Self-Adjusting Helmet

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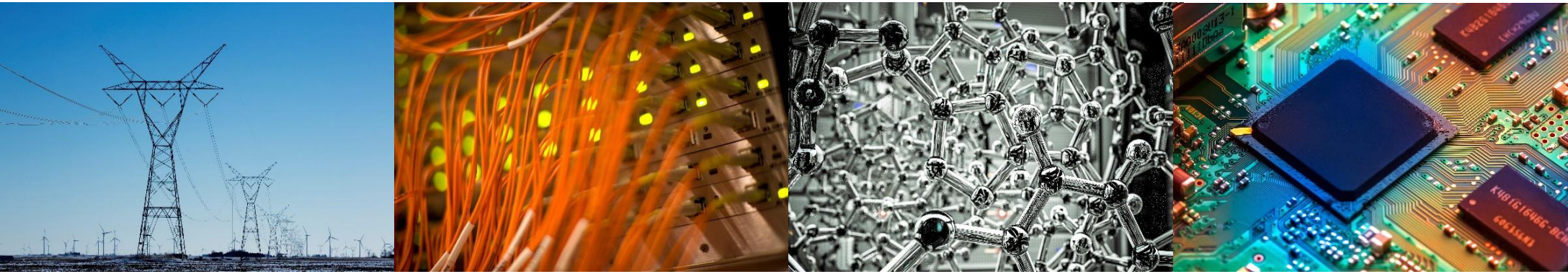
Team 23, TA: John Kan



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Overview

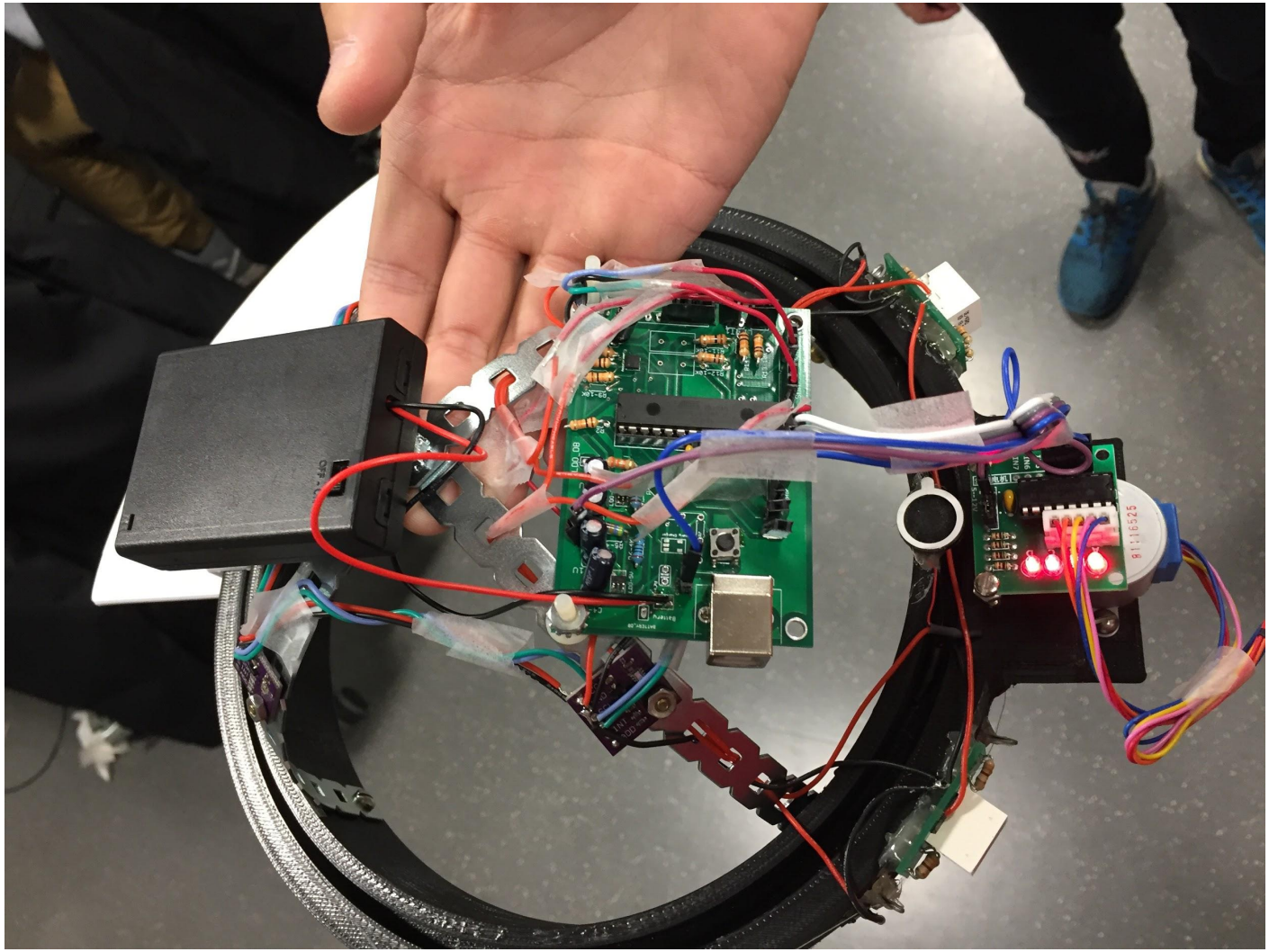
- Introduction
- Objective
- Design
  - Hardware
  - Software
  - Mechanical Structure
- Functional Test
- Successes and Challenges
- Future Work

Introduction

Common Construction Helmet

Problem: Helmet only shield the sunlight from front but not other directions.

Our Solution: Self-Adjusting Helmet



Objective

Objective

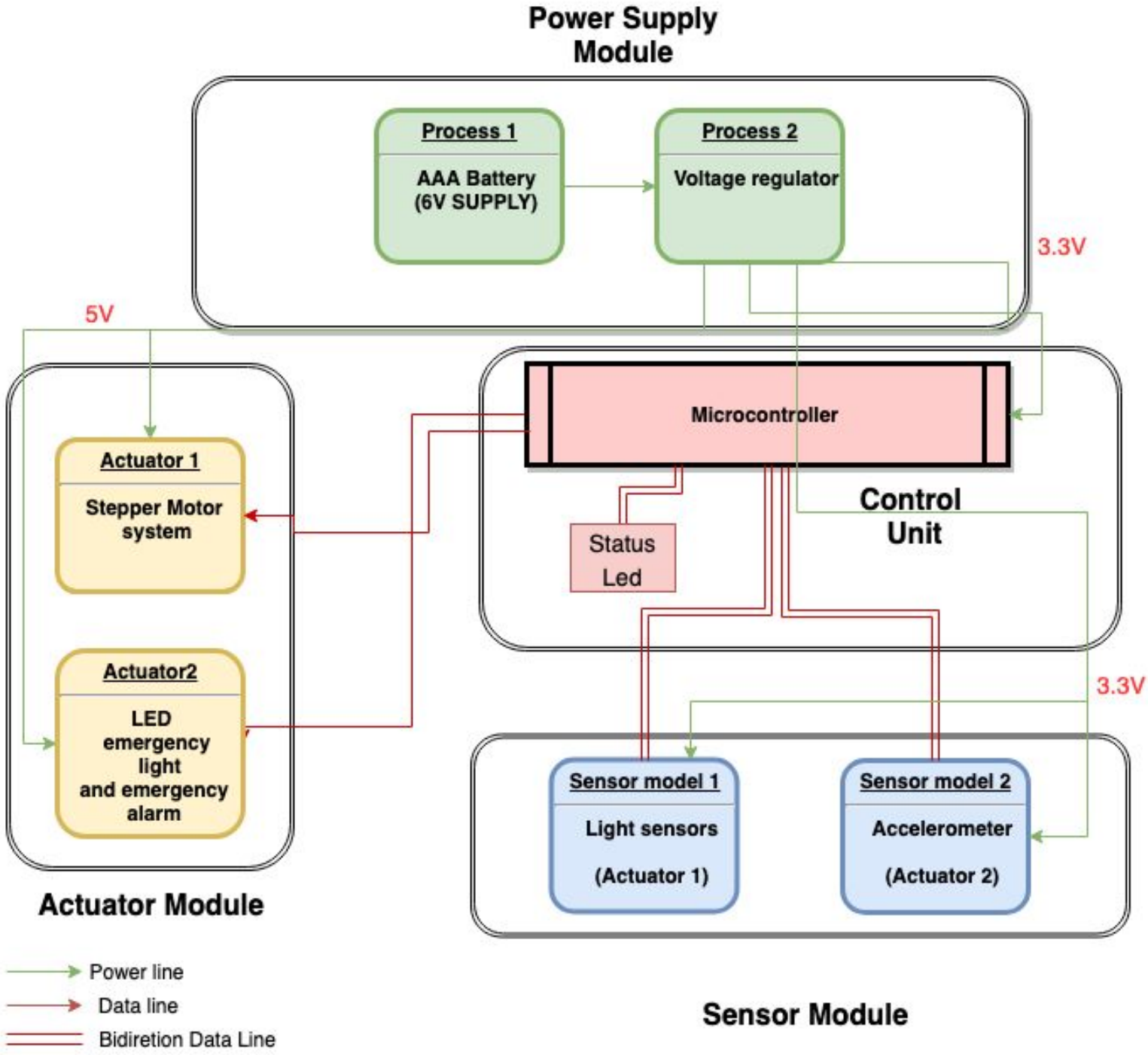
- Brim rotates to the correct directions
- Detect the falling down cases
  - LEDs flash
  - Alarm rings
- Overall cost is affordable

Demo

Design

Hardware Design

- Power Module
- Sensing Module
- Control Module
- Actuator

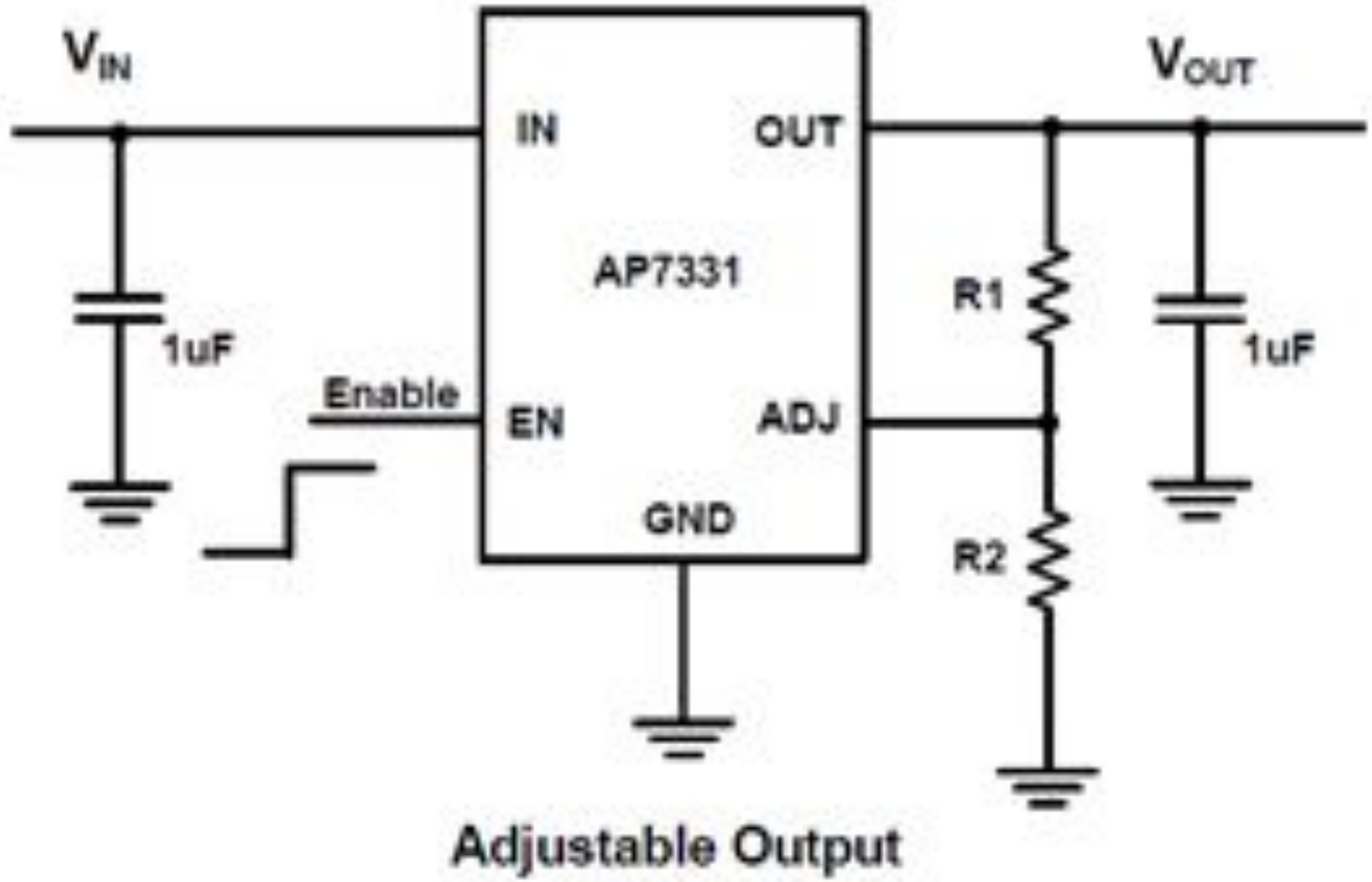

Power Supply Module
Process 1
AAA Battery (6V SUPPLY)
Process 2
Voltage regulator
3.3V
5V
Microcontroller
Control Unit
Status Led
Actuator 1
Stepper Motor system
Actuator2
LED emergency light and emergency alarm
Actuator Module
3.3V
Sensor model 1
Light sensors (Actuator 1)
Sensor model 2
Accelerometer (Actuator 2)
Sensor Module
Power line
Data line
Bidiretion Data Line

Power Module

LDO (5V)

LDO (3.3V)

LDO Circuit



Adjustable Output

LDO Circuit

- Adjustable Output Voltage

$$V_{out} = \left(1 + \frac{R_1}{R_2}\right) V_{ref} \Rightarrow \frac{R_1}{R_2} = \frac{V_{out}}{V_{ref}} - 1$$

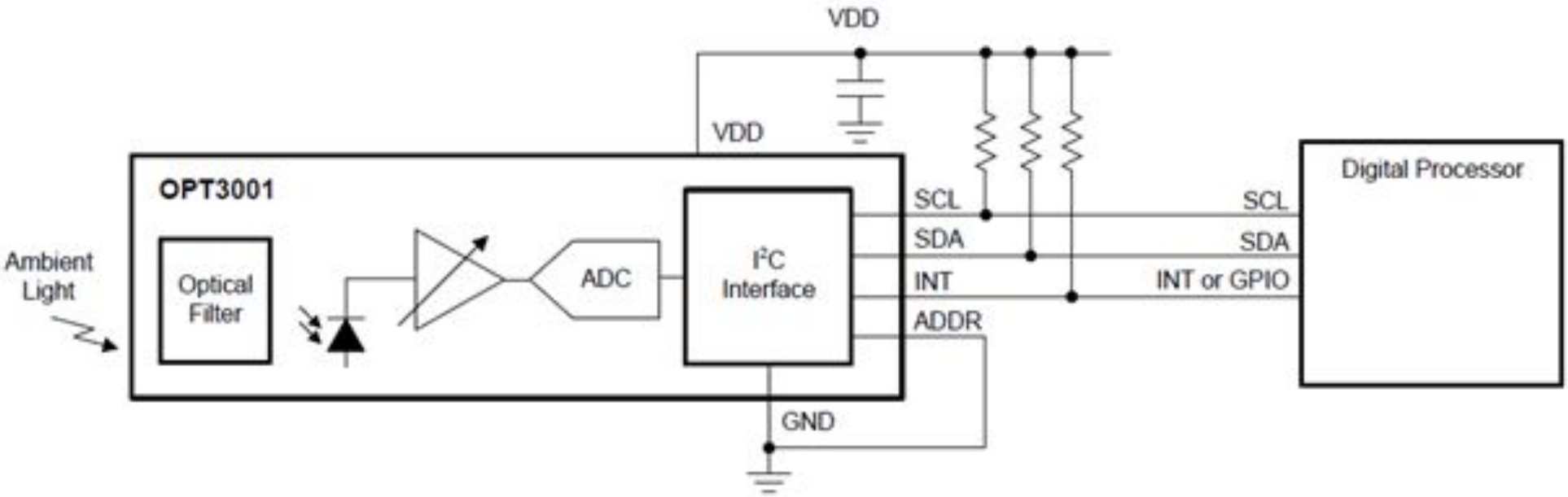
- Choose Appropriate Resistors
  - Reference Voltage: 0.4V
  - 3.3V Output: R1=33k R2=4.7k
  - 5.0V Output: R1=23.5k R2=2k

Sensing Module - Light Sensor

OPT 3001
Light Sensor

Light Sensor Circuit

- I2C Communication
- Wide Detection Range: 0 - 83,000 lux

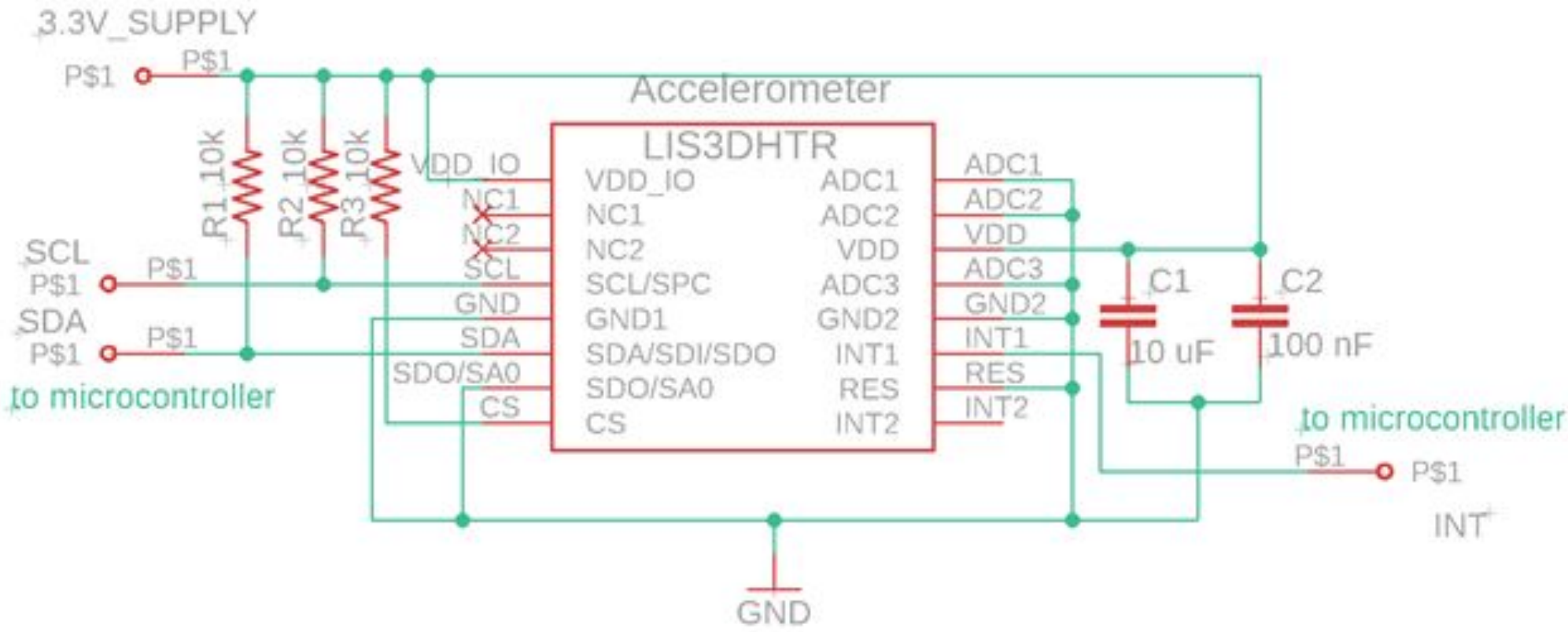


Sensing Module - Accelerometer

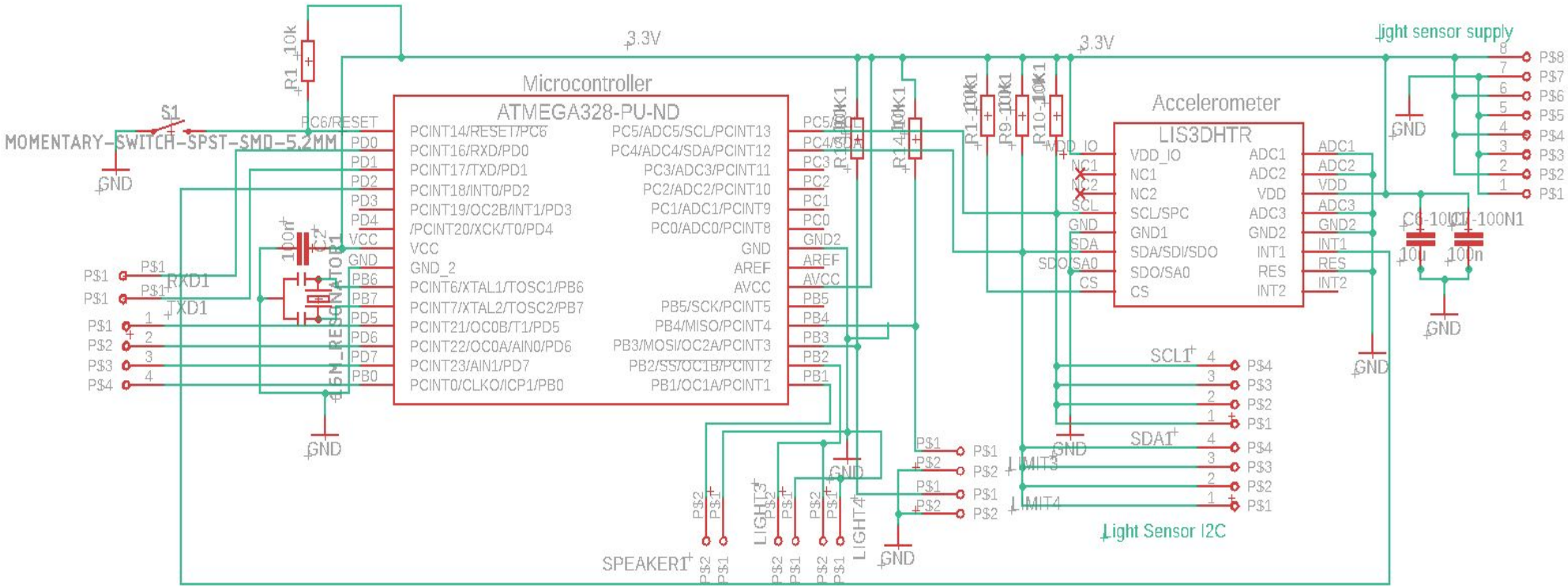
LIS3DHTR Accelerometer

Accelerometer Circuit

- Fall Detection: Interrupt Pin to Controller



Control Module

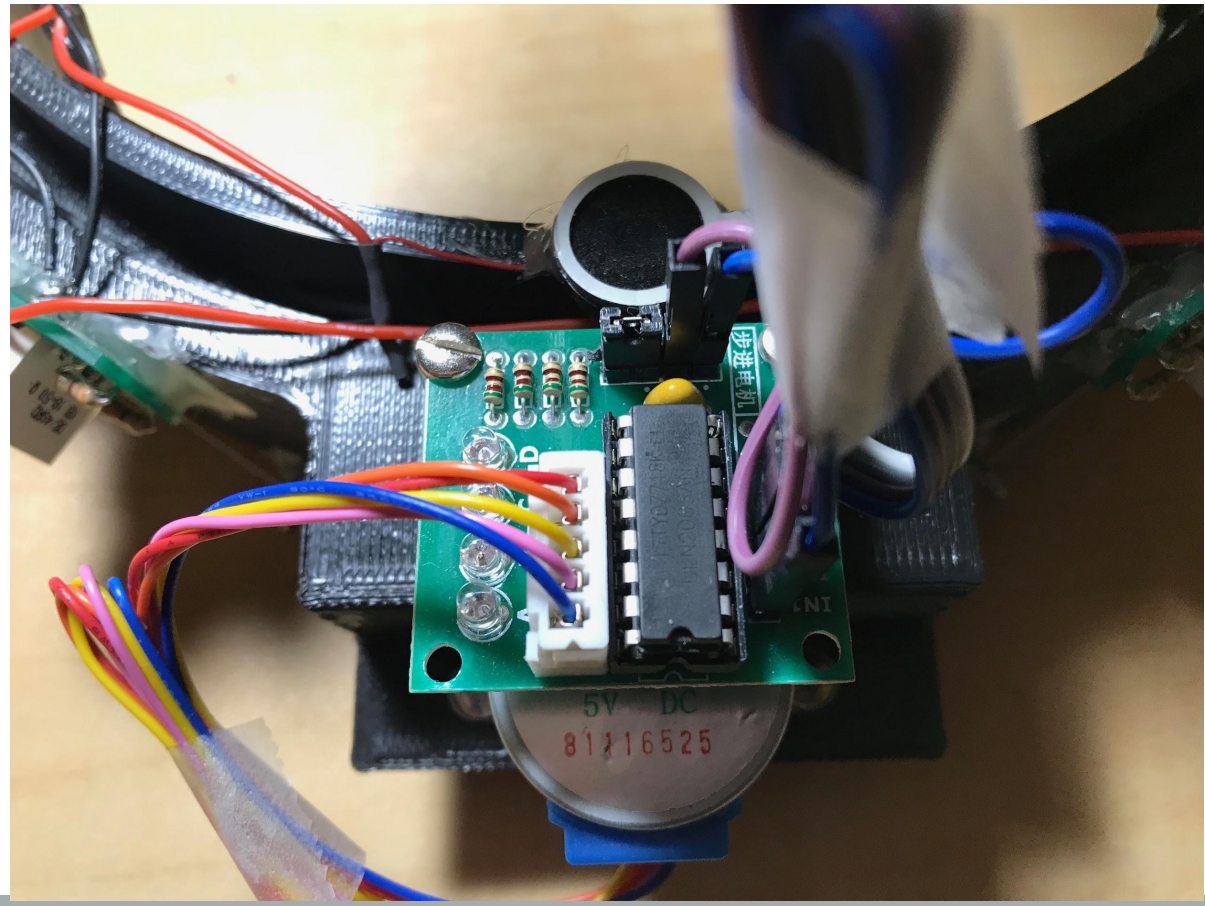


Microcontroller - Control Signal Flow

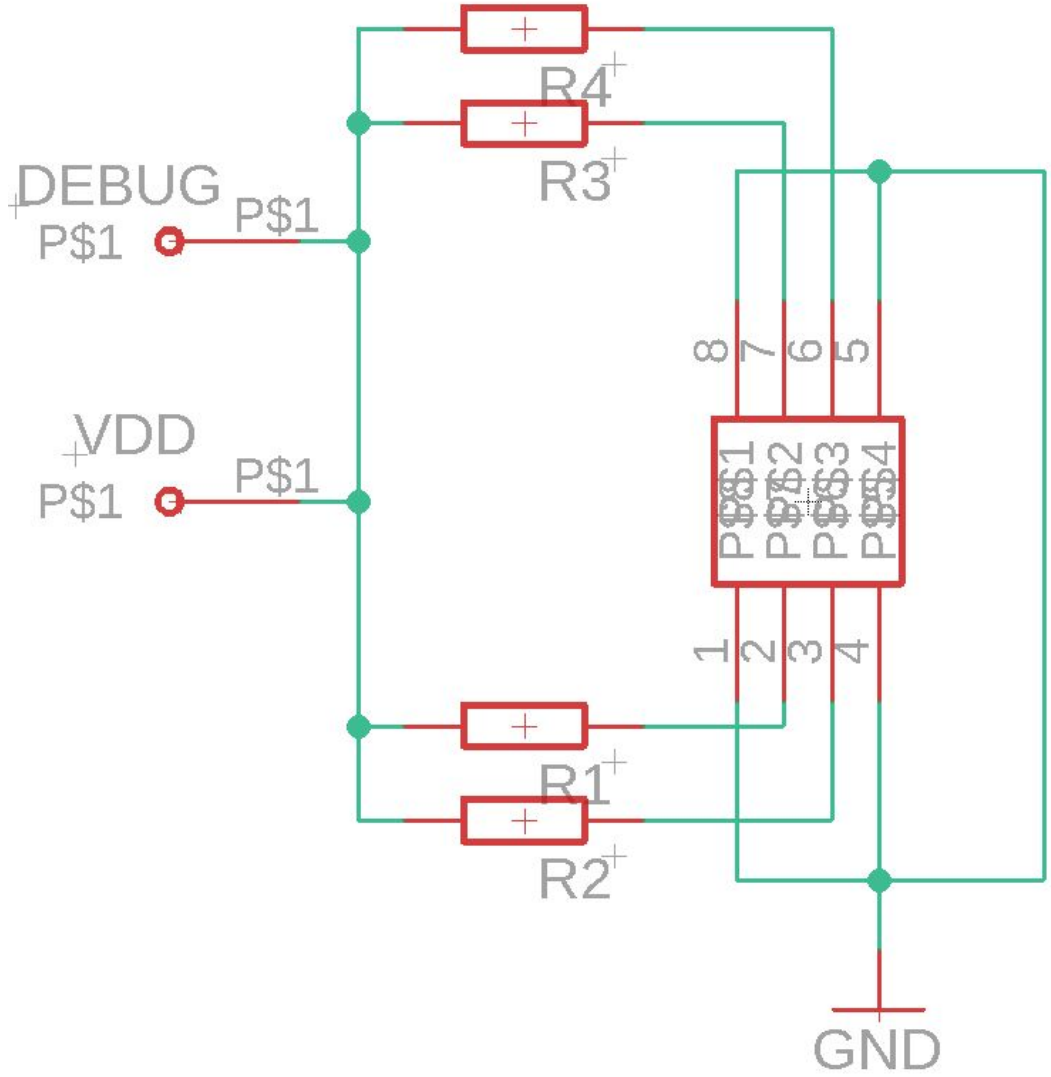
Pin Number	Control Signal Description
PC6	Reset Button
PD2 (Digital Pin 2)	Accelerometer (Interrupt)
PD5, PD6, PD7, PB0 (Digital Pin 5,6,7,8)	Motor Driver
PB1 (Digital Pin 9)	Speaker
PB2 (Digital Pin 10)	LED Bar
PB3, PB4 (Digital Pin 11,12)	Limit Switch
PC4	SDA
PC5	SCL

Actuator - Stepper Motor

- 28BYJ-48 Stepper Motor
- ULN2003 Motor Driver



Alarm LED - Circuit

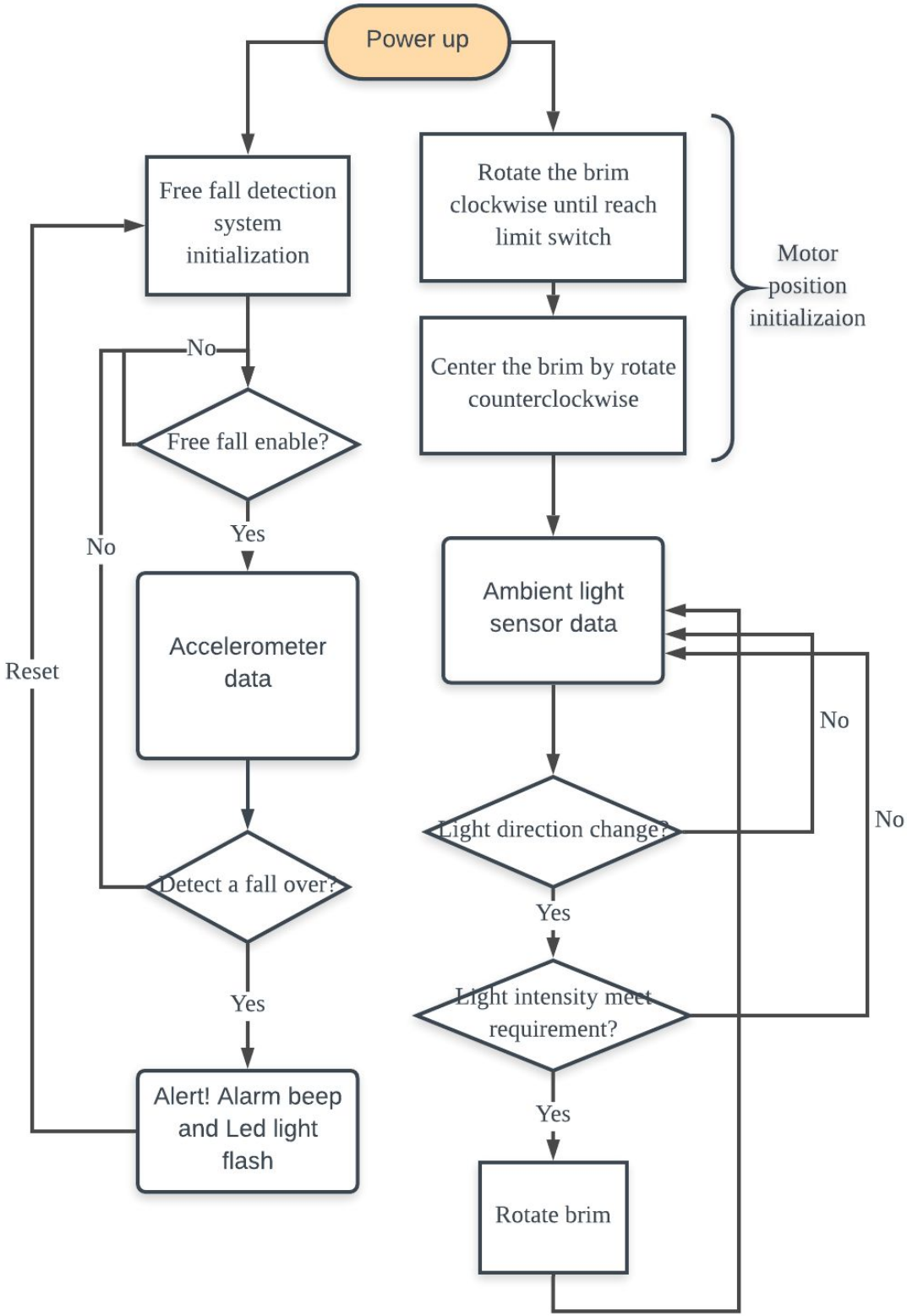


Software Design

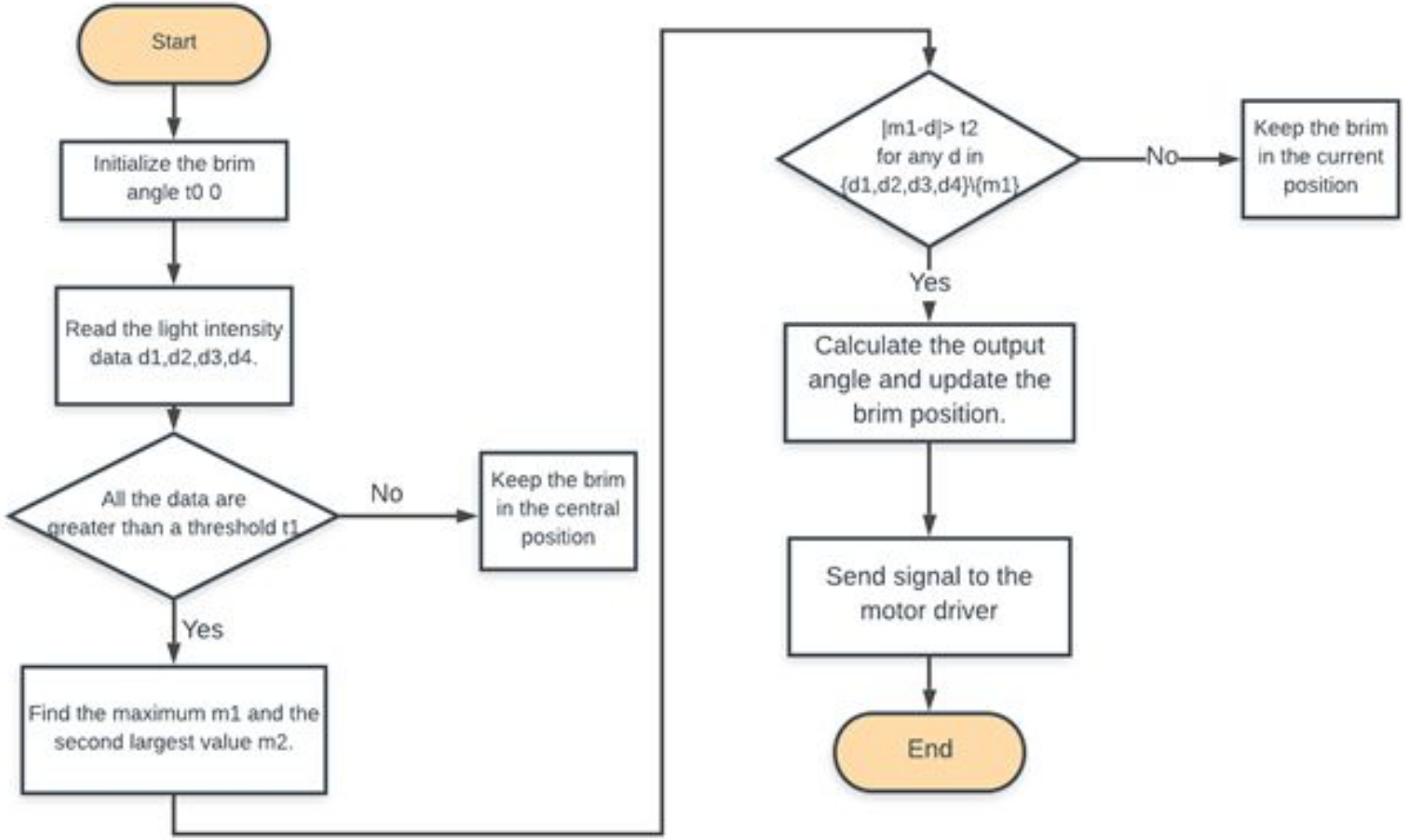
```
// Atmega328p digital pins:
// Accelerometer: pin 2;
// Speaker: pin 9;
// Leds: pin 10;
// Motors: pin 5, 6, 7, 8;
// Limit switch: pin 11,12;
```

Setup motor, IMU;
Initialize communication protocols;
while(not hit switch):
    rotate brim clockwise
Center brim;

while true:
    collect light information and rotate brim
    check fall flag and alarm


Power up
Free fall detection system initialization
Rotate the brim clockwise until reach limit switch
Center the brim by rotate counterclockwise
Motor position initializaion
No
Free fall enable?
Yes
No
Reset
Accelerometer data
Detect a fall over?
Yes
Alert! Alarm beep and Led light flash
Ambient light sensor data
No
Light direction change?
No
Yes
Light intensity meet requirement?
Yes
Rotate brim

Software Design - Light Detection



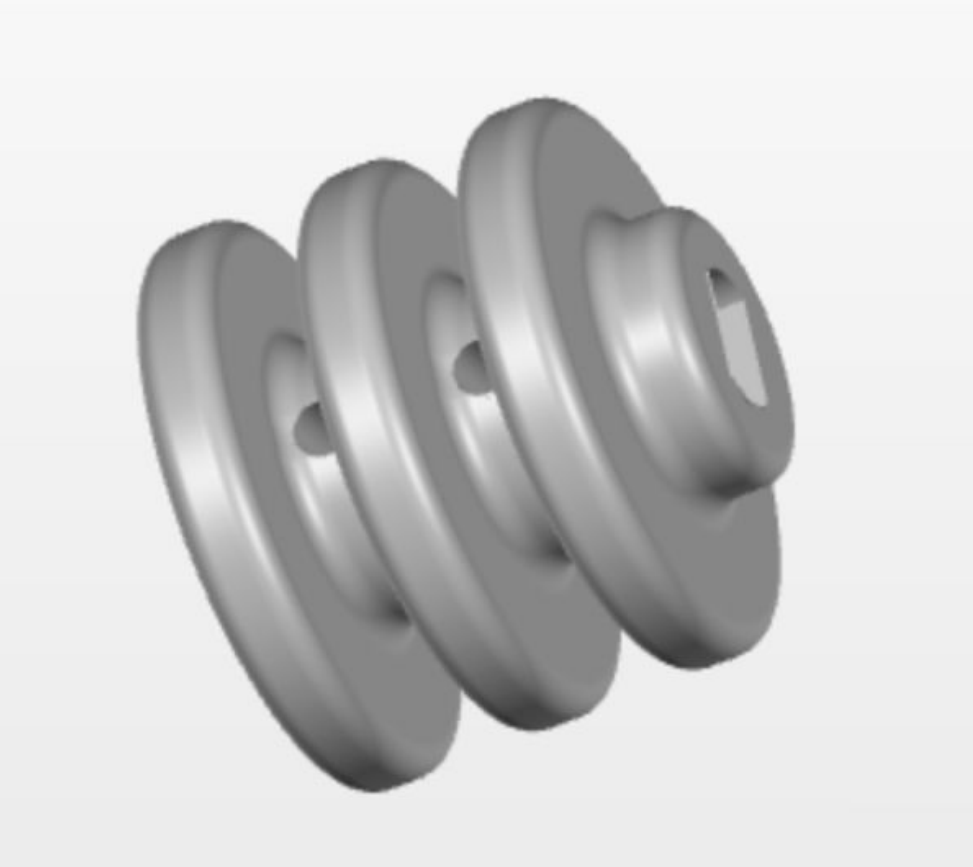
Software Design - Light Detection

- Output Angle Calculation
  - m1: maximum light intensity
  - m2: second largest light intensity

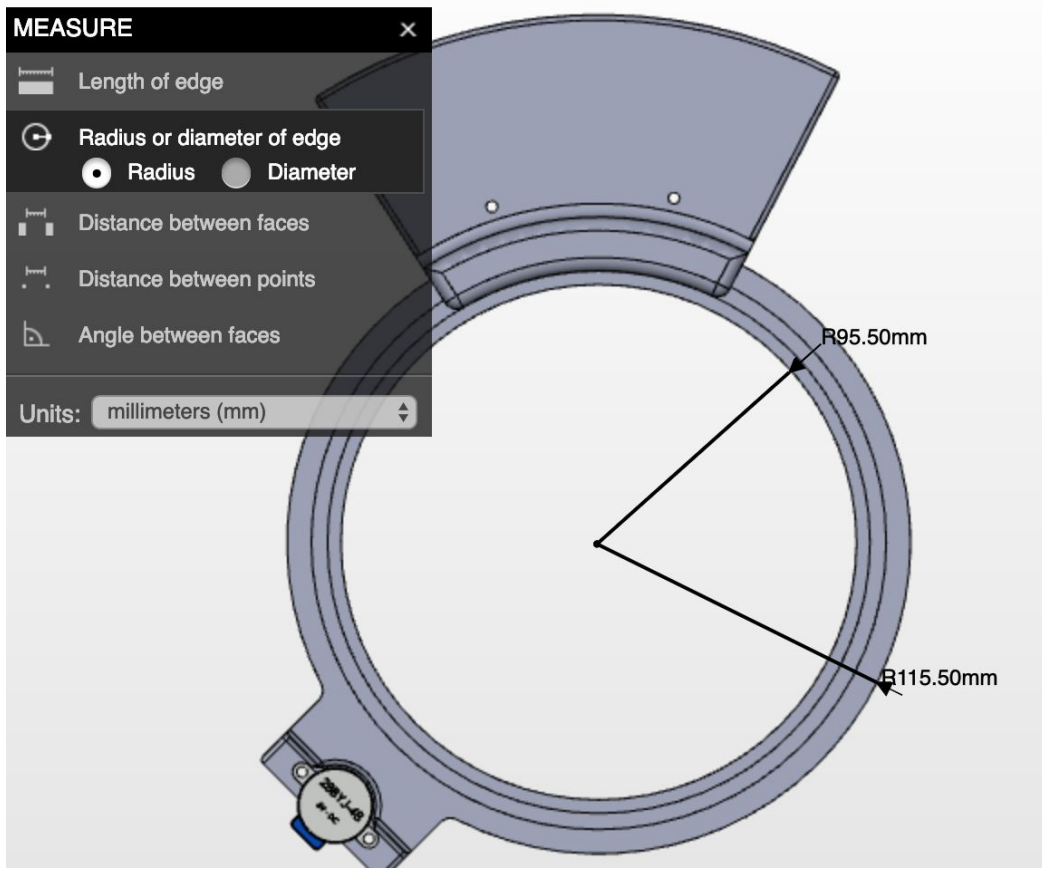
$$r = \frac{m_1}{m_1 + m_2}$$

$$\text{Output Angle} = r \times m_1 + (1 - r) \times m_2$$

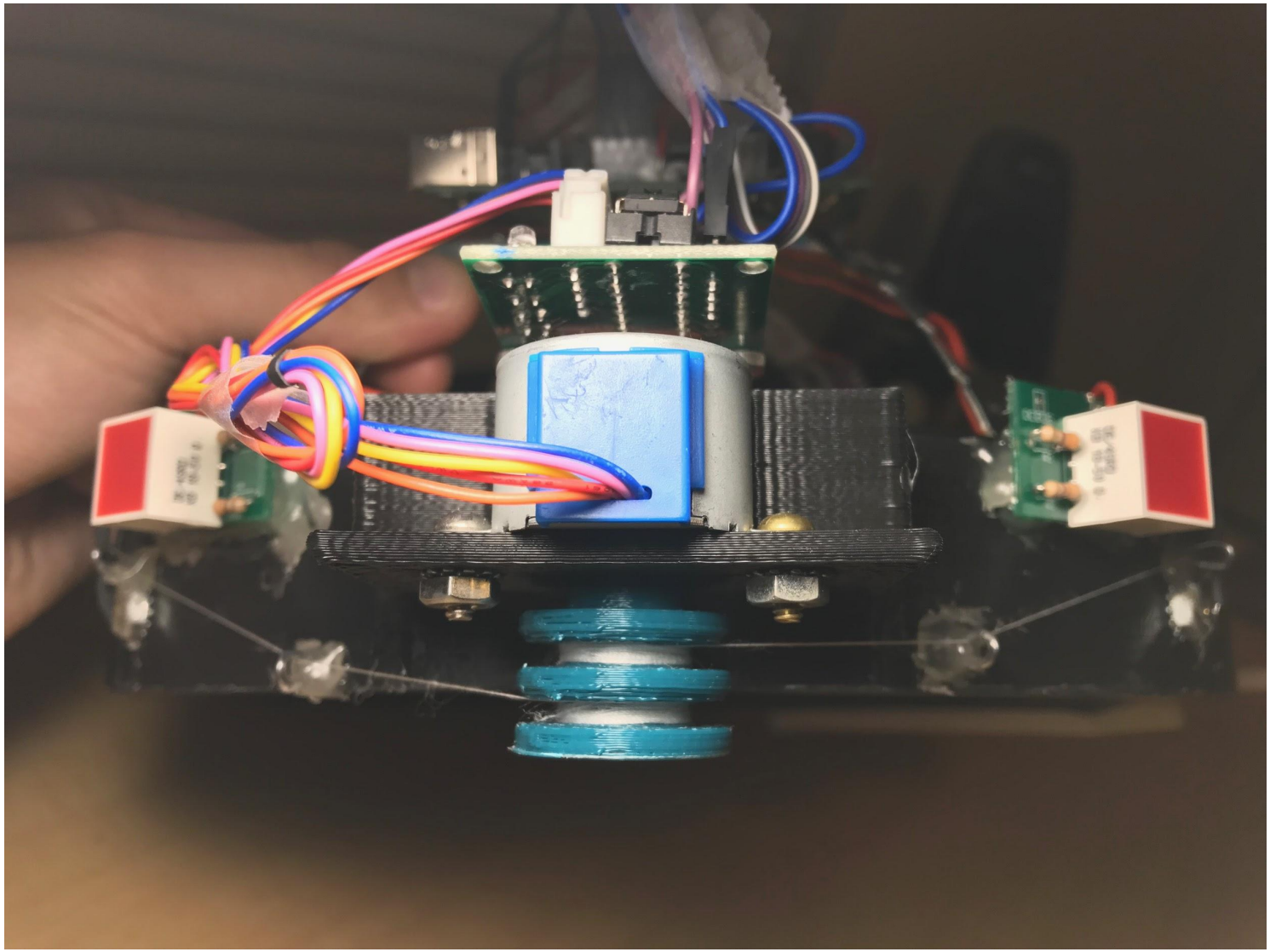
Mechanical Structure

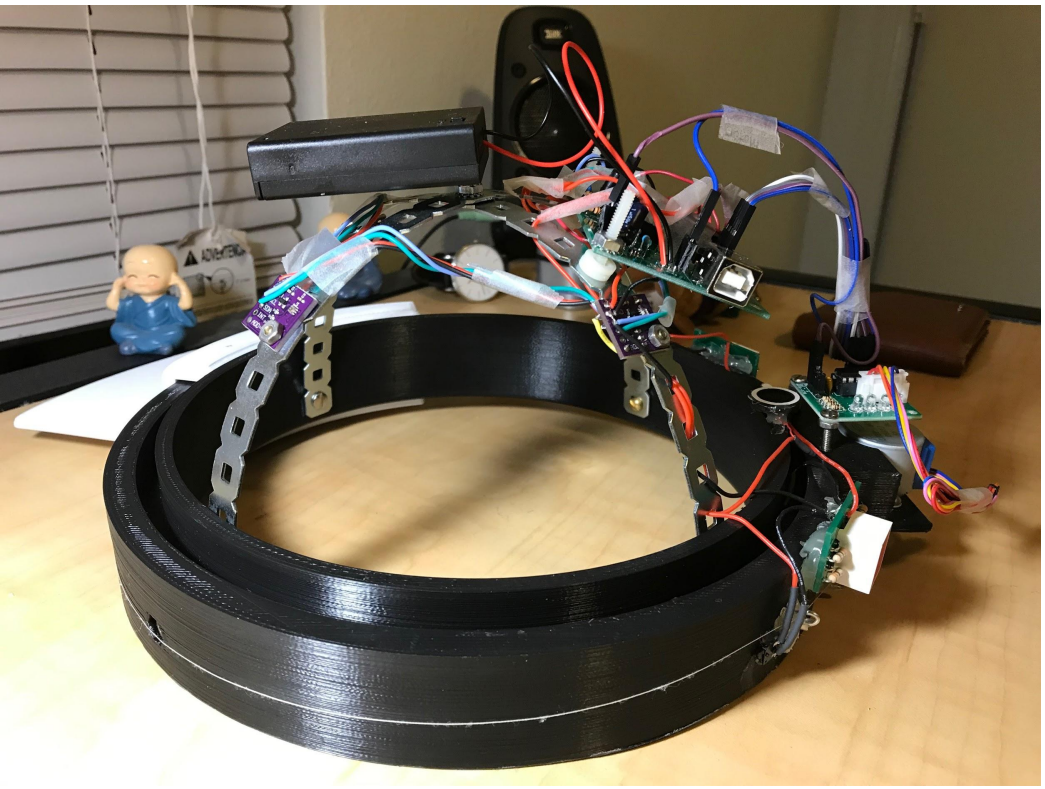


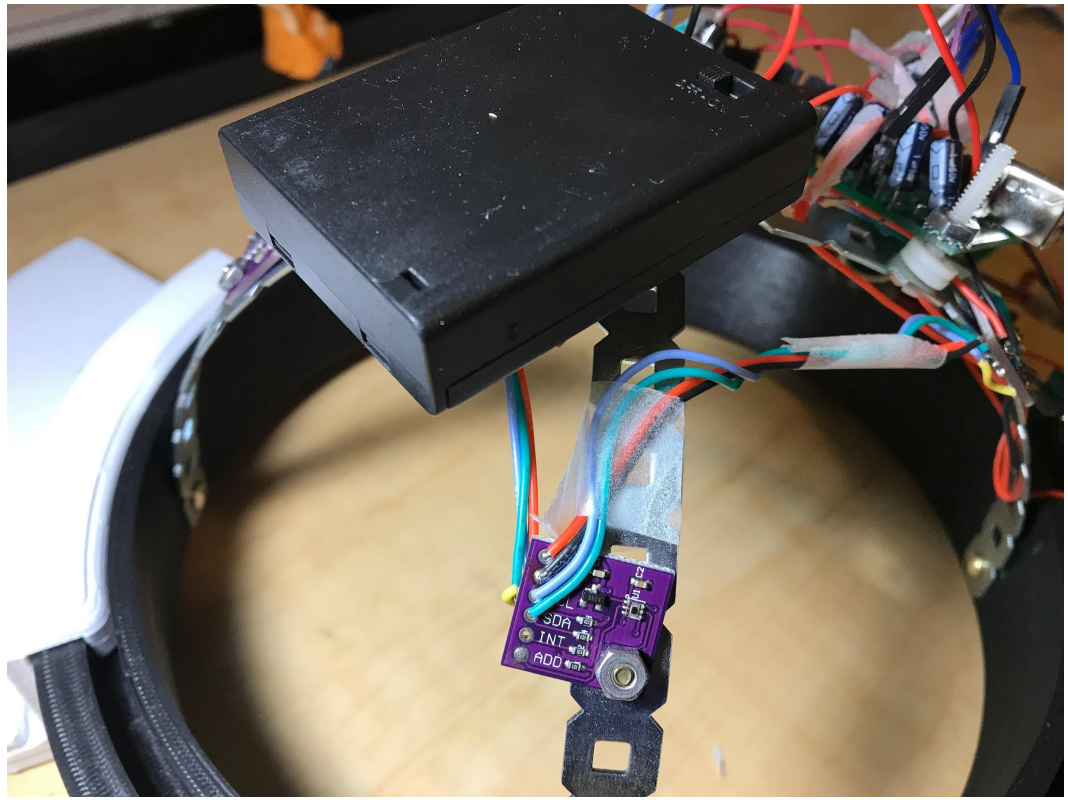
PULLEY
(ATTACHED TO STEPPER MOTOR)

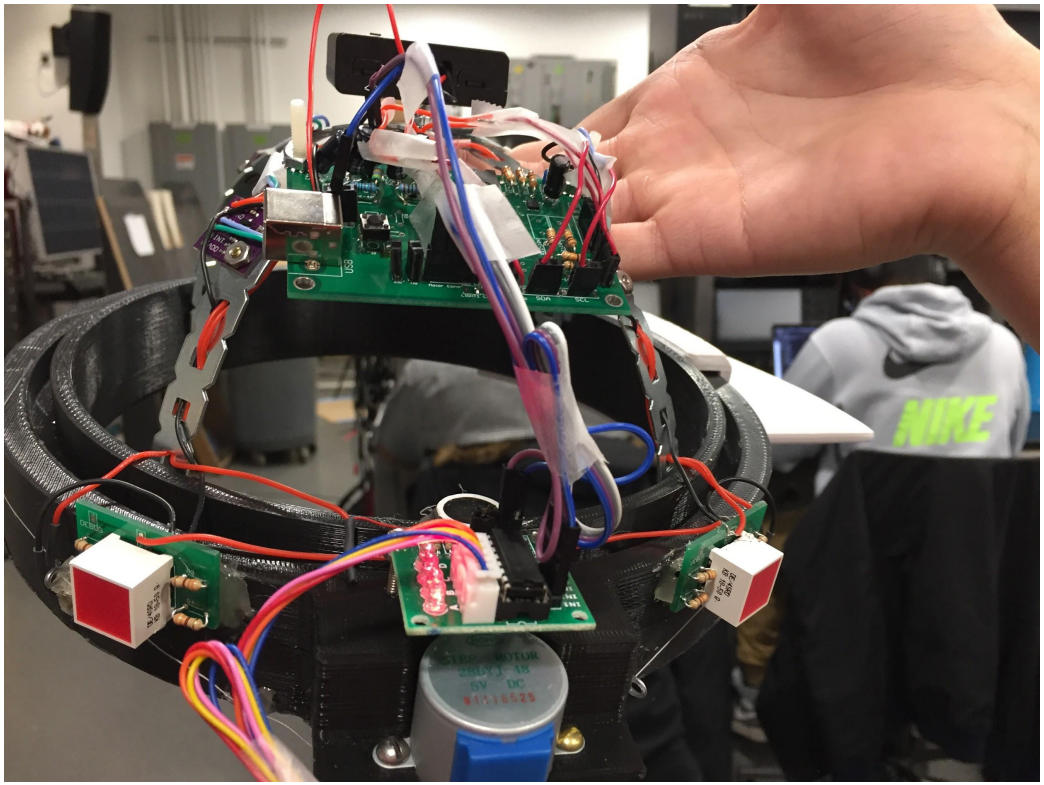


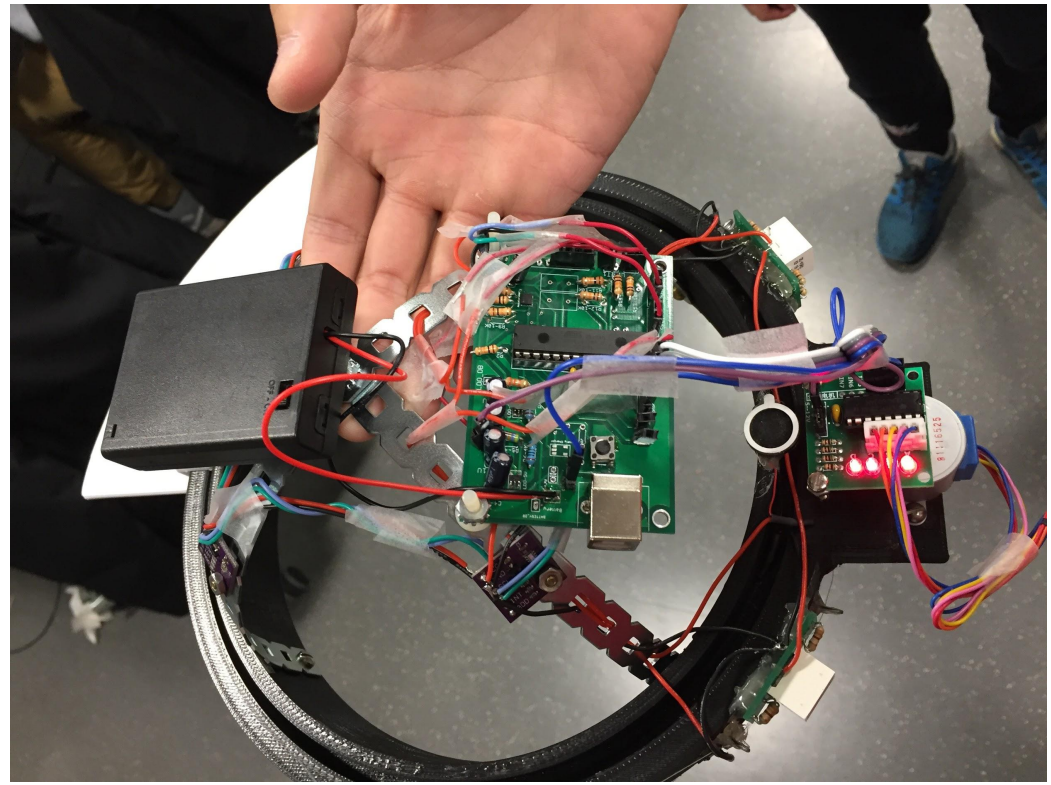
HELMET
(TOP VIEW)






SDA
INT
ADO

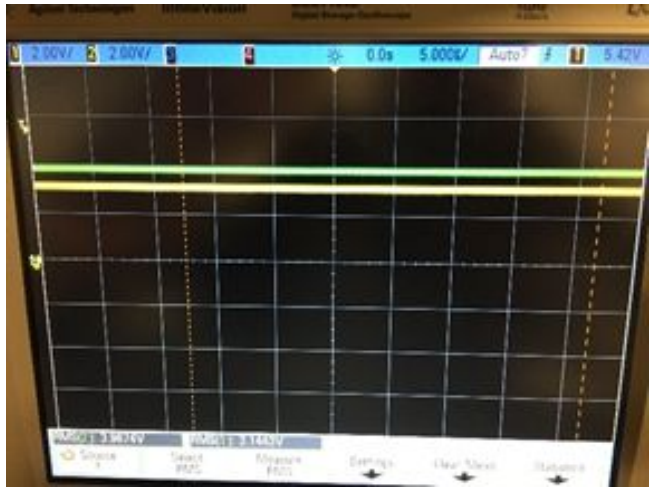

NIKE



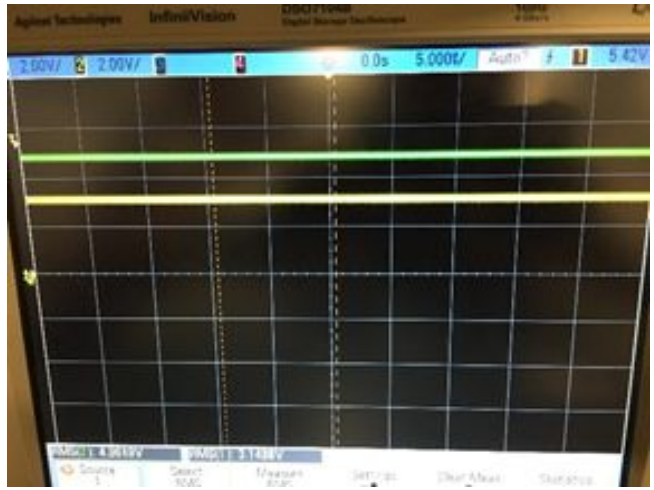
Functional Test

Power Module - 3.3V DC Output Test

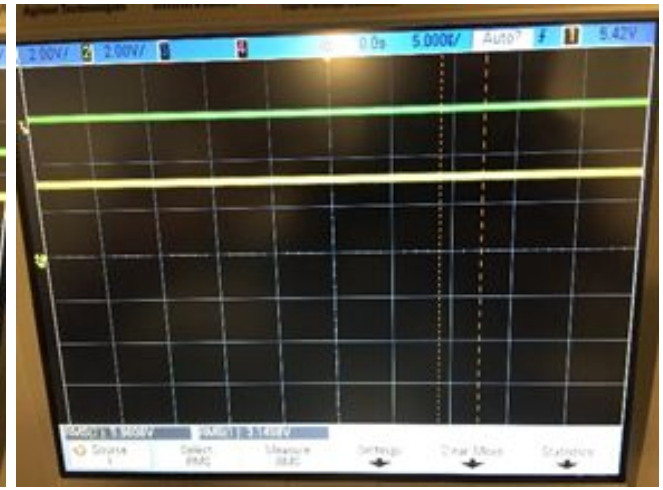
Tests with Different Input Voltages



Input: 4V
Output: 3.144V



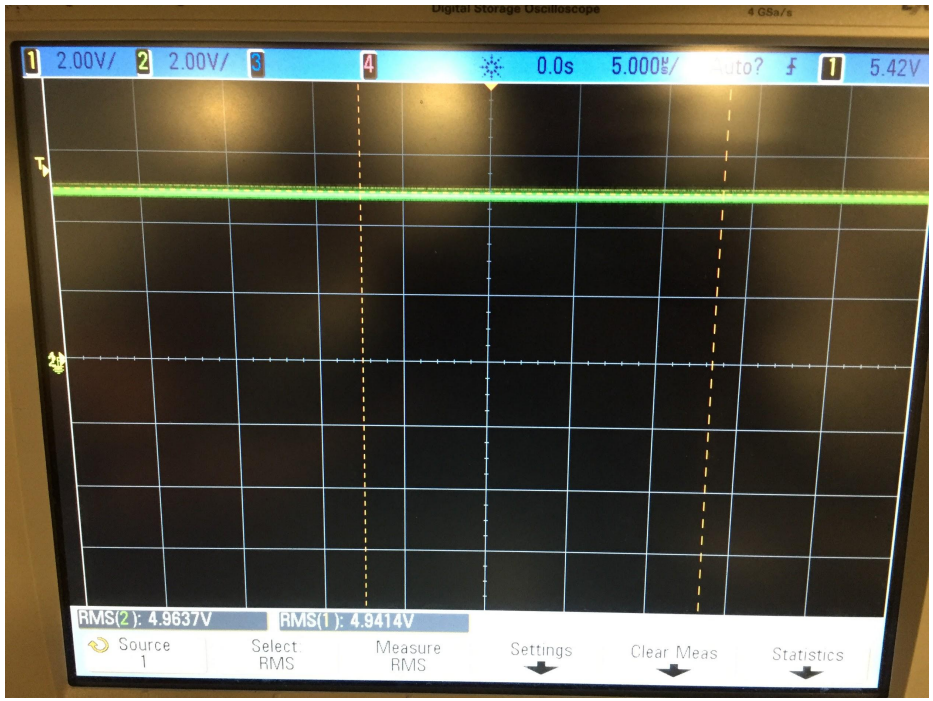
Input: 5V
Output: 3.144V



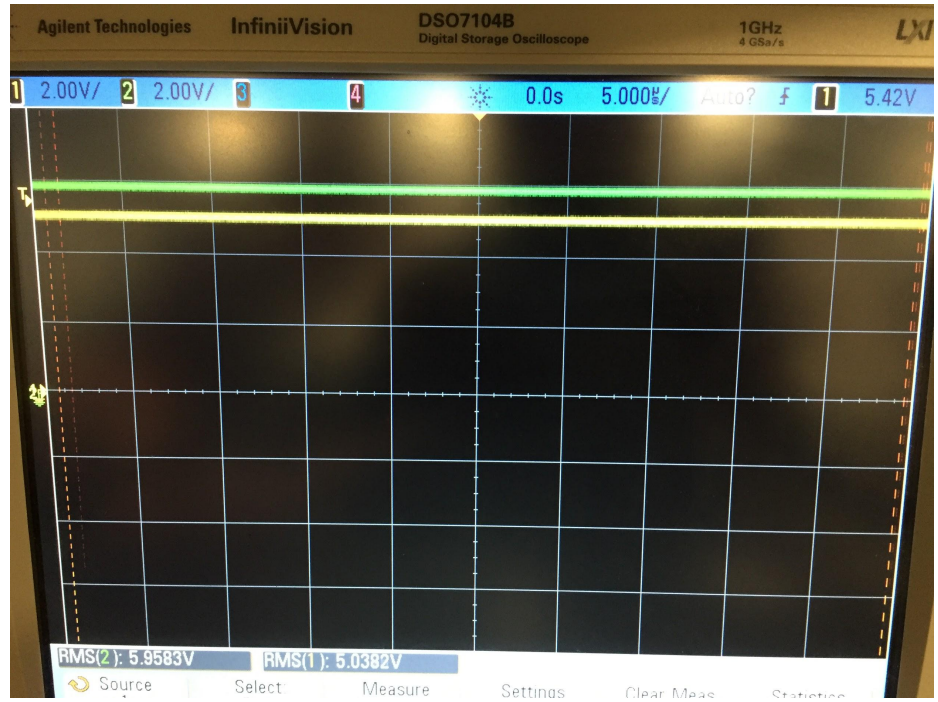
Input: 6V
Output: 3.146V

Power Module - 5.0V DC Output Test

Tests with Different Input Voltages

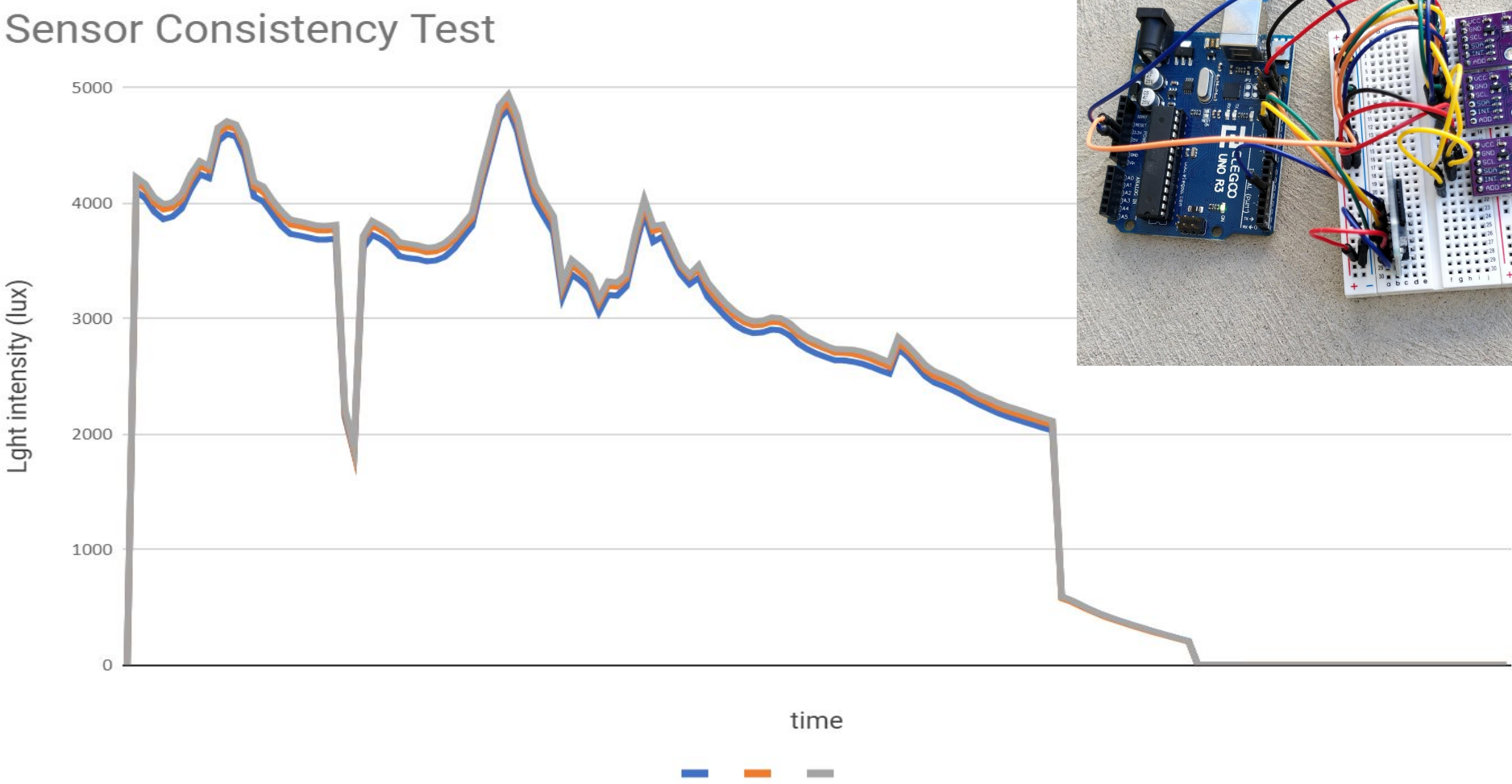


Input: 5V
Output: 4.941V

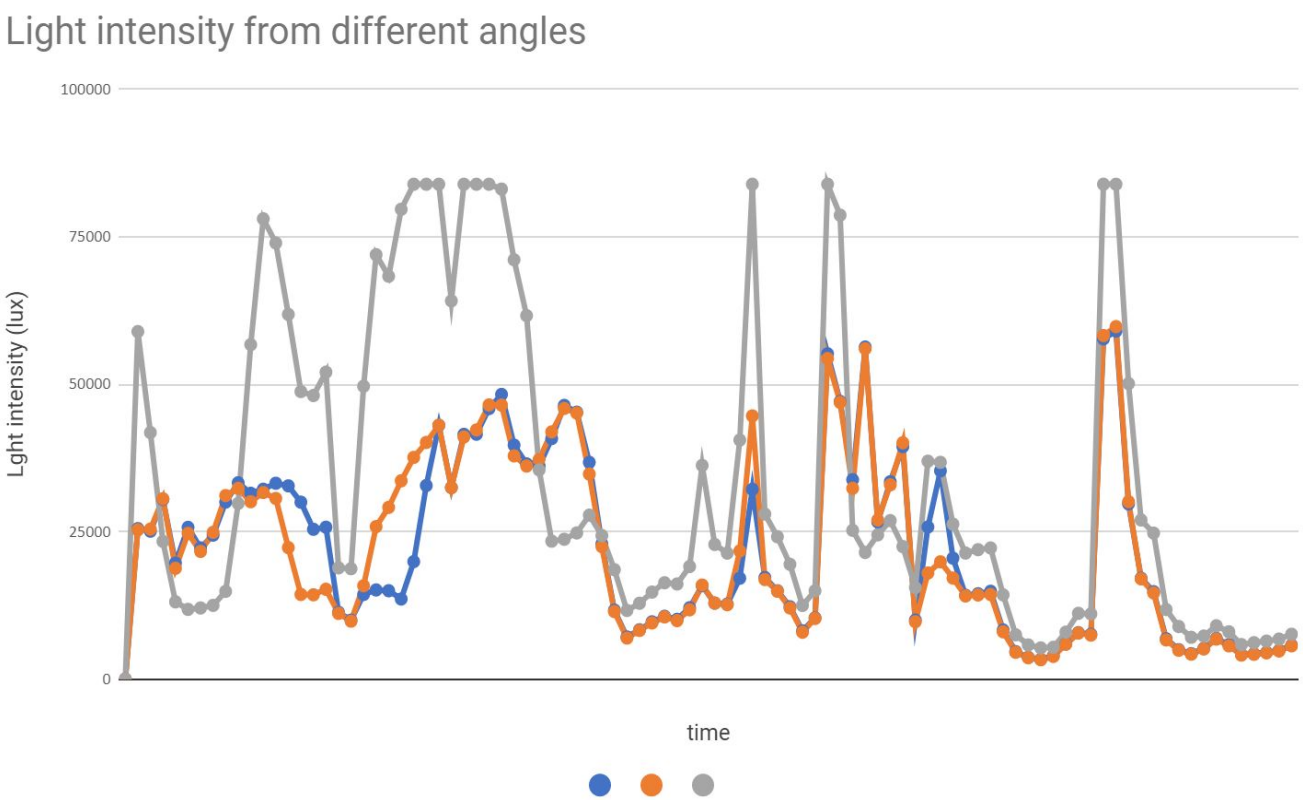


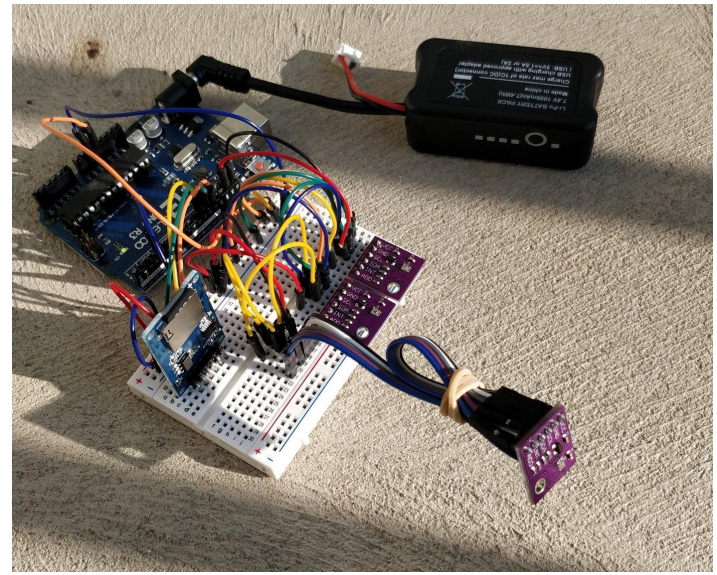
Input: 6V
Output: 5.038V

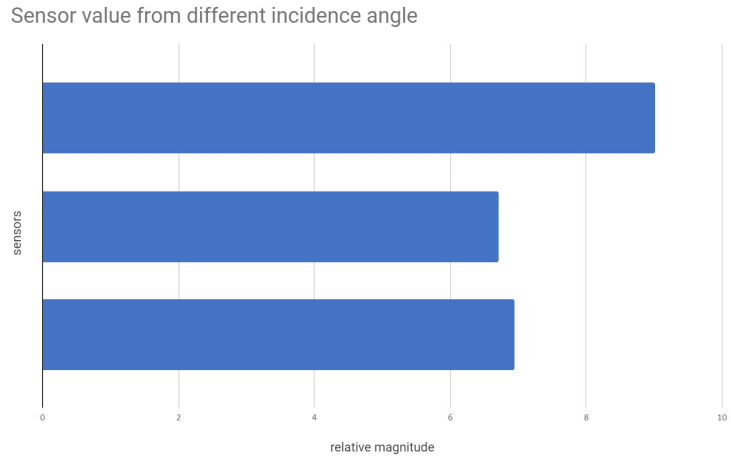
Light Sensor - Light Intensity Measurement



Light Sensor - Light Intensity Measurement







Conclusion

Success

- Accurate Light Detection
- Brim Rotation
- Fall Detection with Few False Alarms

Challenges

- Lithium Battery and Battery Charger
  - Abandoned Because of Voltage Issues
- Light Sensor Board
  - 4 Configurations
- Mechanical Structure
  - Confort
  - Material

Future Work

Future Work

- A magnet that embedded inside the track
  - Brim is driven by attraction of the magnets.
- Integrate the charger module into the design.
- rebuild the software as multiple threads

Credit

- Prof. Fliflet
- John Kan (TA)
- Jiawei Dai (ME, support in design and 3D-printing the structure)
- All ECE 445 faculties and staffs.

Thank you!