Rear Collision Bicycle Warning System

Group 71
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Problem and Objectives

- The rate of automobile on bicycle related accidents has increased alarmingly over the past decade
- The goal of our project is to counteract this continued trend to increase cyclist safety
- Another goal of our project is to provide the cyclist with a sort of “black box” to prove their innocence in the case of an accident

Our Solution

- Our project is a rear collision bicycle warning system
- System combines proactive and reactive approach
  - Proactive: Warn the cyclist and driver to each other’s presence
  - Reactive: In the case of an accident, record relevant information for later use
- Aims to provide a quick response to the cyclist, while also limiting false positives

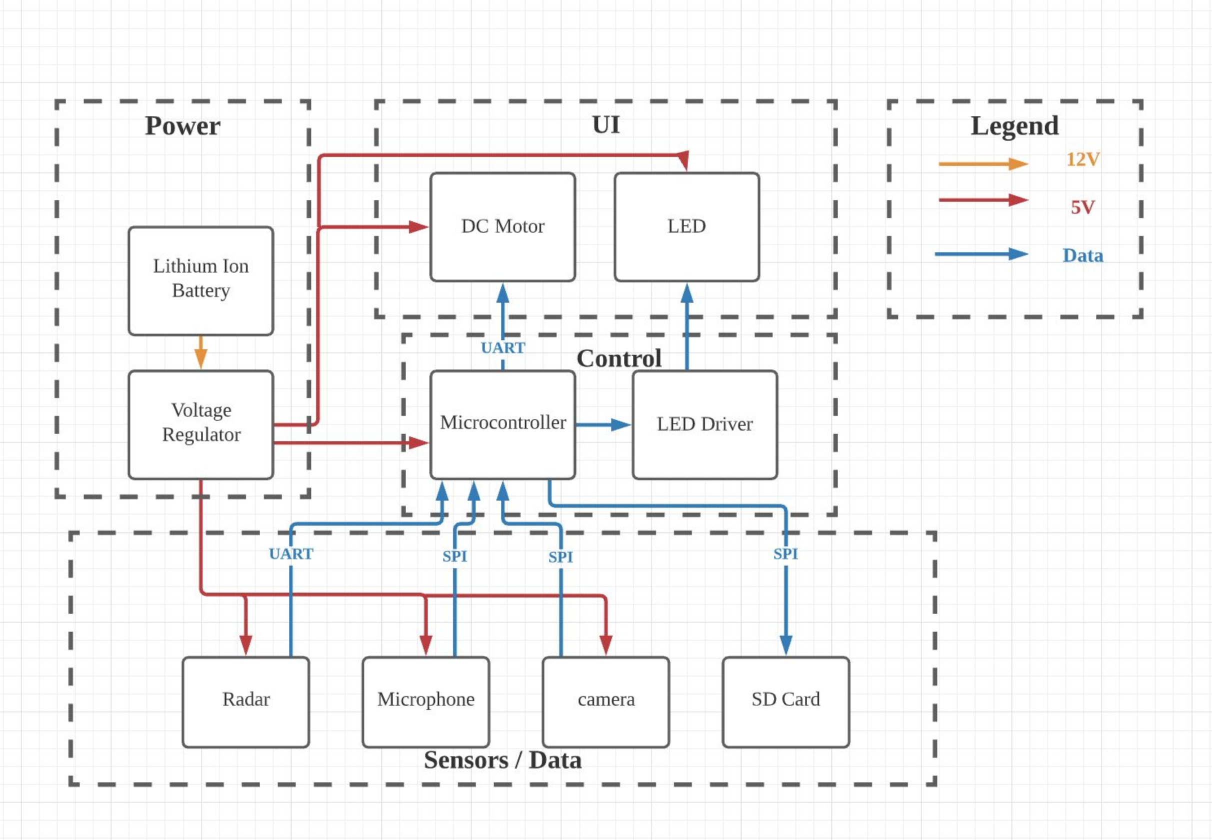
Overall Design 1

- The overall hardware component of our project consisted of six main devices:
    - Radar - Alert
    - Haptic Motor - Alert
    - LED - Alert
    - Camera - Data Collection
    - Microphone - Data Collection
    - SD Card - Data Collection
- The overall software component of our project was divided into two main areas:
    - Data Processing (Radar, Camera, Microphone)
    - Alert/Control Logic

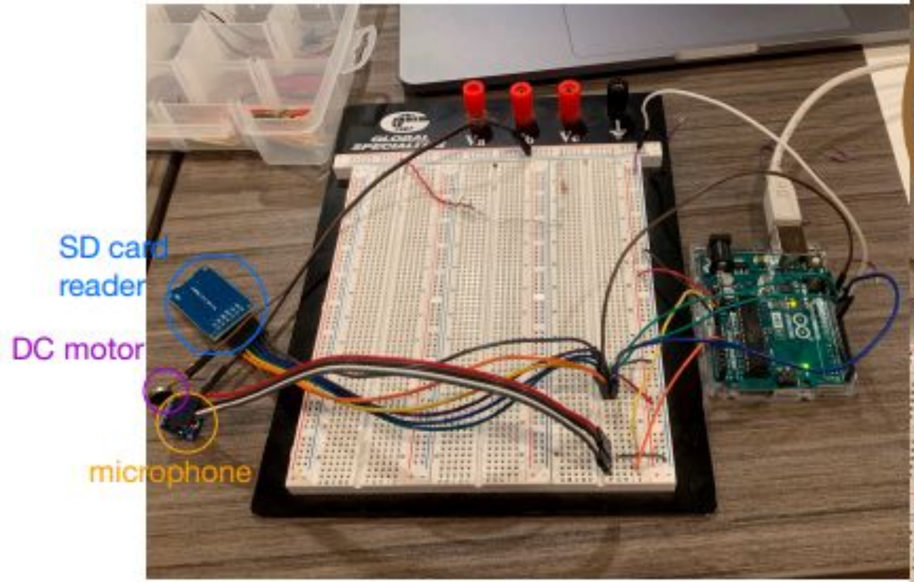
Overall Design 2

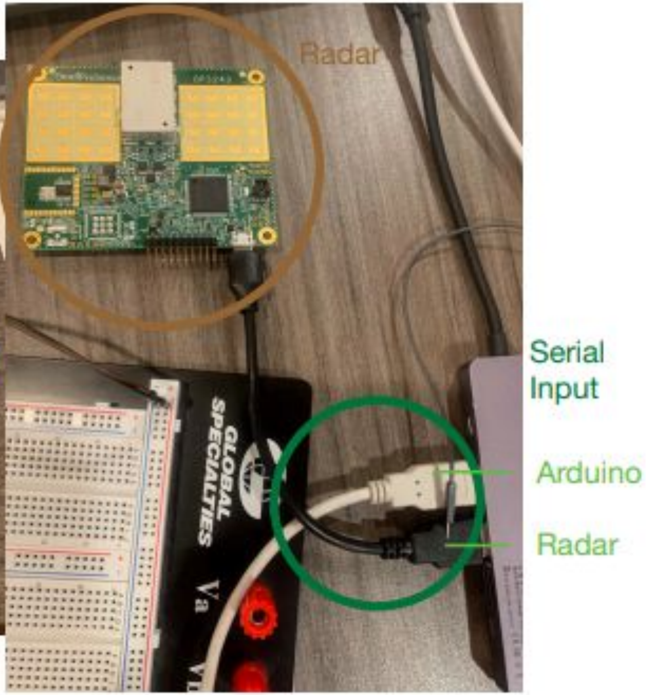
- The hardware devices and software components listed were used to achieve three main goals:
  - Detect objects approaching the device at a distance of ≤ 75m
  - In the case of an accident, save audio and video data
  - Maintain a response time between detection and alert of < 750ms
- Despite numerous complications, we were able to achieve the core components of each of these objectives

Block Diagram



Physical Project Build





Ethical Considerations

- Throughout design, implementation, and testing we had to consider several potential ethical complications:
  - Ensure the motor does not interfere with riding
  - Select an appropriate case so that the device is robust to outdoor conditions
  - Follow appropriate safety measures when working with the power supply and other electrical components
  - Practice safe testing procedures when verifying the radar component
  - Inform the user that no device can entirely replace their own caution
- These main principles especially informed our decisions during the testing phase of the device

Hardware Design

- The hardware consists of four main modules:
  - Power
  - Control
  - Sensors and Data
  - Alert Devices
- These modules correspond to the block diagram
- The specifications of each module that were outlined in the design phase were not all able to be completed, but we were able to complete the core components of each module

Power Supply

- Our power supply was made up of a dual output linear regulator, with an input of 7.2V and outputs at 5V and 3.3V
- We faced significant challenges with getting our power supply to work with the rest of the system
- Several approaches were taken in an attempt to get the power supply to function properly, but we were forced to move on

Tests and Results - Power Supply

- In testing our power supply functioned nominally, we were not able to test with components, only checking the output pins for correct output
- Given more time we would have liked to integrate the power supply into the overall system
- The power supply consumed a lot of time during the early stages of implementation

Microcontroller

- Initially we used one ATMega328p, but after ordering our camera we realized we needed more inputs so we attempted to use two ATMega328p’s one for the camera and one to receive inputs and send outputs from the other components
- This strategy ended up being very tricky to make work and ultimately we decided to not use the camera and instead use an Arduino UNO with 328p

Tests and Results - Microcontroller

- In testing we figured out that the ATMega processor could not clear the incoming data from the radar fast enough
- This meant that in order to process the data fast enough we needed a more powerful chip
- If we were to go back and redo this project we would choose a more powerful chip, such as raspberry pi
- This stage of implementation cost us a very significant amount of time and energy

Sensors and Data

- This module consisted of four main components:
  - Radar - Sensor
  - Microphone - Data Collection
  - Camera - Data Collection
  - SD Card - Data Storage/Retrieval
- The purpose of this module was to:
  - Collect and store data in the case of an accident
  - Sense if an object is approaching the device
  - Send appropriate signals to our alert devices upon detection of an object

Radar

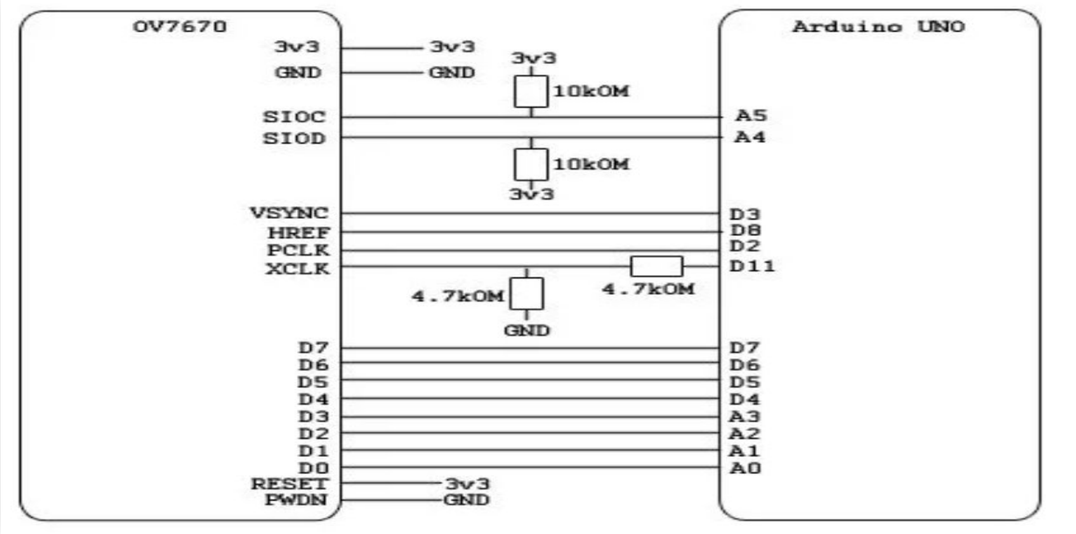
Requirements	Verification	Results
- Be able to detect objects at <= 75m - Be able to communicate object detection to microcontroller	Connect the radar(OPS243) to laptop and observe input. - Street - Human approaching	Detect distance upto about 100m Can be programmed using documented API. - Distance - Data format

Microphone

Requirements	Verification	Results
- Be able to detect sound (variance in voltages)	- Microphone module was connected to arduino to observe its voltage input on arduino serial monitor.	- Voltage input on serial monitor varied as we spoke to microphone.

Camera

Requirements	Verification	Results
- Be able to capture image	- Tested on arduino using below circuit diagram.	- Could capture images through camera. - However, camera module used up more pins than expected.



SD Card / SD Card Reader

Requirements	Verification	Results
- Be able to store data received from microcontroller to SD Card - Data can be retrieved from SD card using computer.	- Connect SD card reader to arduino and record microphone data to SD card through the reader.	- Voltage data collected through microphone was successfully recorded in SD card in txt format that can be retrieved and formatted.

Alert Devices

- For this module, we decided to utilize two devices:
  - LED - Alert drivers to the presence of cyclist in front of them
  - Haptic Motor - Alert cyclist to the presence of drivers approaching from behind
- The purpose of this module was to:
  - Establish a mechanism for communicating detection of a vehicle by the radar to telling the user that a vehicle is approaching
  - Provide a means of alerting drivers to the presence of cyclist as an alternate method of alert in order to increase safety and robustness of the system

Haptic Motor

Requirements	Verification	Results
- Vibrate with enough strength to alert the bike rider	- Supply power to the motor to test its strength manually.	- The size of haptic motor was smaller than expected. - Even though we had 4 of working motor, it was not enough to alert the rider through seat post on a moving bike.

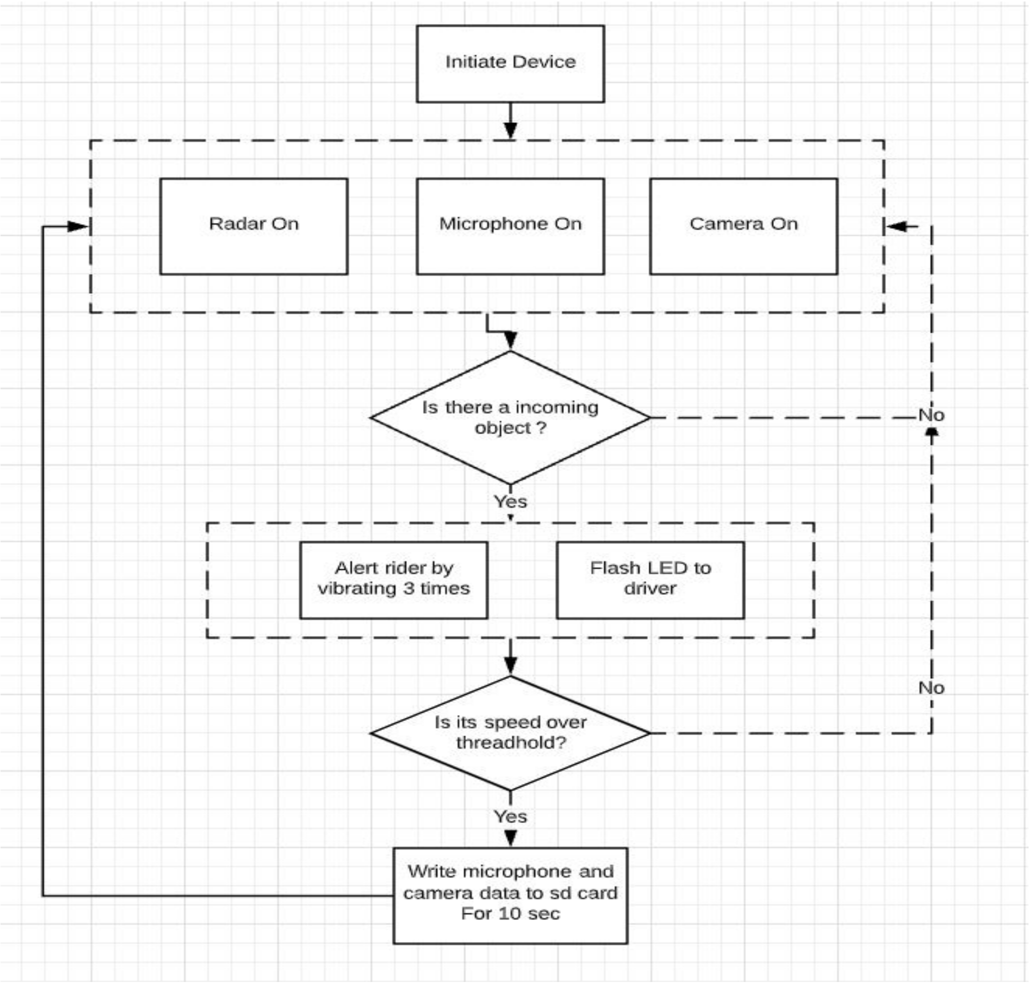
LED

Requirements	Verification	Results
- Bright enough to alert the driver at least 50m away	- Supply power to LED and manually check its visibility from 50m away	- The LED that we had ordered provided visibility only from 15m away.

Software Design

- The software design consisted of two main components:
  - Data Processing (Radar, Camera, Microphone)
  - Alert/Control Logic
- The main considerations for data processing were:
  - How to interpret and utilize radar data
  - How to store data recorded by camera/microphone to the SD card
- The main considerations for alert/control logic were:
  - Outputting an appropriate intensity factor to the alert devices
  - Triggering the alert devices at the correct moments

System Flow



Initiate Device
Radar On
Microphone On
Camera On
Is there a incoming object ?
No
Yes
Alert rider by vibrating 3 times
Flash LED to driver
No
Is its speed over threadhold?
Yes
Write microphone and camera data to sd card For 10 sec

Radar - Data Conversion and Intensity Mapping

```
radar_input_raw = radar.readline()
print(radar_input_raw)
radar_input_decoded=radar_input_raw.decode("utf-8")
print(radar_input_decoded)

state, value = radar_input_decoded.split(',')

state = state.strip('\"')
tmp = value
value = value.rstrip()
print("input",state,value)
print("current",cur_speed,cur_distance)
```

- Input: “[m/mps] + [distance/velocity]”
- Output: Intensity Range: (0 - 1)

- Intensity is calculated using the following formula:
  - (Max_Distance - Current_Distance) / Max_Distance + (Current_Speed / Max_Speed)
  - If object is out of range, return 0
- Intensity factor tells our haptic motor how much to vibrate

```
intensity = ((dist_max - float(cur_distance))/1000+float(cur_speed)/31)/2
```

- Note: We had to adjust some parameters for a smaller testing environment

Alert Triggers and Thresholds

- Use UART to communicate between radar and microcontroller/computer
- Send serial data from microcontroller/computer to arduino to trigger the alert devices/data recording devices
- We tested several thresholds in our smaller scaled down testing environment to simulate a vehicle approaching the device at a proportional distance/speed to that required by our high level goals

```
threshold=0.07
if intensity>= threshold:
    arduino.write(bytes('r','utf-8'))
    time.sleep(0.5)
    print('trigger')
```

```
currentTime=millis();
if ((currentTime-triggeredTime)< 10000){
  writeSD();
  digitalWrite(8,HIGH);
}else{
  digitalWrite(8,LOW);
}
```

```
if (Serial.available()>0){
  zing6();
  flsh();
  triggeredTime=millis();
}
```

```
int zing6(){
  for(int i=0;i< 2;i++){
    for(int j=0; j<6;j++){
      analogWrite(data_pin,255);
      delay(75);
      analogWrite(data_pin,0);
      delay(75);
    }
    delay(250);
  }
  return 0;
}

void flash(){
  digitalWrite(led,HIGH);
  delay(300);
  digitalWrite(led,LOW);

}
```

Data Storage and Retrieval

- The audio data is written to the SD card by the arduino (did not have time for video as discussed earlier)
- Data is retrievable from the SD card by the user as a .txt file
- Can use existing software to convert from .txt → .wav → .mp3 for final retrieval of the audio data
- Onboard conversion would be nice but increases the load of our limited computing resources

```
void writeSD(){
  String dataString = "";

  int sensor = analogRead(microphone_pin);
  dataString += String(sensor);
  Serial.println(dataString);
  File dataFile = SD.open("sound.txt", FILE_WRITE);

  // if the file is available, write to it:

  if (dataFile) {
    dataFile.println(dataString);
    dataFile.close();
  }
  // if the file isn't open, pop up an error:
  else {
    Serial.println("error opening datalog.txt");
  }
}
```

Overall Successes

- For the most part we were able to complete our high level goals but would have liked more time for testing:
  - Device is able to detect objects approaching or moving away at a given distance and speed threshold
  - Device can save audio data upon detection and data is retrievable by user (did not have time for camera)
  - Device response time between detection and alert triggers is almost instantaneous
- Although we had to scale down some of our alert thresholds for testing purposes, we were able to ensure the functionality of our overall system

Overall Challenges

- The main challenges we ran into had to do with our lack of experience with hardware coming into this class
- Faulty PCB designs cost us a significant amount of time and energy
- Interfacing between the hardware and software components of our project proved to be one of the biggest challenges throughout implementation
- Adapting tests and verification methods also proved to be a significant challenge during the final phases of implementation

Future Work

- Adapt the system to be entirely contained within the case we selected and mounted to a bicycle
- Develop a mobile application to communicate with a WiFi module on the radar in order to serve as an alternate means of alerting the cyclist
- Design our own radar module to reduce the overall cost of the system (note that the cost was mainly driven by the radar)

Conclusion

- Main takeaways:
  - Interfacing hardware and software devices presents many challenges
  - Glad to have completed the major goals of our project
  - Would have liked more time for integration and testing
- We are thankful for the opportunity to have taken this class and have learned a lot about the process of developing a product from design all the way to implementation

Thank You!

- We would like to thank our professors for making this course possible despite COVID restrictions
- We would also like to thank our TA Xihang Wu and the entire course staff for their guidance throughout the semester

Questions?