Safety Helmet
Group 3

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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 Projects

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

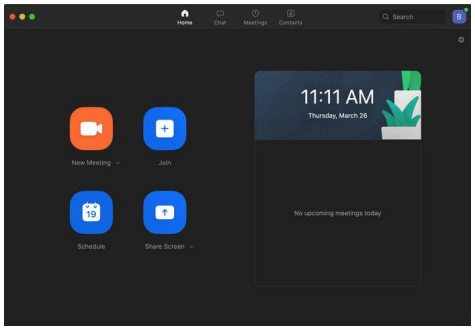
- Research, design, and build a state of the art safety helmet in a timely and efficient manner.
- Use a minimum amount of sensors to detect when objects come into close proximity and alert the driver via OLED display, sound, or led light when it occurs.
- Crash notification system using sensor in helmet 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.

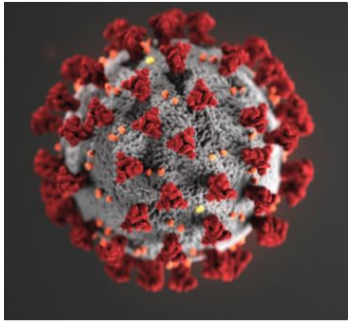
Specifications

- Simple enough for the average person to operate. Set up time should be less than 30 seconds.
- Communicate with mobile device app via bluetooth 4.0
- Helmet equipped with a 128x64 pixel OLED LCD display.
- Two ultrasonic sensors, one located on each side of the helmet to cover dead spots of up to 3 meters.
- 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 contact the phone I.C.E.
- Eye detection monitoring using a Pi NoIR camera powered by a Raspberry Pi.

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.





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

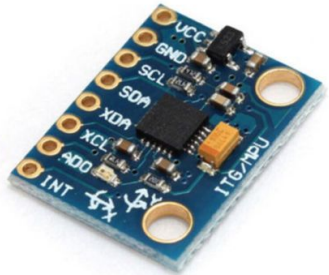
HRLV-Maxsonar-Ez

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 Power	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-Indicators

Display Selection-
SSD13060.96 Inch OLED Module

- Voltage 3.3V-5V
- Resolution: 128 x 64 pixels
- Uses the I2C interference
- Better quality, resolution, and picture compare to an LCD

Led Lights

- Will be used to alert motorcyclist about hazards in blind spots
- Used for debugging microcontroller on PCB

Hardware Selection-Speaker

- Generic 3.5mm earbuds will be used as speaker
- The MCP4725 12-bit DAC will be used to transmit the digital signal from MCU to analog
- The LM386 Audio Amplifier will be used to increase sound from headphones

3.5mm earbuds

- Cost: $5.00
- Power Rating:1W
- Cable Length: 3ft

MCP4725 12-bit DAC

- I2C interference
- Voltage: 3-5V
- Cost: $8.00 from Amazon

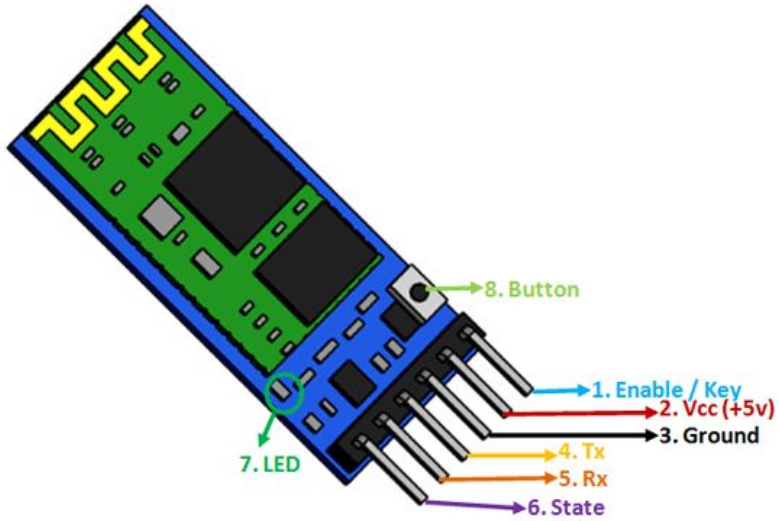
LM386 Audio Amplifier

- Voltage: 5V
- Amplification: gain 20
- Cost: 5PCS for $8.00 from Amazon

Hardware Selection - Wireless transmission

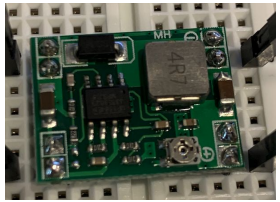
HC-05 Bluetooth Module

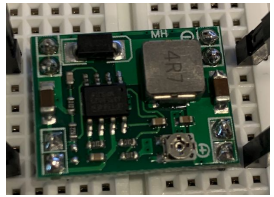
- Serial communication makes an easy way to interface with MCU.
- Bluetooth 4.0
- 2.45 GHz frequency band.
- Transfer rate of data 1 Mbps
- Maximum range 10 meters.



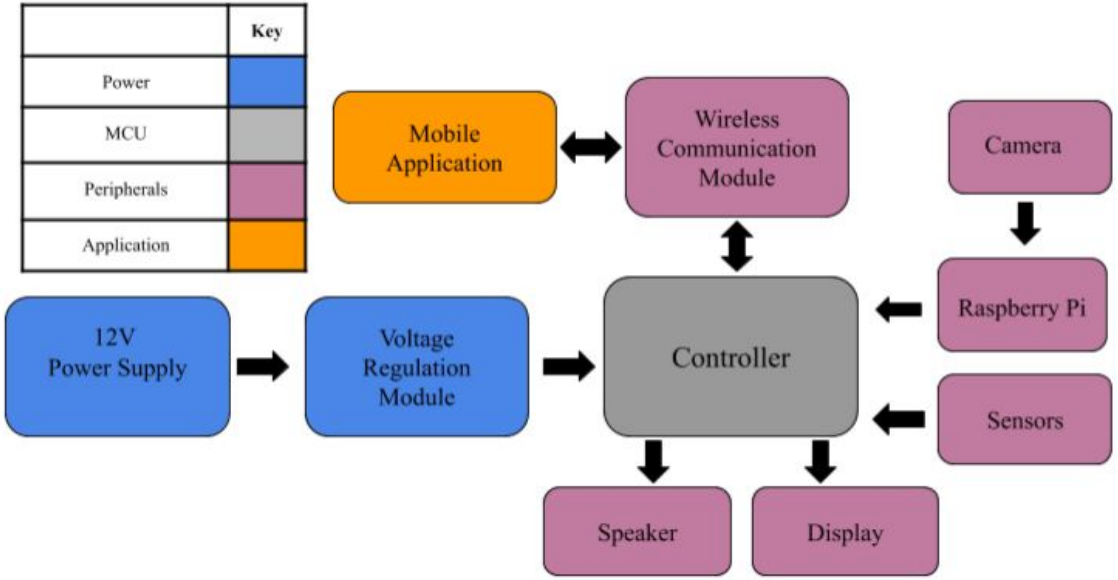
Power Supply

- The Safety helmet will be utilizing the motorcycles 12V battery as the power source.
- Two adjustable voltage regulator modules set at 5V and 3.3V will be controlling power to our PCB and components.





Block diagram



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.
- Software interrupt for sleep detection (from Raspberry Pi).
- Display important information on OLED inside the helmet.
- Communicate with mobile device via Bluetooth.
- Play sound via DAC and amplifier.

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.

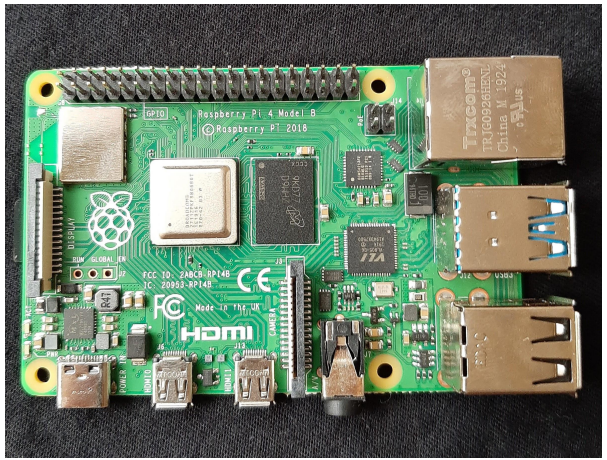
Eye Detection Module

- Leveraging computer vision to help user’s stay awake while on the road
- Subsystem will trigger the microcontroller to commence a waking procedure

Raspberry Pi 4

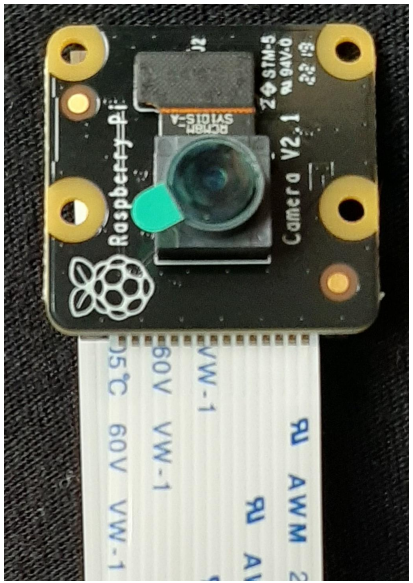
- Relatively inexpensive high performance single board computer.
- Raspbian OS includes many of the tools needed to rapidly develop for computer vision applications

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*)



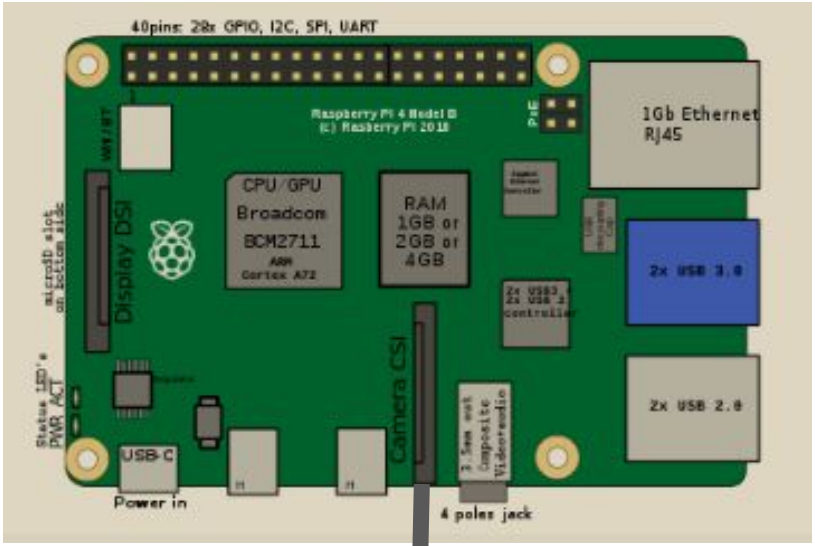
NoIR Camera

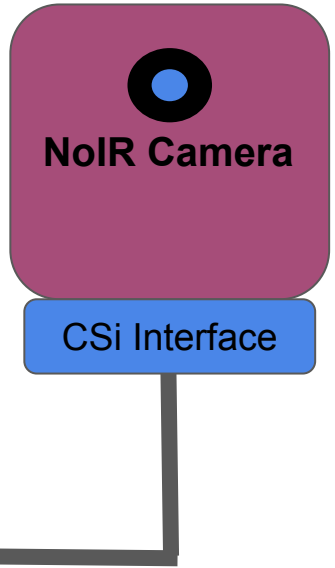
- Regular camera without Infrared filter
- 8-megapixel sensor
- Seamless integration with the Raspberry Pi through CSi
- Relatively small footprint (25mm x 23mm x 9mm)



Interface

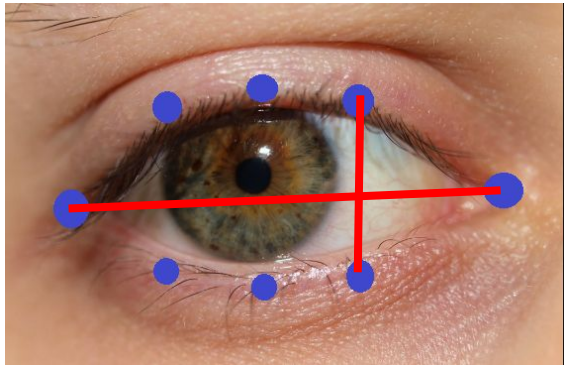
Raspberry Pi 4



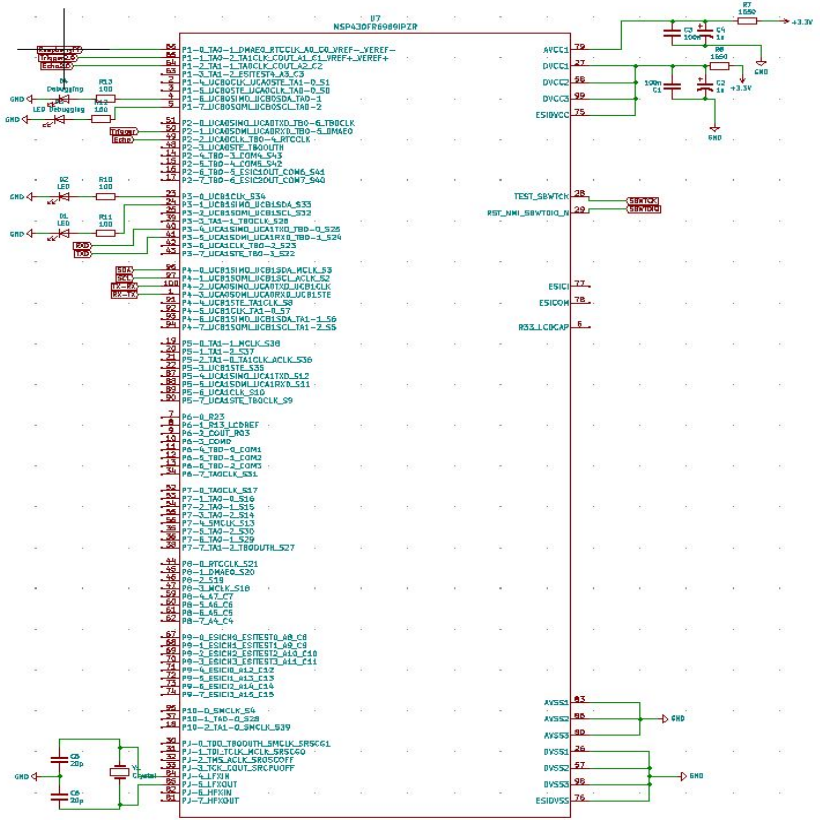


Eye Detection Algorithm

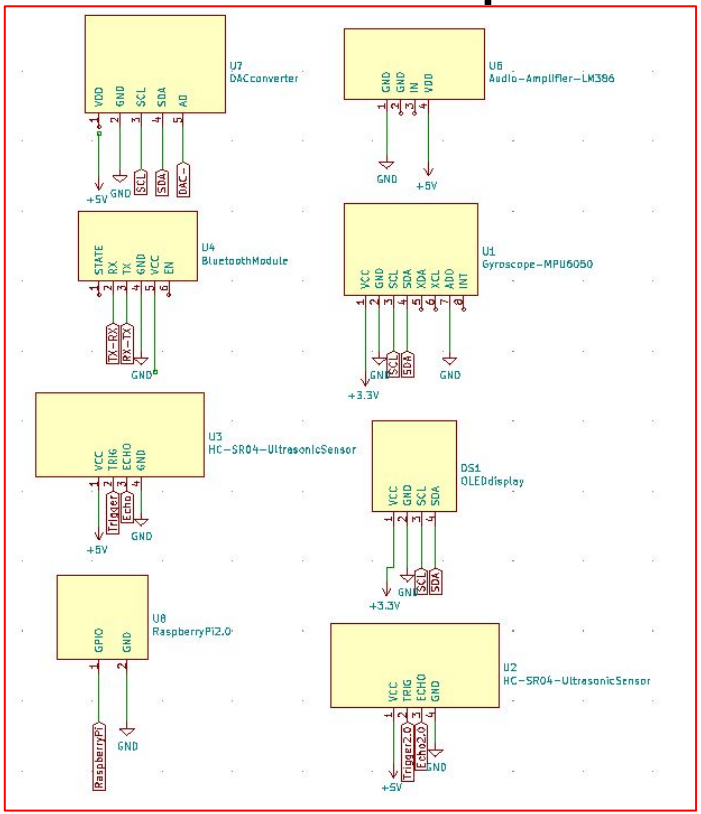
- Dlib (Open-source machine learning / image processing library)
- Using Dlib facial landmark detector to extract the inner segments of the eyelids.
- Perform aspect ratio calculation on points



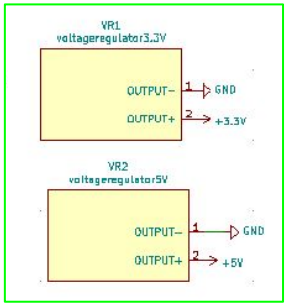
Schematic-MCU



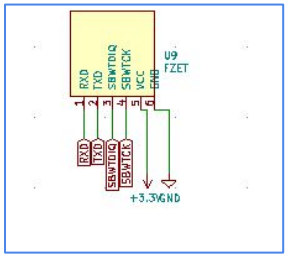
Schematic - Peripherals and Components



Peripherals

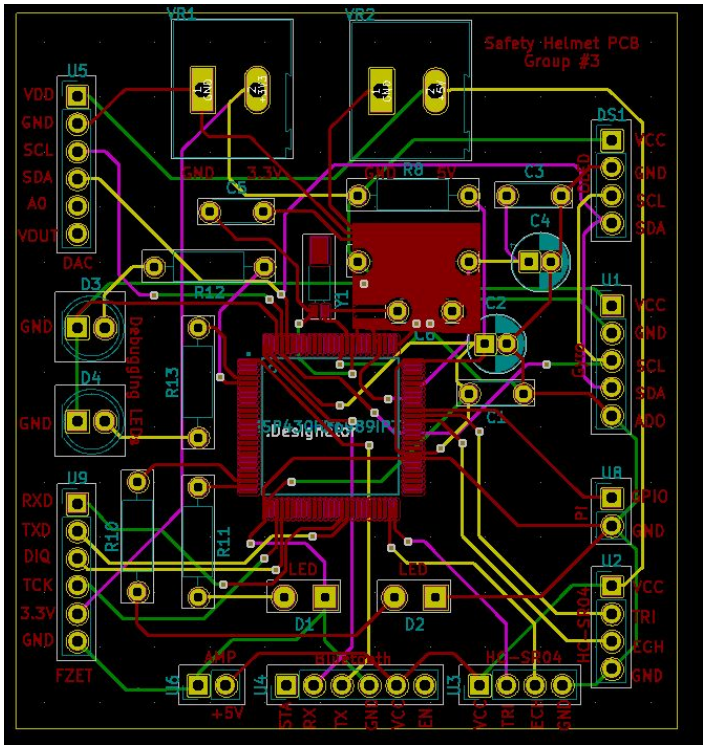


Power

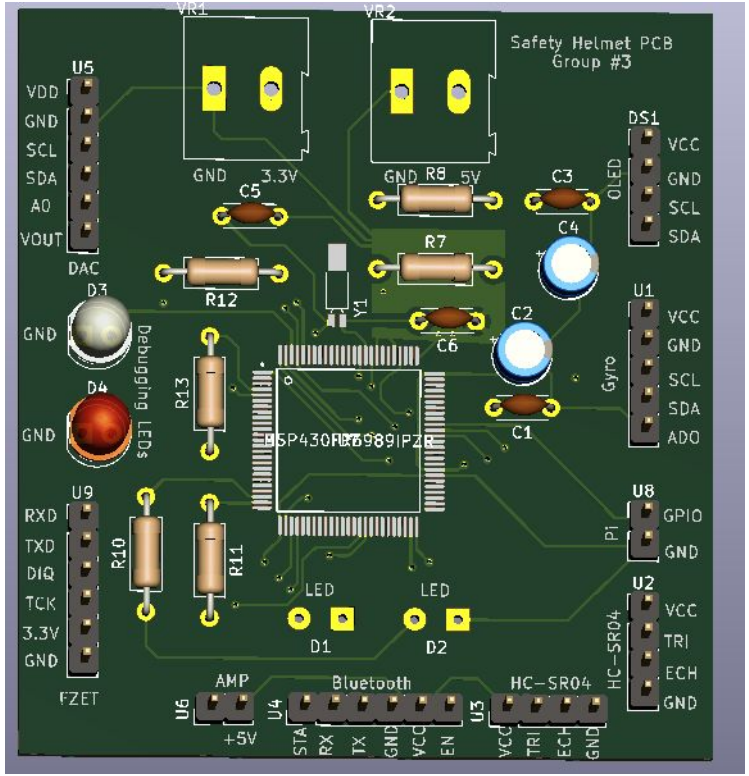


Programing

PCB


Safety Helmet PCB
Group #3
VR1
VR2
U5
VDD
GND
SCL
SDA
A0
VOUT
DAC
DS1
VCC
GND
SCL
SDA
U1
VCC
GND
SCL
SDA
ADO
D3
D4
GND
Debugging LED
R12
R13
R10
R11
C5
C6
C4
C2
C1
R8
Y1
U9
RXD
TXD
DIO
TCK
3.3V
GND
FZET
U8
GPIO
GND
U2
VCC
TRI
ECH
GND
D1
D2
LED
LED
U6
AMP
+5V
U4
U3
TX
RX
EN
VCC
GND

PCB- 3D Design

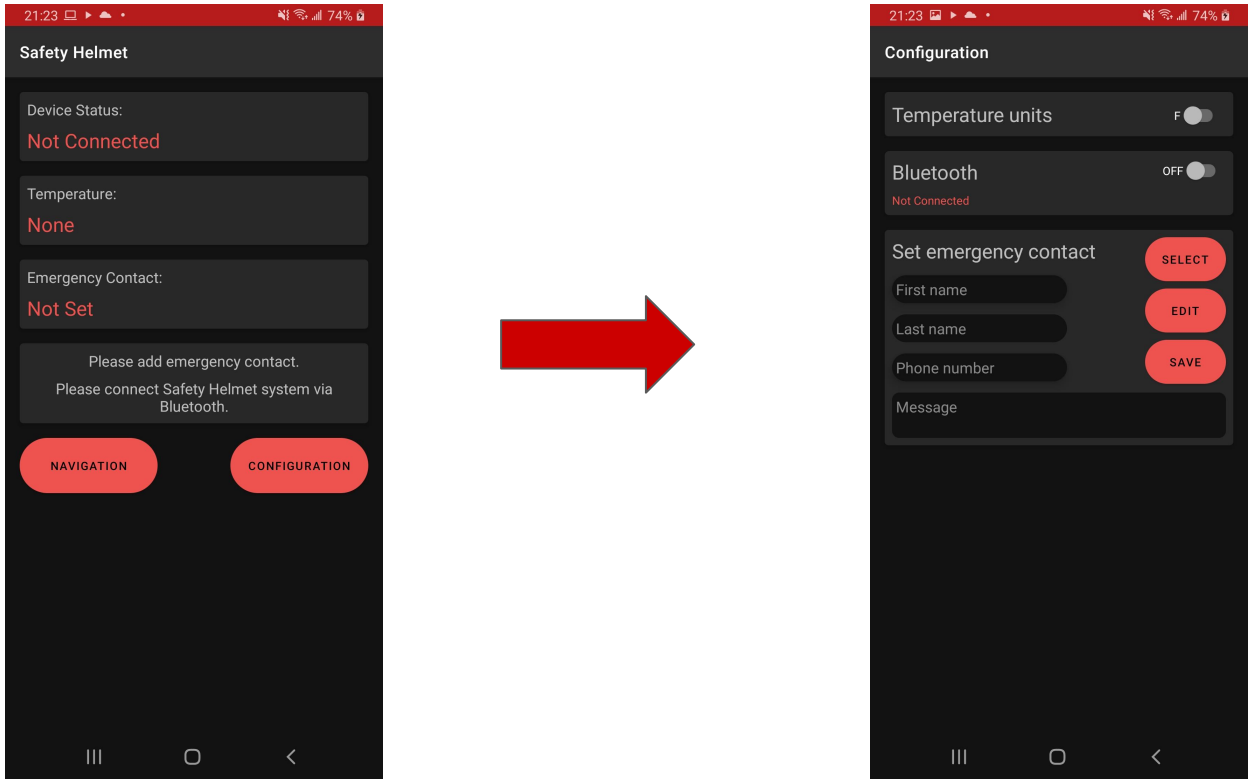


Mobile Application

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.
- Additional features under considerations: Navigation, Music through Bluetooth.

User-Interface



Communication Interface

- 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 pairs to the Smart Helmet
    - Connection information is stored for automatic pairing

Milestones

End of Senior Design 1

System Design		
Procure system components	Team	100%
Power supply design	Mariela/Alex	100%
PCB Design	Mariela/Alex	90%
Create electrical schematics	Mariela/Alex	100%
Design communication between sensors and MCU	Daniel	100%
Design Mobile App features and capabilites	Michael/Daniel	88%
Design Mobile App UI	Daniel	80%
Component Testing	Team	100%
Eye Detection algorithm research	Michael	100%

Senior Design 2

System Integration and Development		
Develop and integrate power system	Mariela/Alex	60%
Finalize and order PCB	Mariela/Alex	90%
Interface mobile application with MCU	Michael	75%
Interface sensors and display with MCU	Daniel	75%
Integrate image processing module + software	Michael	50%
Interface image processing module with MCU	Michael	20%
Grow enclosure for subsystems	Team	0%
Integrate subsystems onto helmet	Team	0%
Integration testing	Team	0%
Final presentation	Team	0%

Budget

Expense Breakdown

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
Total	10	$160.80

Overall Expense Breakdown

Category	Estimated	Actual
Parts	$240.00	$160.80
Misc. Components	$60.00	$0.00
Software	$40.00	$0.00
Total	$300.00	$160.80

Questions