Bicycle Automated Turn Signal (BATSignal)

Project Proposal

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1. Introduction

1.1 Motivation/Statement of Purpose:

Cyclists are often required to use their hands to indicate when they are about to make a turn. This is often difficult and dangerous, especially when biking at nighttime. Several products exist on the market for bicycle turn signals, however all of these products force the cyclist to have to move their hands off of their handlebars to indicate a turn. The current products on the market require the cyclist to have to use a control box located in between the handlebars. This is dangerous for the cyclist to be looking at the controls as opposed to the road.

1.2 Objectives:

1.2.1 Goals:

- Ability to make turns safely while cycling on a road
- Keeping hands on the handlebars at all time while signaling a turn
- Notifying a vehicle following behind when braking or slowing down
- Ability to be noticeable to a vehicle driving behind the cyclist at night

1.2.2 Functions:

- Build a wireless turn signal
- After the turn is completed, turn signal automatically turns off
- Build a brake signal using an accelerometer
- Notify the cyclist while the turn signal remains on

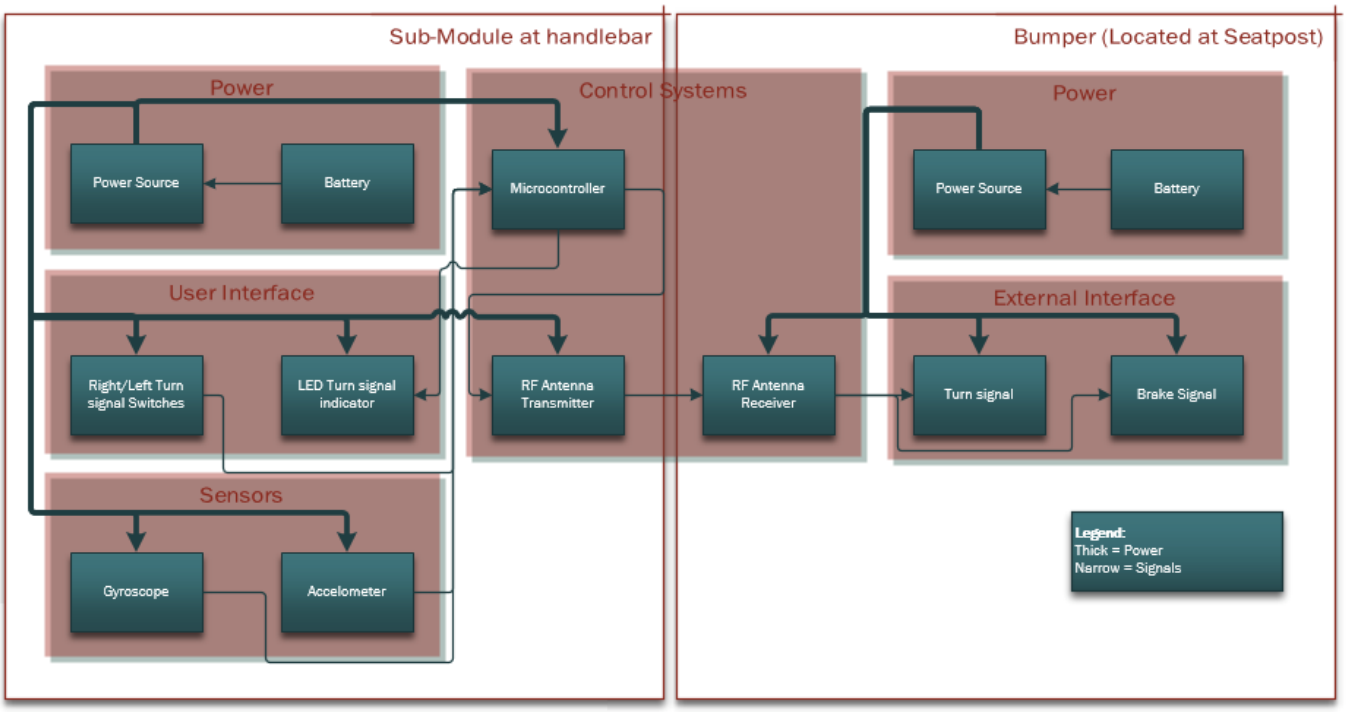
1.2.3 Benefits:

- Cyclist can keep their hands on the handlebar at all times
- Cyclist will avoid dangerous situations that might arise from making a turn on a road
- Ability to ride safely at night
- No need to manually switch signal off after the turn is complete

1.2.4 Features:

- Easy mountable bicycle turn signal
- Easily readable LED screen that shows when the turn signal remains on for the cyclist's convenience
- Bluetooth compatibility with the turn signal and turn signal switches
- Brake signal indicator flashes when cyclist decelerates above a certain threshold

2. Design



2.1 Summary of the System

The system will take inputs from the turn switches on the handle bars that are controlled by the cyclist. As cyclist decides to make a turn, he/she will press the corresponding turn signal switch that is located on the handlebar. That signal will be read by the microcontroller. Next, the microcontroller will send the signal by using a RF Transmitter Antenna to the RF Receiver Antenna that is located at the rear of the bike. The bumper component at the rear of the bicycle will be attached to the seat post of the bicycle. It will include a power source, RF receiver antenna and turn/brake signals. As long as the receiver antenna receives the signals, it will toggle on the corresponding turn signal to indicate that the cyclist is making a turn.

In making a turn, there are three possible ways in which a cyclist can complete a turn. First, the cyclist can steer the wheel to the direction in which the cyclist intends to turn. Second, the cyclist can lean on the side of the bike in which the cyclist intends to turn. Finally, the cyclist can both steer and lean towards the direction in which the cyclist intends to turn.

If the cyclist makes a turn by mainly using the steering wheel, the gyroscope located in the handset of the bicycle will detect the change in velocity of the rotation of the front wheel and send this data back to the microcontroller. As the user steers back the handlebar to its original position, the gyroscope will detect this change and send the data to the microcontroller. Once the microcontroller detects that the turn is completed, it will stop sending the signal to the turn signal and stop blinking the LED to the cyclist, indicating that the turn has been completed.

If the cyclist makes a turn by mainly leaning to the side in which the cyclist intends to turn, then the accelerometer will measure the tilt angle and the microcontroller will detect from

the change in angle that the cyclist is making a turn. After the cyclist returns back to their original position, the microcontroller will detect that the turn is completed. It will then stop sending the signal to the turn signal and stop blinking the LED, indicating that the turn is completed.

If the cyclist makes a turn by using both the steering wheel and leaning to the side, then both of the input from the gyroscope and the accelerometer will be used to determine when the turn is completed.

As for detecting brakes, we will use the same accelerometer. The accelerometer will read how much the bike accelerates in the x direction. As the bicycle deaccelerates over some threshold, the microcontroller will infer from its input that the biker is braking. Then by using the RF transmitter antenna, it will send a signal to the RF receiver antenna on the bumper to turn on the brake signal LED. As the force applied on the force sensors disappears, the microcontroller will no longer send any signals and the brake signal will turn off.

2.2 Description of Blocks

2.2.1 Microcontroller:

The microcontroller will collect all the inputs coming from the turn signal switches, force sensors on the brakes, gyroscope on the headset and accelerometer. It will then process these inputs to determine which state the bicycle is current on and what it should do. Next, it will output a signal to the RF antenna transmitter. For the purposes of this project, an Atmel ATMEGA328P-PU chip as a microcontroller will be used. Its 23 general purpose I/O pins will be enough to cover all the inputs and outputs. 6 of these I/O are analog and 13 are digital pins of which 6 of digital pins have PWM (Pulse Width Modulation). The chip requires 1.8V-5.5V volts to operate. It has 32 general purpose working registers and 3 timer/counters which will be useful in analyzing turns. The microcontroller sub-module also includes a 16 MHz crystal, and two 20 picofarads capacitors.

2.2.2 Gyroscope/Accelerometer:

The InvenSense MPU-6050 chip will be used for this portion of the design. The chip includes both a 6 axis gyroscope as well as an accelerometer. The accelerometer will be used to determine the tilt angle (how much the cyclist leans to the side) of the bike during a turn. It will also be used to determine when the cyclist is braking. The accelerometer x-axis will be placed along the bike, z-axis going up, y-axis to the left. When the cyclist leans to the left or right, its y-axis and z-axis will change, indicating that the cyclist is making a turn. As the cyclist deaccelerates, the x-axis will increase in the negative x direction indicating a brake. The gyroscope will determine the rotation of the front wheel. It will be used to convert the angular position of the wheel and handlebars to digital code to be used by the microcontroller to determine if a turn has been completed. This chip has an operating voltage of 2.375 - 3.46 V.

2.2.3 Power:

The power supply supplies power to each component block and consists of a single lithium ion battery (3.6 V, 24mA average). We will attach this to a boost converter to raise the voltage to 5V (17mA average) to power the circuitry. We will require two of these power supplies, one for the circuitry at the handlebars and one for the circuitry at the bumper. The size

of the overall design will be small since we are only using a single battery for each power supply.

2.2.4 RF Transmitter/Receiver:

This block will establish the connection from the device mounted on the handlebars and the LED board mounted on the back. There are 4 signals that need to be communicated at any time, and they are as follows: nothing, left turn, right turn, brake. Since the Tx/Rx will be operating at a high frequency, i.e. a frequency high enough such that LEDs flashing at that frequency will seem continuous to a human eye, multiple signals can be transmitted at once without any problem (e.g., a brake signal while turning left). Although we will need a minimum of 2 bits to encode these 4 signals, redundant bits will be added to ensure external noise does not interfere with the system.

2.2.5 Turn/Brake LED Signals:

This will be located in the bumper part of the design. It consists of yellow LEDs for the turn signals and red LEDs for the brake signal. These signals will be used to warn the vehicle behind the bicycle about any action the cyclist might take. The LEDs will receive their inputs from the receiver and they will be powered by a 5V source.

2.2.6 Right/Left Turn Signal Switches:

This will be located on the handlebar of the bicycle. It will be located at a reachable distance from the cyclist's hands. The switches will send input to the microcontroller about the state of the switches.

3. Requirements and Verifications:

3.1 Power:

Requirements	Verifications
The power supply voltage is 5V with a +/- 10% tolerance	1. Measure power supply output with oscilloscope to determine voltage ripple 2. Measure power supply output with multimeter to determine average voltage output
The power supply voltage is 17mA with a +/- 10% tolerance	1. Measure power supply output with oscilloscope to determine current ripple 2. Measure power supply output with multimeter to determine average power

3.2 Control Systems:

Requirements	Verifications
The microcontroller has at least 5 output pins for 5 bits sent out	1. Test that there are at least 5 digital-based pins allocated for output
The microcontroller has a built-in clock with minimum frequency of 60 Hz	1. Connect the microcontroller to a Spectrum Analyzer to record the frequency of the clock
Antenna: It can transmit and receive signals of at least two bits over the minimum length of the bike necessary	1. Test each bit combination 25 times (100 total) to determine if the receiver is receiving correctly and the transmitter is transmitting correctly

3.3 Sensors:

Requirements	Verifications
1.Accelerometer can detect a full scale range of 30 to -30 m/s^2 acceleration 2. It can detect when the cyclist is braking	1. We will measure the RPM of the bicycle wheel using external sensors and calculate the acceleration 2. The sensor can detect the cyclist braking 60% of the time
Gyroscope can detect a minimum turn angle of the handlebars of 30 degrees	1. Use a protractor/angle gauge on the ground along the y axis to measure the angle of the front wheel and verify that 10 degrees is the minimum detected
Gyroscope can detect a minimum tilt angle of 10 degrees of the entire bicycle when the cyclist leans to turn	1. Use a protractor/angle gauge on the ground along the x axis to measure the angle of the bicycle tilt and verify that 10 degrees is the minimum detected

3.4 User Interface:

Requirements	Verifications
The left and right switches on the handlebars interface with the microcontroller	1. Write a simple loop that checks that the switches are being registered when pressed
The LED turns on and blinks when the turn signal is on	1. Test by writing a loop that checks if the turn signal is registered as on or off 2. Check if the LED has turned on when the turn signal is registered as on

3.5 External Interface:

Requirements	Verifications
The turn signal lights up in the back and turns off when necessary	1. Test that the turn signal switches work to light the LEDs 100 times for both the right and left turn signals 2. Test that the LEDs turn off 100 times after the turn is completed
The brake signal lights up in the back and turns of when necessary	1. Test that the brake signal turns on when the bicycle is braking 100 times 2. Test that the brake signal turns off when the bicycle is moving again 100 times

3. Tolerance Analysis:

4.1 Critical Component: Turn Signal Completion Detection

4.2 Acceptable Tolerance:

We have determined that the most critical portion of our turn signal is that it can detect that a turn has been completed and that the signal is turned off automatically. An acceptable tolerance would be detection of a turn angle from 30-90 degrees of the handlebars and 10 degrees of the bicycle's frame. It should be noted that this tolerance level makes it unable to determine when the cyclist is changing lanes. It will only determine if the cyclist is making a full right or left turn.

4.3 Test Procedure:

We will test the bicycle on the road at a four-way intersection. Using an angle gauge at a minimum of 30 degrees, we will determine if the turn signal satisfies the tolerance requirements. We will be able to tell that the requirements are met if the turn signals automatically turn off once the turn at a 90 degree corner has been done. This component will be a success if it passes 60% efficiency.

4.4 Presentation of Results:

We will present our results in a table of data that shows the lower bound of detection of a turn signal for both handlebar angle lower bound and bicycle frame angle lower bound.

5. Cost and Schedule

5.1 Labor:

Name	Hourly Rate	Total Hours Invested	Total = Hourly Rate x 2.5 x Total Hours Invested
Bora Cukurova	$32.50	150	$12,187.50
Natalya Bapst	$32.50	150	$12,187.50
Hanna Zayed	$32.50	150	$12,187.50
Total		450	$36,562.50

5.2 Parts:

Part	Part Number	Unit Cost	Quantity	Total
LEDs	LED SuperBright	$.1475	20	$2.95
Zener Diode	MultiComp 1N4742A	$0.25	2	$0.50
Microcontroller	Atmel ATMEGA328P-PU	$6.49	1	$6.49
Lithium Ion Battery (3.6V)	Panasonic CGR19650CG	$5.99	2	$11.98
Capacitors	Varies	$0.25	20	$5.00
16 MHz Crystal	HC49/US Package	$0.95	1	$0.95
Resistors	Varies	$.0475	30	$1.43
Antenna	Link Kit Module 433 MHz	$1.29	1	$1.29
Inductors	Varies	$0.19	10	$1.90
Accelerometer/Gyroscope Chip	InvenSense MPU-6050	$2.95	1	$2.95
Switches	LED Tactile Button	$1.95	2	$3.90
Total				**$39.34**

5.3 Schedule:

Week	Task	Responsibility
9/11	Finalize and hand in proposal	Natalya Bapst
	Mock Design Review Sign up	Hanna Zayed
	Plan parts needed to be ordered	Bora Cukurova
9/18	Design receiver/transmitter	Hanna Zayed
	Order parts/Mock Design Review	Natalya Bapst
	Create circuit diagrams	Bora Cukurova
9/25	Finalize circuit diagrams	Natalya Bapst
	Commence breadboarding	Bora Cukurova
	Design receiver/transmitter	Hanna Zayed
10/2	Breadboarding	Bora Cukurova
	Breadboarding antenna	Hanna Zayed
	Design Review	Natalya Bapst
10/9	Design PCB	Hanna Zayed
	Design PCB	Bora Cukurova
	Design PCB	Natalya Bapst
10/16	Order PCB	Hanna Zayed
	Microcontroller Coding	Bora Cukurova
	LED Assembly	Natalya Bapst
10/23	Antenna Assembly	Hanna Zayed
	Microcontroller Testing	Bora Cukurova
	LED Assembly	Natalya Bapst
10/30	Antenna Assembly	Hanna Zayed
	Microcontroller Assembly	Bora Cukurova
	LED Assembly	Natalya Bapst
11/6	Debugging	Hanna Zayed
	Debugging	Bora Cukurova
	Debugging	Natalya Bapst
11/13	Mock Demo	Hanna Zayed
	Testing	Bora Cukurova
	Testing	Natalya Bapst
11/20 (Thanksgiving)	Debugging	Hanna Zayed
	Debugging	Bora Cukurova
	Debugging	Natalya Bapst
11/27	Demonstration	Hanna Zayed
	Demonstration	Bora Cukurova
	Demonstration	Natalya Bapst
12/4	Final Proposal	Natalya Bapst
	Final Proposal	Hanna Zayed
	Final Proposal	Bora Cukurova