Aftermarket Hazard Detection for Cyclists

ECE 445 Project Proposal - Fall 2023

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1 Introduction

1.1 Problem

According to a study from the U.S. Department of Transportation, only 17 percent of personal vehicles have blind spot technology as a standard feature and 57 percent have it as an upgrade option [1]. The number of personal vehicles equipped with the capabilities are on the rise, preventing an estimated 50,000 accidents [2]; the same can't be said for cyclists. As urban cyclists, we've experienced situations where hazard detection could have prevented close encounters, especially on campus.

Collision detection technology is the cycling industry that severely lags behind that of the automotive industry. Currently, Garmin dominates the cyclist market for blind spot and hazard detection technology. We believe that market competition is essential to avoid monopolization and to protect consumers. Therefore, we advocate for the development of more products in this field to ensure cyclist safety, enforce market fairness, and drive innovation.

1.2 Solution

To address this problem, we are proposing to develop and implement a hazard detection system for bicyclists. The system will utilize radar technology to detect objects in the bicycle's rear and an audio-visual handlebar display system to notify cyclists, with capability for indicating directional and severity based on radar data.

The main goal of our project is to create a market-competitive product to ensure ride safety, where reliability and accuracy alongside comfortability and usability are paramount to the success of our project.

1.3 Visual Aid

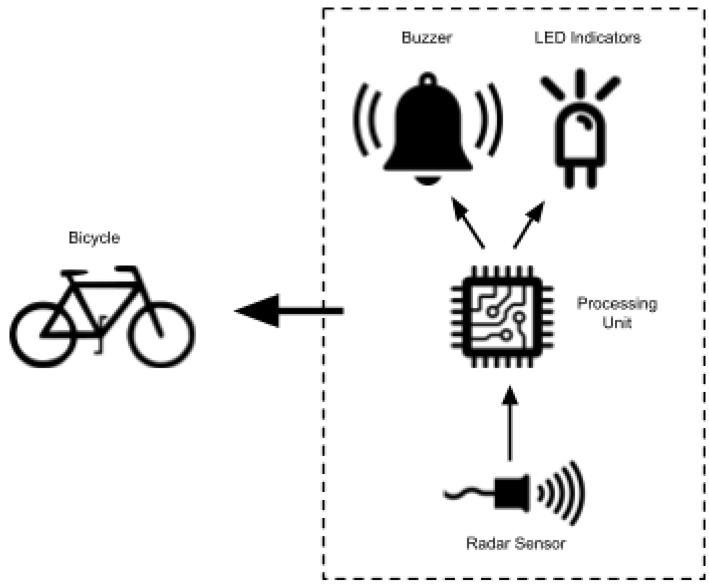

Figure 1.3.1: Hazard detection integrated on bicycle.

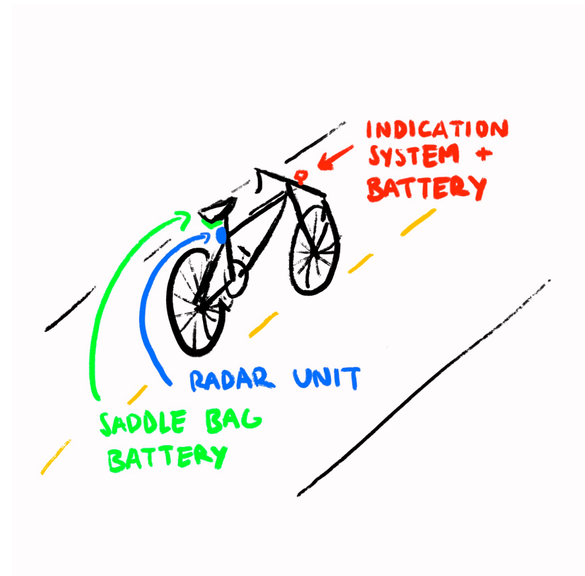

Figure 1.3.2: Mounting diagram.

The radar sensor will send data to the MCU which will do processing and signal the LEDs and buzzer. This setup will be installed on various positions of the bike. The radar sensor, power system, and one LED will be underneath the seat in some fashion towards the back of the bike. Another LED and buzzer will be placed on the handle bars with power to provide adequate alerts to the rider.

1.4 High-Level Requirements

- The hazard detection system will detect and continuously track any potential hazards in its operational environment while maintaining accuracy; when hazards are detected their proximity will be determined.
- The indication system of LEDs and a buzzer alerts the rider when hazards are in a respective range; when hazards become more imminent the buzzer intensity will change accordingly.
- The entire system functions on a battery pack setup with battery duration lasting a sufficient time for cycling trips; when system is installed complete bicycle functionality is maintained.

2 Design

2.1 Block Diagram

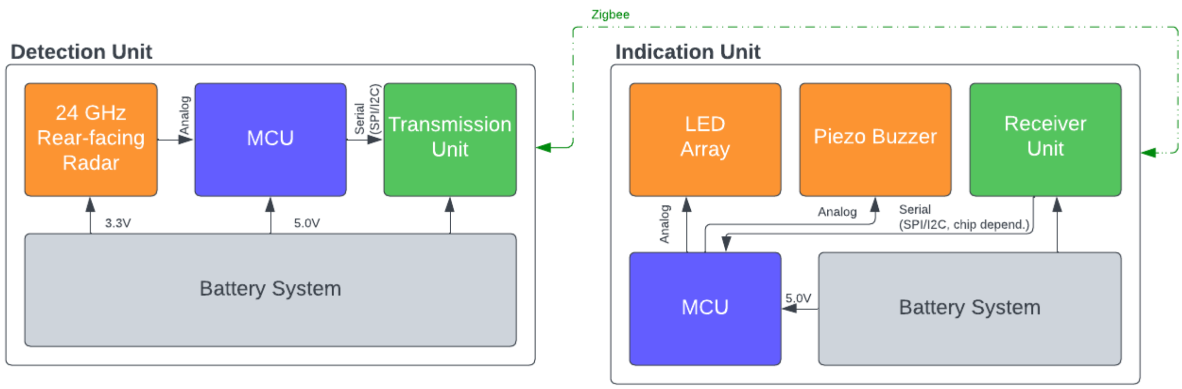

Figure 2.1.1: Block diagram of subsystems.

2.2 Subsystem Overview

2.2.1 Sensor

This subsystem will be the “eyes on the back of your head” to collect a variety of data on the cyclist’s surroundings and provide additional data.

Sensor we intend to implement is:

- Infineon 24 GHz Radar Module
    - Utilized for tracking surrounding objects and measuring distance to approaching vehicles

This sensor will be directly tied to a MCU to handle data processing and hazard evaluation, which will transmit signals to the indication system via its transceiver unit.

2.2.2 Indication System Controller

The indication system is composed of a microcontroller and wireless interface to drive the end cyclist interface. The wireless interface will be responsible for accepting wireless signals from the processing unit, and delivering it to the microcontroller. The microcontroller is then responsible for driving the LED and buzzer in the indication system.

2.2.3 Indication System

This subsystem will provide audio-visual cues for imminent hazards detected by the sensors.

Indicators we intend to implement are:

- LED
  - Utilized for strong visual cueing of direction and proximity of potential hazards
  - Provide alert for approaching suspects to notify of cyclist ahead
- Piezo-electric Buzzer
  - Utilized for strong auditory cueing urgent and imminent threats to the cyclist
  - Variable pitch and rhythm can be used to describe level of urgency

2.3 Subsystem Requirements

2.3.1 Sensor Subsystem

Requirement	Implementation
Radar is capable of detecting foreign objects within its mapping range.	• Read sensor data to validate cross-section and proximity of incoming vehicles
Sensor MCU is correctly able to discern between static objects and foreign vehicles.	• Dynamic filtering • Historical proximity analysis
Sensor MCU is able to recognize sensor failure and inform cyclists.	• Read sensor data and design ability differentiate bad sensor responses ○ Inform indication MCU and trigger warning response

2.3.2 Indication Subsystem

Requirement	Implementation
Indication system correctly responds to signal	● LEDs and buzzer respond to signaling from the controller over wireless connection instantaneously
Indication system able to detect failure to communicate with sensor system	● SYN/ACK-type or similar handshake implementation to ensure communications are sent and received correctly

2.4 Tolerance Analysis

2.4.1 Sensor Subsystem

Requirement	Verification
Radar unit is able to detect foreign objects within a ±5% margin of error.	● Test accuracy of radar module at various ranges while reading in analog data, comparing it to the data sheet for reference
Power unit capable of continuously delivering 3.3V/5V to radar, transceiver, and MCU for a reasonable trip time, ±0.1 V margin of error.	● Measure voltage output power unit during zero and full load throughout various points of a simulated trip. ● Ensure voltage through simulated trip does not drop or exceed the margin of ±0.1 V using a multimeter/voltmeter
Power unit is able to run for approximately 6 hours.	● Charge battery to full and run the sensor in normal operation, verifying that the output voltage does not fall below 3.3 V at the end

2.4.2 Power Subsystem

Requirement	Verification
Power unit capable of continuously delivering 3.3V/5V to radar, transceiver, and MCU for a reasonable trip time, ±0.1 V margin of error.	● Measure voltage output power unit during zero and full load throughout various points of a simulated trip ● Ensure voltage through simulated trip does not drop or exceed the margin of ±0.1 V using a multimeter/voltmeter.
Power unit is able to run for approximately 6 hours.	● Charge battery to full and run the sensor in normal operation, verifying that the output voltage does not fall below 3.3 V at the end

3 Ethics

With the design and implementation of our hazard detection system we don't expect many ethical concerns to present themselves. The system will be designed and tested solely by us and should not make use of any unlawful activities along the way. One minor concern one might bring to the table is the damaging of property when such a system is installed. According to statement II.9 in the IEEE Code of Ethics, no injury should be caused to people or property by ill intent [3]. With an aftermarket detection system being installed on a bike, there is the possibility of some incidental scratching and/or wear on the bicycle. However, this will not be intentional and kept to the absolute minimum. Potential damage will be inevitable with the number of hours spent testing and using these machines not to mention installation. The user will be aware of this from the very beginning and if some damage is caused, all parties will act accordingly to take care of the situation. In terms of people, no person should be harmed by the detection system. The LED indicators and buzzer will be used in a way to visually and audibly notify the rider, but will be tested and configured to ensure light and sound will not impair or impede anyone.

The entire point of the hazard system is to make traveling safer for the user. This goes hand in hand with statement I.1 in the IEEE Code of Ethics which states, “to hold paramount the safety, health, and welfare of the public” [3]. As a group we saw a huge area where breaches in safety lead to fatal situations. Keeping safety at the forefront of our system will be vital to upholding this statement. During the progression of our project we will revisit these statements to provide motivation as well as structure for our development.

4 Safety

While none pose an immediate threat to ourselves or the user, there are a few safety concerns with the detection system. To remove common risks, all components and wiring will be low voltage (5V or less) and current barring design changes in the future. Before testing, whether it be in the lab or in the field, all circuit elements will be checked to ensure stable connections. Mechanically our design will not impede the maneuverability of the bike with any wiring and devices firmly attached.

The biggest concern comes with the use of a battery pack to supply power to the system. On the battery safety guideline document it mentions covering terminals and providing a circuit to ensure no overcharging or over discharging along with other regulations [4]. The setup we hope to use is a stand alone battery pack (bank) with most safety features already built in to prevent over charging, over discharging, etc. The exact pack hasn't been chosen yet, so these regulations will be revisited at that time. To minimize risk of injury or damage to property we decided a pack of this nature was important. Designing our own pack would lend itself to unneeded potential harm. The pack will be stored in isolation with no devices connected to help meet the storage requirement. The pack will also be examined before each use to ensure there is no visible damage or alteration.

The last thing to mention is the magnitude of the alert system. While LED lights and a buzzer will be used to inform of hazards, the intensity of both will be set to ensure the rider is not impaired. The last thing the system should do is cause harm from distraction or impediment.

References

[1] S. Zhu, “Blind spot warning technology contributes to a 23 percent reduction in lane change injury crashes,” Real-world benefits of car safety technology, 2019.

[2] J. B. Cicchino, “Effects of blind spot monitoring systems on police-reported lane-change crashes,” *Traffic injury prevention vol. 19,6*, 2018.

[3] *IEEE Code of Ethics*, IEEE, 2020.

[4] *Safe Practice for Lead Acid and Lithium Batteries*, Spring 2016 Course Staff, 2016.