ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

Cycling Assist System with Rear Camera Detection

Team #12

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1 Introduction

1.1 Problem

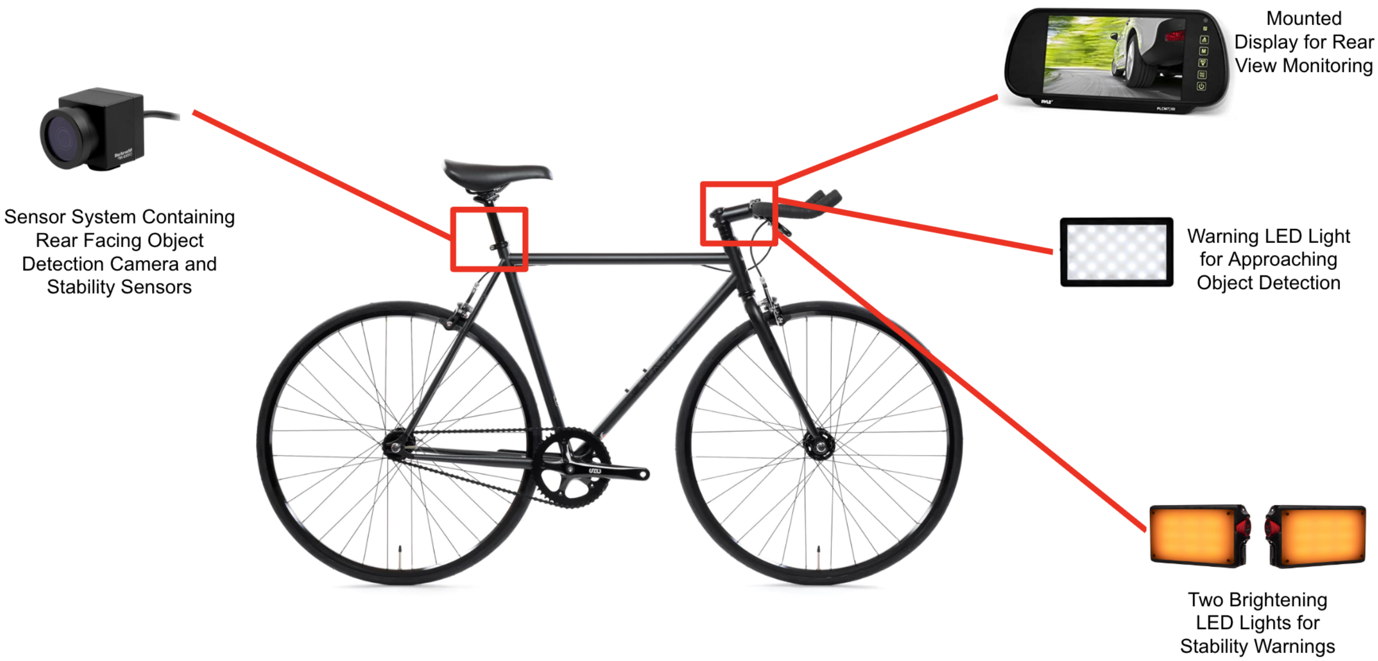
Cycling is a very popular activity among many different age groups. With new eco-conscious initiatives launching across the United States, more and more people are opting for cycling as a mode of transportation. However, as common of an activity as it is, biking can also be extremely dangerous. Over 130,000 people are injured while biking in the United States every year [1]. Because more people are using cycling for transportation, there are even more bicycles riding on main roads. While new monitors and tracking systems for bicycles appear on the market all the time, there are a few safety features that have yet to be made.

Currently, there is nothing on the market that assists the user by providing warnings when a bike leans too far in a certain direction. A cyclist could lose track of how far they are leaning after a long ride or on slippery roads. Another necessary feature for frequent cyclers is rear view detection. Whether cycling on the main road or a busy trail, blind spot detection could be imperative to the safety of cyclers. Along with this, while there are many different detection systems available, many require you to order separate sensors to monitor different features. There are very few systems that encompass different cyclist safety features in one compact dashboard. For example, the Garmin Varia RTL515 uses RADAR blindspot detection [2]. However, in order to detect other features, another sensor must be bought and installed in parallel to this sensor.

1.2 Solution

In order to solve this issue, a sensor system paired with a user display system could be made to assist cyclists. The sensor system would be placed so that it faced behind the bicycle. This system would contain a rear camera made to show the cyclist the rear view on their dashboard. This will be fed into OpenCV with object detection so that the system can detect other vehicles and bikes. This camera will be a small 1080p USB camera. The sensor system would also contain an IMU sensor. This sensor would monitor cyclists' roll stability by informing them about how far they are leaning in certain directions. Both of these sensors would be held by a 3D-printed enclosure. The camera enclosure will then mount to the back of the bicycle seat. Along with this system, a custom dashboard will be created to display the aforementioned cycle rear view. This dashboard would be a 3.5-inch LCD display mounted on the handlebars of the bike. To give warnings regarding imminent danger, there will be an array of LED indicator lights to warn cyclists how close an object may be approaching. Along with this display system will come two brightening LED lights that will inform the driver how far they are leaning to the left or right. The dashboard would include an STM32 chip mounted directly on a PCB.

1.3 Visual Aid



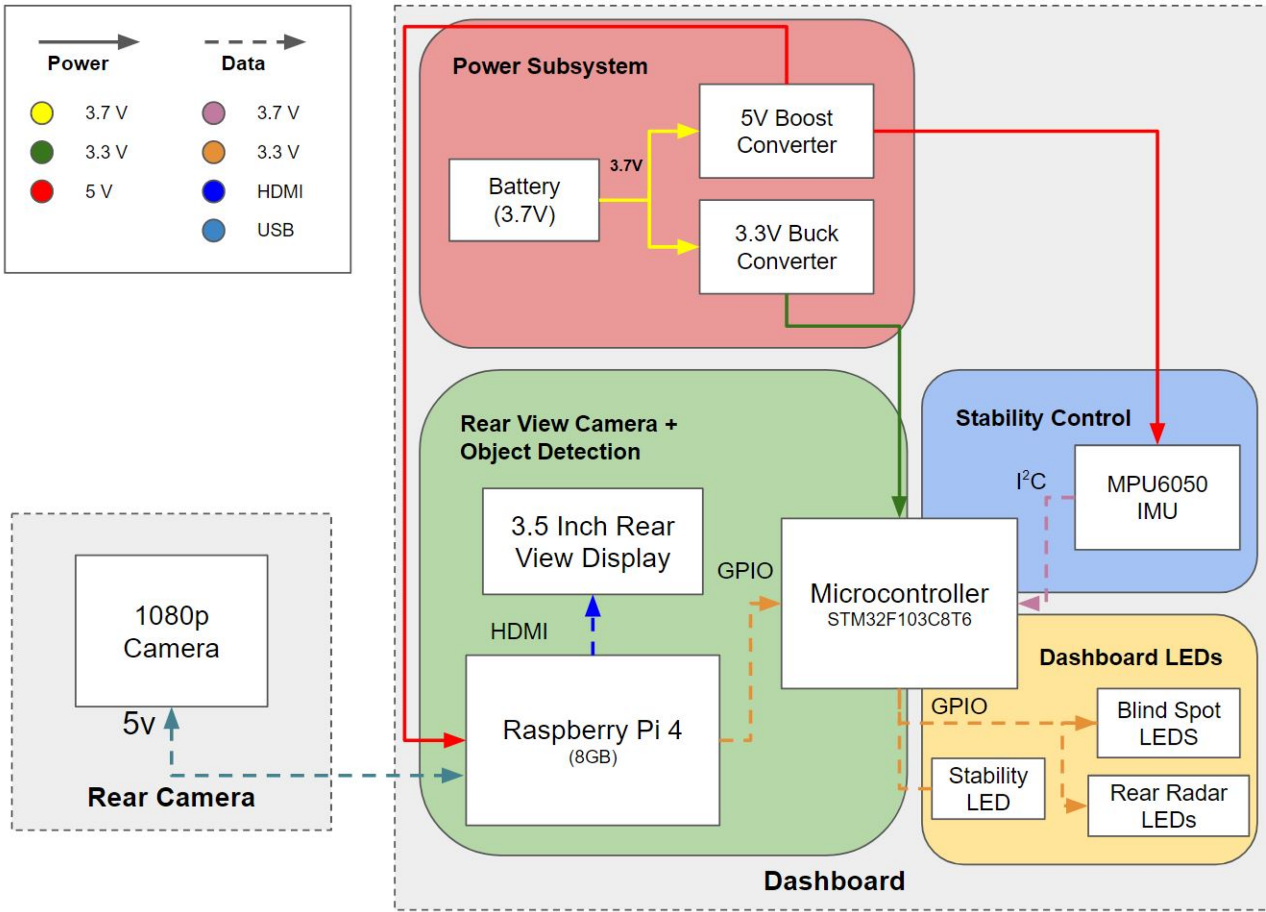
1.4 High-Level Requirements List

Three quantitative characteristics that this project must exhibit in order to solve the problem mentioned include:

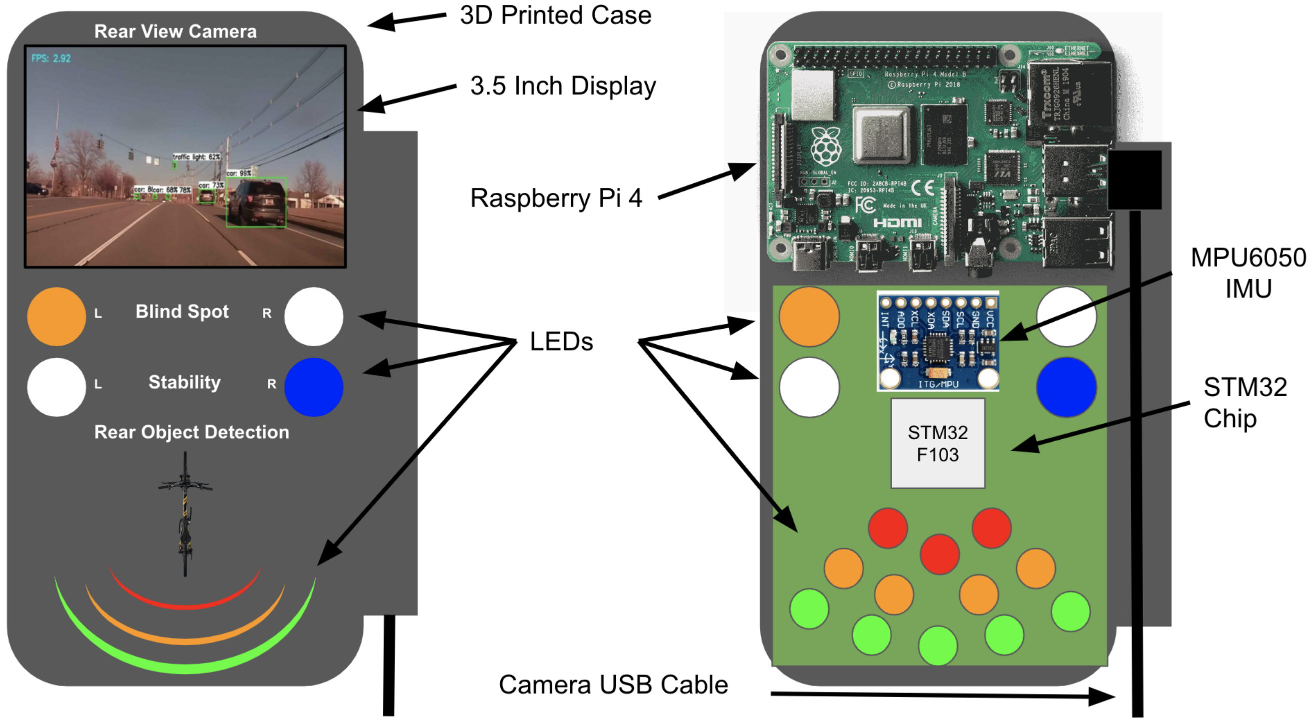
1. The system needs to be able to use a rear view camera to display the rear view of the bicycle on the dashboard display.
2. Device needs to detect rear approaching objects within at least 5 meters using object detection software and warn the cyclist using dashboard LEDs.
3. Device needs to be able to inform the user using brightening LEDs how far they are leaning in each direction.

2 Design and Requirement

2.1 Block Diagram



2.2 Dashboard



2.2.1 Power Subsystem

Battery:

The battery will be located in the dashboard so that it can supply electricity to all of the components on the dashboard as well as the rear-view camera. The system will contain one 3.7V lithium ion battery.

Requirement: A charged battery should provide at minimum 3.7V with tolerance of ±10%

5V Boost Converter:

A boost converter is needed to provide the required voltage of 5V to the Raspberry Pi 4 and MPU 6050 IMU. Using the 3.7V battery as its input, it will step up the voltage to 5V for use in the dashboard.

Requirement 1: Must provide the 5V with tolerance of ±10%.

Requirement 2: Must provide output current of at least 1A.

3.3V Buck Converter:

A buck converter is needed to provide the required voltage of 3.3V to the STM32F103 microcontroller as well as. Using the 3.7V battery as its input, it will step down the voltage to 3.3V for use in the dashboard.

Requirement: Must provide the 3.3V with tolerance of ±10%.

2.2.2 Rear View Camera + Object Detection

Raspberry Pi 4 (8GB):

The Raspberry Pi 4 (8GB) will capture the live video from the rear view camera and display that video on the dashboard display, as well as run object detection software on the video. The Raspberry Pi will provide the needed processing power and display driver for our system. It will also be able to send flagged objects to the STM32 microcontroller so that it may light the warning LEDs for the cyclist.

Requirement 1: Must be able to drive the 3.5 inch display with live video at a frame rate of 5fps or higher.

Requirement 2: Must be able to detect rear objects at a frame rate of 1fps or higher.

Requirement 3: Must be able to send flagged objects to the STM32 microcontroller through GPIOs at 3.3V ±10%.

3.5 Inch Display:

The display will provide the cyclist the ability to see behind them with the rear mounted camera. It should be large enough that the cyclist can effectively tell what is behind them.

Requirement: Display must be able to provide quality video at 720p or higher resolution.

Microcontroller (STM32F103C8T6):

The STM32F103C8T6 microcontroller will control both the dashboard LEDs as well as the stability control IMU. Using I2C communication, the STM32 will read the IMU gyroscope values and decide when the stability lights should brighten. The microcontroller will also connect the Raspberry Pi and wait for object detection flags to be sent to determine when each blindspot or rear object LED should light up.

Requirement 1: Microcontroller must be able to communicate over I2C and through GPIO pins.

Requirement 2: Microcontroller must be able to accurately turn LEDs on and off when the correct conditions are met within 500ms.

2.2.3 Stability Control

Inertial Measurement Unit (MPU 6050):

The IMU will be used to measure (using the integrated gyroscope) the roll of the bicycle. The roll value will then be sent to the STM32 microcontroller to track how close the cyclist is leaning on each side of the bike.

Requirement: Must be able to accurately measure the roll (degrees) of the bicycle with tolerance of ±10%.

2.2.4 Dashboard LEDs

Blind Spot LEDs, Stability LEDs, Rear Object LEDs:

Each of the LEDs will be located on the custom PCB in the dashboard enclosure. The dashboard will include visible light holes for the LEDs to shine through and warn the driver. Each LED will be connected to GPIO pins on the STM32 microcontroller to easily be turned on and off.

Requirement: Must be at least 100 mcd of brightness to be able to warn cyclists in all light conditions.

2.3 Rear Camera

The rear camera will be used for both the 3.5 inch live rear display and for the object detection algorithm on the Raspberry Pi 4. The rear camera will be mounted under the bike seat in the area the cyclist cannot see. All of the data will be transferred over USB to the dashboard.

Requirement: Camera must be able capture live video in at least 720p resolution and at a frame rate of at least 10 fps.

2.4 Risk Analysis

The hardest system to implement is the rear camera display + object detection. This system will be very complex both hardware and software wise since all of the data will need to be sent from the rear of the bike to the dashboard, into the Raspberry Pi 4, displayed on the dashboard display, and fed through the object detection algorithm. The Raspberry Pi 4 will be needed since this system will require a lot of processing power. If this system fails or is at a lower frame rate the cyclist will still be safe and able to ride, but will lose efficiency in the assist system performance. Otherwise the other systems are fairly simple and won't require too much processing power.

3 Ethics and Safety

There are some ethics and safety policies that should be considered carefully. The purpose of this project is to assist cyclists using a sensor system and a user display system to keep track of the rearview and stability of a bike. This purpose falls under safety standards by IEEE's Code of Ethics Section I.1, which is "to hold paramount the safety, health, and welfare of the public… and to promptly disclose factors that might endanger the public or the environment" [3]. This project aims to assist cyclists by giving effective warnings and informing them of their status while they are cycling. However, the system will not be able to physically assist cyclists by restoring balance, which means the risk of cycling will not be eliminated. Therefore, group members will explicitly mention this to users before giving any further instruction, and this follows the IEEE's Code of Ethics Section I.5, which is to "acknowledge and correct errors, to be honest, and realistic in stating claims or estimates based on available data, and to credit properly the contributions of others"[3].

Furthermore, group members working together will respect each other and treat others fairly through frequent and effective communication either in person or online. This practice follows IEEE's Code of Ethics Section II.2, "to not engage in discrimination based on characteristics such as race… gender identity, or gender expression" [3].

Finally, the team will follow the COVID-19 CDC Guideline when planning to meet in person to work on the project. This fall under the COVID-19 CDC Guideline, "Reiterating that regardless of vaccination status, you should isolate from others when you have COVID-19" [4] and "Recommending that if you test positive for COVID-19, you stay home for at least 5 days and isolate… Wear a high-quality mask when you must be around others at home and in public" [4]. The team will also follow the Lab Safety Guidelines when working on PCB and circuits.

References

[1] "Bicycle Safety." (2022), [Online]. Available: https://www.cdc.gov/transportationsafety/bicycle/ (visited on 09/14/2022).

[2] "Garmin Varia™ RCT715." (), [Online]. Available: https://www.garmin.com/en-US/p/721258 (visited on 09/14/2022).

[3] "IEEE Code of Ethics." (2016), [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html (visited on 09/14/2022).

[4] "CDC streamlines COVID-19 guidance to help the public better protect themselves and understand their risk." (2022), [Online]. Available: https://www.cdc.gov/media/releases/2022/p0811-covid-guidance.html (visited on 09/14/2022).