design into hydrogel, which could lay inside the headset on the scalp

Pros: Decrease real estate and increase portability, ensure good conductivity

Cons: Circuit too complicated to implement, machinery not accessible to high school students

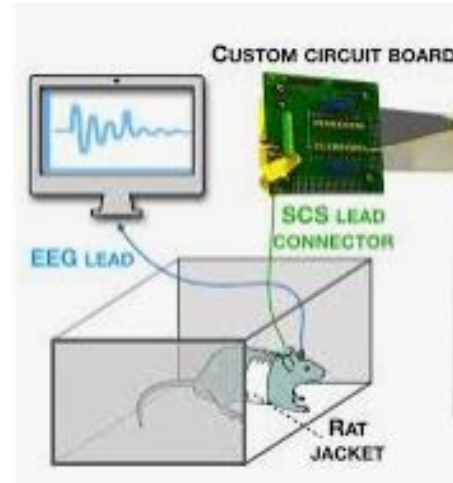
Ultimately, this option was discarded.

Electrode Placement: Human Edition



- Eight recording nodes with one for the reference and one for ground
- Each electrodes are 10 cm apart

Design 1: Circuit Card Positioned on Cage



Pros: Keep circuit card simple, easy and convenient to set up

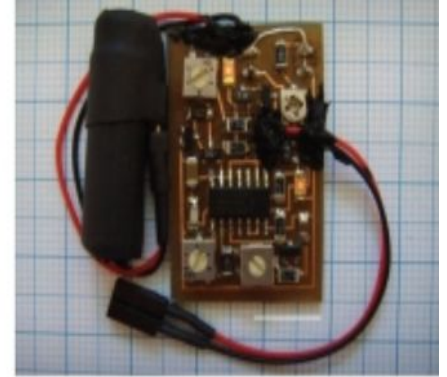
Cons: Length of wires can introduce more noise and possibly get in the way of the rat

Due to this simply approach, we've decided to try this option first to test the first prototype headset and circuit design

Design 2: Circuit Card Rat Backpack



(a)



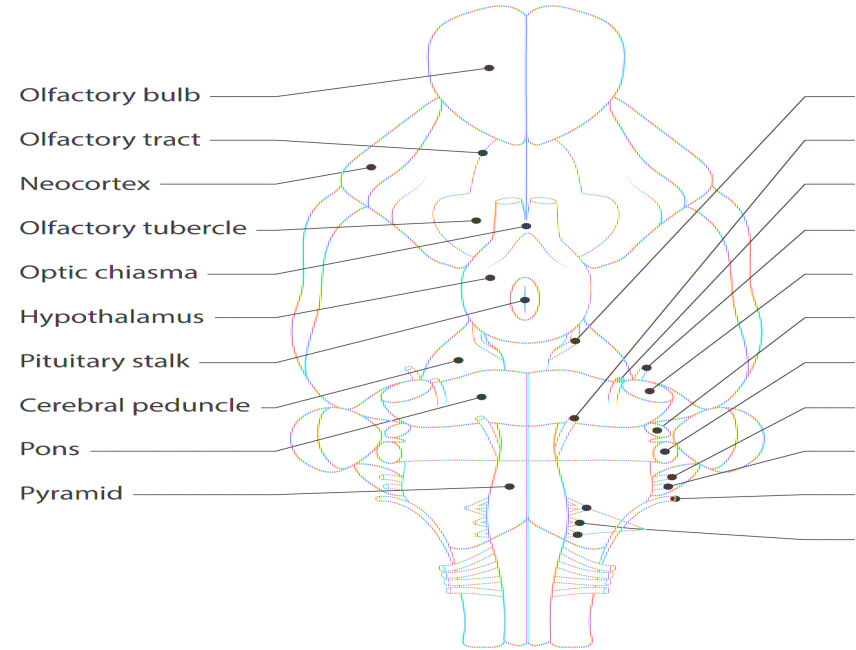
(b)

Pros: Good conductivity, very portable, will not get in the way of the rat as it moves freely

Cons: It will be a challenge to modify circuit design so that it fits on small circuit card and is light enough for rat to carry, Arduino Nano might not fit on this real estate.

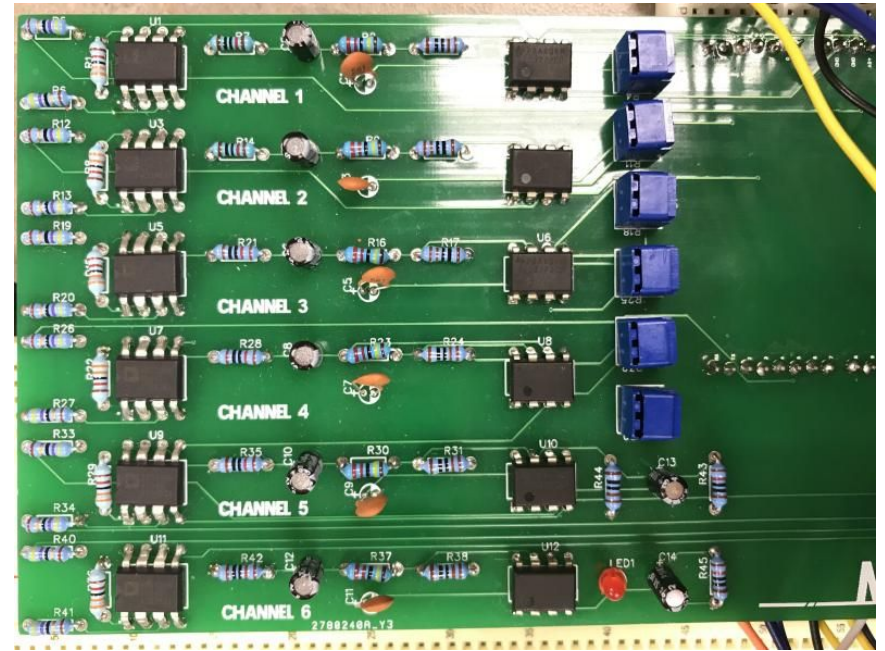
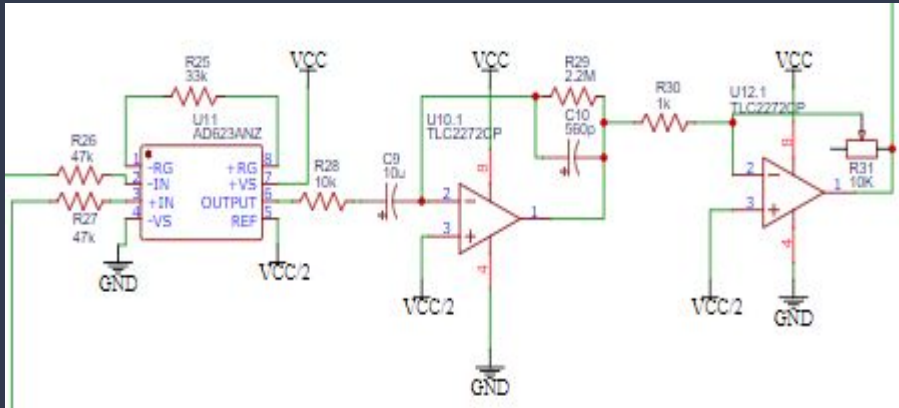
Once Option 1 is built and works, we can continue with Option 2

Electrode Placement: Rat Edition

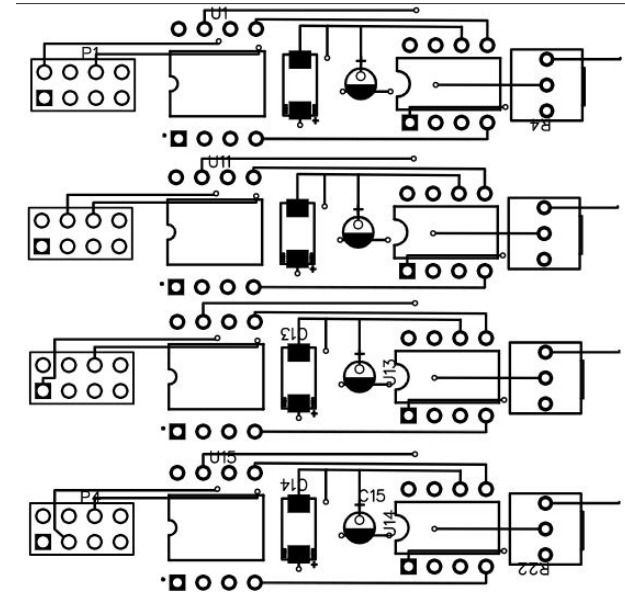


- Not much information about the electrode placing for the rat
- Normally, electrode is placed through surgery

Circuit Board



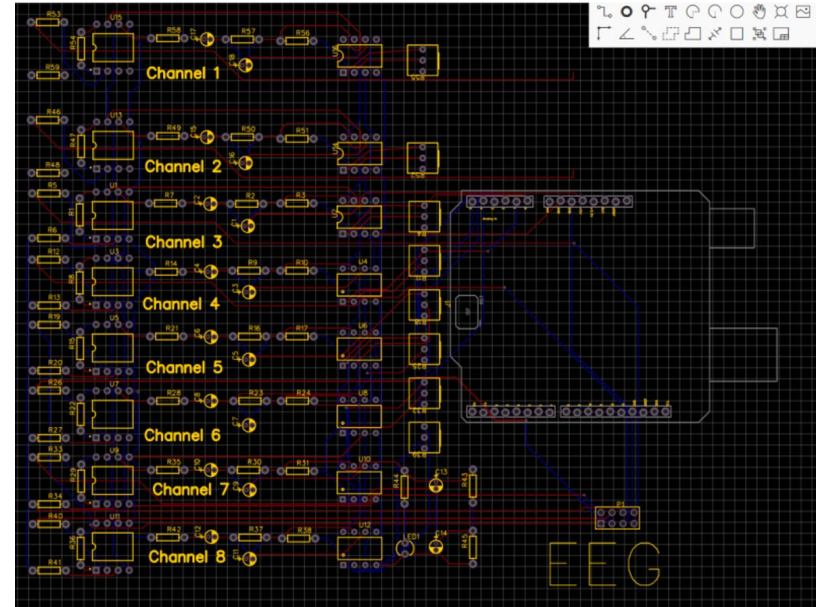
Conceptual Development: Rat Edition



Circuit Specification:

- Frequency Range is (0.5Hz ~ 200Hz) using Bandpass filter.
- Circuit has amplification, filtering and gain adjustment repeated for 4 channels.
- VCC is 5V.
- Surface mount components are used instead of through hole components.

Conceptual Development: Human Edition



Circuit Specification:

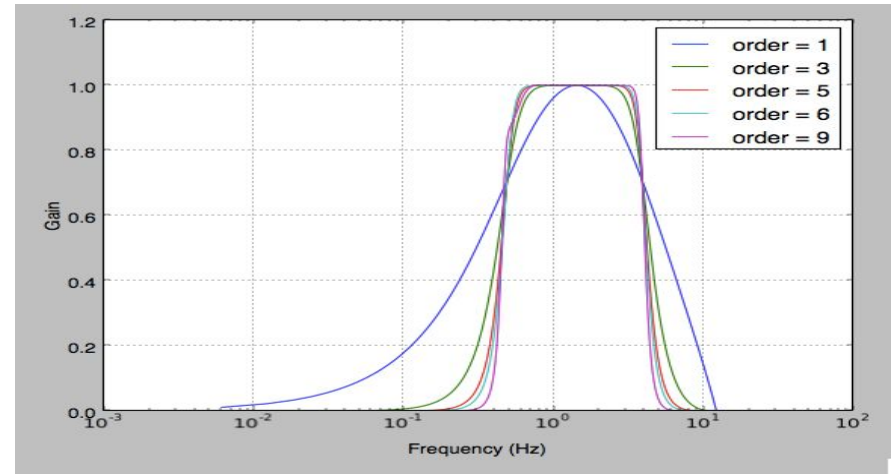
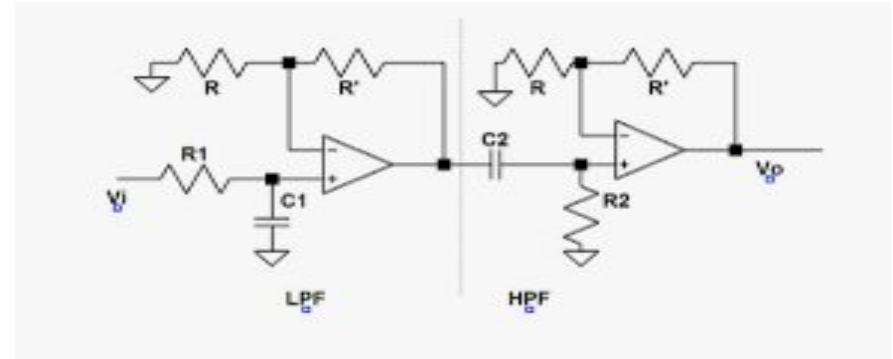
- Frequency Range is (1Hz ~ 120Hz) using Bandpass filter.
- Circuit has amplification, filtering and gain adjustment repeated for 8 channels.
- VCC is 5V, with ground and reference ground.
- Through Hole Components are used in this model.

Conceptual Design: Bandpass Butterworth Filter

Pros: Would greatly reduce noise and output clean signals, very high quality

Cons: The component itself would be very expensive, one example was found to be \$20. These kinds of Butterworth filters are also typically used for higher frequencies

This option might not be used because of cost, further research and simulations will be done during 2nd semester .



Recommendations and Justification

- Wig Cap Design
 - Increased pressure for electrodes
 - Cheap material
 - Doesn't require 3D printing
 - Electrodes can be sewn in
- Circuit
 - 10 electrodes since having 2 references worked well
 - 8 recording, 2 reference
- Software
 - Build our own GUI because current programs are lackluster

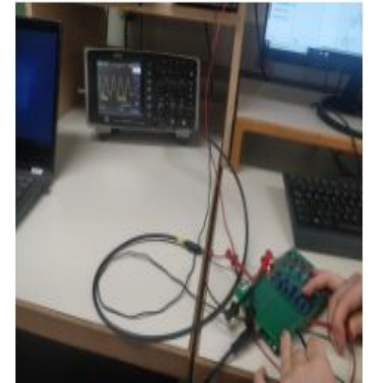
Identification of Risks and Mitigation

- Going Over budget
 - Budget will only be increased with client approval
 - Team will keep in mind goal to reduce cost

Validation Approach

BE, ME, and EEs will begin validating data collection from the current design of the headset while the CS students work on/with the publicly available datasets to confirm the functionality of the GUI/software.

Validation Approach: Human Edition Circuit



Pictured to the left is the output at 0 Hz.



Pictured here is the output at around 50 Hz with little to no noise

Human Edition Circuit Part 2



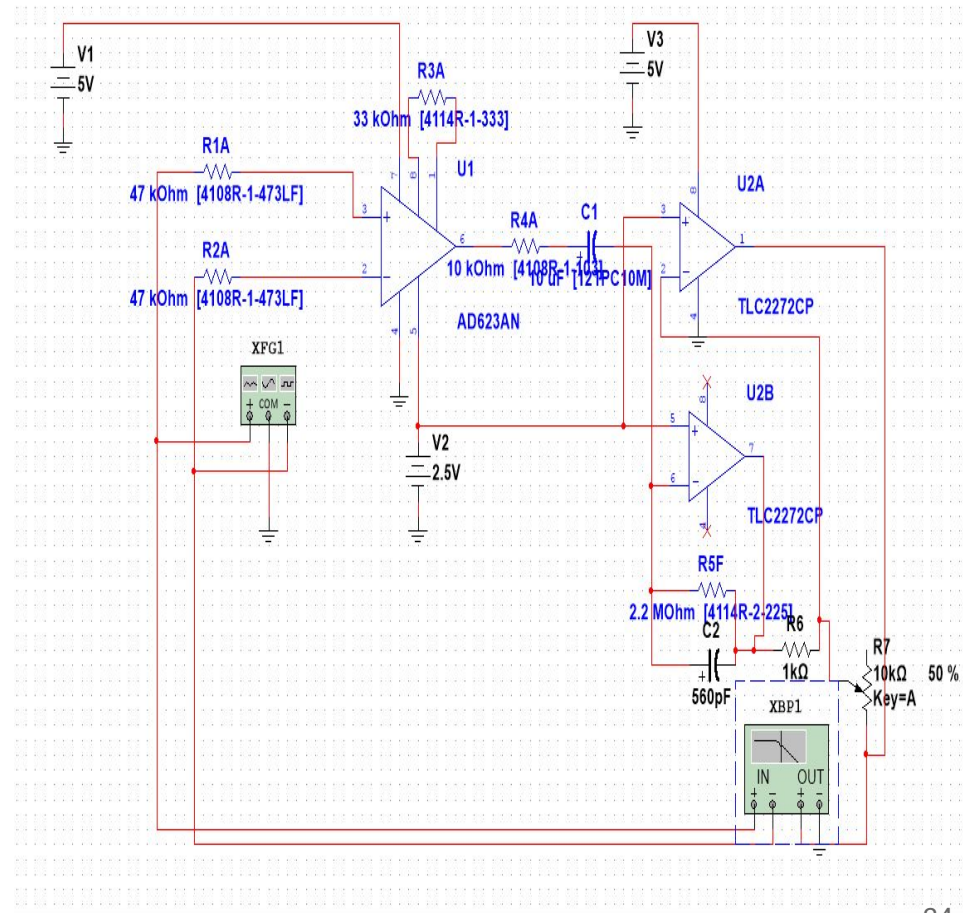
Output here
pictured at 120
Hz, the very edge
of the upper limit.



Output here
was at 200
Hz,
attenuated to
0.

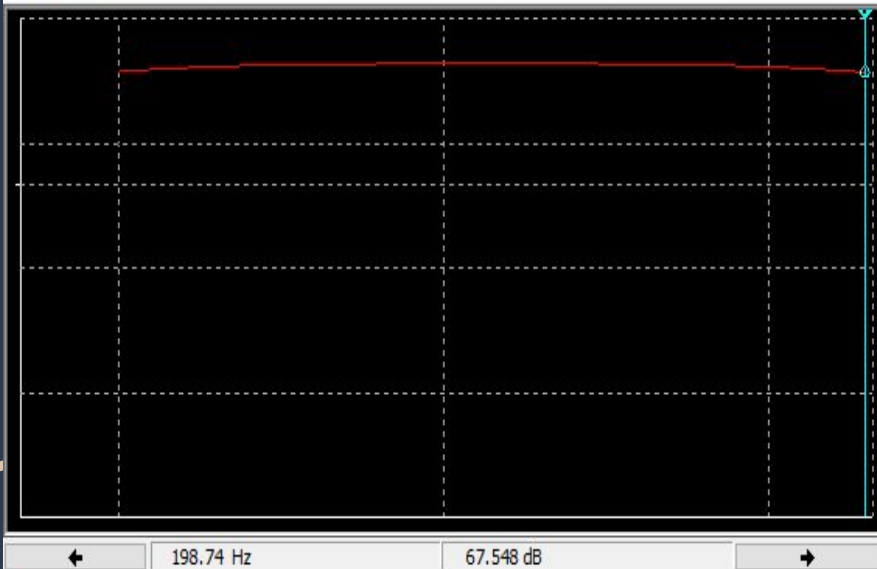
Human Circuit Simulation

Multisim was used to simulate the original circuit, a signal generator was used to provide an input signal with varying frequencies to test the output with a Bode plot.

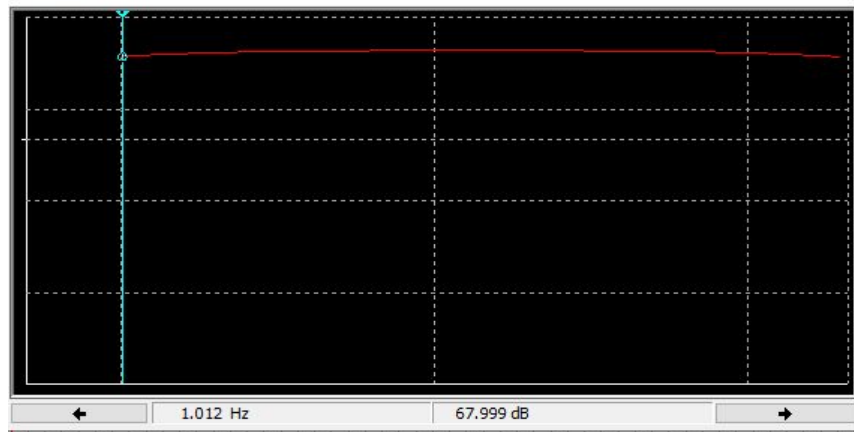


Simulation Bode Plot Readings

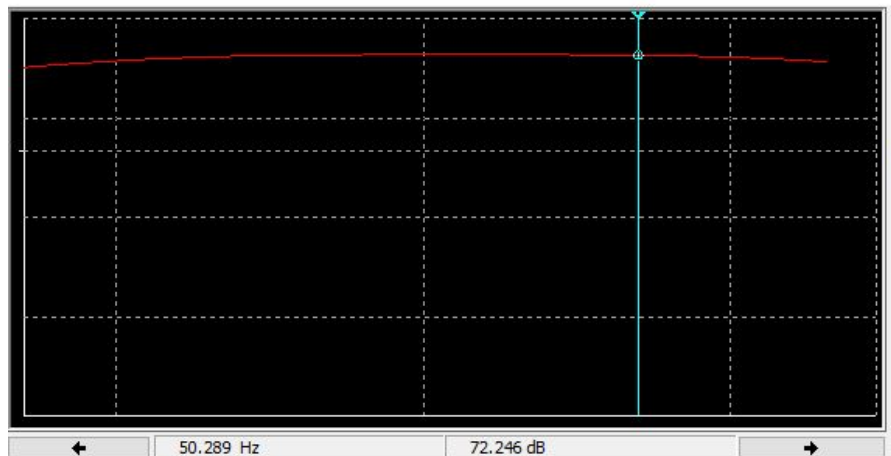
Bode Plotter-XBP1



Bode Plotter-XBP1



Bode Plotter-XBP1



User Interface

Arduino - digital for EEG, analog for bluetooth module

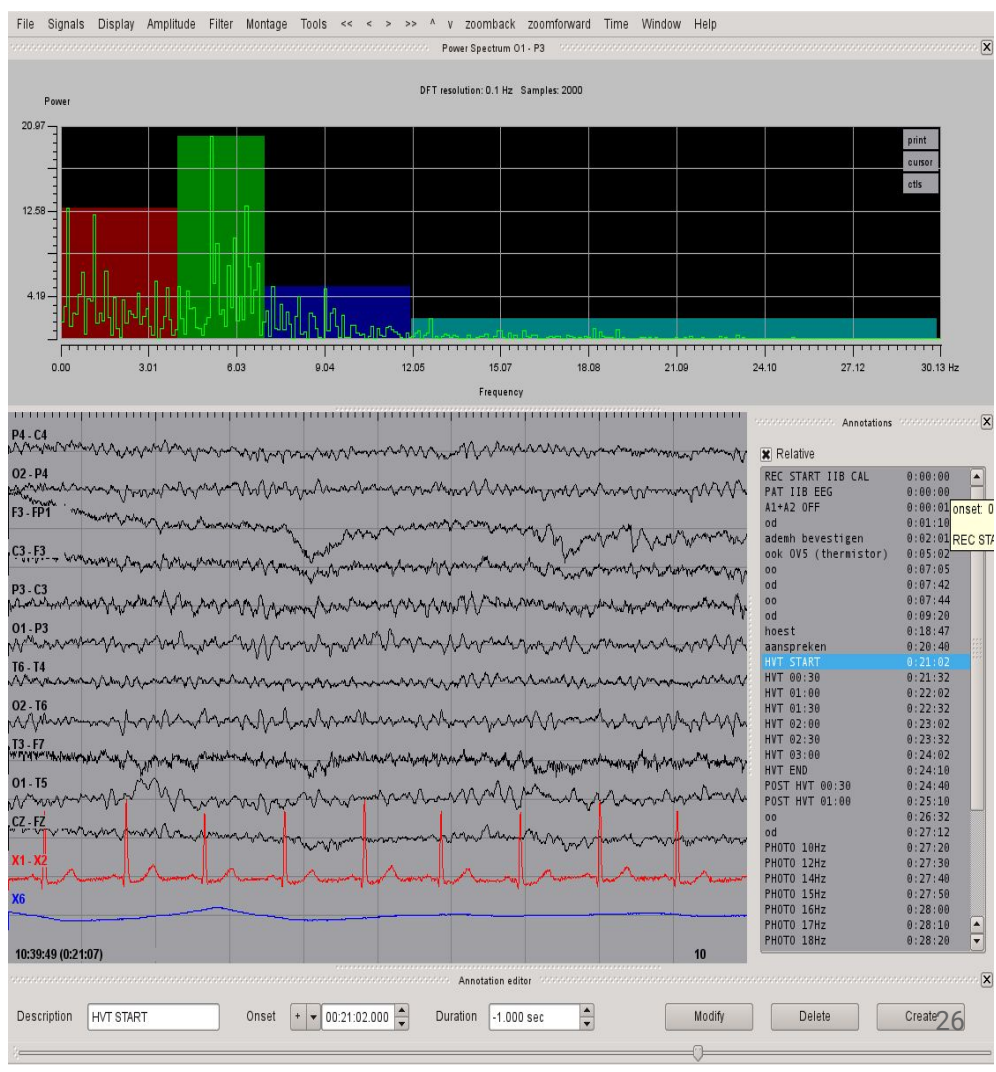
- Python - useful for deep learning libraries
- Tkinter - Python graphics library to build the GUI
- Qt - cross-platform GUI tools
- Matplotlib - library to visualize charts and models

A Conceptual design of User Interface

Image credits: University of Tennessee at Knoxville. "Open source EEG visualization tool."

ScienceDaily. ScienceDaily, 5 December 2019.

www.sciencedaily.com/releases/2019/12/191205155305.htm.



Machine Learning Algorithms

How do we separate good EEG readings from outlier readings?

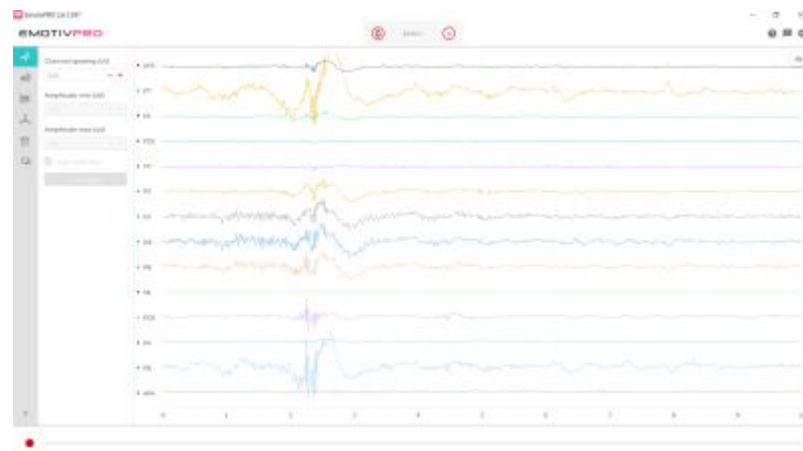
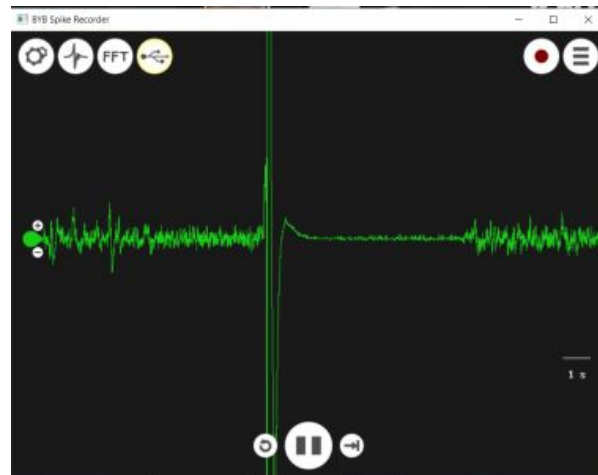
Keras machine learning

- + Easy to use, well documented
- + Has pre-trained statistical models
- Can be slow, error prone, hard to visualize

TensorFlow

- + Easy to visualize, lots of available libraries
- + Efficient, high performance
- Steep learning curve
- Need to supply statistical models

Testing



Schedule

https://vandalsuidaho-my.sharepoint.com/:x/r/personal/varn5606_vandals_uidaho_edu/Documents/EEG%20Capstone%202020-21/C_Project%20Management/Capstone%20Gantt%20Chart.xlsx?d=w22204d5236cf4825a8c16e5730c14c48&csf=1&web=1&e=1kHJWW

Budget

Capstone Project Budget Template - Fall/Spring

Project: Tiny low-cost EEG device for measuring brain signals from rats/mouse and Low-cost EEG device for measuring brain signals
 Last Updated 11/7/2020

Expense Items	Year								Item Total
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Equipment/Tools:									
Sewing Kit									\$ -
License for emotiv pro software		\$30.00	\$30.00						\$ 60
Travel:									
									\$ -
Supplies / Parts / Services:									
3d printer filament			\$22.99						\$ -
electrodes for rat			\$50.00						\$ 50
electrodes for human									\$ -
battery pack			\$5.99						\$ 6
batteries, 9v			\$10.00						\$ 10
adhesive			\$15.00						\$ 15
arduino board		\$25.00							\$ 25
breadboard x 2			\$6.49						\$ 6
soldering supplies			\$10.99						\$ 11
saline									\$ -
copper wires and jumper cables			\$30.00						\$ 30
capacitors			\$12.99						\$ 13
resistors		\$9.99							\$ 10
dc-dc converter			\$12.99						\$ 13
aluminum tape for shielding			\$5.74						\$ 6
bluetooth module			\$9.88						\$ 10
neoprene helmet		\$14.95							\$ 15
felt									\$ -
									\$ 240
Shop Usage (est. Hrs):									Hours
3d printing			8	8	8	8			32
pcb printing			8						8
									0
									0
									0

Graduate Student Support \$ - including fringe
 Shop Overhead \$ -
 University Overhead \$ 12 5% of all expenses

Totals \$ 252 \$ 300 \$ 30
 Budget Excess

Future Work

- Design test games to make using the device more fun
- Continued work on the GUI and software
- Integrate software with simple robotic controls

Questions?