Bioelectric Generator
Project Presentation

Team 4 - Electric Juice
April 12, 2022

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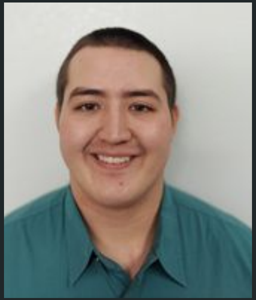

Introduction

- What is a pacemaker?
  - A heart monitor/regulator for patients with irregular heartbeats
- What were we assigned to do?
  - Design a charging system for a pacemaker battery.
- Why do we need this?
  - Eliminate need for replacement surgery
  - Lower cost

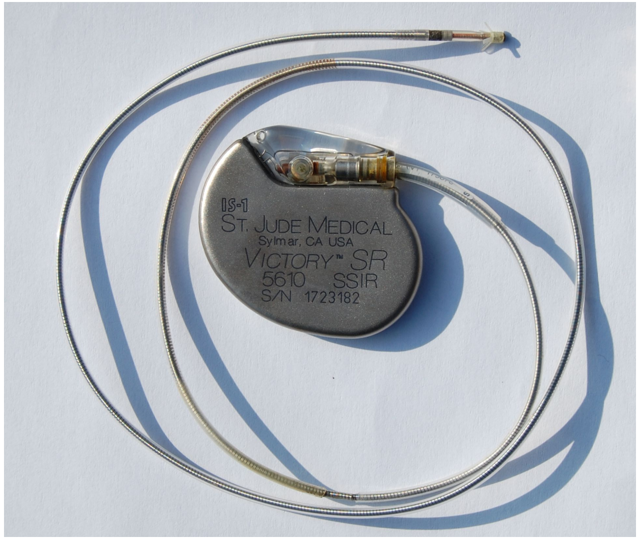

Figure 1: Pacemaker Device

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Major Requirements

Our requirements for success are:

1. The device must charge a pacemaker battery in a safe manner for both the client and the battery.
2. The charging must stop when the battery is full.
3. The device cannot be powered via any form of coupling or inductance.
    a. We wanted to take a more innovative approach since there are many previous designs that use inductance

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Prototypes - NIR Photodiode Generation

- Powered by Near Infrared Light (850nm).
- Prototyping was performed with a singular BPW34 photodiode.
- An Arduino Uno was used to read the voltage produced by the photodiode then the current was calculated based off of the resulting value.

Figure 1: BPW34 Photodiode Array

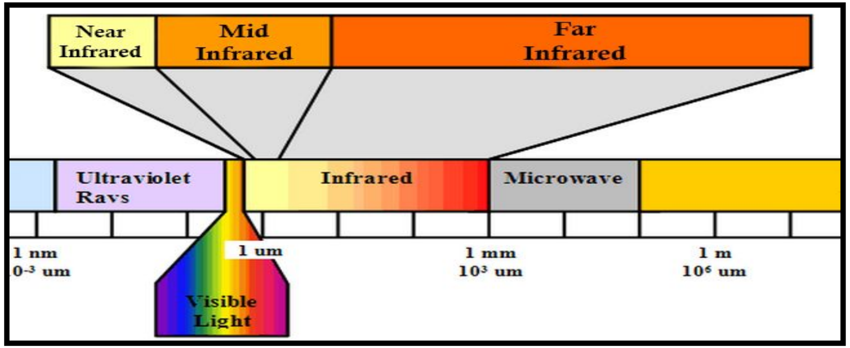

Figure 2: Electromagnetic spectrum

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Prototypes - NIR Photodiode Generation cont.

- Initial results proved that an array of photodiodes could provide the voltage and current necessary to charge the battery.
- The values calculated for the current were wrong, leading to unexpected testing needing to be done in the future.

Figure 1: NIR Lamp

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Prototypes - Piezoelectric Generation

- Powered by piezoelectric crystal stimulation.
- Other parts used: LED, resistor, capacitor, and a switch.
- Verify piezo could be used to power LED.
- Piezo could light LED for less than a second.
- Voltage and current were lower than we expected.

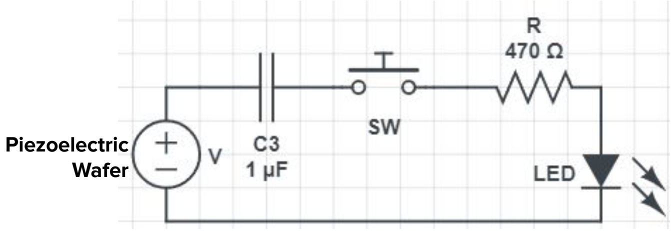

Figure 1: Prototype Circuit

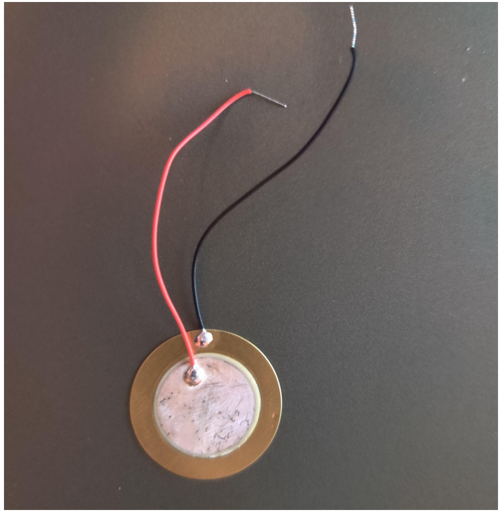

Figure 2: Piezoelectric Wafer

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Prototypes - Wireless Communication System

- Initial prototyping of the wireless communication system consisted of developing the code for an Arduino that would transmit data over a Bluetooth signal.
- This prototype was successful and transmitted the serial data of the Arduino correctly.
- The success of this prototype completed half of the wireless communications stretch goal.

Figure 1: Arduino Nano 33 BLE

Zach H.

Prototype Conclusions

Based of prototyping, we concluded that:

- NIR photodiode generation is our best option.
  - This ruled out Piezoelectric generation.
- Arduino Bluetooth data transmission is feasible.
- Prototype design included 100 photodiodes.
  - 20 photodiodes in series repeated 5 times in parallel.
- All charging components will be placed in an implant.

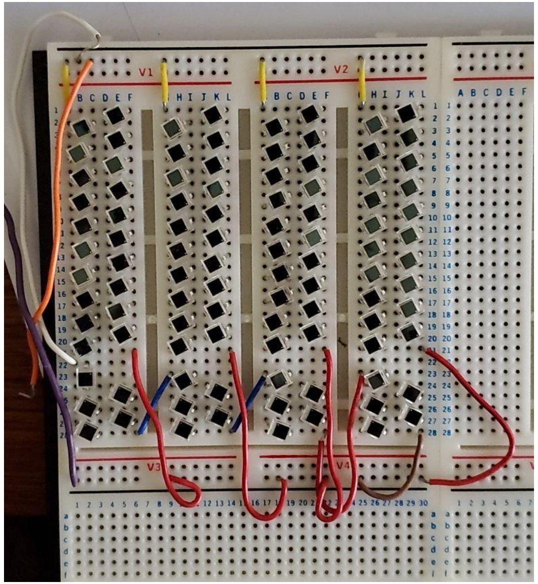

Figure 1: Prototype Photodiode Array

System Architecture

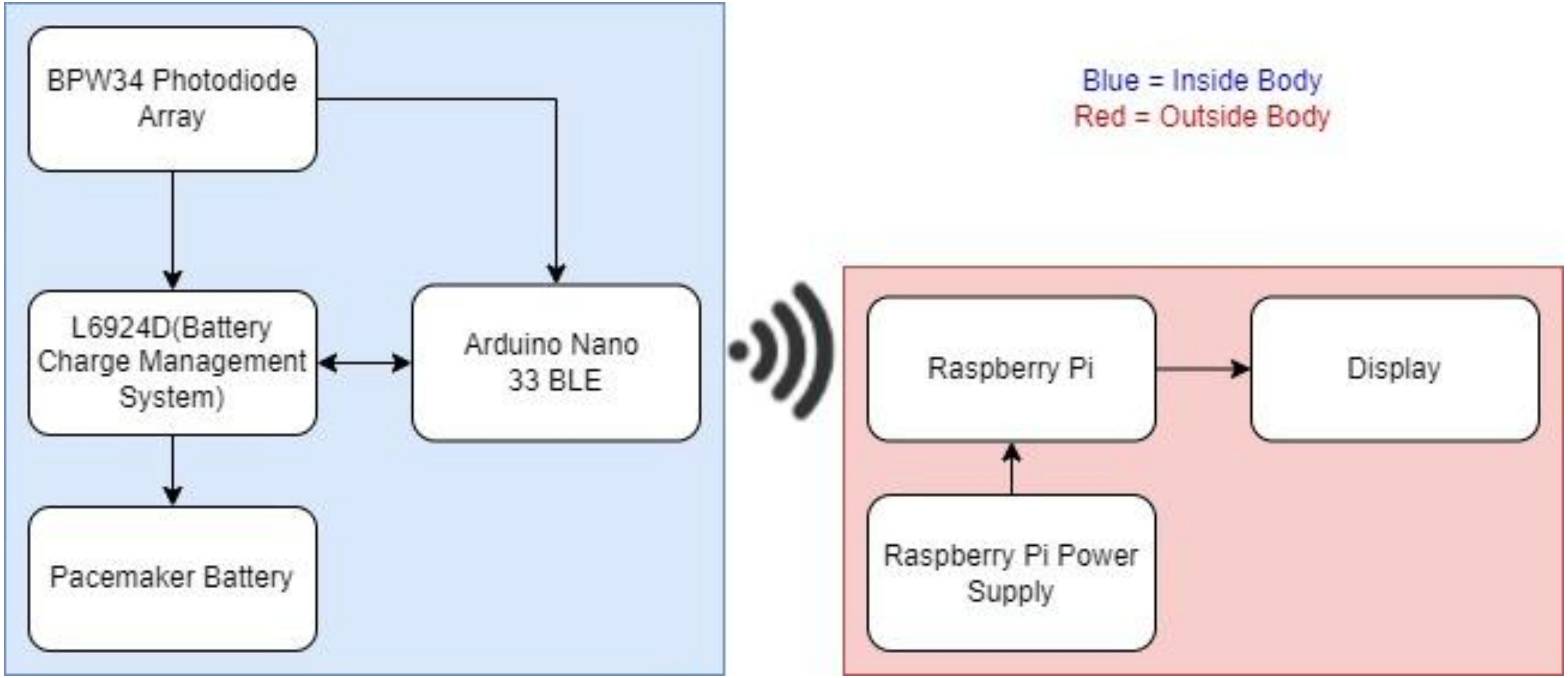

Figure 1: System Architecture

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PCB (Printed Circuit Board) Photodiode Array

- Kept prototype photodiode array design of 20 photodiodes in series repeated 5 times in parallel.
- The PCB has a more compact design than the breadboard allowing for the lamp to be brought closer while still covering all photodiodes.

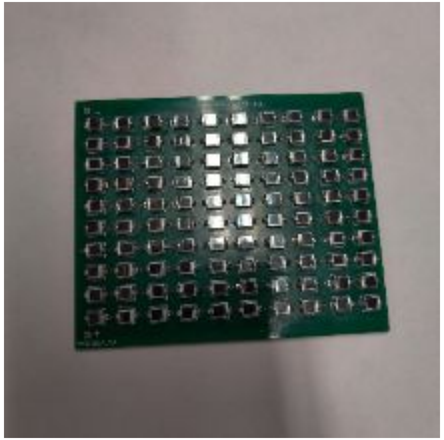

Figure 1: NIR Photodiode PCB

Testing - Photodiode Array Current

- This test consisted of determining the current generated based on the distance from our NIR lamp.
- Distance was increased in 2 inch increments for testing.

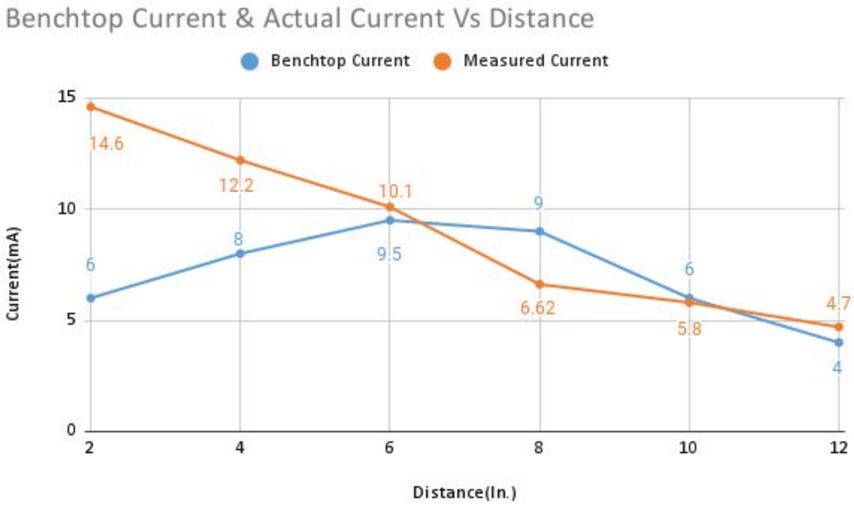

Figure 1: Current vs. Distance graph

Figure 2: Photodiode Array Testing

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Testing - Photodiode Array Voltage

- This test consisted of determining the voltage generated based on the distance from our NIR lamp.
- Distance was increased in 2 inch increments for testing.

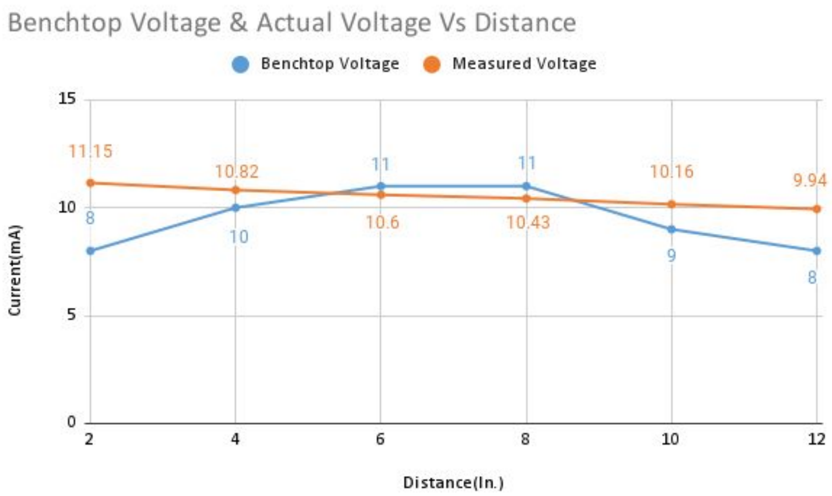

Figure 1: Voltage vs. Distance graph

Figure 2: Photodiode Array Testing

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Testing - Arduino Controlled Charge Management

- This test consisted of controlling the L6942D IC that determined whether the battery would receive charge based on current battery level.
- This was done using an Arduino to send a cut off voltage to the IC if the battery level exceeded a predetermined level.

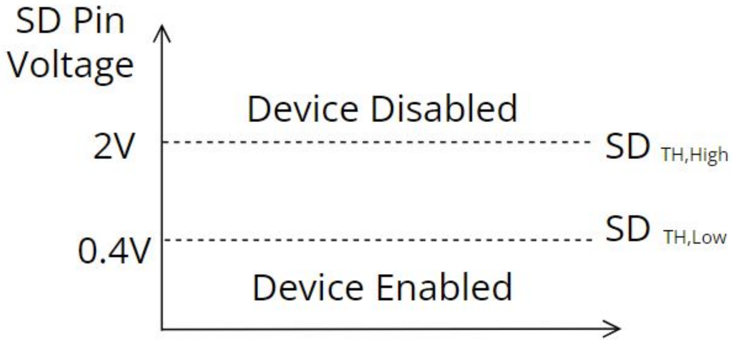

Figure 1: Charge Shutdown diagram

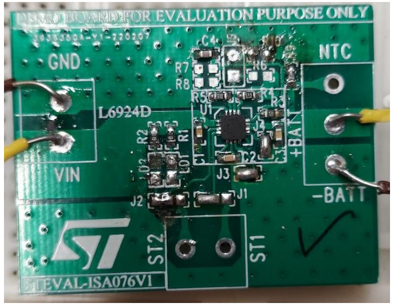

Figure 2: Charge Management PCB

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Case Design

- The reason we needed a case is to keep all components protected inside the body.
- The dimension of this case are 7.7cm x 9.2cm x 1.1cm.
- This case was 3D printed with a thermoplastic, PLA (Polylactic Acid).
    - Non-toxic

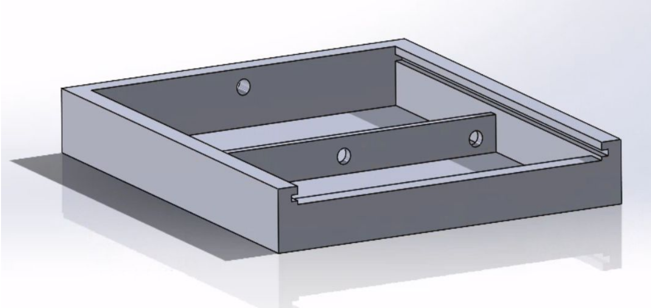

Figure 1: Case Design

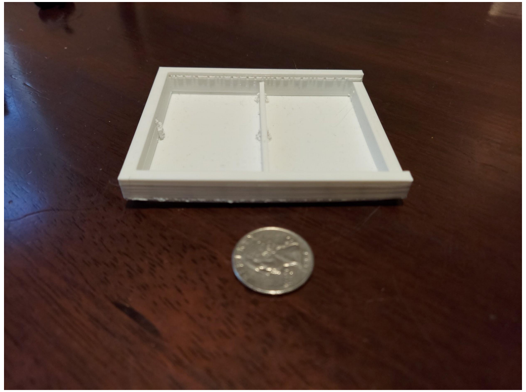

Figure 2: Prototype Case

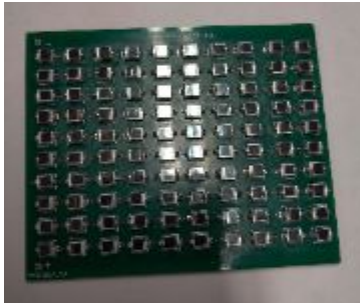

Figure 3: NIR Photodiode PCB

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Results

- Our bioelectric generator successfully charged a LiPo battery from dead to 3V in 20 minutes before ceasing to charge the battery. This means that we met all of our primary requirements set for the generator.
- Our generator failed to successfully wirelessly communicate the battery data with an external display due to technical issues with the raspberry pi. This caused us to fail to meet the stretch goal requirement.

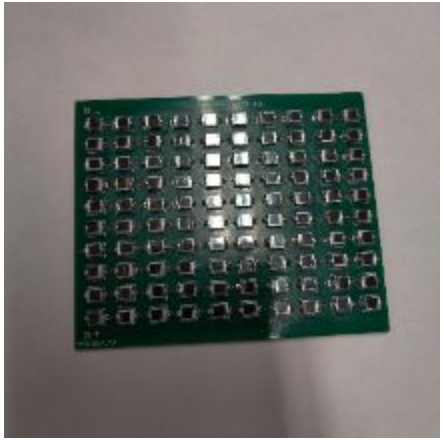

Figure 1: NIR Photodiode PCB

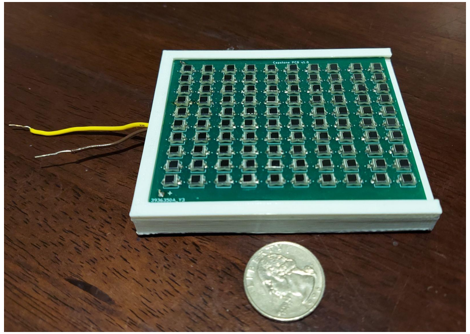

Figure 2: Completed Device

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Challenges

- Initial Prototyping Issue
  - During prototyping of the NIR photodiode, an incorrect calculation led us to believe the current produced by a single photodiode was greatly higher than it actually was. This led to us creating an incorrect design for the prototype photodiode array.
- Meeting power requirements for all components
  - The infrared photodiodes' voltage and current output were less than what our components needed.
- Bluetooth Communication
  - The external display intended to be used alongside the Raspberry Pi had several issues related to usability that were fixed.
  - The Raspberry Pi had a persistent, undiagnosed technical issue that caused it to disconnect from the Arduino Bluetooth signal after a few seconds. This problem remains unresolved.

Figure 1: Raspberry Pi 3 Model A+

Figure 2: Raspberry Pi Display

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Future Improvements

- The voltage and current generation can be increased in order to charge the battery faster.
- Further refine photodiode array PCB in order to reduce size of case.
- Designate more time to the development of the external display in order to have enough time to diagnose and solve technical problems.
- Find a method to reduce Arduino power consumption.
- Improve sealing on case to increase protection of internal components.

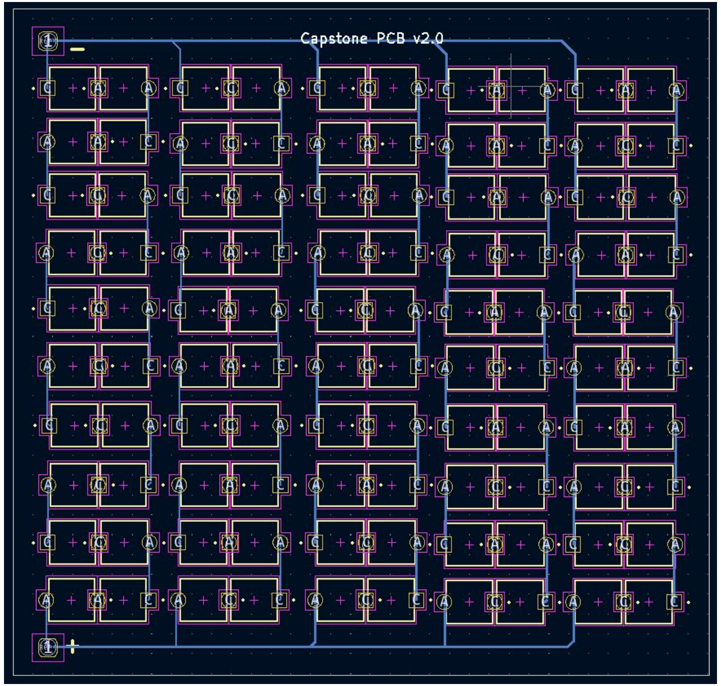

Figure 1: Photodiode PCB v2.0

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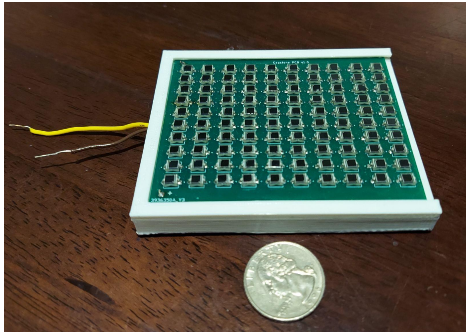
Conclusion

We would like to thank W. L. Gore and Northern Arizona University for this opportunity. Also, we extend our thanks to DJ Mongeau, Dr. Robert Severinghaus, and Mahsa Keshavarz for the assistance they provided throughout this process. Over the course of this last year, we learned many different skills and gained experience that will greatly help us in our post-education lives.



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