Safety Helmet
Group 3

Alejandro Velasco: Electrical Engineer
Mariela Barragan: Electrical Engineer
Daniel Ram: Computer Engineer
Michael McCoy: Computer Engineer

Introduction

Safety Helmet

Motivation

- Data from the NHTSA shows that in 2017 per registered vehicle, the fatality rate for motorcyclists was 6 times the fatality rate for passenger car occupants.
- 5172 motorcyclists were killed in motor vehicle traffic crashes that same year.
- NHTSA estimates that current helmets are only 37% effective in preventing fatal injuries
- Smart helmets currently on market don't focus on safety and are very expensive.

Similar Project Tech Comparisons

CrossHelmet X1

- Dual-monitor HUD system
- 360 degree vision in a glance
- Wide-angle rear camera
- LEDs mounted on side of helmet
- Mobile app

Jarvish X-AR

- Bluetooth connectivity
- Amazon Alexa
- 2K helmet camera
- AR projections
- Retractable HUD

Quin Design: SpitFire-Rosso

- Crash detection and response system
- SOS beacon and response system
- Bluetooth 4.0, invisible integration
- Lithium Ion battery, 60+ hours standby
- Waterproof housing within the helmet

Skully Fenix AR

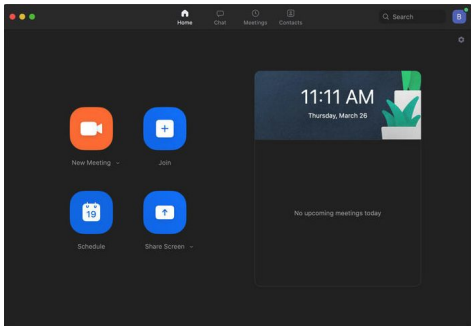
- Heads up display
- Bluetooth connectivity
- Ultra wide angle rear camera
- Mobile app
- Company went bankrupt

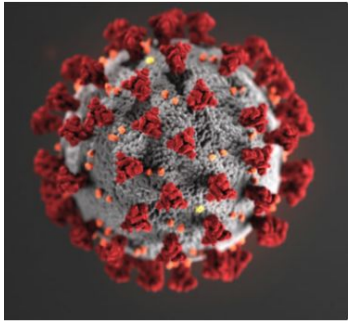
Goals and Objectives

- Research, design, and build a state of the art safety helmet in a timely and efficient manner.
- Use a minimum amount of sensors to detect when objects come into close proximity and alert the driver via OLED display, sound, or led light when it occurs.
- Crash notification system using sensor in helmet which will communicate with mobile application via bluetooth.
- Thermal camera along with eye detection technology to detect when a person is falling asleep at the wheel.
- Have our design be user friendly and be able to be used worldwide.

Challenges

- Covid-19 pandemic.
- Limited budget.
- Equipment to perform testing on hardware.
- Shipping turnaround times.
- Only virtual meetings allowed in the beginning and when recently started meeting face to face adhering to social distancing requirements.
- PCB fulfillment and testing in a short period of time.

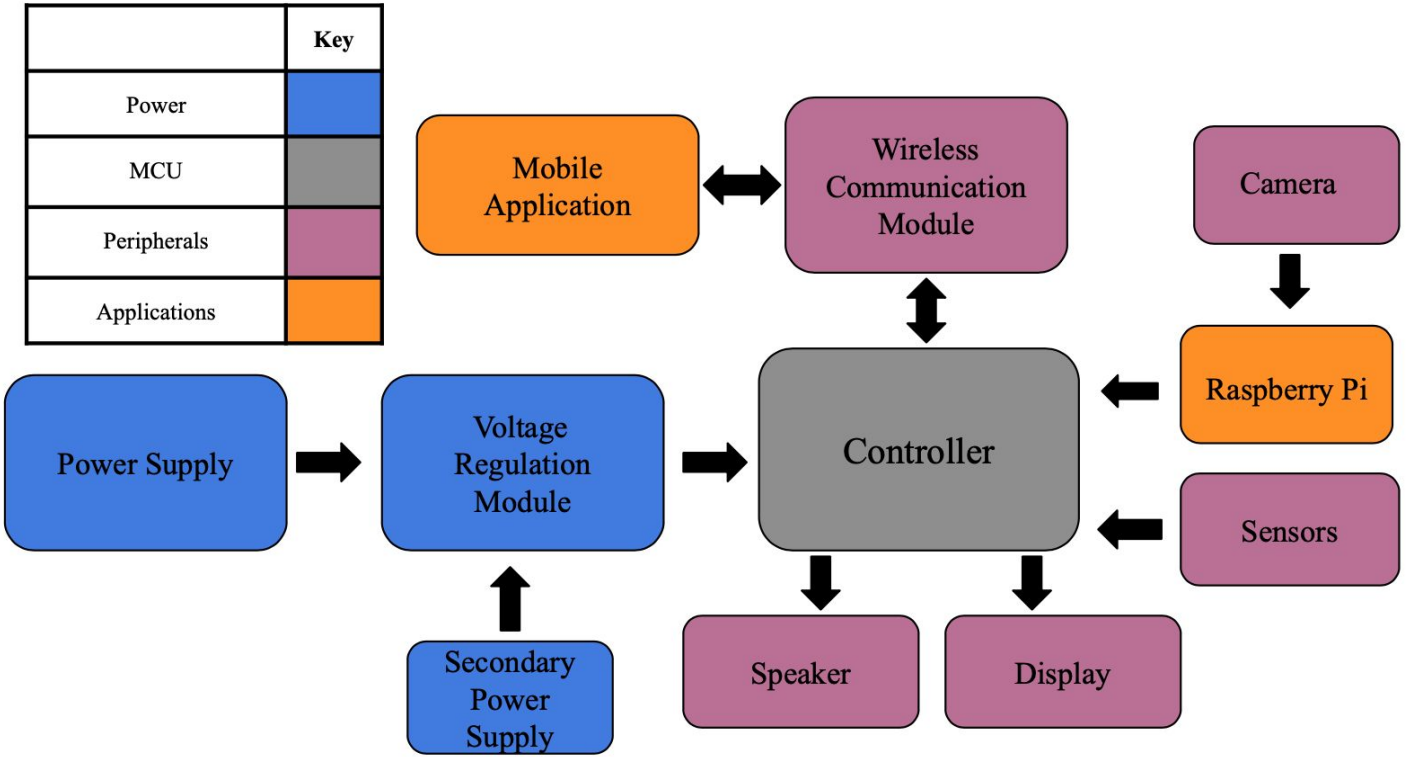




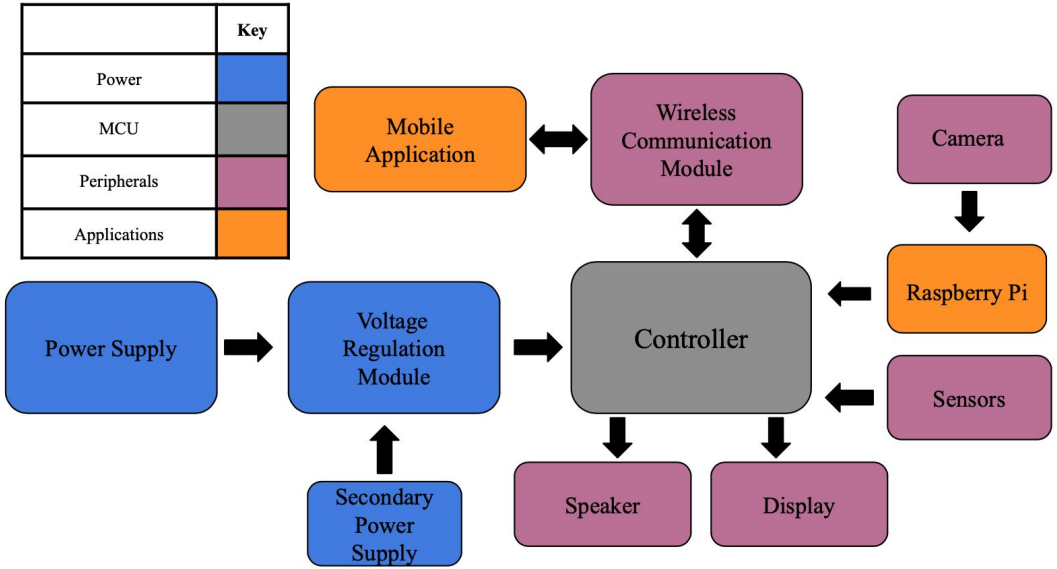
Specifications (Highlighted specs demonstrable via video demo)

1	Simple enough for the average person to operate. Set up time should be less than 30 seconds.
2	Communicate with mobile device app via bluetooth 4.0
3	Helmet equipped with a 128x64 pixel OLED display.
4	Two ultrasonic sensors, one located on each side of the helmet to cover dead spots of up to 1.5 meters.
5	A 3 Axis Gyroscope + Accelerometer sensor to detect if the rider has been involved in any kind of accident. When accident occurs MCU will notify mobile app and send SMS to set emergency contact.
6	Eye detection monitoring using a Pi NoIR camera powered by a Raspberry Pi.

Block diagram



Overall Work Distribution



	Primary	Secondary
Power	**Alejandro Velasco**	**Mariela Barragan**
MCU	**Daniel Ram**	**Michael McCoy**
Peripherals	**Mariela Barragan**	**Alejandro Velasco**
Mobile Applications	**Michael McCoy**	**Daniel Ram**

Hardware Selection-Indicators

	SSD13060.96 Inch OLED Module	16x2 Character LCD
Voltage	3.3-5V	5V
Resolution	128 x 64 pixels	2 lines x 16 characters, with character resolution 5 x 8 pixels
Dimension	29.28 x 27.1 mm	80mm x 35mm x 11mm
Interference	I2C	I2C with adaptor
Price	$15 for 3	$3
Manufacturer	Digi-Key	Digi-Key

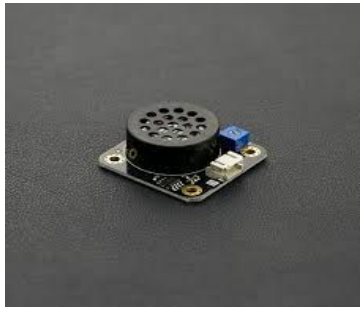
OLED
SSD13060.96 Inch OLED Module

16x2 Character LCD

Sound

	3.5 mm Earbuds	FIT0449 - Digital Speaker Module
Voltage	-	2.0V-5.5V
Cost	$5.00	$7.00
Power Rating	1W	0.5W
Cable Length	3 ft	-
Size	40mm x 40mm	-
Manufacturer	Amazon	Digikey

3.5 mm Earbuds



FIT0449- Digital Speaker Module

Hardware Selection-Proximity Detection

	HC-SR04	HRLV-Maxsonar-Ez	Sharp GP2Y0A21YK0F
Price	$3.95	$29.95	$13.07
Size	43×20 ×15mm	22.1 ×19.9×15.5mm	29.5×13.0×13.5 mm
Manufacturer	Digi-Key	Digi-Key	Digi-Key
Operating Voltage	5 V	2.5 V - 5.5 V	4.5 V to 5.5 V
Min/Max Range	400 cm	645 cm	10 cm to 80 cm
Output Type	Echo	Analog Voltage	Analog Voltage
Current Consumption	15 mA	2.5 mA to 3.1 mA	30 mA

HC-SR04

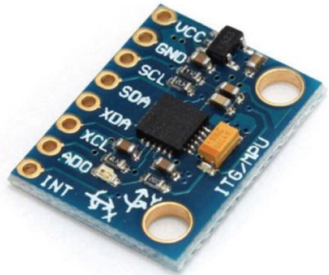
HRLV-Maxsonar-Ez

Sharp GP2Y0A21YK0F

Hardware Selection-Motion Detection

	Gyro Sensor SN-ENC03R0	Tilt Sensor- AT407	MPU-6050 3 Axis Gyro
Price	$18.80	$1.95	$9.95
Size	22.86 x 22.86 x 5.08 mm	29X5.2mm	21.2x 16.4mm x 3.3mm
Manufacturer	Digi-Key	Digi-Key	Digi-Key
Measurement Range +/-	300 °/s	30 °/s	250 500 1000 2000 °/s
Current Consumption	3.5 mA	<6 mA	3.6 mA
Operating Voltage	3 V~ 5.25 V	Up to 24 V	3 V - 5 V
Axis	Single	None	Three

Tilt Sensor- AT407

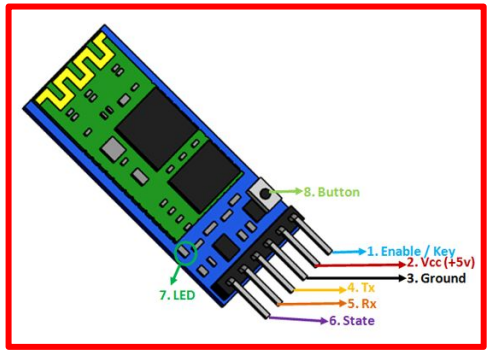


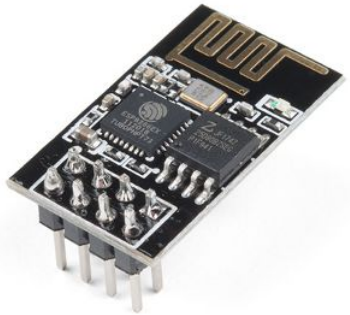
MPU-6050 3 Axis Gyro

Gyro Sensor SN-ENC03R0

Hardware Selection - Wireless transmission

	HC-05 Bluetooth Module	ESP8266 WiFi Module
Power Voltage	4V-6V	3V-3.6V
Current Consumption	30 mA	80 mA
Range	100 m	480 m
Support	USART & TTL	Wifi Direct &TCP/IP
Standards	IEEE 802.15.1	802.11 b/g/n
Clock Frequency support	2.4 GHz	Up to 80 MHz





Power Supply

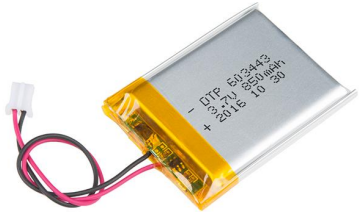
	On board lead acid 12V battery	Alkaline	Lithium Ion
Rechargable	yes	no	yes
Nominal Voltage (V)	2.1	1.5	3.2
Energy Density (Wh/kg)	30-40	85-190	1060
Amp Rating	48 Ah	3000 mAh	3200 mAh
Shelf LIfe (yrs)	1	5-10	2-3
Cost	low	low	low

Main Power

On board lead acid 12V battery

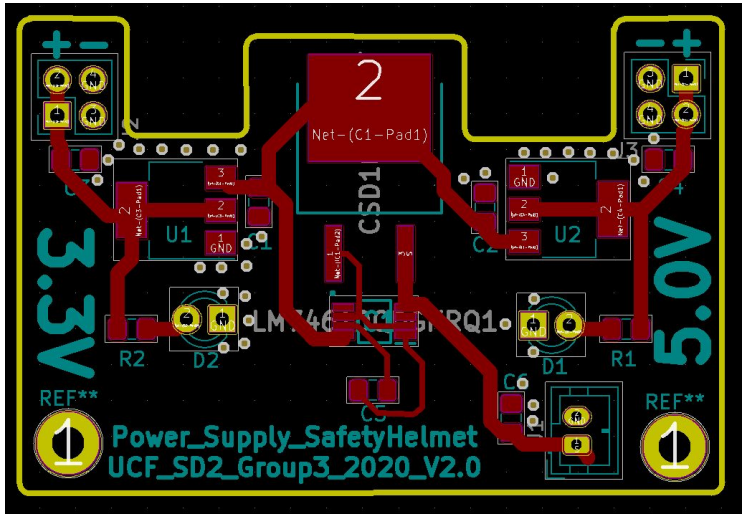
Secondary Power

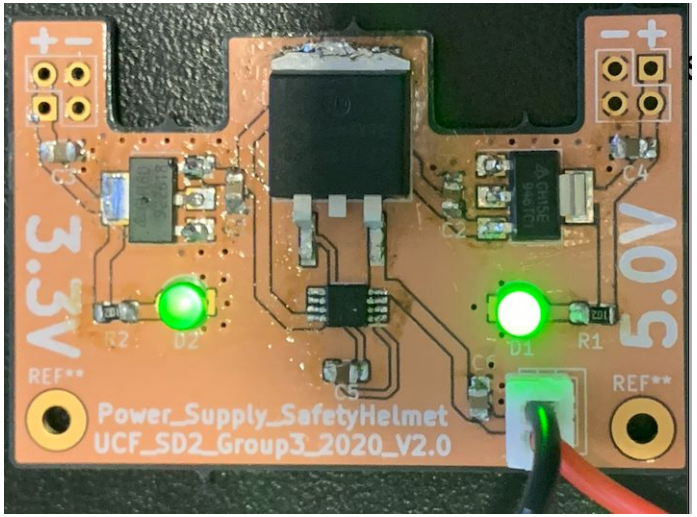
Alkaline



Lithium Ion

Fixed Linear Voltage Regulator Design





- All Safety Helmet components powered by either 3.3V or 5V supply.
- PCB created using KICAD software to ensure proper power.
- 3.3V and 5V **Diodes Incorporated** fixed linear regulators.
- **Texas Instrument** Smart Diode and N-Channel Power MOSFET for reverse polarity protection.

Microcontroller

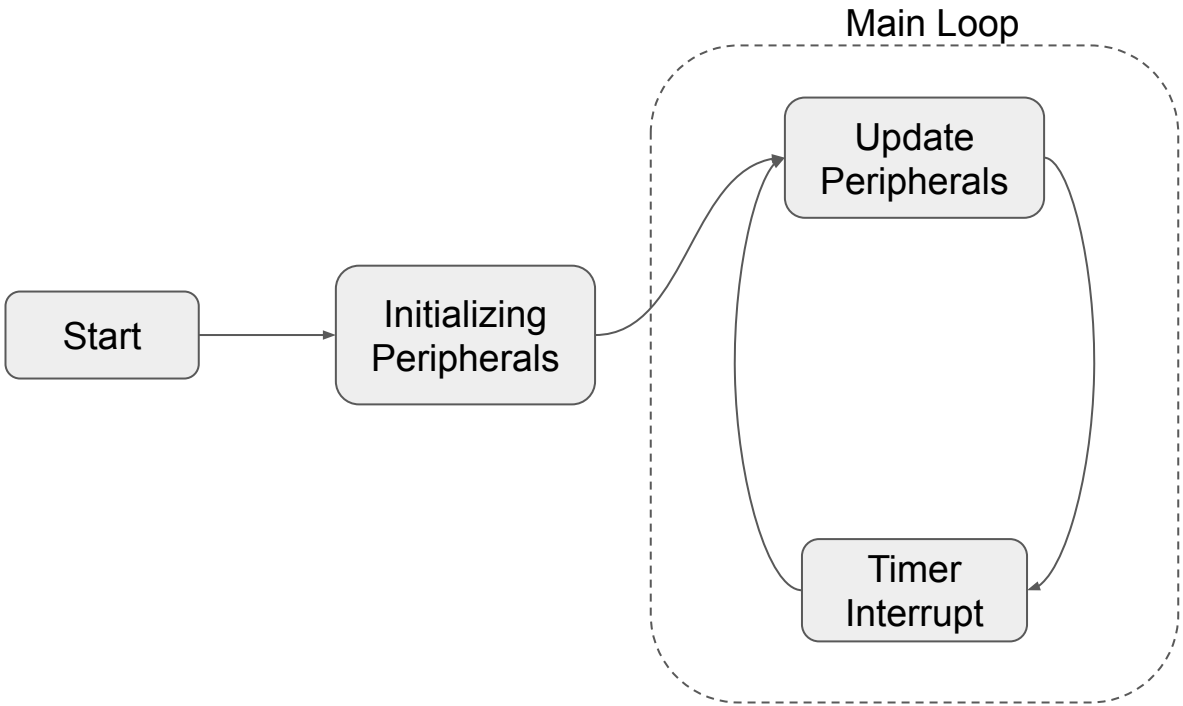
Microcontroller choices:

	STM32F102CB	ATSAMC20G17A	MSP430FR6989
Power Consumption	540mW	460mW	8mW
Memory Size	128KB	256KB	128KB
Cost	$4.70	$1.84	$8.60
Clock Frequency	48MHz	48MHz	16MHz
I/O Pins	51	84	100
Number of Timers	6	8	5
ADC Resolution	12-bit	16-bit	12-bit
Operating Voltage	2.0 to 3.6V	2.7 to 5.5V	1.8 to 3.6V
Number of Interrupts	16	16	16

Microcontroller Software

- Register level programming.
- Software interrupt for distance sensors, nearby vehicle detection.
- Timer interrupts to update information such as temperature and angle of inclination.
- Display important information on OLED inside the helmet.
- Communicate with mobile device via Bluetooth.

Microcontroller Software Flowchart



Microcontroller Peripherals

- 32KHz crystal oscillator for accurate timing procedures.
- Two LEDs for debugging and errors.
- JTAG programmer.
- Power switch and push buttons to interface with the settings.

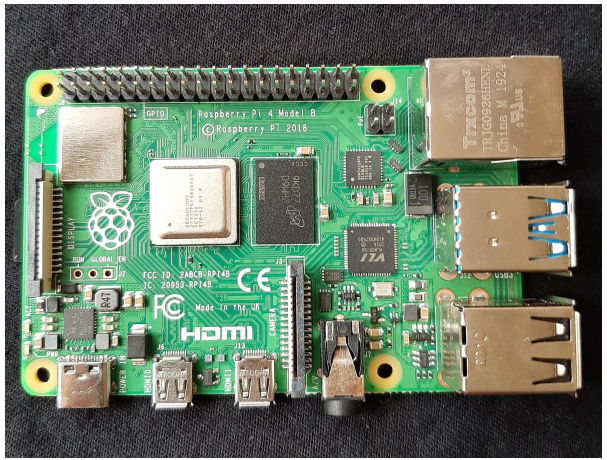
Drowsiness Detection Module

- Leverages computer vision to help user’s stay awake while on the road.
- Once the user is found to be falling asleep, the module will output an audio alert in an attempt to wake the user.
- This safety mechanism is in place to wake the users before they actually fall asleep.

Raspberry Pi 4

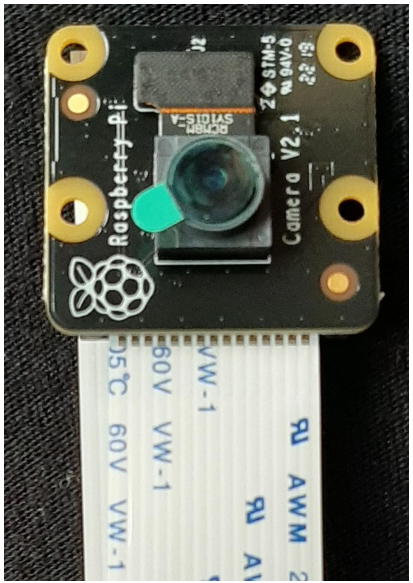
- Relatively inexpensive high performance single board computer.
- Raspbian OS includes many of the tools needed to rapidly develop for computer vision applications.

General Specifications
Quad core Cortex-A72 (ARM v8) 64-bit SoC @ ***1.5GHz***
2GB RAM
2-lane MIPI CSI camera port
5V DC via USB-C connector (minimum 3A*)

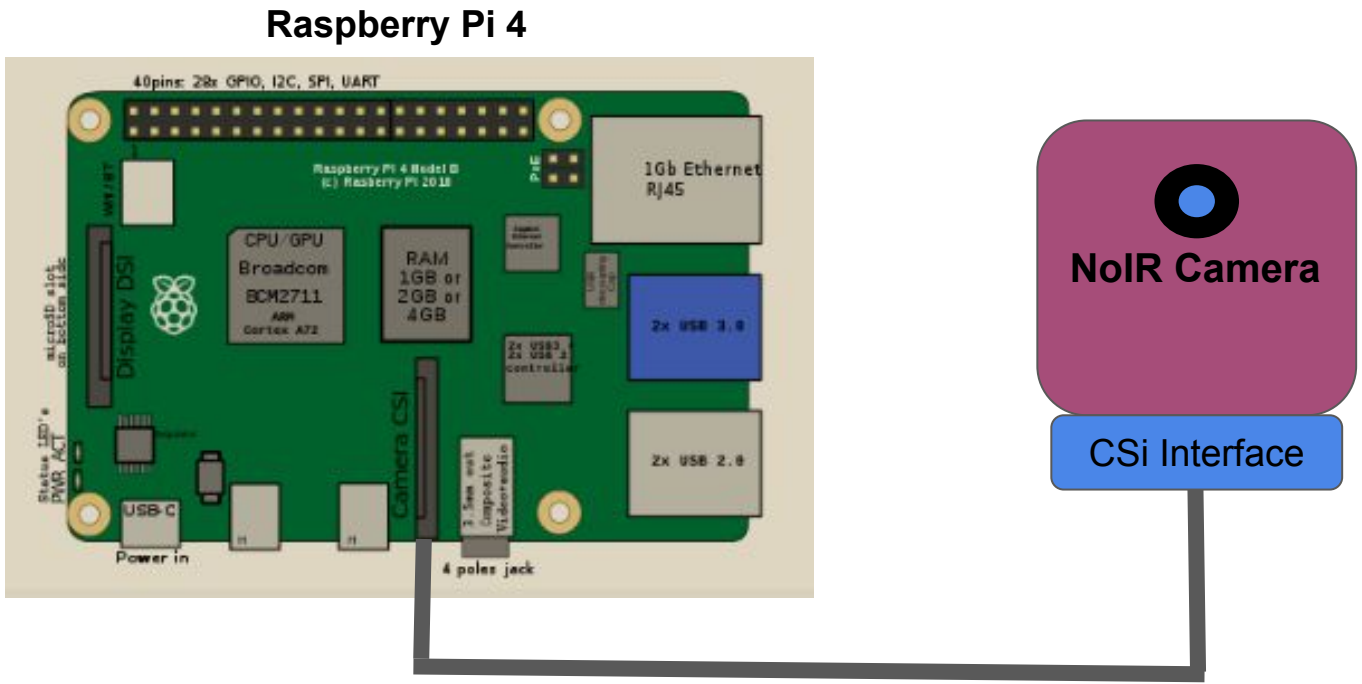


NoIR Camera

- Regular camera without Infrared filter
- 8-megapixel sensor
- Seamless integration with the Raspberry Pi through CSi
- Relatively small footprint (25mm x 23mm x 9mm)



Raspberry Pi4 + NoIR Camera

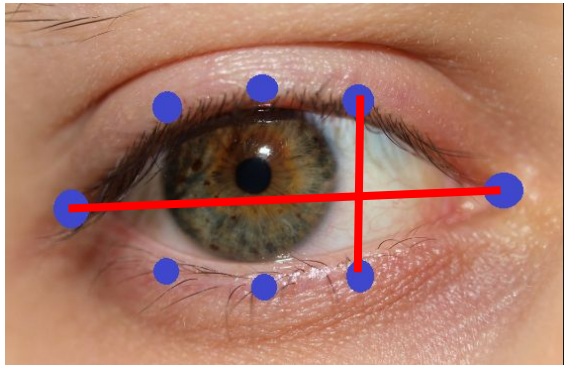


Face Alignment (Dlib)

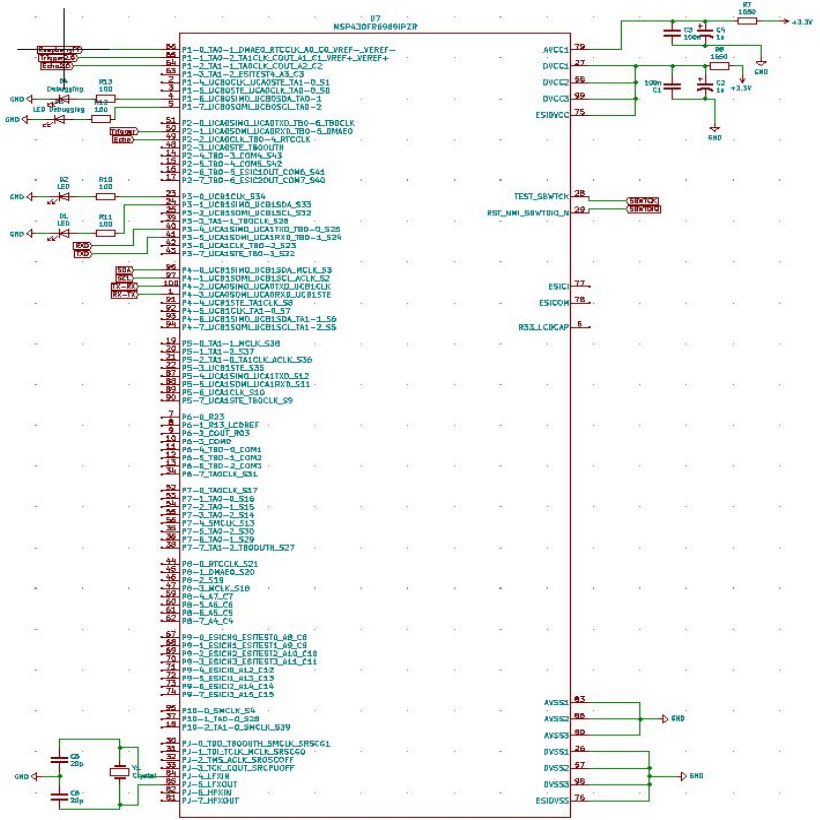
- Based on the research paper "*One millisecond face alignment with an ensemble of regression trees*" by **Vahid Kazemi** and **Josephine Sullivan**.
- Given an image of a face, align a number of points to the features of the face.
- Uses many images of labeled faces to estimate where the points should located.
- Points positions are optimized through a series of regression stages.
- Each regression stage is made up of "decision tree" like structures.

Eye Drowsiness Detection Algorithm

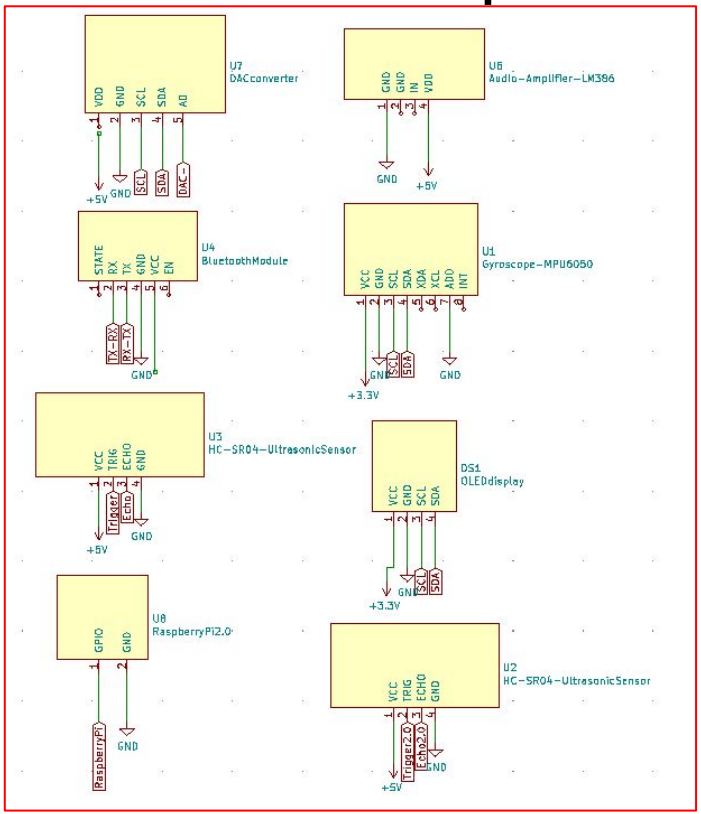
- Using Dlib facial landmark detector to extract the inner segments of the eyelids.
- Perform aspect ratio calculation on points.



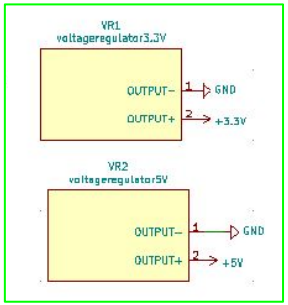
Schematic-MCU



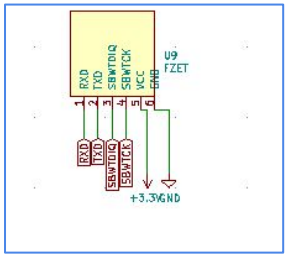
Schematic - Peripherals and Components



Peripherals

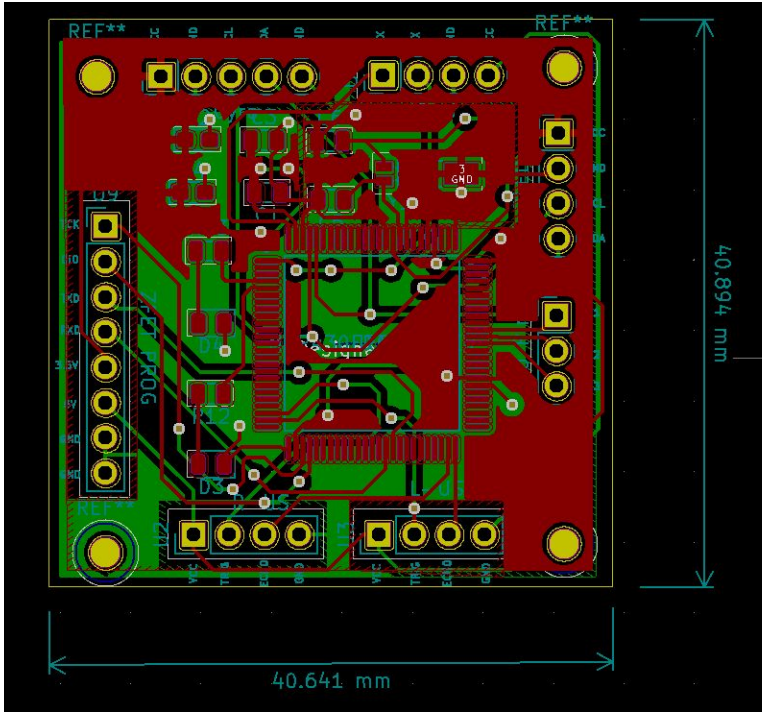


Power



Programing

PCB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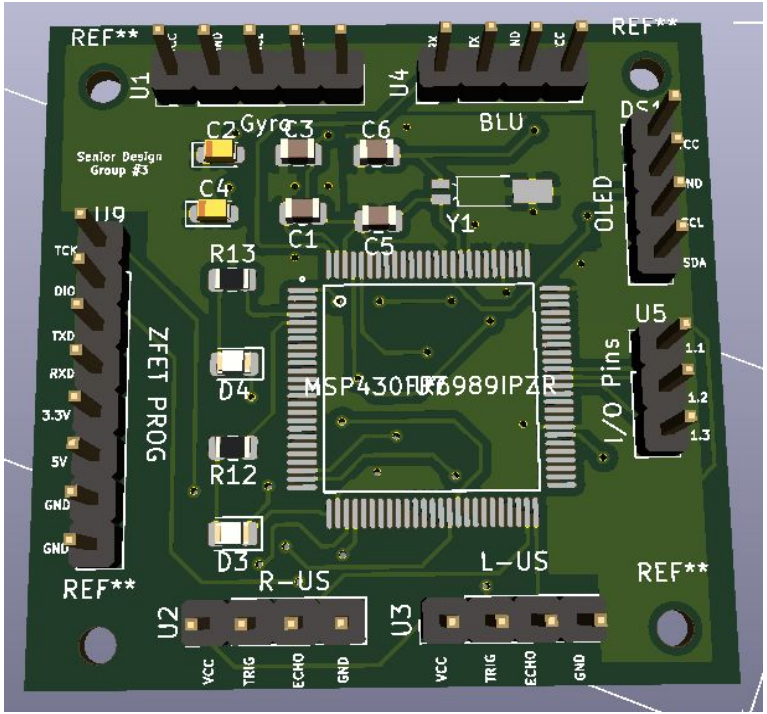
40.894 mm
40.641 mm


REF**
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U1
U4
Senior Design
Group #3
C2
Gyro
C3
C6
BLU
C4
C1
C5
Y1
OLED
J19
TCK
DIO
TXD
RXD
3.3V
5V
GND
GND
ZFET PROG
R13
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R12
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MSP430FR6989IPZR
U5
I/O Pins
1.1
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R-US
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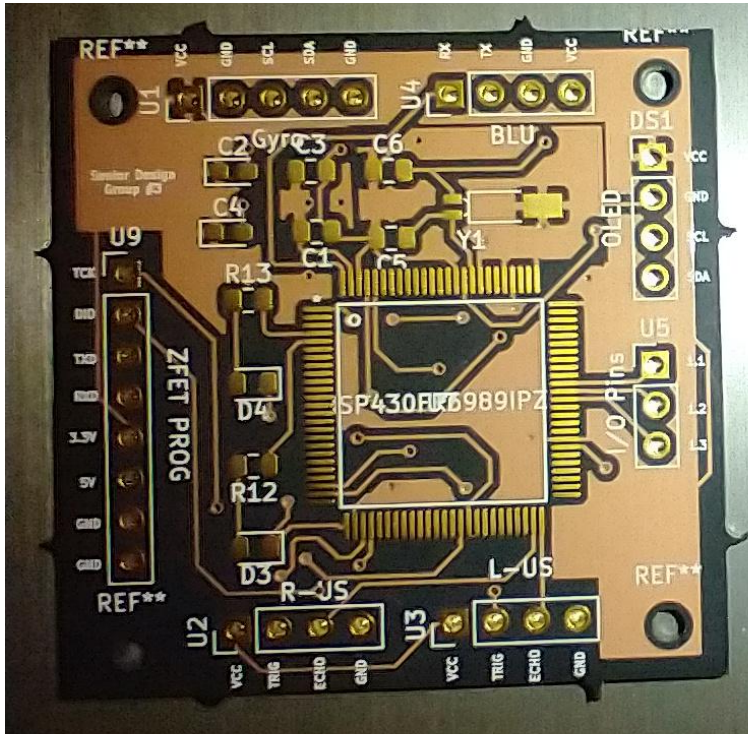
U2
U3
VCC
TRIG
ECHO
GND
VCC
TRIG
ECHO
GND

PCB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U4
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Gyro
C3
C6
BLU
DS1
OLED
C4
U9
Y1
C1
C5
R13
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I/O Pins
D4
MSP430FR6989IPZ
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U2
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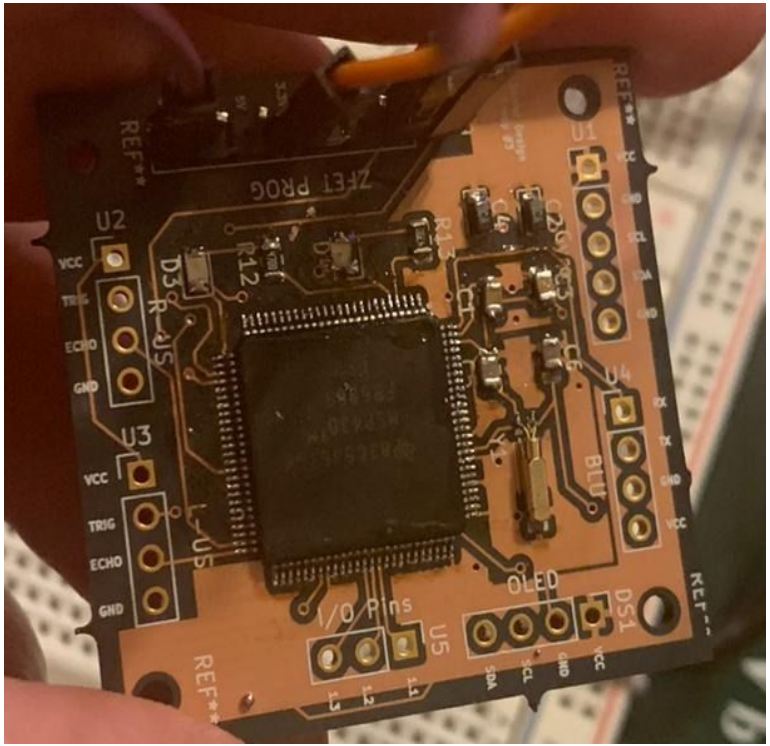
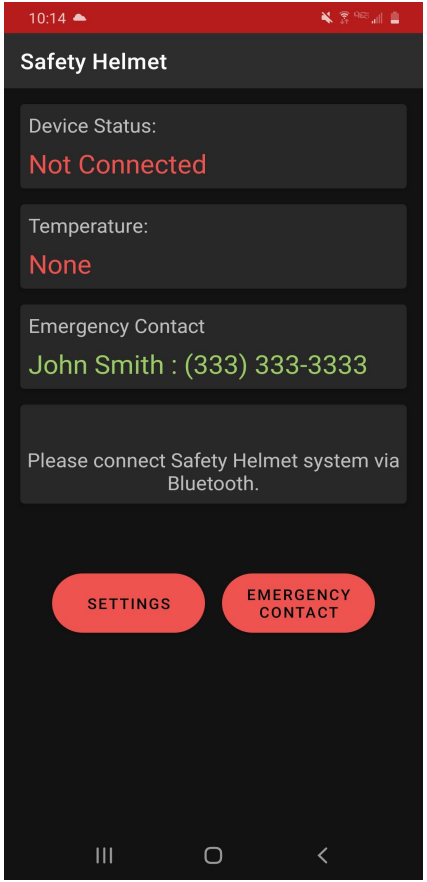
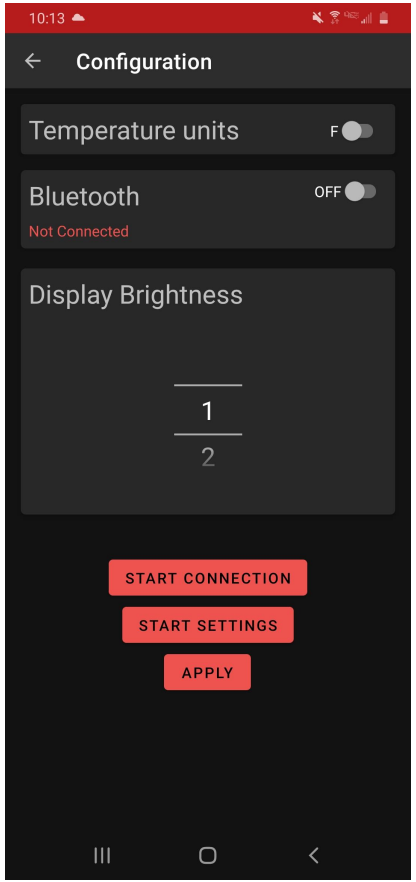

REF**
ZFET PROG
U2
D3
R-US
U3
L-US
BLU
OLED
I/O Pins
U5
DS1
VCC
TRIG
ECHO
GND

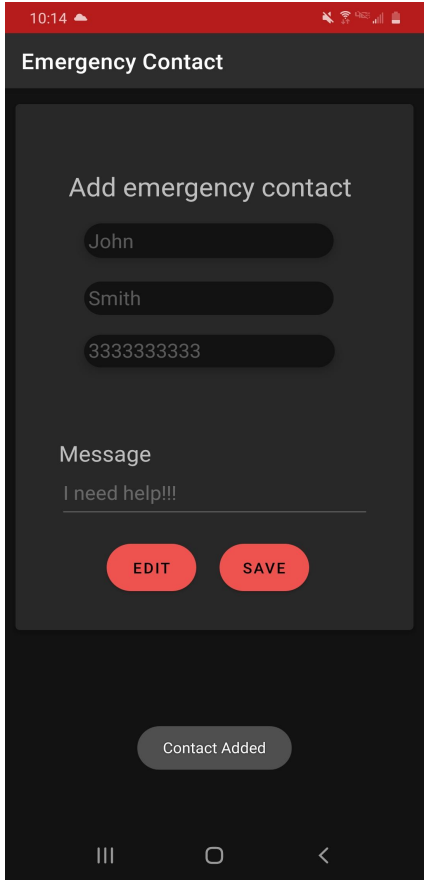
Mobile Application

The chosen mobile platform is Android.

- Programmed using android studio.
- Application main purpose is to send emergency message when needed.
- Extra features such as outside temperature from MCU sensors.
- User need to set up emergency contact ahead of time.


10:14
Safety Helmet
Device Status:
Not Connected
Temperature:
None
Emergency Contact
John Smith : (333) 333-3333
Please connect Safety Helmet system via Bluetooth.
SETTINGS
EMERGENCY CONTACT


10:13
Configuration
Temperature units
F
Bluetooth
OFF
Not Connected
Display Brightness
1
2
START CONNECTION
START SETTINGS
APPLY


10:14
Emergency Contact
Add emergency contact
John
Smith
3333333333
Message
I need help!!!
EDIT
SAVE
Contact Added

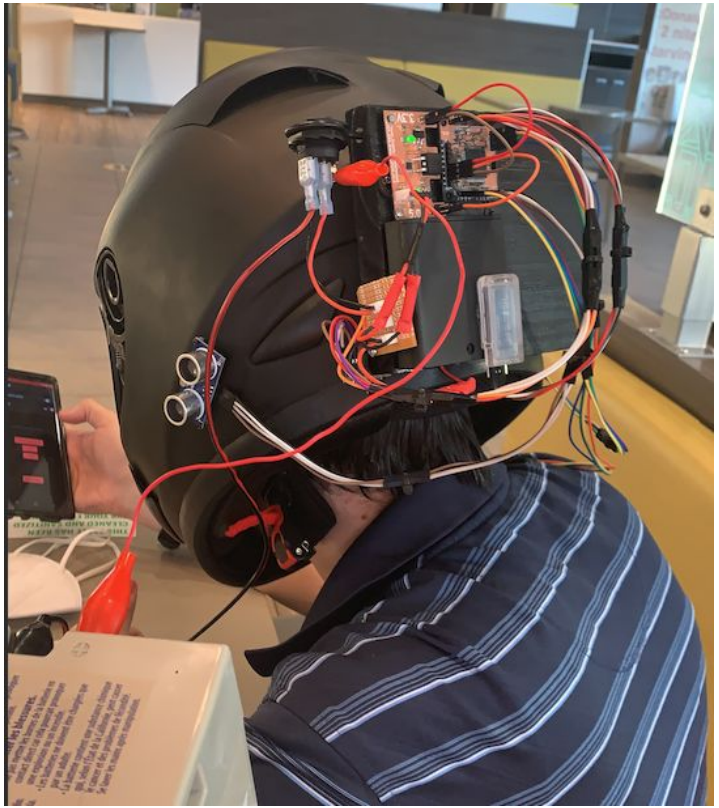
Mobile Application Interface to MCU

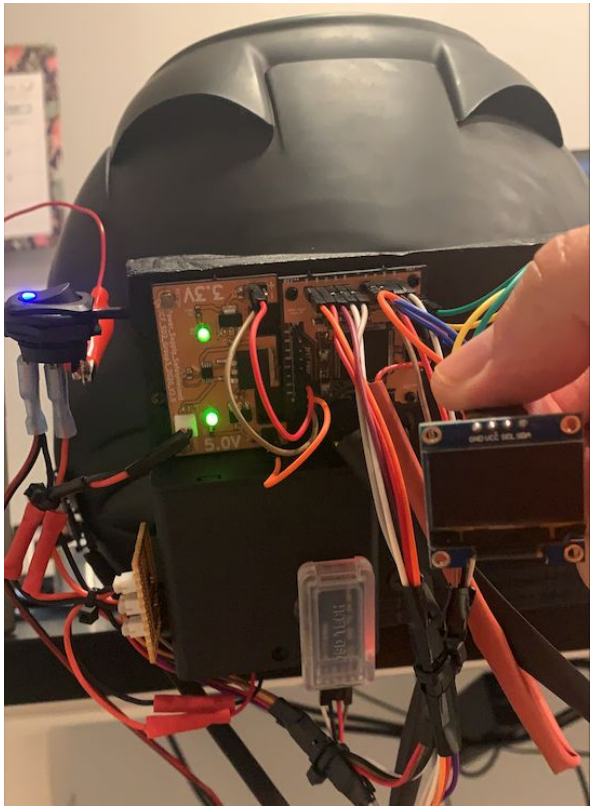
- Bluetooth will be used to interface the mobile application with the microcontroller on board the helmet

  Connection Steps:

  - User initiates a bluetooth connection through a switch on the configuration activity
  - Bluetooth capabilities are enabled
  - Discovery for bluetooth devices starts
  - Once Smart Helmet bluetooth module MAC address is found:
    - Mobile application authenticates itself to the bluetooth module and finishes the pairing process
    - Connection information is stored for automatic pairing

Placement of Components





Project Milestones

Milestones met for Senior Design II

System Integration and Development		
Develop and integrate power system	Mariela/Alex	100%
Finalize and order PCB	Mariela/Alex/Daniel	100%
Interface mobile application with MCU	Michael	100%
Interface sensors and display with MCU	Daniel	100%
Integrate image processing module + software	Michael	100%
Create mounting platform for system components	Team	100%
Integrate subsystems onto helmet	Team	100%
Integration testing	Team	100%

Project Budget

Parts	Quantity	Cost
MPU-6050 3 Axis Gyro	1	$13.65
HC-SR04 Ultrasonic Range Finder	2	$7.90
SSD1306 0.96 inch I2C OLED display	2	$8.00
Generic 3.5mm earbuds	1	$7.50
Motorcycle Full Face Helmet HJM A110 Matt Black	1	$50.00
Raspberry Pi 4 (2GB)	1	$41.80
MSP430FR6989	1	$4.47
Raspberry Pi NoIR Camera Module V2 - 8MP	1	$27.48
Misc Components: Cables, Jumpers, Enclosure	-	$44.50
PCBs (Power supply board & Main controller board)	2	$24.99
Total	12	$230.29

Category	Estimated	Actual (4/2/20)
Parts	$240.00	$185.79
Misc. Components	$60.00	$44.50
Software	$40.00	$0.00
Total	$300.00	$230.29

Questions