Wireless Bicycle Signaling System

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I. Introduction

1.1 Objective and Background

In today's society, bicyclists continue to utilize hand signals to communicate their intended direction of turning to other cyclists and vehicles. We aim to eliminate the need for hand gestures as they sometimes pose a lack of physical clarity (especially at night) as well as provide more convenience for riders in keeping their hands on handlebars. "In 2015 in the United States, over 1,000 bicyclists died and there were almost 467,000 bicycle-related injuries" [1]. Numerous of these deaths result from vehicle drivers having low visibility of other road bikers either at night or miscommunication from unclear bicycle signaling. Our project aims to resolve this issue through small modules fitted to bicycles.

On the front of the bicycle, two pressure sensing handlebar pads will slipped onto the inner sides of both handlebars, which we will refer to as pressure sleeves. On both sides of the handlebars, will be accelerometers. Attached to the bottom-side of the bicycle seat will be a module holding LED lights as well as a Bluetooth receiver. The system will work as follows: When a cyclist is ready to signal turning, he/she would squeeze the pressure sleeve corresponding to the right or left turn. These pressure signals detected by our PCB board (mounted on the front-side) will transmit a Bluetooth signal to the receiver connected to the LED lights. The appropriate LEDs will light up to display the cyclist's intended turn. After the cyclist completes the turn, our accelerometers will detect the bicycle returning to a straight path. This action will trigger another wireless signal sent to the LEDs and turn them off.

Additionally, another module we'll attach to the back of the bicycle includes an encasing of ultrasonic sensors and another set of LED lights. When these sensors detect another object approaching the bicycle too closely, a signal would trigger these LEDs to start flashing. The goal is to prevent collisions when other vehicle drivers become unaware of or do not see the cyclist. There will also be a switch to turn this safety feature off.

Evidently, our approach provides more than simply convenience for cyclists, but also promotes better road safety as it's shared by countless other cyclists and road vehicles. The rest of this proposal paper will outline a list of hardware components necessary to complete this project, show various block diagrams of the connected parts in our system, discuss high-level implementations of our hardware features in more detail, elaborate on risk analysis, safety, ethics and resources.

1.2 High Level Requirements

- Sensors mounted on the handlebar of the back need to communicate with the lights on the back seat wirelessly.
- The turn lights located beneath the seat must be visible and with certainty convey the direction the biker is moving.
- The accelerometers must be able to detect when the bike is done turning and signal the lights to turn off.

2. Design

2.1 Block Diagram

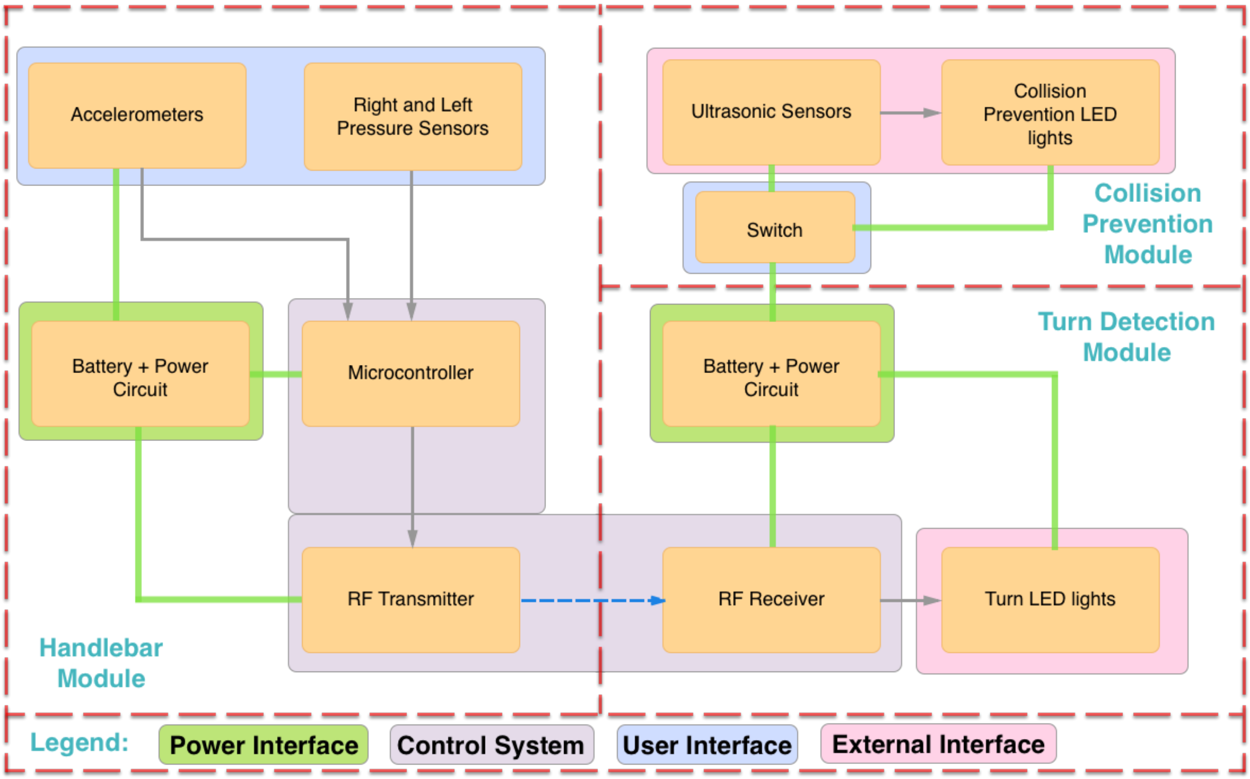

Figure 1. Block Diagram of Wireless Bicycle System.

Our model follows an action-reaction design whereby movements by the biker influences the state of the turn-lights. The pressure sensor must be able to detect if the biker indicates that he is turning and relay this information to the lights. The lights must clearly and timely signal where the biker is turning towards with no false-positives, as they would cause confusion for other bikers/drivers. Finally, the accelerometers must be able to detect when a turn has come to a stop without needing attention from the bike. This is in order to notify other road-goers as well as creating a fail-safe against the biker forgetting to turn their signals off.

2.2 Physical Design

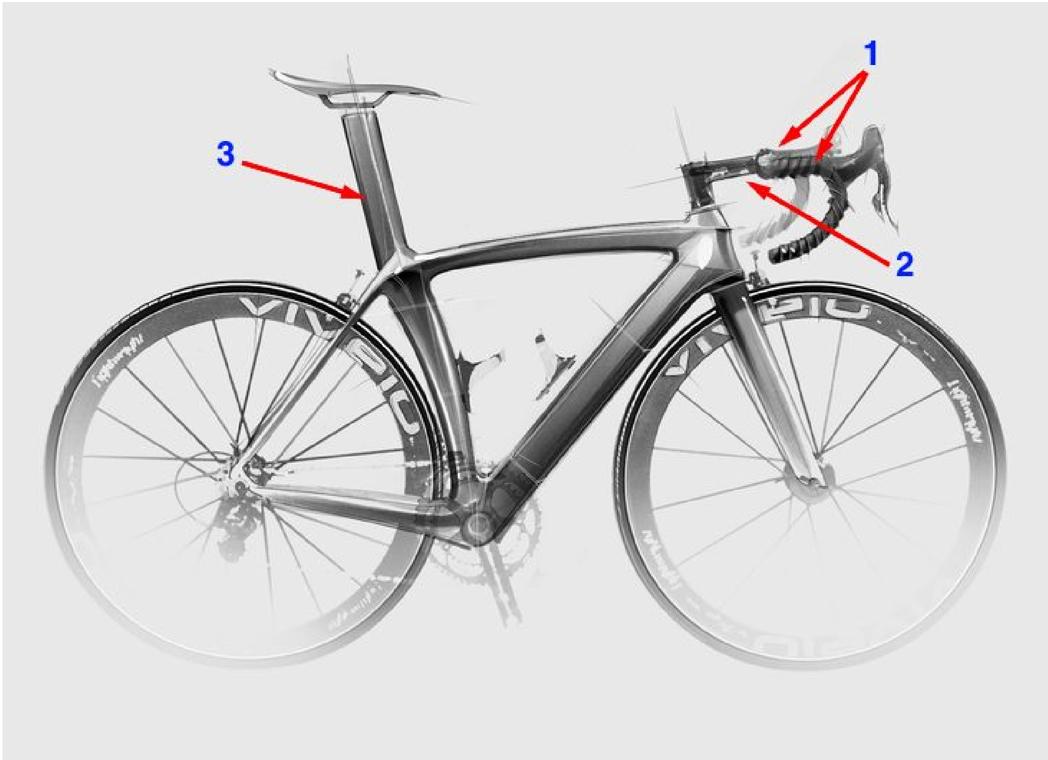

Figure 2. Road bicycle annotated with placement locations of modules.

Figure 3. Top-down view handlebars annotated with placement of sensors.

In Figure 3, our sleeves containing pressure sensors will be fitted on the inner sides of the handlebars as shown. These soft sleeves will be small such that it would fit fine on most bicycles. These sleeves are denoted by the ‘1’ annotation in Figure 2. Under these pressure sensing sleeves, is a module holding our microcontroller, battery, accelerometers and RF transmitter (denoted by the ‘2’ annotation in Figure 2). The last annotation: ‘3’, denotes the location where our Turn Detection Module and Collision Prevent Module will be placed.

2.3 Functional Overview

2.3.1 Microcontroller:

Our microcontroller will server as our processing unit for managing all sensor input signals, computing any necessary logic and outputting the desired results to the RF transmitter that is described in Section 2.3.5. We have not yet decided on a specific microcontroller as it will be dependent upon on the configurations and specifications of the rest of our components in this system.

2.3.2 Power Sources:

There will be two power sources, one located at the front of the bike near the handlebars, and one in the back. The power source in the front will help run the microcontroller as well the accelerometers and RF transmitter located near there. The power source in the back will power the LEDs, the RF receiver, and the ultrasonic sensor. These power sources will be 5V and will run on rechargeable batteries. Our physical design must be compact and will revolve around proper placement and utilization of the power sources.

2.3.3 Pressure Sensor (x2):

For our pressure sensors, we intend to use two force sensitive sensors (https://www.sparkfun.com/products/9375), with one mounted on the inside of each handlebar. The sensors will only be half an inch in diameter and will be easily accessible to the biker, but will also be positioned conveniently so as to not be accidently pressed. The resistors will respond to touch and force, with more force on the sensor yielding a lower resistance. Through testing, we can easily set a threshold on the resistance for determining if the sensor if pressed. This information can then be relayed to the microcontroller. The two sensors will be independent part and the microcontroller should control the logic of communicating to the turn-lights when to turn on and off.

2.3.4 Accelerometer (x2):

Two accelerometers (https://www.sparkfun.com/products/10345) will be mounted on opposite ends of the handlebar. The accelerometers should be able function on all 3 axes and detect changes in acceleration (speed and direction!) in both handlebars. Together, they should be able to accurately relay when the handlebars are done turning and the biker is going in a straight line. The biker will have initiated a turn when the accelerometers experience acceleration in different directions, caused by the swivel of the handlebar and the front wheel. When both accelerometers then experience the same acceleration in the same frontwards direction, the driver must be going straight again. The accelerometers will communicate directly with the microcontroller, which will implement the logic as well as propagate the correct command to the LEDs on the back of the bike. The accelerometers will be powered by the 5V power source at the front of the bike.

2.3.5 RF Transmitter/Receiver:

An RF transmitter (https://www.sparkfun.com/products/10534) will be included near the handlebar of the bike which will control message transmission from the front to the back of the bike. The RF transmitter will receive instructions from the microcontroller, indicating what message is should convey. The messages that we would want to send would be to turn left light on, left light off, right light on, or right light off. These messages can be encoded into two bits that can be sent if the microcontroller sees that the state of the lights must be changed. The RF receiver (https://www.sparkfun.com/products/10532) will be mounted on the back of the bike with the light submodules. Depending on the command word received from the transmitter, it will either power on or power off the respective lights.

2.3.6 Turn Lights (x2):

Two sets of turn lights will be located at the back of the bike, underneath the seat. These lights will consist of bright yellow LEDs arranged in an arrow shape, which will indicate the direction the driver is going in. These lights will will receive commands from the microcontroller. The RF receiver will read in these commands and divert current to the respective section of LEDs. The LEDs will be powered by the 5V power source located in the back of the bike. The LEDs are our project's major signal to the external world and must always display accurate information.

2.3.7 Collision Prevention Module:

The collision prevention module is intended to work separately from the turn detection module. The core of the module is composed of an Ultrasonic Sensor (https://www.sparkfun.com/products/8503) which will be peering behind the biker to detect if a car or another biker is there. The ultrasonic sensor will also receive power from the batteries already located at the back of the bike. This sensor will control a set of collision prevention LEDs (separate from our turn-lights) which will produce a light if an object is behind the biker. The biker can manually flip a switch to override this process and guarantee that the lights remain off, which could be useful is they are biking in a group. This module is designed to keep bikers safe in the dark by warning drivers behind them, as well as being power efficient, because the lights will only turn on when a driver is nearby.

2.4 Block Requirements

2.4.1 User Interface

Requirements	Verification
1. Pressure sensor can detect when the user is squeezing the sensor indicated he or she wants to turn	1. We squeeze the pressure sensor with around the same amount of force of an average person and see if the sensor reaches the threshold we set 2. The pressure sensor should reach the set threshold whenever the user squeezes it at least 90% of the time
1. Accelerometer on each of the handlebars	1. When beginning a left turn the

both help determine when the user is finished turning by measuring the acceleration of the handlebar.	accelerometer on the left handlebar would have a negative value and the accelerometer on the right would have a positive value and when the handlebar is going back to the straight position the values would reverse and end at close to zero
1. Switch to turn cut the connection between the power supply and the MCU.	1. When the switch is turned off then there is nothing to power the MCU and none of the sensors should trigger anything 2. When the switch is turned on then the MCU and sensors should work as normal 3. We will use an ammeter to measure if there is any current going between the MCU and battery

2.4.2 External Interface

Requirements	Verification
1. Ultrasonic sensors determines the presence of a car or another bike is within 15 feet of the bike.	1. Whenever we place an object within approximately 15 feet of the sensor then we should see a LED that indicates the presence of nearby objects turn on
1. Specific LED lights should turn on whenever a bluetooth signal is received.	1. When the right pressure sensor is squeezed then the LED's that correspond to the right arrow

2.4.3 Control System

Requirements	Verification
1. Microcontroller	
1. RF transmitter and RF receiver should send and receive data through bluetooth.	1. Whenever we send a few bits of data from the RF transmitter we should see the same bits received by the RF receiver.

2.4.4 Power Interface

Requirements	Verification
1. The power supply will give us 5 volts of power at a current of about 15 mA with a tolerance threshold of +/- 10%.	1. Measure the power supply with a multimeter to ensure the power and current stays within our tolerance threshold

2.5 Risk Analysis

The most difficult component of this project will be connecting the control system together. The microcontroller must rely on the RF transmitter and receivers to function properly in order to deliver the results of user input signals to the appropriate LEDs. We believe it will be very difficult to thoroughly test the wireless communication aspect, being Bluetooth, on various metrics such as reliability and power consumption. Moreover, if we are unable to transmit signals wirelessly, inputs from the cyclist will remain useless. As a group, none of us have any experience working with transmitter/receiver devices that are used for wireless communication. It will take much research, understanding and analysis on our parts before we can successfully integrate two major pieces of this system together through this specific communication medium.

3. Ethics

The greatest ethical concern for our project is the potential of placing the cyclists and the people around them in more danger than if they have never used our system in the first place. For example, if the user gets used to routinely utilizing our product and assumes the turn lights will always turn on when the switch is flipped, there may be unexpected consequences. These negative consequences may result from broken or faulty lights; thus, putting the cyclist at more risk than he or she would normally be. Thus, this is our primary focus in ensure Conduct 1 of the IEEE Code of Ethics is not violated [2]. The rest of the conducts (Conduct 2-10) will not be concerns for us for the following reasons: there is one clear objective for this project, there will be an organized structure for how are components are verified and constructed, there is no sponsorship, there will be emphasis on following safety procedures and guidelines, we will hold the responsibility in the safety of potential users, and the agreement that we must work together in an organized, professional environment.

4. Safety

The first safety concern we need to address is making sure that our device does not change how the user would operate the bike normally and making sure that our sensors will not interfere with the functionality and safety of the bike. Additionally if the cyclist were to fall off the bike we want to make sure none of the components in our design could potentially shatter and inadvertently hurt the cyclist.

5. Citations and References

[1] Centers for Disease Control and Prevention (CDC). Web-based Injury Statistics Query and Reporting System (WISQARS). Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Available at www.cdc.gov/injury/wisqars. Accessed on 09/19/2017.

[2] “IEEE IEEE Code of Ethics.” IEEE - IEEE Code of Ethics www.ieee.org/about/corporate/governance/p7-8.html. Accessed 20 Sept. 2017.