Rear Collision Bicycle Warning System

Jusin Davis, Gus Kroll, Seongwoo Kang
TA: Xihang Wu

1 Introduction

1.1 Objective

According to the Insurance Institute for Highway Safety (IIHS), 854 cyclists were killed and more than 47,000 cyclists were injured in motor vehicle crashes in 2018[1]. Since 2010, the number of cycling fatalities per year has increased by 38%[2]. It has also been shown that the likelihood of cyclists suffering a severe injury resulting from a motor vehicle accident is substantially higher with SUV’s and that the overall likelihood of a collision occurring is also significantly higher for hybrids and electric vehicles[1]. With an increasing number of SUVs on US roads and the growing adoption of electric vehicles, the number and severity of motor vehicle accidents involving cyclists is likely to increase in the short-term.

To counteract this expected rise in the number of accidents and fatalities in bicycle-motor vehicle collisions, we propose an affordable rear collision warning system for bicycles. This unit will be able to detect vehicles behind the cyclists and notify them of a vehicle's presence via an audible alert. It will also include an integrated tail light that will flash when it detects a vehicle in an attempt to alert the driver of the cyclist's presence on the road. It will also function as a sort of black box for the rider. The included camera will always be on and will be triggered to save data by a collision and/or when a vehicle is detected as being exceptionally close and moving quickly next to the bike. This system will allow the rider to focus on what is happening in front of them, giving them the peace of mind that our sensor will warn them about what is going on behind them.

1.2 Background

There are currently just a few bike dash cams and only a single rear collision warning product available on the market. No one has yet combined these two features into an all-in-one bike safety device. Garmin's product has a detection range of 150m and requires the use of your smartphone or external screen to give users notifications. This system is very expensive and also beyond the specification of what a more casual rider needs. Fly6's camera system is currently available for pre-order and costs $229, yet only has a 4 hour battery life.

In order to reduce the likelihood of an accident and catch aggressive drivers, integrating these two systems into a product that is more affordable, and easy to use along with a longer battery life should make this product more appealing to a wider group of riders. We propose to reduce the detecting range to 75m, with the assumption that riders will not be riding in areas where the maximum speed a car will be traveling is greater than 55mph. This will give a rider a minimum of 3 seconds notification that a vehicle is approaching from behind. Then in the event of a collision or fast-moving object near the cyclist, the built-in camera will save the preceding video/audio to be used as evidence after the fact.

1.3 Physical Design

Figure 1: Device Location

#1

All of our components except the external unit (vibrating motor) will be encased in a protective box and attached to the seat support to collect data.

#2

The vibrating motor will be attached to the bottom of the seat as an external unit and alerts the user of incoming vehicles/ objects. It's intensity will vary depending on the moving object's speed and distance from the user.

1.4 High-level requirements

- Accurately detect objects coming towards the unit at a distance of at least 75m, while maintaining a low false positive rate.
- Be able to trigger video and audio save based on extreme movement in the direction of the cyclist and/or upon detection of a collision.
- The unit should be small enough to be able to mount on the rear seat post of a bicycle.

2 Design

2.1 Block Diagram

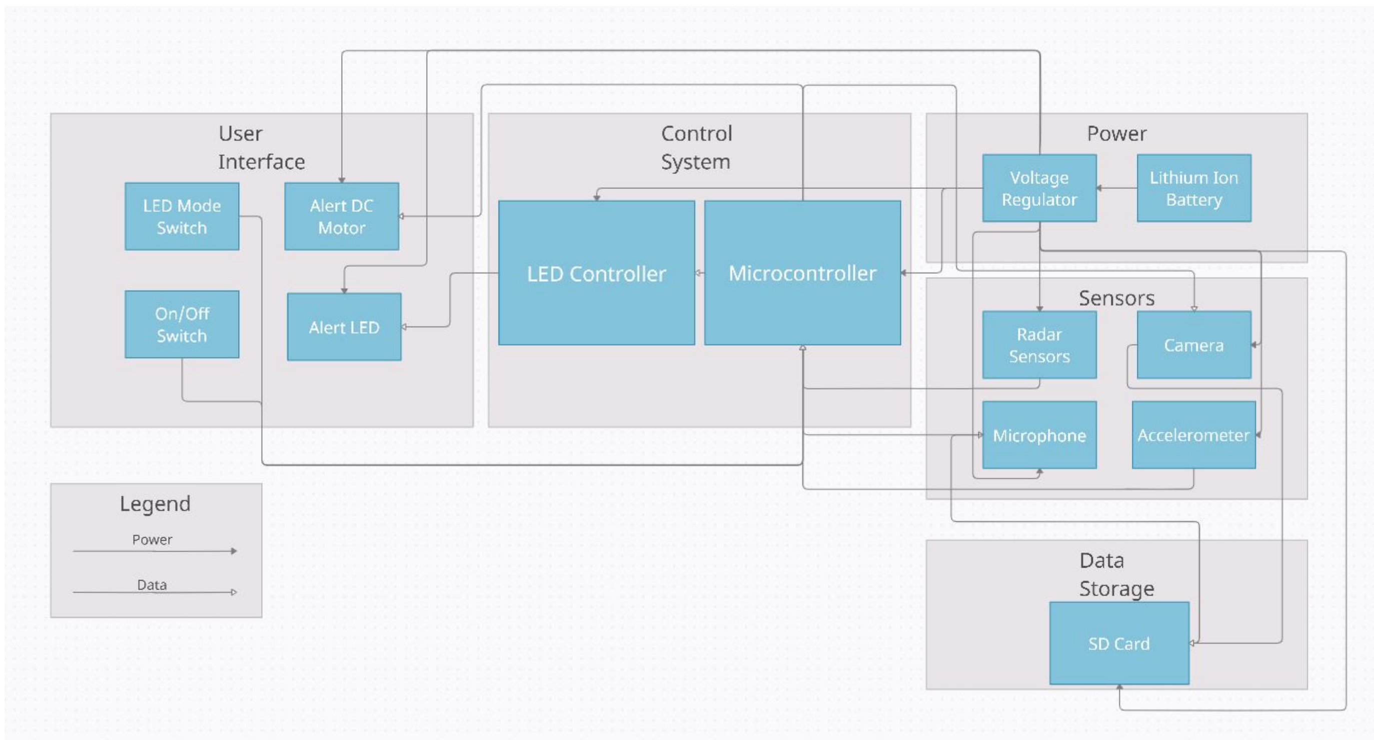

Figure 2: Block Diagram

2.2 Functional Overview

2.2.1 Power

This block is responsible for regulating and supplying power to all parts of our device. It will be supplied by a rechargeable battery that can charge via USB.

2.2.2 User Interface

The parts in this block will be how the user interacts with the device. Through the DC Motor the user will be notified of approaching vehicles via seat vibrations, with increasing intensity and frequency as the risk to the rider increases. The LED light will flash when cars are detected to identify the bike to drivers. The On/Off and Mode buttons will provide a robust, and simple way for the user to turn the device on and off, and switch between collision detection triggered video recording and always on recording. This will provide the user the option to determine the device functionality that best suits their needs. Lastly, the Micro SD Card will provide the user with an easy way to record and transfer data from the unit.

2.2.3 Control System

The microcontroller will process all incoming data from the radar sensors and then send out the appropriate signals to the User Interface. This includes flashing the LED light at detected vehicles, triggering the auto save of video/audio in the event of a collision, and sending notification of approaching vehicles to the rider via the seat vibration unit.

2.2.4 Sensors

This block will be responsible for reading the environment behind the cyclist and detecting collisions. The radar will detect approaching vehicles, the camera will record what is happening behind the cyclist and the microphone will capture the accompanying audio. Lastly, the accelerometer will detect collisions in order to trigger the auto save feature, if the user is not in the always recording mode.

2.2.5 Data Storage

This block is responsible for storing image/sound data recorded by camera and microphone. The data stored here will be retrievable by the user in the case of a crash or other traffic incident.

2.3 Block Requirements

2.3.1 Battery

For easily accessible and rechargeable battery, lithium ion battery will be used to supply power to all components in the system. Battery needs to supply voltage up to 6 hrs with LED on.

2.3.2 Voltage Regulator

As time passes, voltage supplied can drop easily. Voltage regulator needs to maintain the output voltage from the battery at a steady rate of 5V.

2.3.3 LED Controller

The LED controller must be able to communicate with the LEDs to set the proper mode for the LEDs as dictated by the LED mode switch. This controller must also be able to communicate with the LEDs to trigger them if a vehicle is detected when the LED mode switch is set to the flash upon detection mode. Finally, the LED controller must be programmed to receive relevant information about the mode of the LEDs from the microcontroller.

2.3.4 Microcontroller

The microcontroller must be able to read input data from the radar sensors and accelerometer and be programmed to analyse input data and control the DC motor, camera, microphone, and LED accordingly. The microcontroller must also be able to read data from the two different mode switches in the UI module. The LED mode switch will switch the mode of the LED and the on/off switch will set the LED to be on or off and reset the mode previously set by the LED mode switch. The microcontroller must be able to detect changes in these switches so that it can control the other devices in our system accordingly.

2.3.5 LED Mode Switch

This button will allow the user to switch the modes that LED is in (Always On, Flashing, Flash upon detection). (No quantitative measure) Must be able to send mode information to the microcontroller to change the behavior of the LED.

2.3.6 On/Off Switch

This button will allow the user to turn on/off LED attached to the device to save power by turning it off during daytime when riders are easily visible. (No quantitative measure) Must be able to send on/off information to the microcontroller to turn the LED off and reset the mode of the LED dictated by the LED mode switch.

2.3.7 Alert DC Motor

DC motor should be firmly and stably mountable on the bottom of the seat, or it would not be efficient in alerting the rider in a constantly moving bike. It should be able to take up to 12V input.

2.3.8 Alert LED

Alert LED should be clearly visible from 75m away from the rider. The LED must be triggered when vehicles are detected by the sensor unit and the LED mode is set to flash upon detection. The purpose of this device is to alert the user, pedestrians, drivers, and other cyclists in the proximity of the user.

2.3.9 Radar Sensors

Must be able to detect vehicles, pedestrians, and other cyclists up to 75m away to give ample time for the user to respond to alerts triggered by these sensors. Must be able to send data to the microcontroller in order to alert the user.

2.3.10 Camera

The camera must be able to be triggered by the control unit when a crash or other traffic incident is detected by the radar sensors and accelerometer. The camera must then save video data to the SD card from 30 seconds prior to the beginning of the incident and 30 seconds after the beginning of the incident.

2.3.11 Microphone

The microphone must be able to be triggered by the control unit when a crash or other traffic incident is detected by the radar sensors and accelerometer. The microphone must then save audio data to the SD card from 30 seconds prior to the beginning of the incident and 30 seconds after the beginning of the incident.

2.3.12 Accelerometer

The accelerometer needs to be able to detect significant changes in the movement of the bicycle to be able to determine if a collision or other traffic incident has occurred. The accelerometer must then communicate this to the microcontroller so that relevant information can be saved by other sensors.

2.3.13 Micro SD Card

Must be at least 64gb to prevent having to format it too frequently. Must be able to store audio and camera data recorded by the microphone and camera sensors.

2.4 Risk Analysis

The most difficult part of the project will be accurately detecting objects that are approaching the cyclist via the radar sensors. In busier areas there will be more moving objects and thus more data being taken in by the sensors. Therefore it is critical that our software is able to accurately filter out these false positives at a high rate, and only send alerts to the rider when a dangerous vehicle is detected (i.e. moving at a high-rate of speed towards the cyclist). If we are unable to send accurate alerts with a minimal false positive rate, then the unit will not be useful to riders.

3 Ethics and Safety

Our device makes use of a haptic motor attached to the bottom of the bike seat to alert the user of incoming vehicles/objects. If the motor runs too robust, it will interfere with riding rather than serving as a warning mechanism, so the power of vibration must be moderated carefully.

Our device will be used outdoors attached to a moving bike, so it will have to sustain a small amount of dust and water along with impact in case of collision. Thus, the device will be encased in a protective box with circuit being IP54 [3].

Even though our device alerts the user of potential danger around them, it is still their responsibility to constantly monitor their surroundings since there is always a possibility for malfunction in the device. However, being accustomed to the functionality of the device, users can often forget to do so. It is our responsibility to ensure their safety from accidents that can possibly be caused by the device, which is inline with Code of Ethics I.1 “To accept responsibility…”[4]. We will strive to accomplish this by emphasizing safety procedures in using the device and reminding the user that no device can replace the users’ carefulness.

References

[1] "Pedestrians and Bicyclists." *IIHS-HLDI Crash Testing and Highway Safety*, 2020, www.iihs.org/topics/pedestrians-and-bicyclists.

[2] "Fatality Facts 2018: Bicyclists." *IIHS-HLDI Crash Testing and Highway Safety*, 2020, www.iihs.org/topics/fatality-statistics/detail/bicyclists.

[3] "IP Rating Chart." *DSMT.Com*, 23 Feb. 2019, www.dsmt.com/resources/ip-rating-chart.

[4] "IEEE Code of Ethics." *IEEE Code of Ethics*, 2020, www.ieee.org/about/corporate/governance/p7-8.html.

[5] Chen, Yuqing, et al. "A Review of Lithium-Ion Battery Safety Concerns: The Issues, Strategies, and Testing Standards." *Journal of Energy Chemistry*, vol. 59, 2021, pp. 83–99. *Crossref*, doi:10.1016/j.jechem.2020.10.017.

[6] Hawkins, Andrew. "Superstrata Unveils 'World's First' 3D-Printed Unibody Electric Bike." *The Verge*, 13 July 2020, www.theverge.com/21318648/superstrata-3d-printed-electric-bike-arevo-price-specs.