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Innovative Magnetic Motor Assembly for Stroke Rehabilitation Therapy

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Department of Electrical, Computer, and Biomedical Engineering, University of Rhode Island, Kingston, RI

BIOMEDICAL ENGINEERING

Introduction

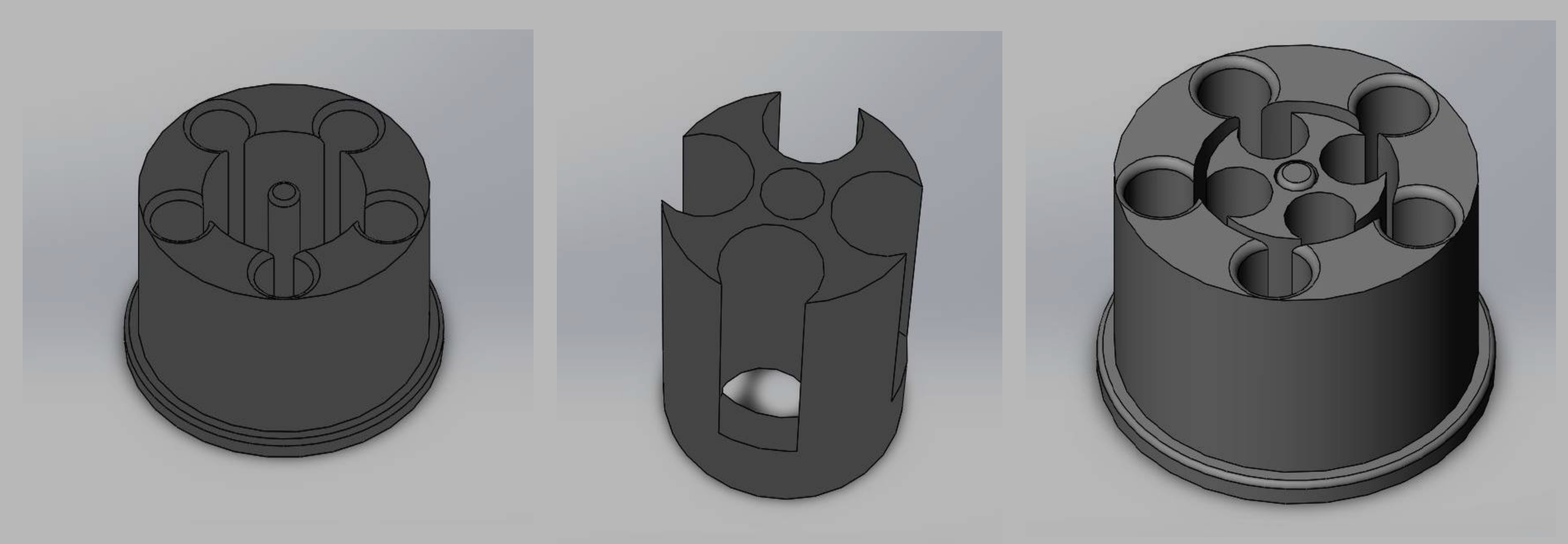
Transcranial magnetic stimulation (TMS) is a method of stroke victim rehabilitation. In previous years students of the biomedical engineering capstone course have built prototype TMS helmets that proved the concept of at home TMS therapy. These previous iterations however are loud and uncomfortable to use. The goal of this project was to design and construct a quieter electromagnetic motor assembly to be used for a TMS helmet that could potentially make at home treatment a more viable option. This will be done using electromagnetic coils, a 3D printed assembly, and an external circuit using a PIC18F4525 microcontroller.

Approach & Design

Four neodymium magnets produce the magnetic field for TMS. Five electromagnetic coils rotate the magnets using Toshiba TA8428K H bridge chips designed for controlling motors in conjunction with the PIC18F4525 microcontroller. Coils constructed of enameled wire and iron nails. Motor assembly designed in SolidWorks and 3D printed.

Methods

The core of this project is to spin the permanent magnet assembly at a frequency of 10 Hz at a strength of ⅓ Tesla for each magnet. Electromagnetic coils are put within a 3D printed housing around the magnet assembly to influence the magnets.



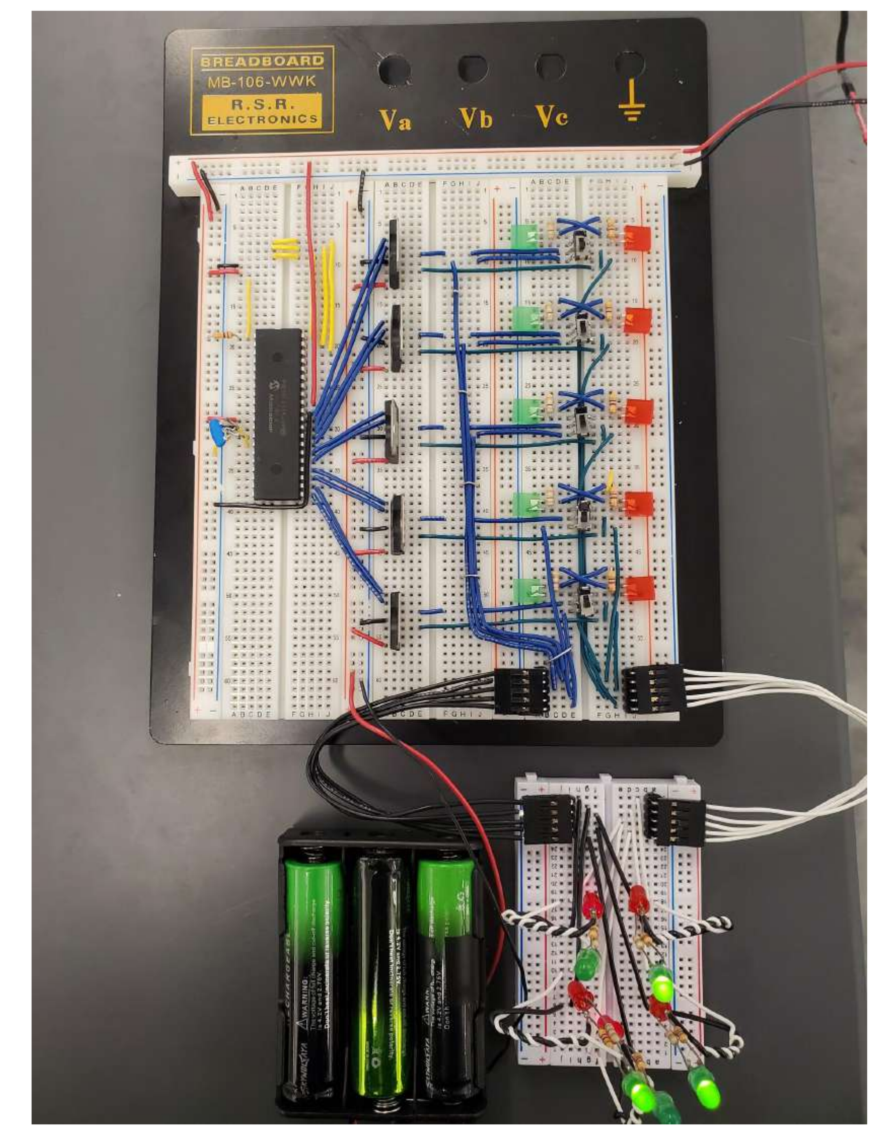
By alternating the direction of current within the coils, the magnetic polarity will change in an alternating pattern and rotate the magnet assembly. Currently, LEDs take the place of the electromagnetic coils to simulate the changing states of polarity.

N	N	N	N	N	S	S	S	S	S
S	S	S	S	N	N	N	N	N	S
N	N	N	S	S	S	S	S	N	N
S	S	N	N	N	N	N	S	S	S
N	S	S	S	S	S	N	N	N	N

Table 1: Sequence of 5 electromagnetic poles to induce a rotation of the permanent magnets. Each row represents the sequence of one coil.

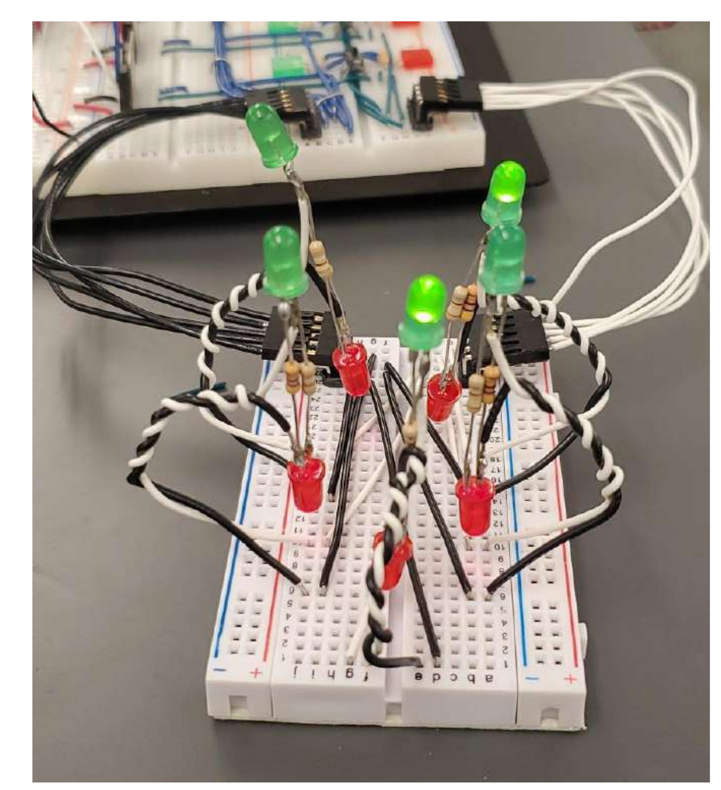
The alternating states of each coil are showcased in the figure on the left. Each individual coil is timed to push the magnet assembly into another phase of rotation. Decreasing the time between each state will control the frequency and induced magnet strength and allows us to project different settings for the device.

Control Circuit



Breadboard circuit was constructed to test the output of the PIC18F4525 to the H bridge chips to demonstrate software written works correctly.

Separate power supply used to drive the H bridge output to LEDs, electromagnetic coils will be added in next steps.



Connected to the main breadboard is a smaller circuit that is used to better visualize demonstration of the alternating poles being simulated by the LEDs. This alternate output is controlled by a series of switches.

Future Works

Wiring the printed assembly with installed coils to test spacing that will turn the magnets accordingly.
Implementing a control system for speed adjustments.
Confining the circuit to a PCB for practical use.
Test methods for maximum noise reduction.

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Balance Detection with Vibro Feedback for Lower Limb Prosthetic

Amanda Celia, Becky LeBlanc, Steph Hamilton, Dr. Ying Sun, Kunal Mankodiya Ph.D

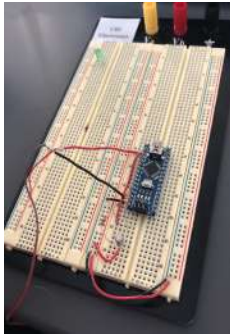
Background Information

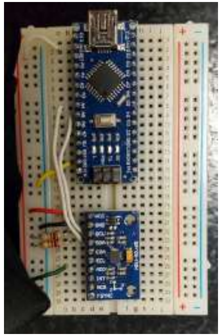
- There are 185,000 new lower extremity amputees per year in the United States alone.
- Most prosthetics made for lower extremity amputees are unstable and affect the patient's balance and coordination

Objective

- To create a lower limb prosthetic that detects when the amputee is at a certain range of imbalance
- To communicate back to the amputee an imbalance on the prosthetic limb using a vibrotactile feedback sensor

Methods





Future Work

- To combine both circuit boards to one
- To test different tilt angles to determine the best one for vibrotactile feedback

A Model Smart Home For An Independent Living Environment

Lexie Duntzee, Kiera Mantyla, and Mackenna Dunn

Objective:

Our project is a 16:1 scaled down version of a two story home with several enhancements so that a person with disabilities can live an independent lifestyle

Methods:

Hardware:

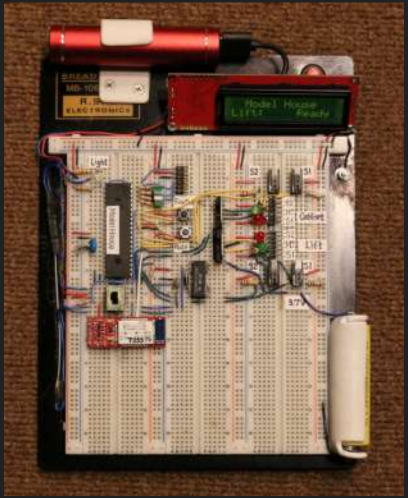
- Breadboard components including the DC motor and H-bridge chip
- Mechanical components on the house including railing and pulley system

Software:

- Create a code to run all motor functions in the home
- PIC microprocessor is used to connect hardware and software components

Goals:

Develop an app to control all motor functions in the home



Voltage Clampable Neuron Emulator

Biomedical Engineering Capstone Design 2019-2020

Klara Szilagyi[1], Madison Lewis[1], Ying Sun[1]

[1]*Biomedical Engineering, University of Rhode Island, Kingston, RI, USA*

Introduction

The original emulator was developed to model the active and passive components of a live neuron. Having this tool would allow the user to change different conditions and study the effects without suspecting a live organism to these changes. Current problems with the existing Neuron Emulator are:

- Fast rise time
- Inaccurate peak in action potential
- Noisy signal
- Inability to be voltage clamped

Fixing these will allow further studies on voltage change in specific physiological conditions in addition to increasing the accuracy and similarity to a live neuron. To fix the action potential, different values for the capacitor will be implemented to hopefully produce a more accurate action potential signal. The ability to voltage clamp is the next task and to achieve this the signal needs to be slowed down significantly to be clampable. This fix will be a combination of software and hardware.

Design Process

- Top down process
  - Taking an already existing Neuron emulator and improving it
- Software
  - Updated to version 4.15 of MPLABX
  - Tried new compiler
  - Global variables
- Hardware
  - Circuit theory
  - Resistance values
  - Capacitor values
- Progress
  - Changed resistor values in Na and K circuits change shape
  - Corrected size
  - Slowed down rise time to acceptable value
    - Still needs improvement

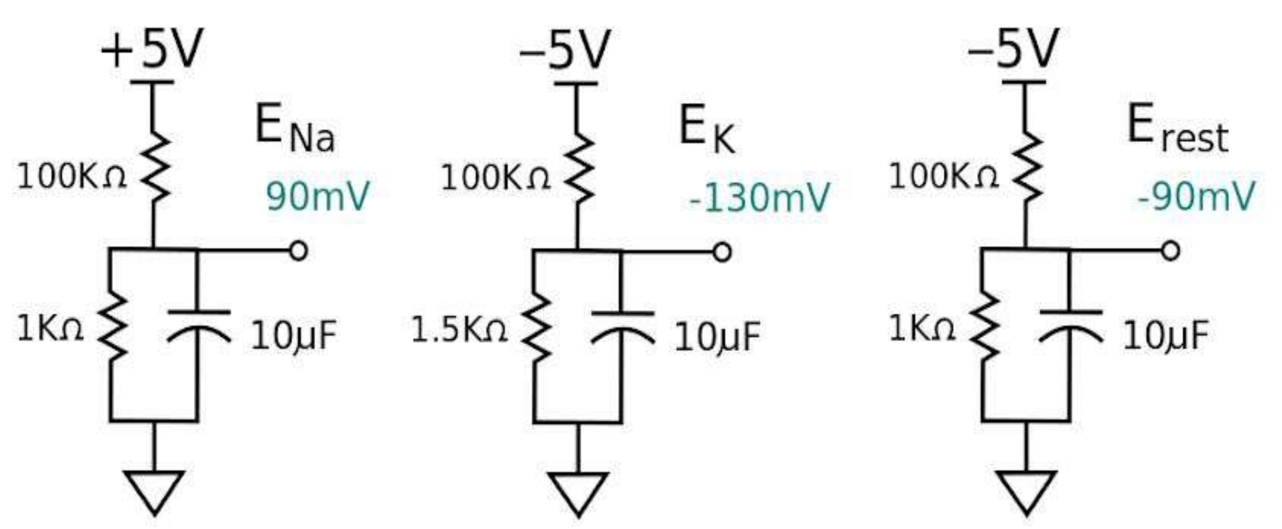


Figure one: The RC circuits responsible for the inward and outward currents for thee action potential

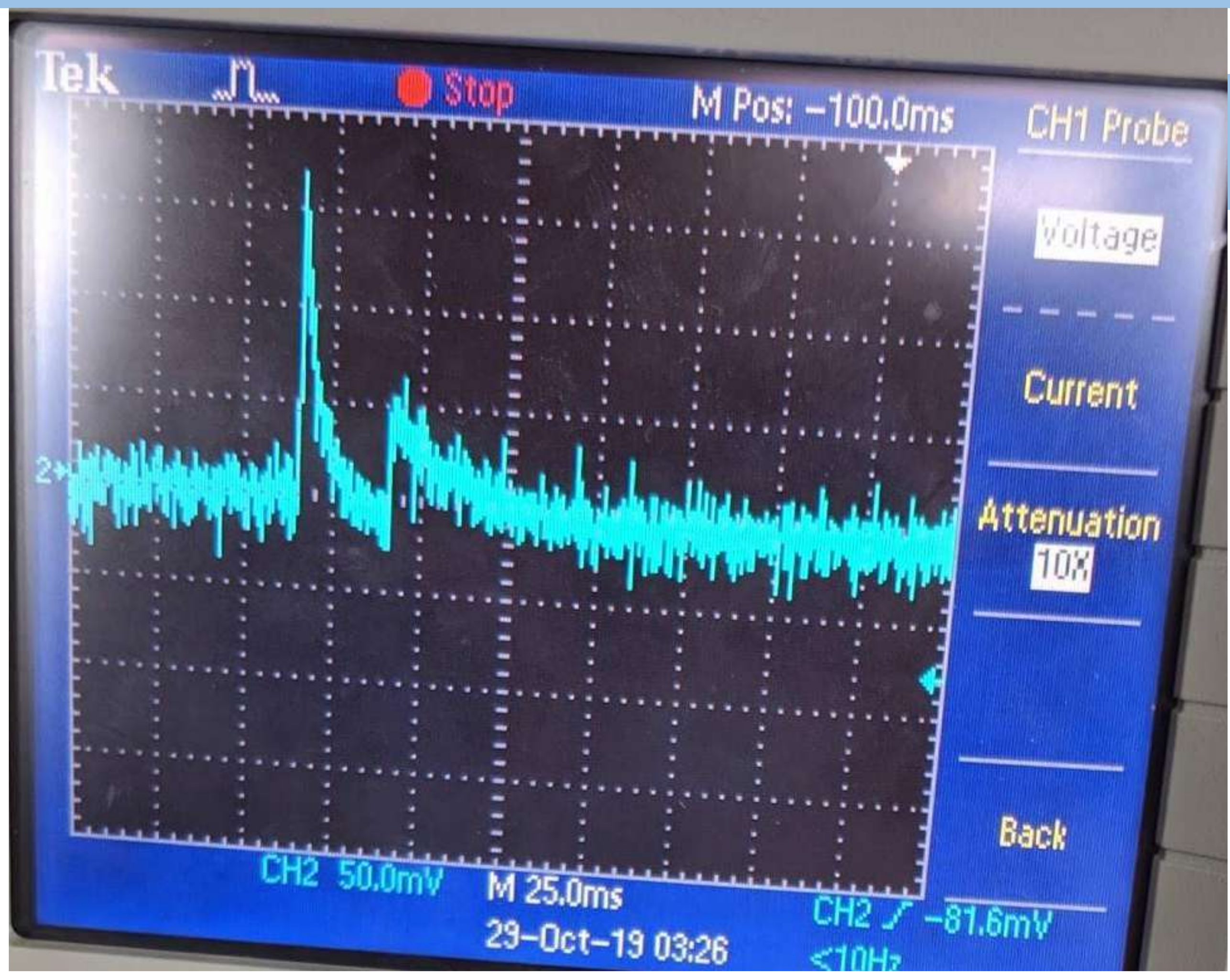


Figure two: The action potential before the changes

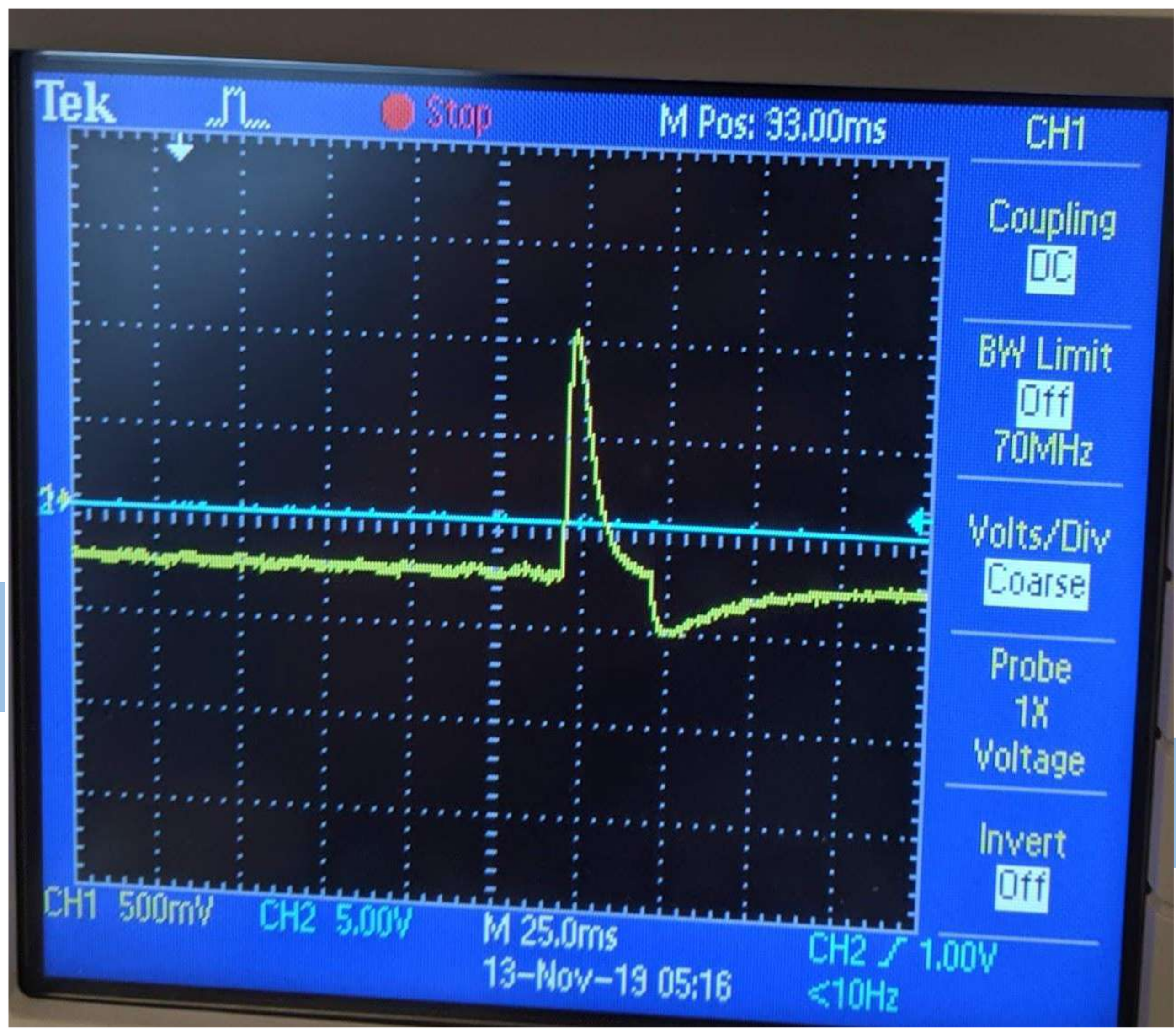


Figure three: The action potential after the changes

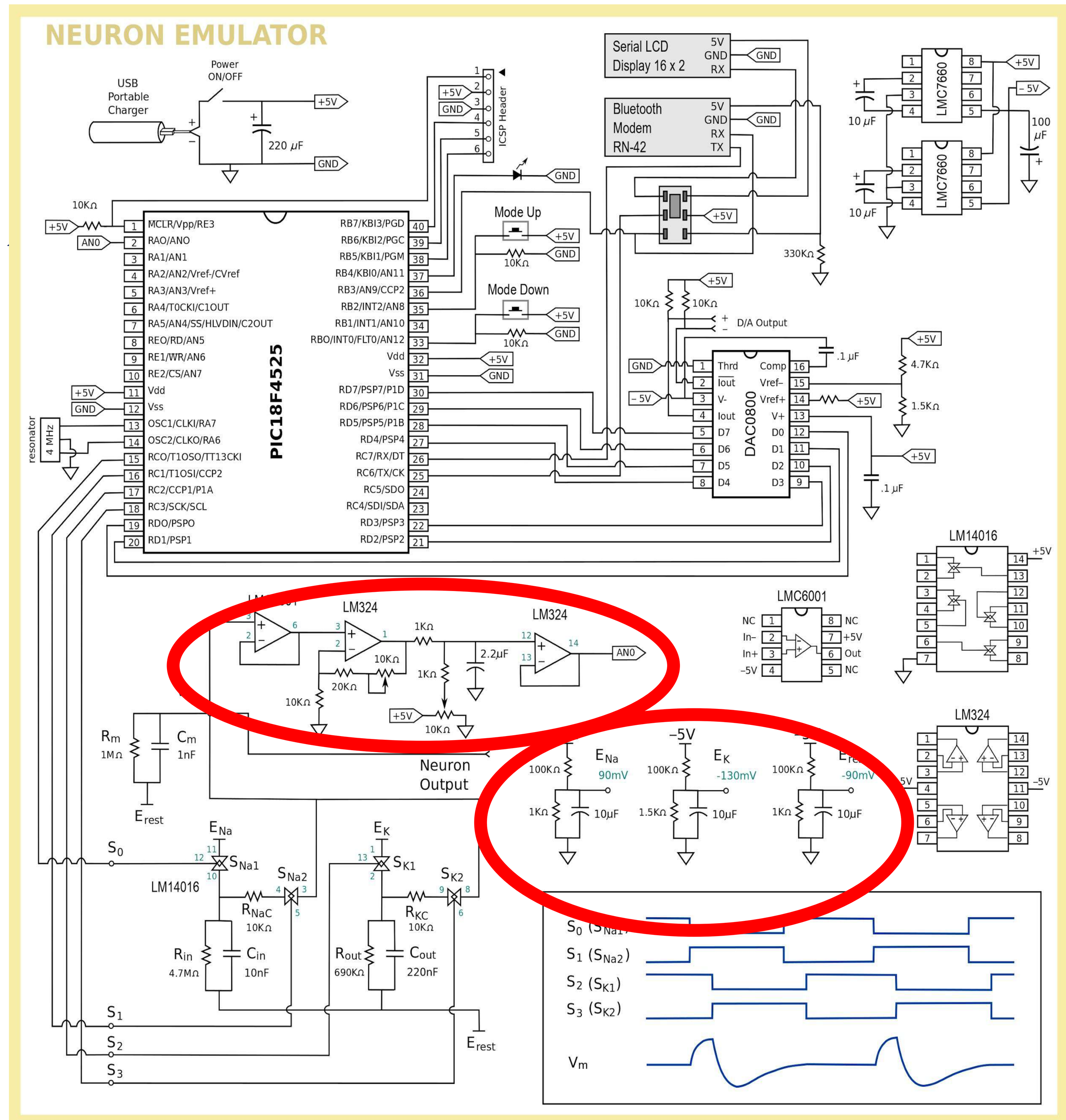


Figure four: The schematic for the emulator with the two problem areas highlighted

Results

- Newer version of MPLABX and compiler used
  - Different global variables
- Using a higher resistor value in both the Na and K sections of the circuit allowed for a more accurate action potential shape.
  - Eliminated the peak
- Also increasing the resistor value increased the rise time into the acceptable range for a live neuron.
- Debugged circuit so the output can display all functions implemented from the MPLABX code.

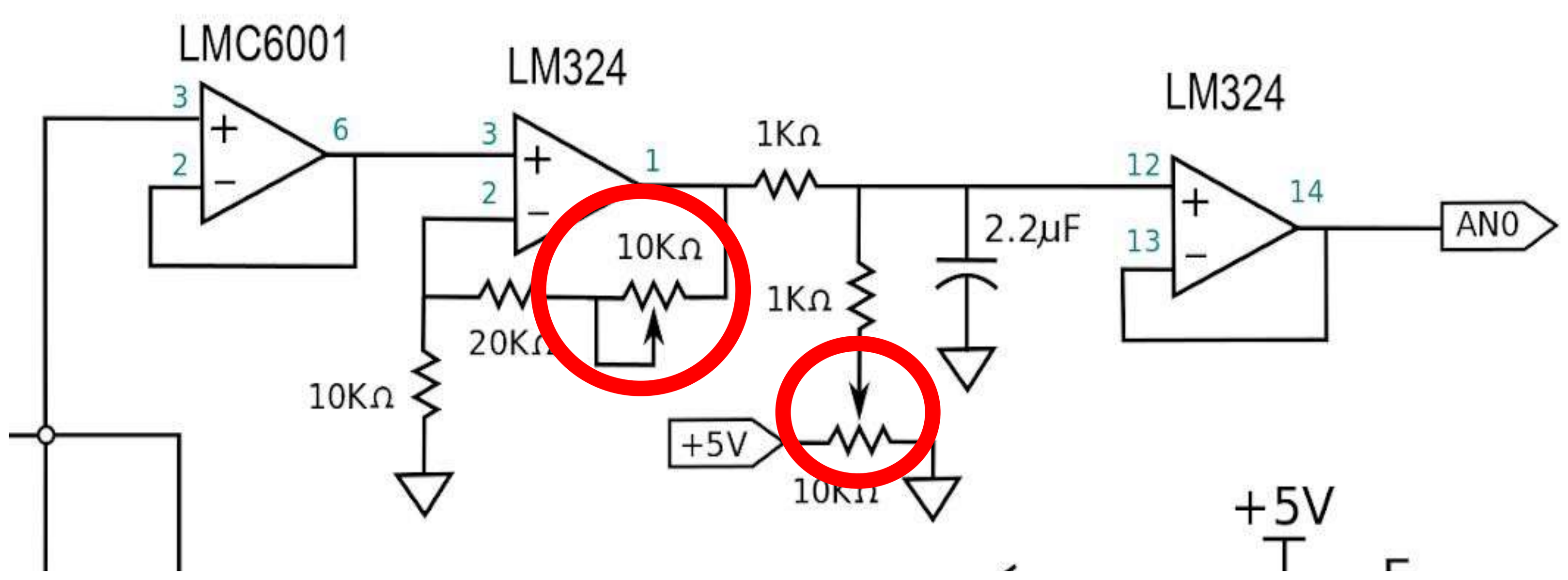


Figure five: The potentiometers that were changed

Discussion

- First time completing research with little instruction and guidance
  - Real world/ industry experience
- Put our own time in to complete project
  - Extra 5 hours/ week
- Realistic problems and limitations
  - Funding
  - Budget
  - Materials
  - Time constraints

Conclusion

The Neuron Emulator has a new and improved shape along with more accurate rise time and resting state voltage.

In future research, the voltage clamp will be implemented to allow for more experimental studies using the neuron emulator to be conducted. Also the reduction of noise will create a more accurate signal.

REFERENCES:

[1] Ausfresser, G., and Y. Sun. "Neuron emulation, instrumentation, and communication for a neuroscience instrument." 38th Northeast Bioengineering Conference, Philadelphia, PA, pp. 259-260, 2012.

[2] *GeneClamp 500B.* Axon Instruments., Union City., CA, United States, 1997.

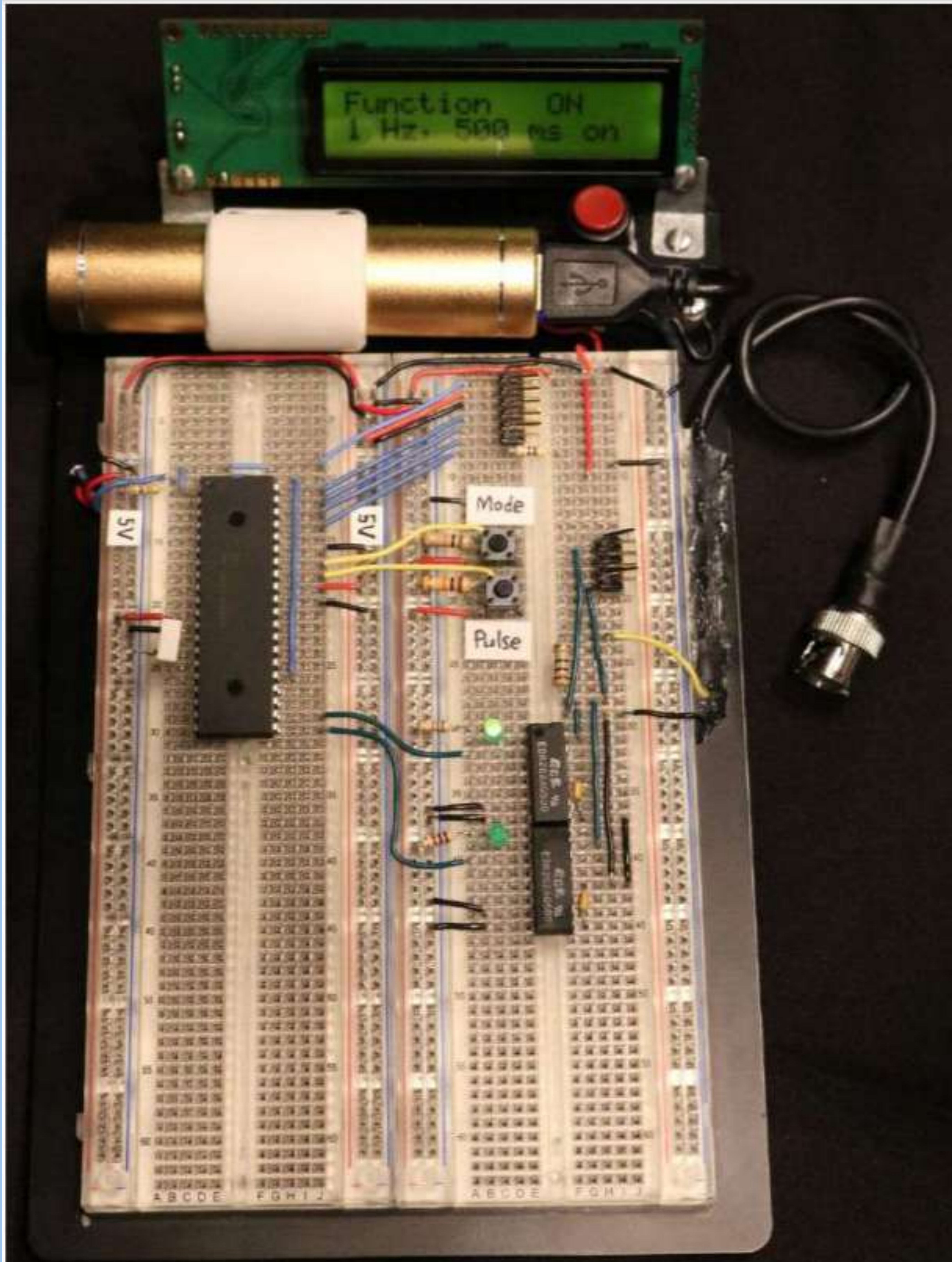
[3] Wu, Y. C., J. Y. Chen, R. Rieger, and Y. Sun. "A neuron emulator for single-electrode settings." 37th Annual Northeast Bioengineering Conference, Rensselaer Polytechnic Institute, Tory, NY, 2011.

[4] K. M. Dabrowski, D. J. Castaño, and J. L. Tartar, "Basic Neuron Model Electrical Equivalent Circuit: An Undergraduate Laboratory Exercise", JUNE, *Journal of Undergraduate Neuroscience Education*, vol 12(1):A49-A52, 2013.

Emulating Capacitance change during Cell Exocytosis and Endocytosis

John Ketzenberger[1], Aaron Landry[2]
[1]Department of Electrical, Computer, and Biomedical Engineering at the University of Rhode Island

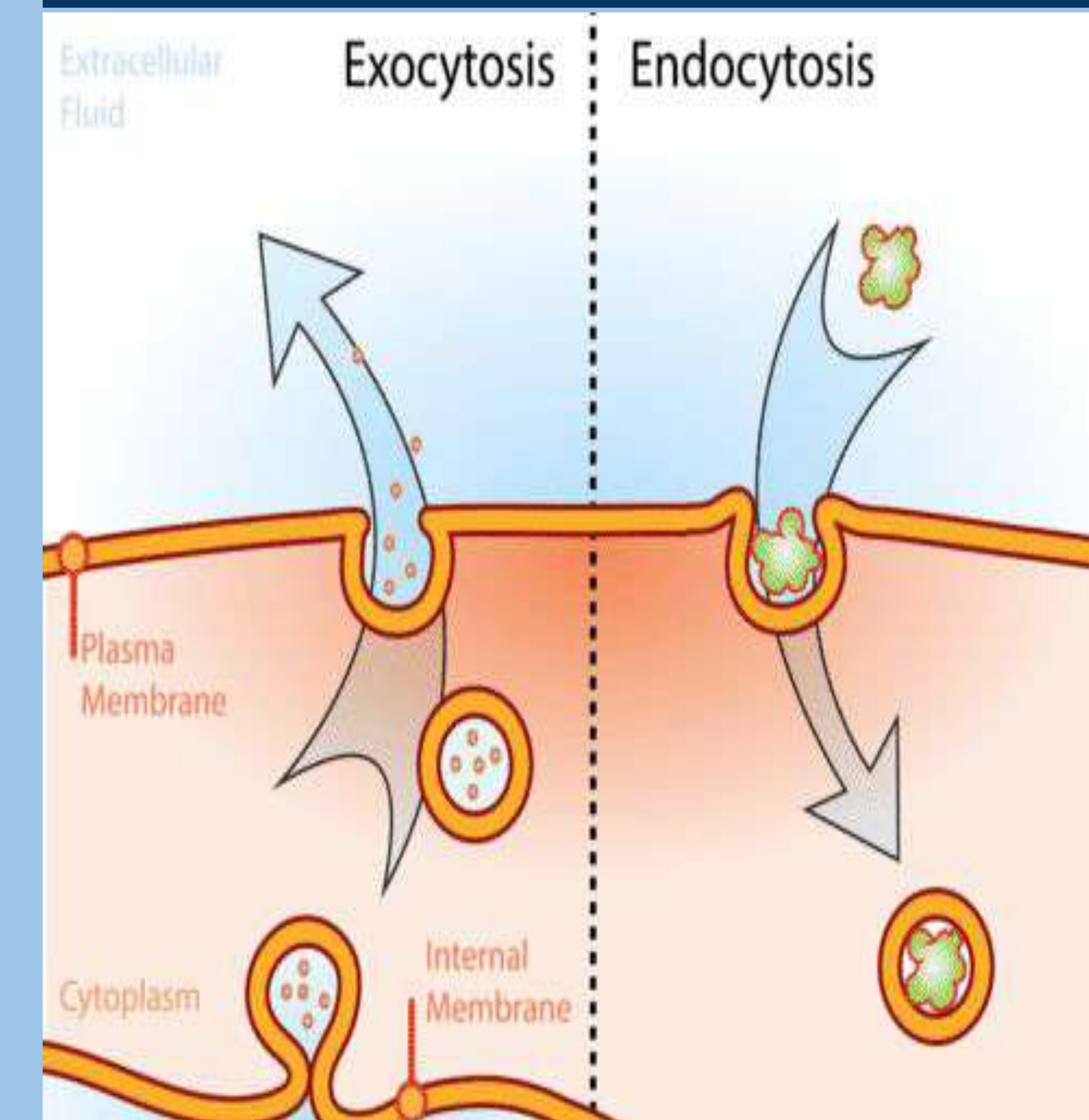
Cell Capacitence Circuit



Current State

- Current cell capacitor model uses a switching method paired with measuring the difference in two capacitors.
- Real time exocytosis is on the measure of 10 FemtoFarads and takes 1-2 milliseconds.
- The current model of the cell capacitance emulator is state of the art, able to measure on the level of 10 FemtoFarads with a time change of 500 milliseconds.

Exocytosis & Endocytosis



Future Considerations and Implications of the Project

-The goal of this project is to develop an electronic model of the dynamic changes that occur on the cell membrane capacitance during vesicle transportation in real time. We can model the cell membrane capacitance because the membrane composition, thickness, and dielectric constant are all invariant and do not change due to the difference in membrane protein density.

-This project is based upon the prior Nobel Prize winning work of James E. Rothman, Randy W. Schekman, and Thomas C. Sudhof "for their discoveries of machinery regulating vesicle traffic, a major transport system in our cells".

-Completion of this project will help us make great strides in replicating biological systems and make discoveries in the medical field in relation to drug delivery and neuroscience.

References

[1] Instrumentation of Measuring Cellular Capacitance via Signal Processing Tool Mosa Al Zowelei
[2]ttps://dr282zn36sxxg.cloudfront.net/datastreams/f-d%3A98646f6a2e38671584e2ec44988708defc4766dc847a5e49e0fa5e48%2BIMAGE_THUMB_POSTCARD_TINY%2BIMAGE_THUMB_POSTCARD_TINY
[3]The Nobel Prize in Physiology or Medicine 2013. NobelPrize.org. Nobel Media AB 2019. <https://www.nobelprize.org/prizes/medicine/2013/summary/>

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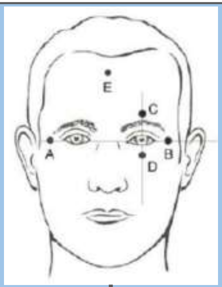
Machine Learning for an Eye Blinking Switch

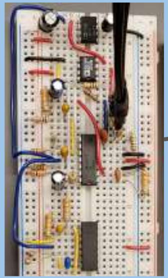
Dylan Kennedy, Graem Timmons, and Renee Gordon

Data Acquisition



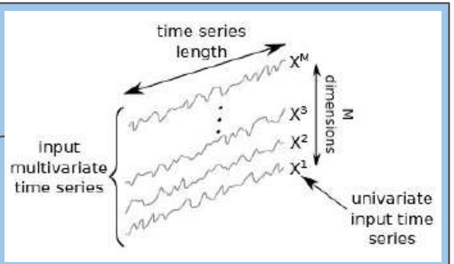
Processing Device

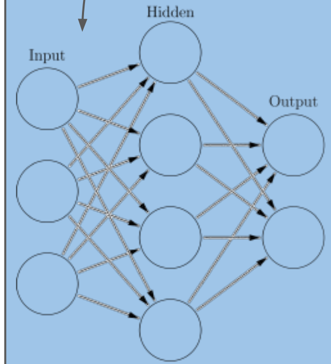
Amplifier



Microcontroller

Data Processing



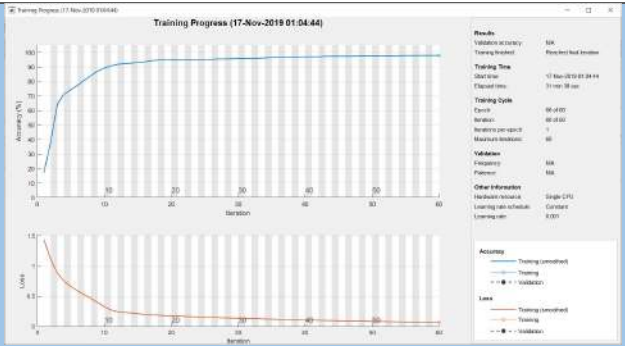


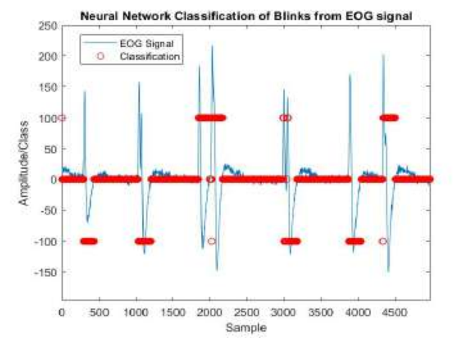
Neural Network

Classify EOG Signal

- Eye Open
- Intentional Blink
- Unintentional Blink

Result





Post-Stroke Limb Monitoring System to Prevent Blood Clot by Measuring Patient Movement to Allow for Research and Feedback to Patient During Recovery

Ryleigh Alfonse, Kate O'Rourke, Jackson Gutekunst, Eugene Chabot, Ph.D., Brian Silver, MD

Background Information

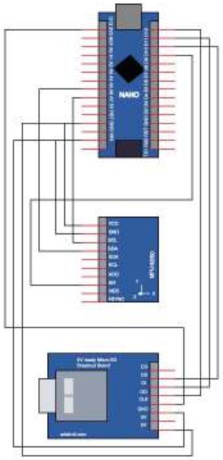
- ➢ Blood clots result in the death of 60,000 to 100,000 people every year.
- ➢ Blood clots are common in patients after stroke due to inactivity.
- ➢ This project aims to mitigate these risks by allowing patient monitoring and data collection.

Objective

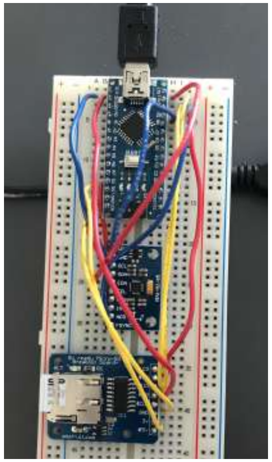
- ➢ Tracking and storing data continuously for 24 hours
- ➢ Monitor all 4 limbs
- ➢ Record triaxial acceleration
- ➢ Calculate total displacement

Methods

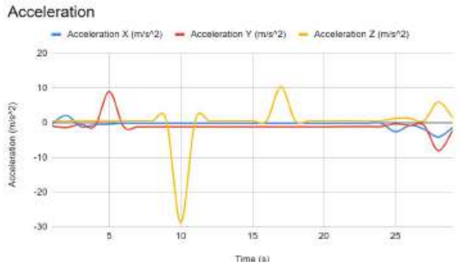
Current Schematic

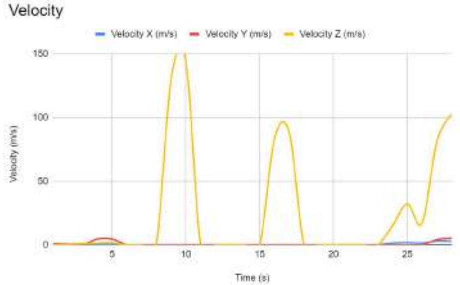


Hardware Design



Results





Future Work

- ➢ Implement another Arduino board with more SRAM
- ➢ Have all four accelerometers working together
- ➢ Make the accelerometers comfortable to wear
- ➢ Improve filtering of data for excel sheet

THINK BIG WE DO℠

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Developing Adaptive Sports Equipment for Visually Impaired Veterans

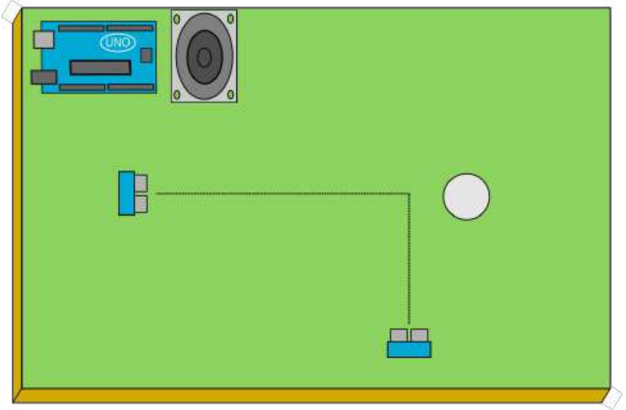
Alex Hastings, Brendan Driscoll, Prestor Saillant

Goal

https://usblindgolf.com/

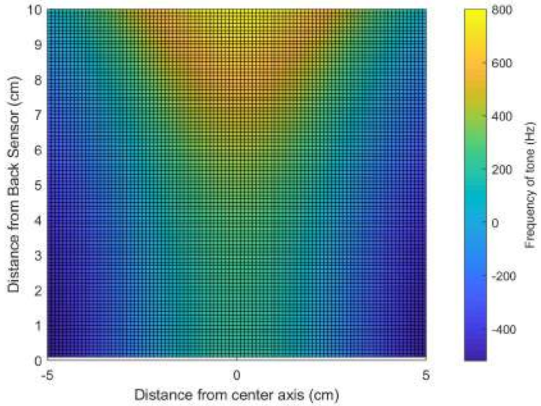
We are looking to help veterans who have impaired vision get back to playing golf with more independence. Not only is golfing a hobby but it would also provide rehabilitative benefits.

Solution



Based on a previous year's capstone, we have developed a mat to help the player line up their shot without the help of a coach.

How it Works



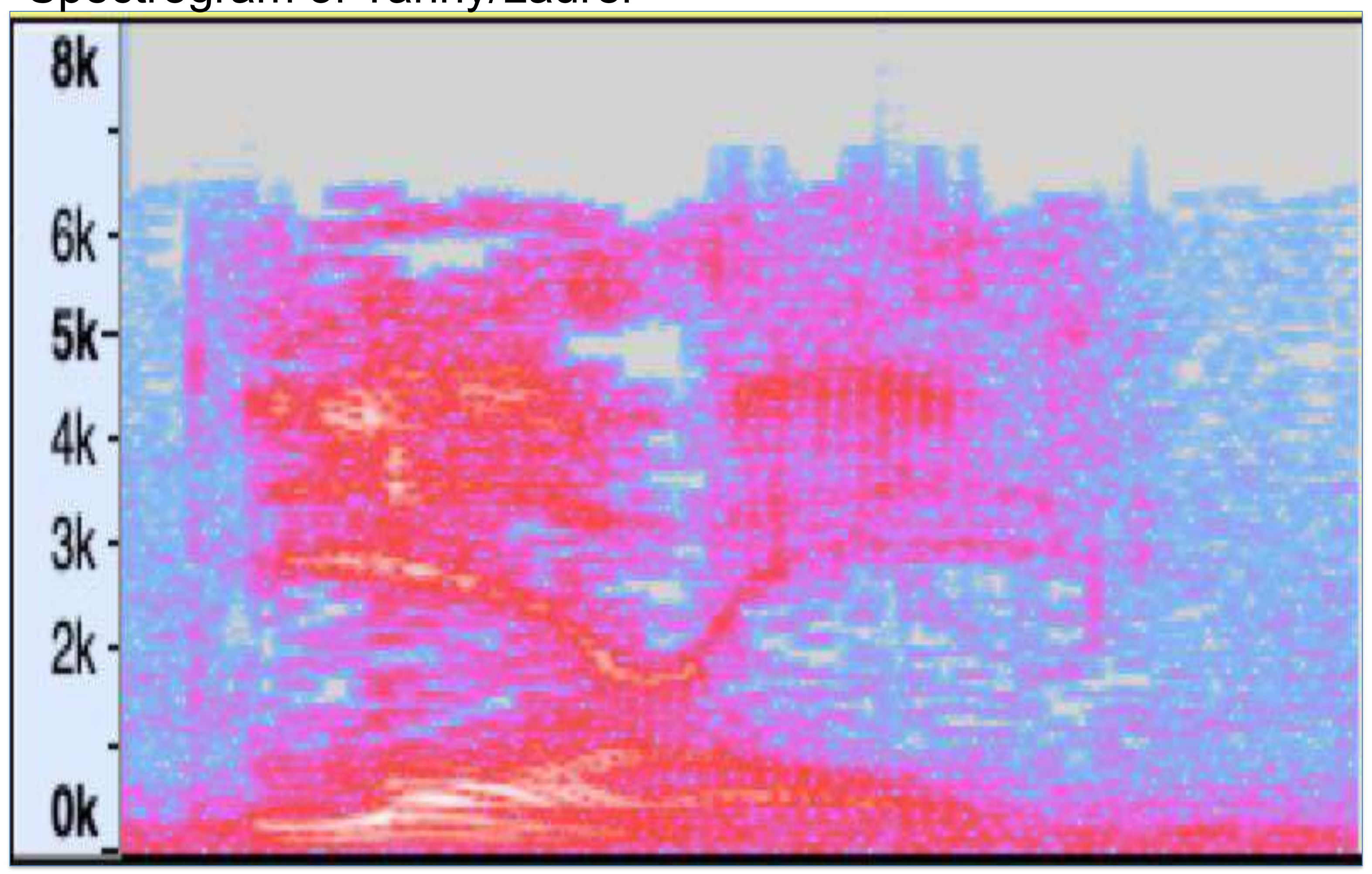
Using ultrasonic sensors, the mat, when the club is lined up behind the ball, emits a constant tone of a certain pitch.

Web-Based Evaluation for Hearing Loss

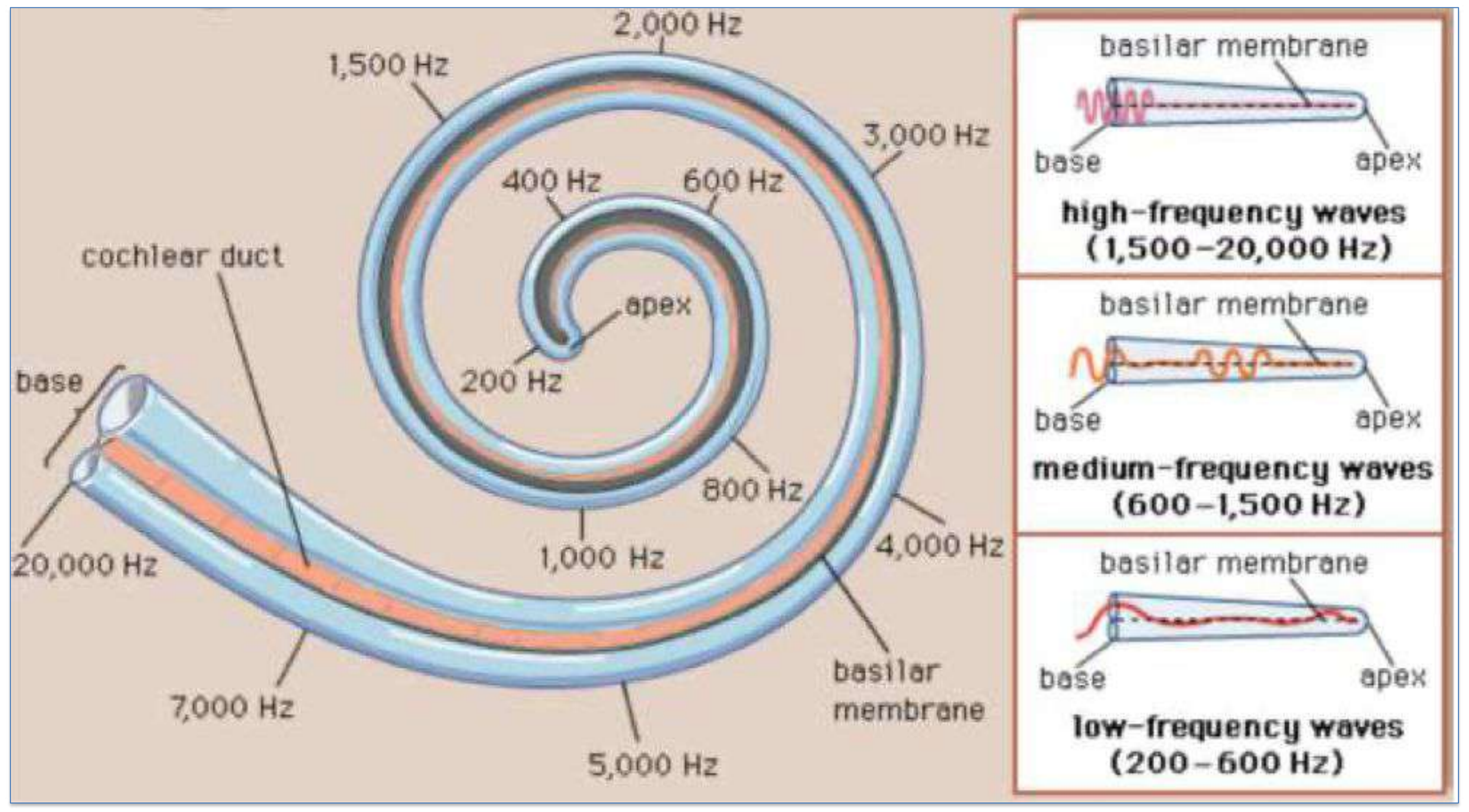
Michael Kulkuski , Arjita Bhasin, and Richard Sirisouk

Yanny or Laurel

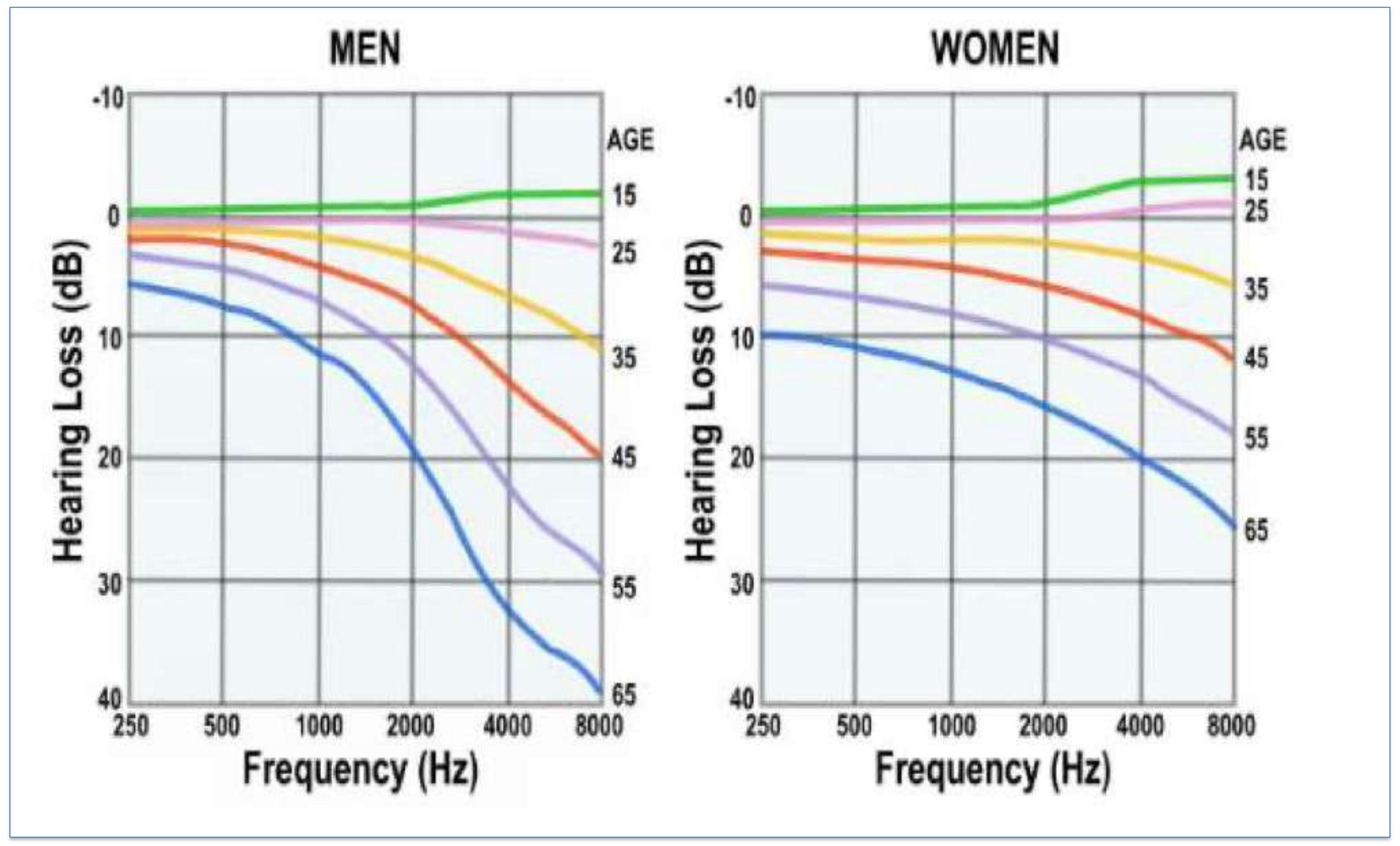
Spectrogram of Yanny/Laurel



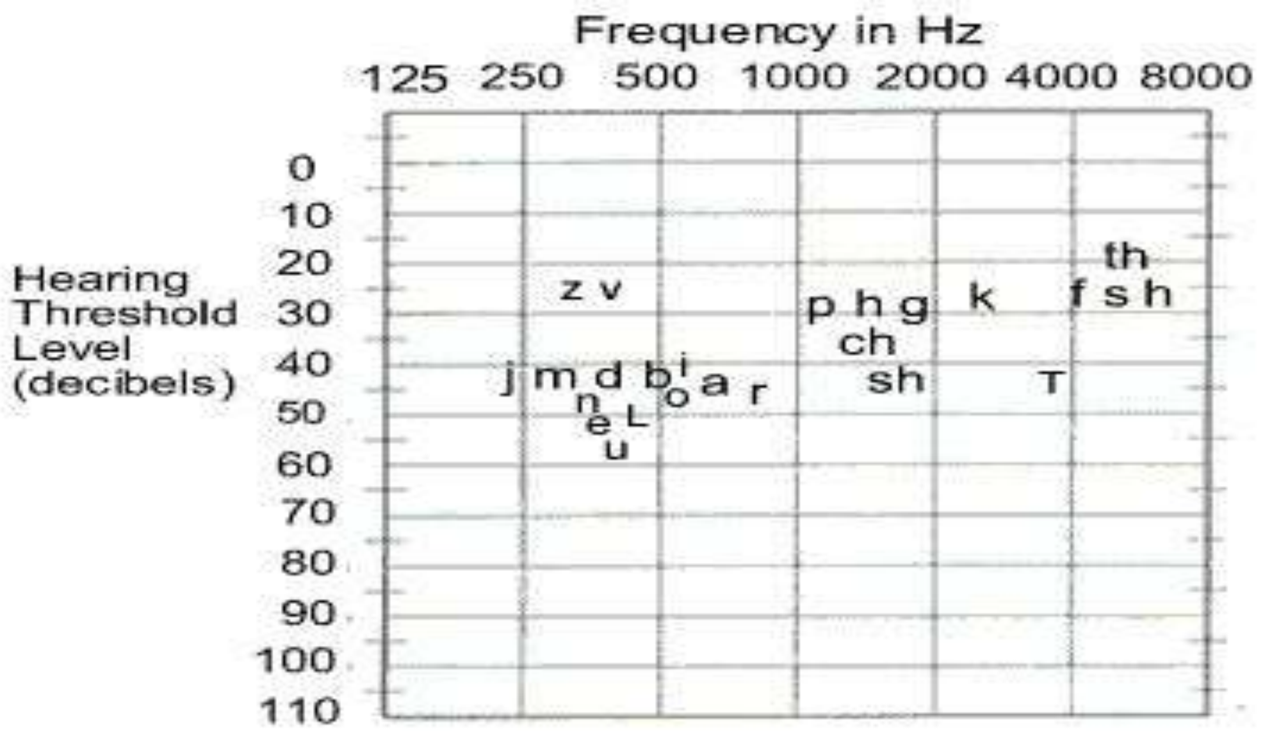
Cochlea

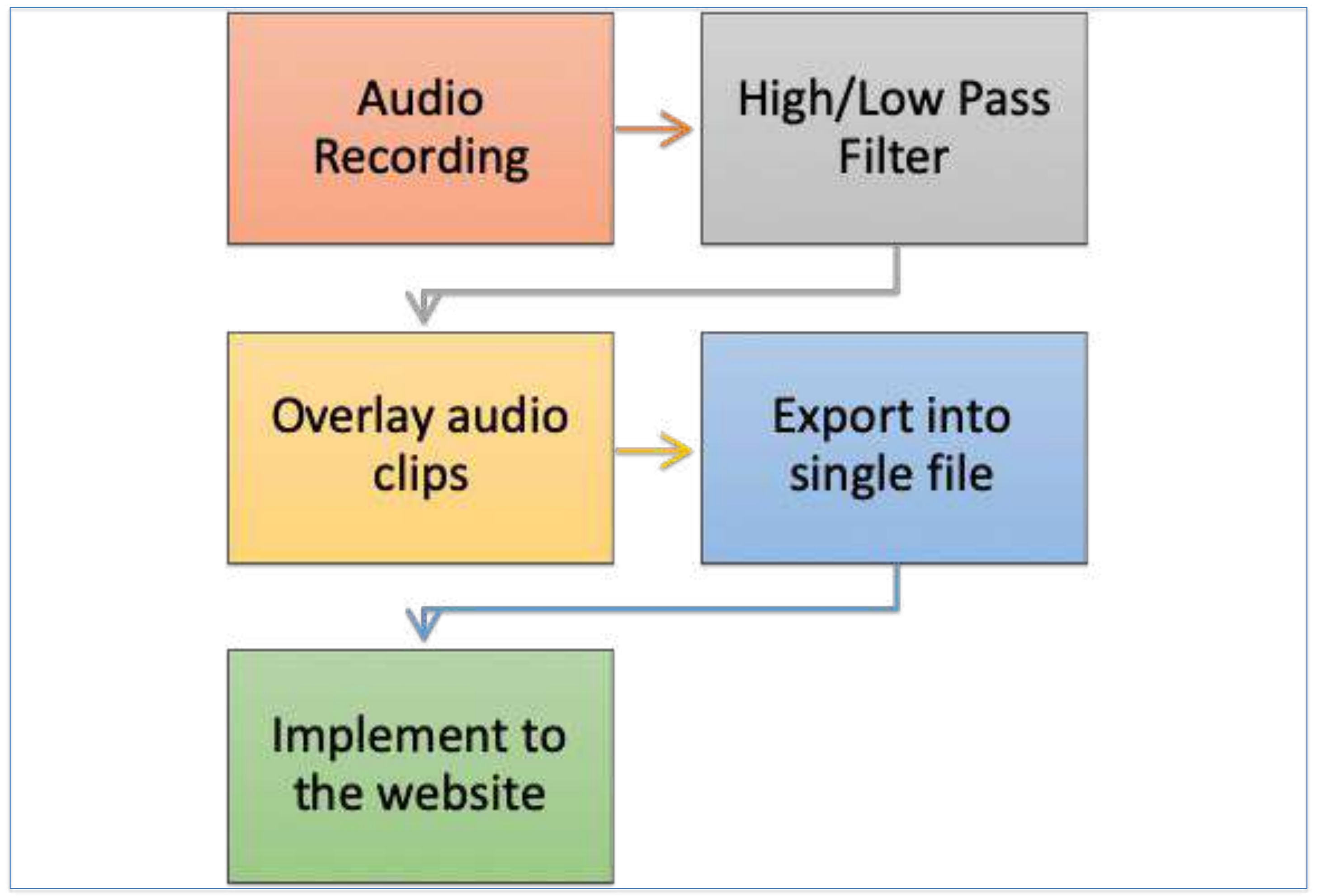


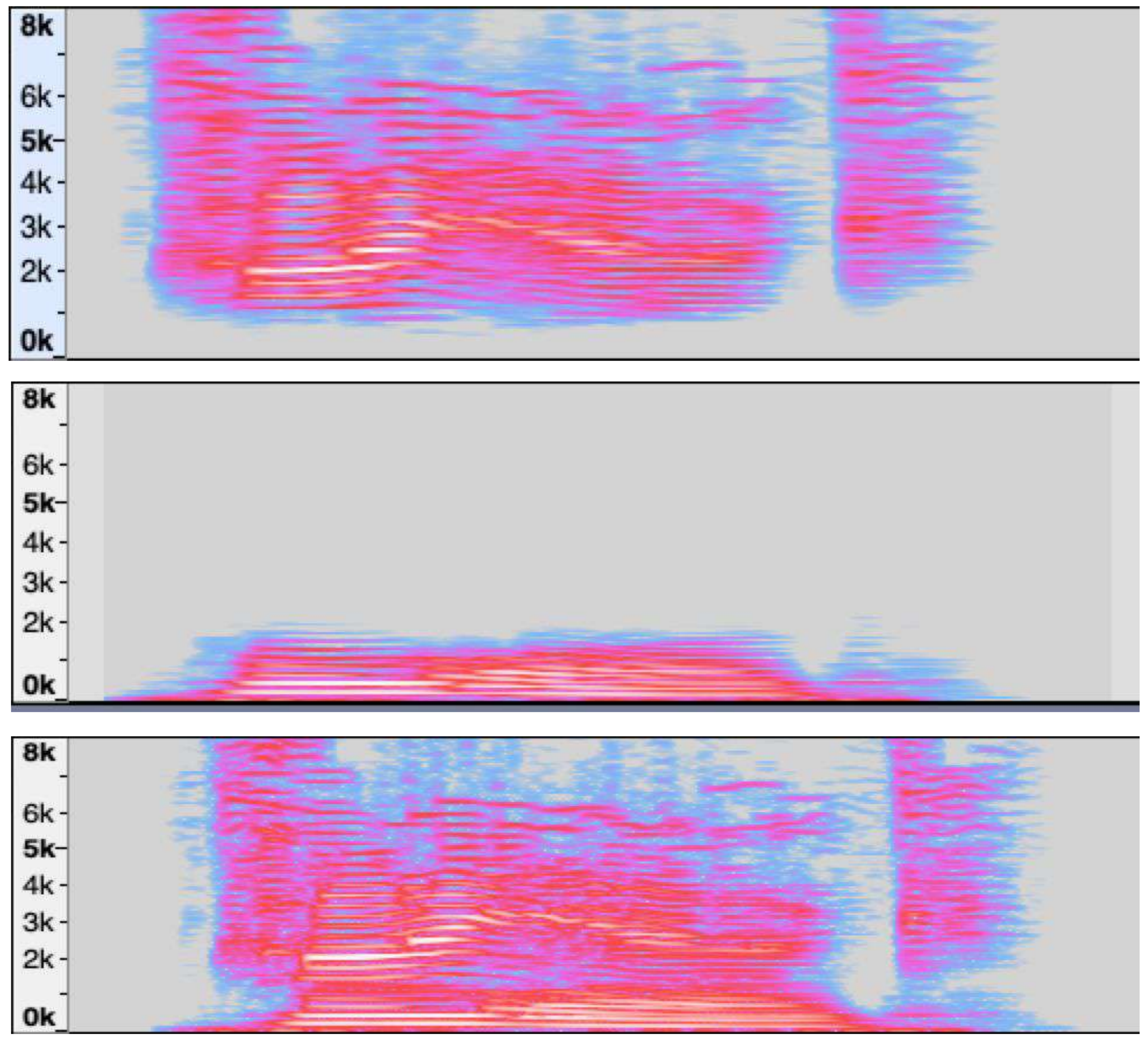
Normal Aging Process



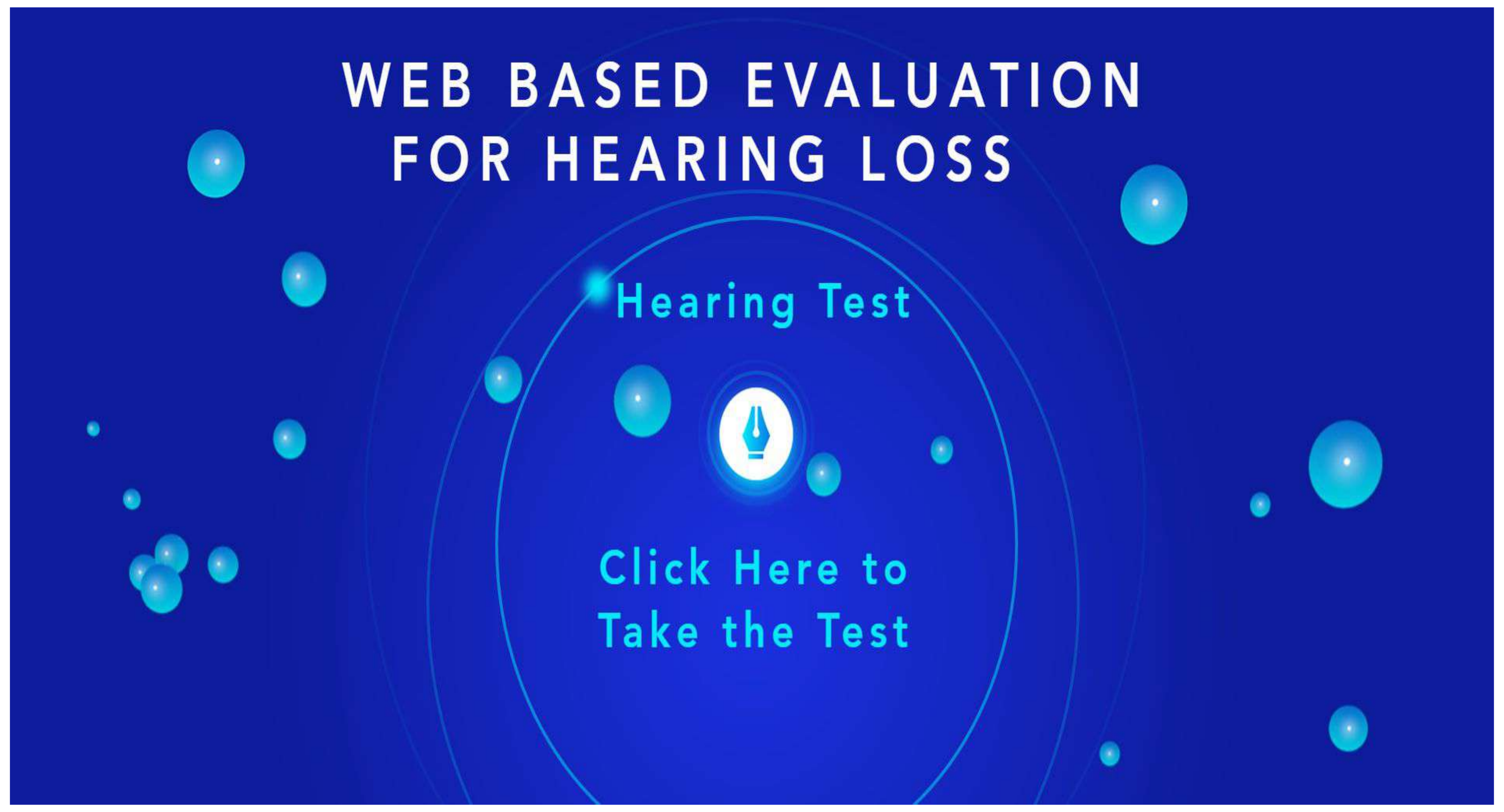
Our Simulation







Website



Web-Based Evaluation for Hearing Loss

Instructions: This quiz will present a series of questions to determine the degree of hearing loss. Please click the PLAY icon on each audio recording to hear a pair of sounds. Then select an answer which best describes the sound being played.

TAKE QUIZ

- Link to website & quiz: https://hearingeval.wixsite.com/site-1

Future Plans

- Fine-tune audio clips
- Finalize the website
- Do a study upon IRB approval

Smart Wobble Board for Ankle Rehabilitation Utilizing Knee Motion Tracking

Project Manage: Rafael Javier Hardware Engineer: Daniel Erwin Software Engineer: Tobi Williams

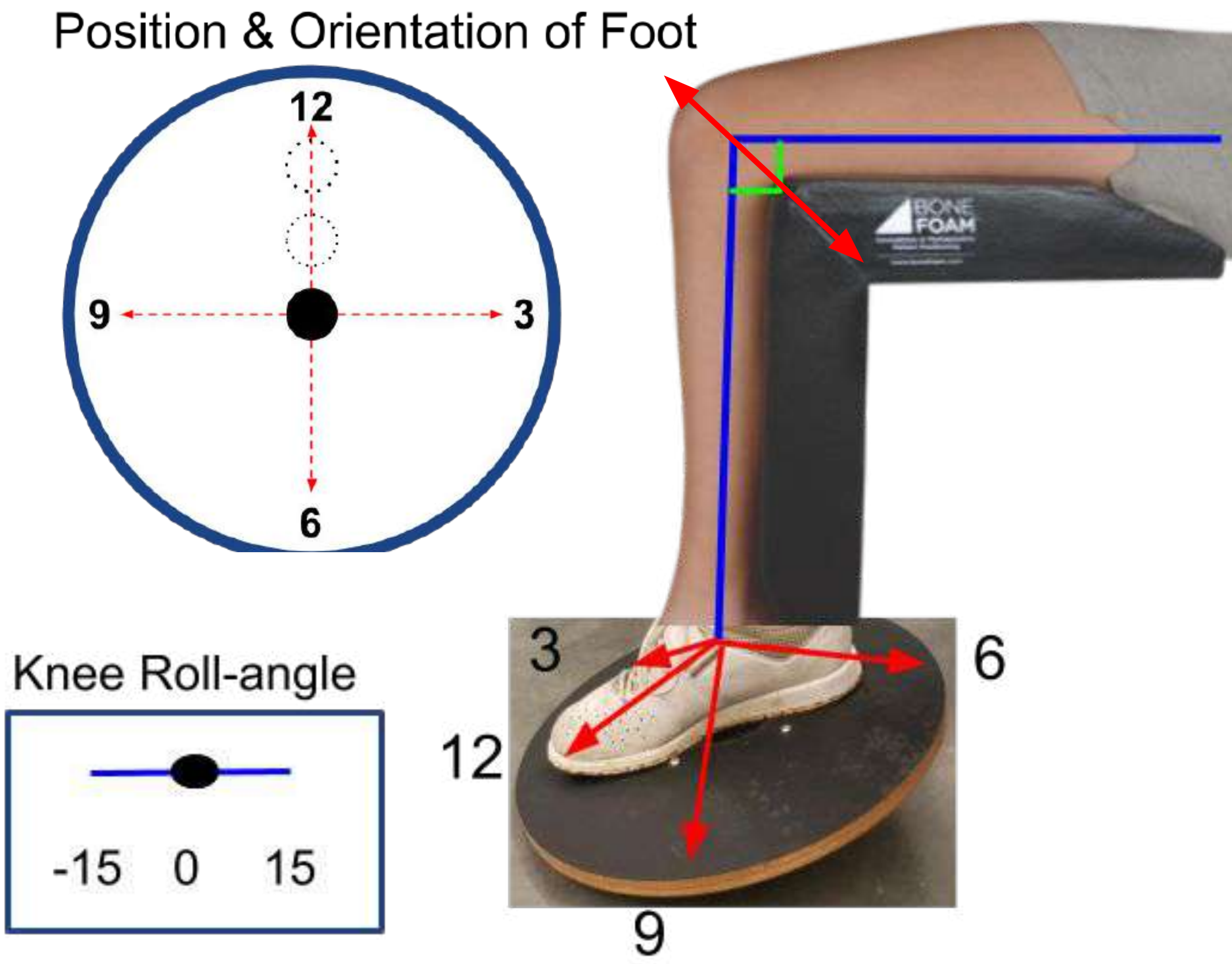
Objective:

To minimize knee movement during wobble board testing using motion tracking. Product developed for the purpose of accelerating the rehabilitation of ankle injuries by reducing harmful behaviors.

Methodology:

Hardware -- Accelerometer and gyroscope are used to measure the magnitude, roll and pitch of the ankle relative to knee. Data transmission done via Bluetooth.

Software -- Python script programs Arduino board to read and transmit accel/gyro data from chip to Bluetooth connector and displays position and orientation on interface using QT.



Motion Activated Turn Signal for Helmet Application

Rock Fortna, Josh Brodeur, Alex Roduit
Biomedical Engineering, University of Rhode Island

Objective

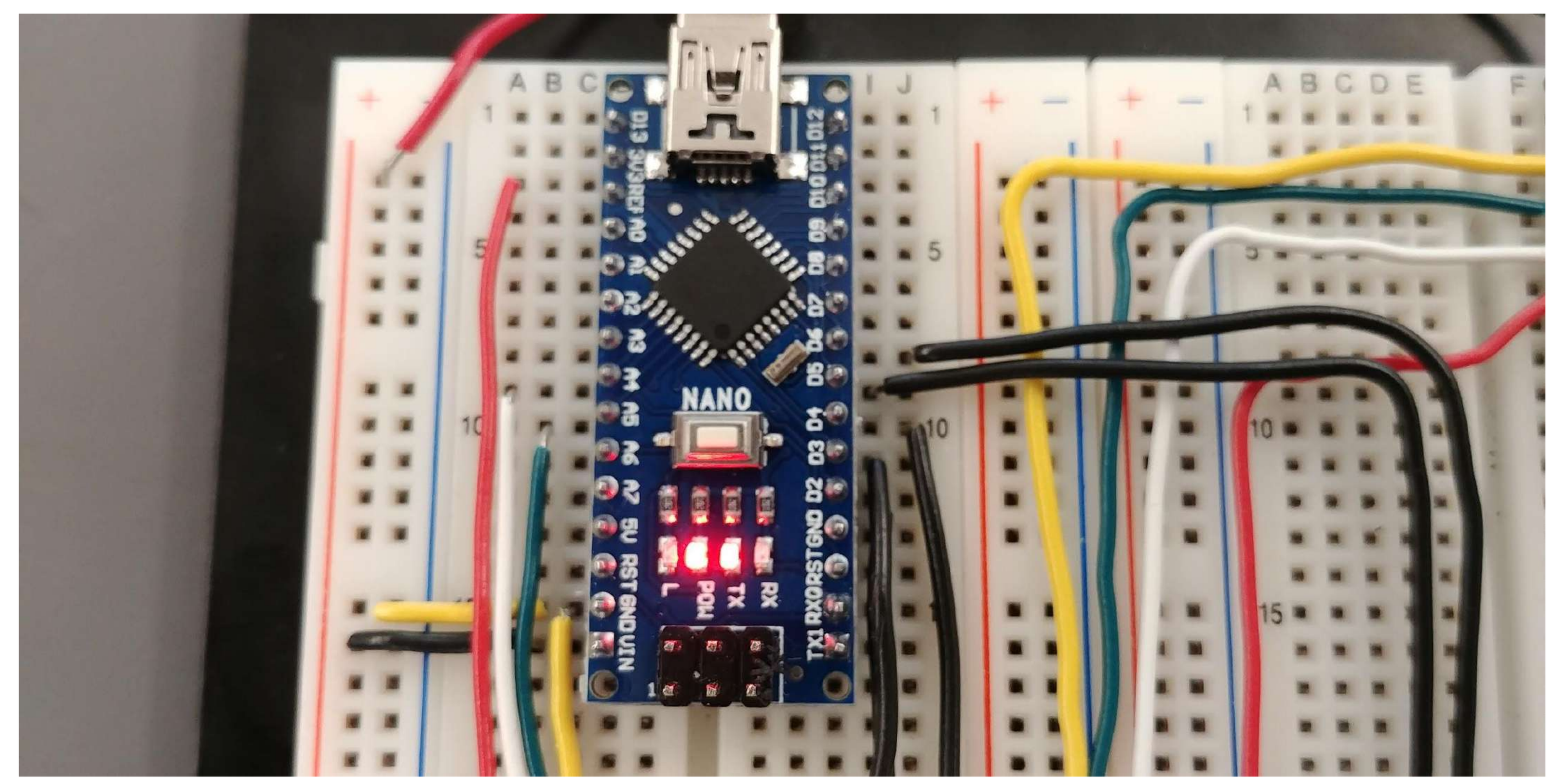
Current product:

Our Model:

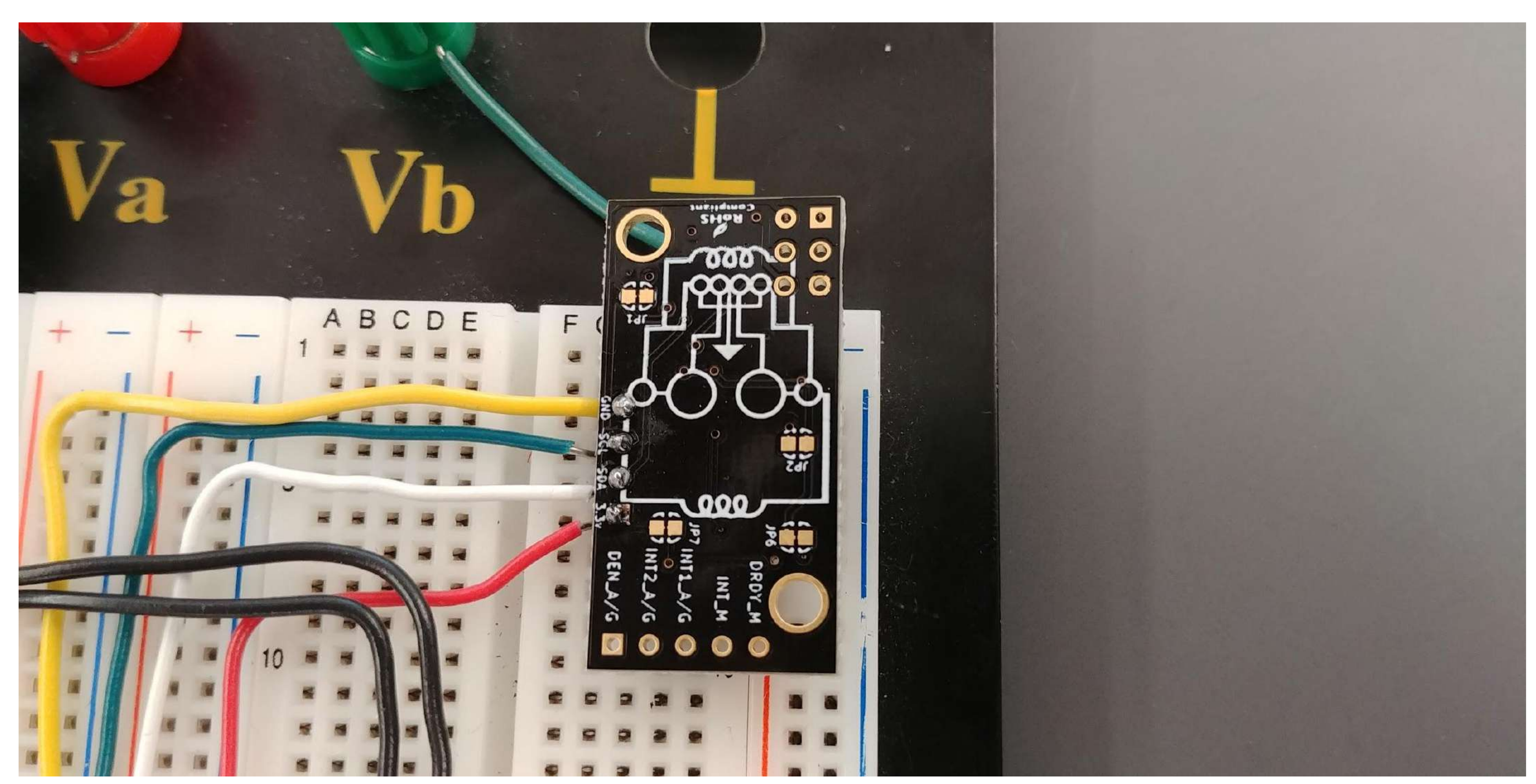
- More affordable
- Hands-free
- Safer
- Easier to weatherproof
- More Durable

Approach

Hardware:
-Arduino Nano



-Accelerometer/Gyroscope Sensors



Progress:
Ability to detect a certain threshold in acceleration and direction in order to activate a corresponding LED sequence.

Future

Determine ideal values to detect head jerk and eliminate false positives

↓

Transfer from breadboard to printed circuit board

↓

Arrive at final helmet design and LED layout

↓

GPS
Phone application
Different models

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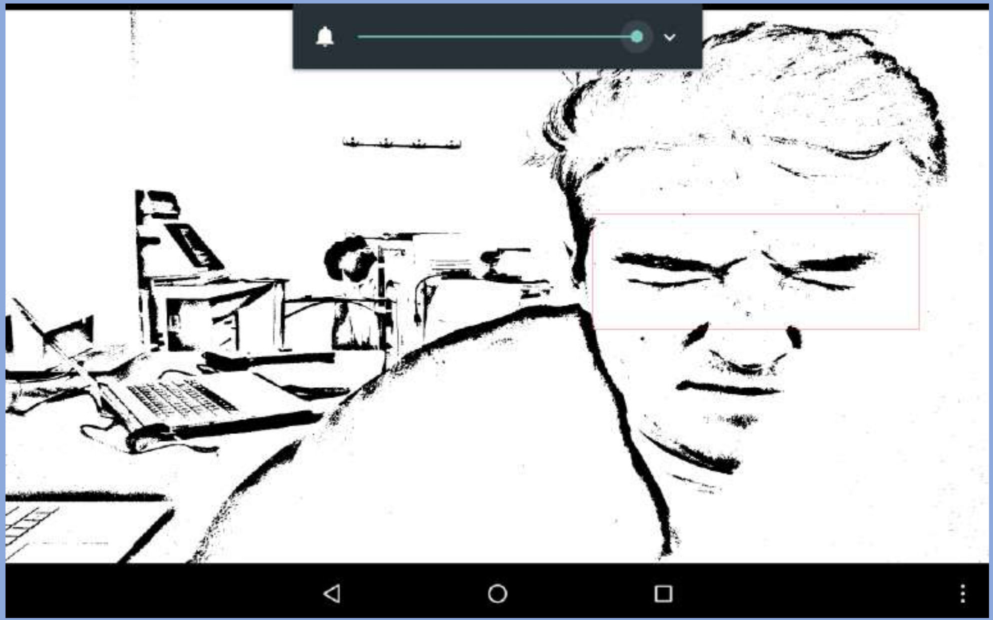
Using a scaling feature to improve a video-based pain detection application for individuals who are non-verbal

THINK BIG WE DO™

1. Translate OpenCV program to Android studio from Eclipse to make it run on an android device (with a camera)
2. Implement a scaling feature so that the face of the individual being monitored can be at a variable distance rather than a fixed distance
3. Add a notification feature to the application to send a text message to a caretaker when the algorithm detects the person is in pain
4. Improve the sampling rate (frames per second) of the application



← Scaled template image ^

The way we implemented this is by making the parameters for the eye detection bounding box variable, we do this by using an OpenCV face detection algorithm for the bounding box parameters.
After this, we force the template image to resize in order to have the same number of pixels as the inside of the bounding box.
In order to classify the subjects face as in pain, we compare the ratio of black and white pixels, so the amount of pixels in the template must match the amount of pixels in the bounding box

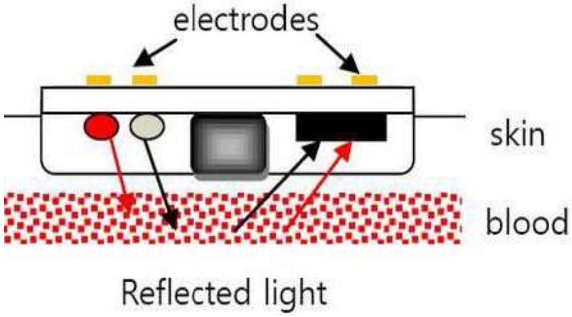
James McIntyre, John Kearns, Amal Guptan

Monday November 17th, 2019

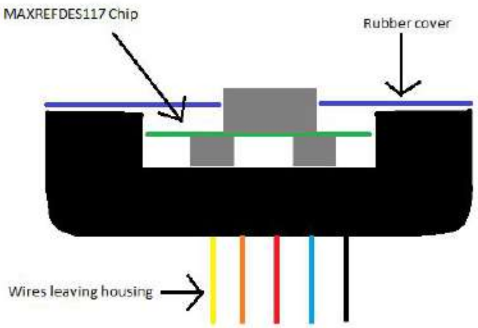
Reflective Heart-Rate and Pulse-Oximetry Monitor Implementation with PIC Microprocessor

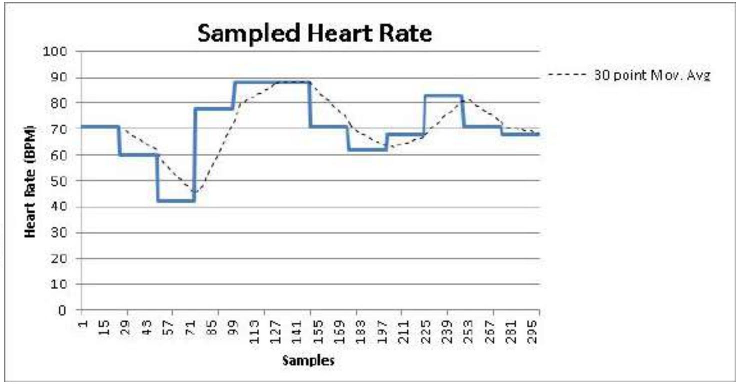
By Nicholas Akers, Douglas Coppa, Nathan Labonte

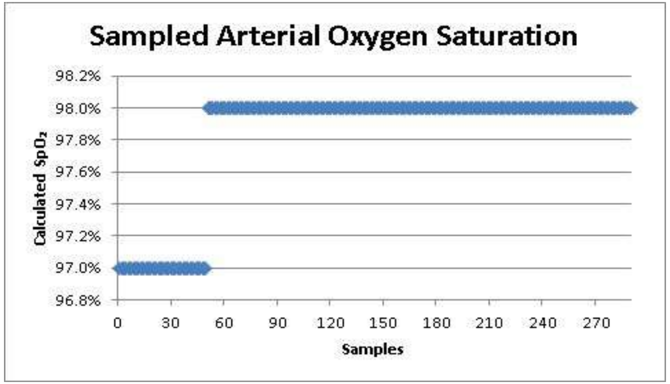
Reflective Pulse Oximetry



Housing Unit Cross-Section







Next Steps:

I^2C integration with PIC

- Research and modify given I^2C code; currently not compatible with lab code

Research new algorithms for heart rate and arterial O_2

- Current codes with chip meant for 32 bit processor

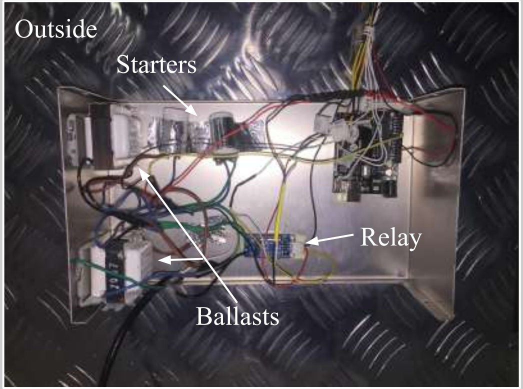
THINK BIG WE DO

Disinfecting Medical Equipment Using UV Light

Elizabeth Bushey, Samantha White, Rebecca Donegan, Jordan Anderson
University of Rhode Island, Kingston, RI 02881

Objective: To address the issue of hospital acquired infections in today's healthcare system

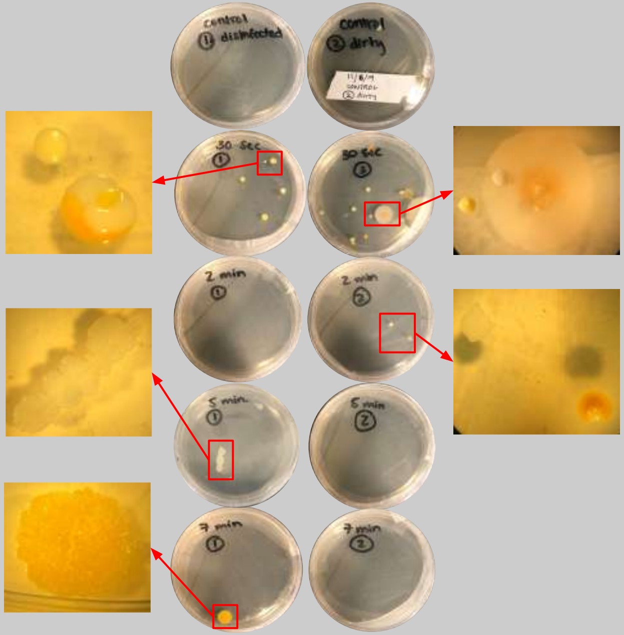
External Hardware



Safety Features:
Lights turn off when door is opened, no cracks in any seals to prevent UV leakage.

Physical Features:
Temperature Display, LCD Display, Countdown Timer, External Serviceable Box.

Clinical Testing



Methods

Most plates with possible cultures of *Staphylococcus spp, Bacillus spp., Micrococcus spp., etc.*

- For identification - isolate cultures
- Test with different time intervals
- Test with different amount of light bulbs
- Run incremental testing between time intervals where we see a "drop off" in bacterial growth

Future Goals

- Add additional light bulbs, repeat testing
- Increase safety features
- Determine optimal settings