Blind Spot Warning System for Bikes

Team 32

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ECE 445 Project Proposal --- Fall 2017

1. Introduction

1.1 Background:

Blind spot has been an well-known problem for automobile drivers and engineers have come up many ways to solve this problem. Blind spot warning system is one of the most prevalent solutions installed in many modern car models which provide critical warnings of rear-side approaching vehicles to driver and reduce number of potential collisions.

However, Blind spot is not a problem only for the automobile drivers. Bicyclists face the same problem as well and it's unsafe for them to turn their heads backward while riding on the road. While car drivers enjoy the privilege of having the blind spot warning system, there isn't any such device in the market yet that is designed for a common bicyclist. The number of people who are willing to go to work by bike has been rising over the past decade in the US, so is the bike accidents. According to Centers for Disease Control and Prevention (CDC), in 2015 in the United States, over 1,000 bicyclists died and there were almost 467,000 bicycle-related injuries.[1] A Blind Spot Warning system would definitely help to reduce the bike accidents by alerting the rider of the approaching vehicle behind.

1.2 Our goal:

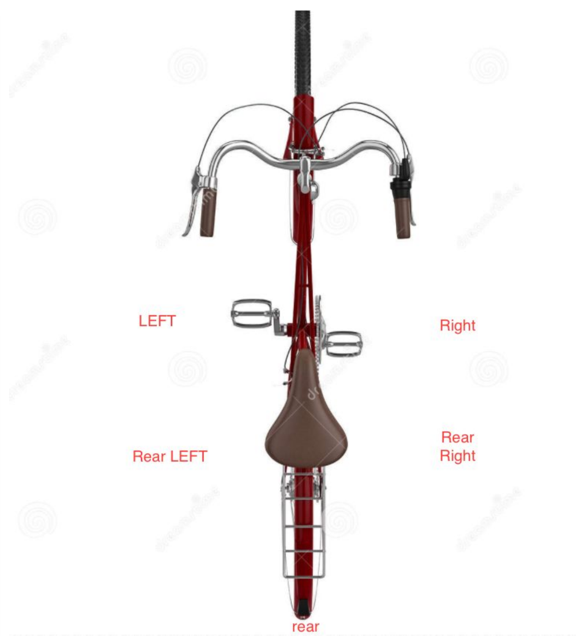
In an effort to reduce number of incidents involving cycling, we plan to design and prototype such a system for bikes that would notify cyclist of the presence and location of rear-approaching objects.

1.3 High Level Requirements:

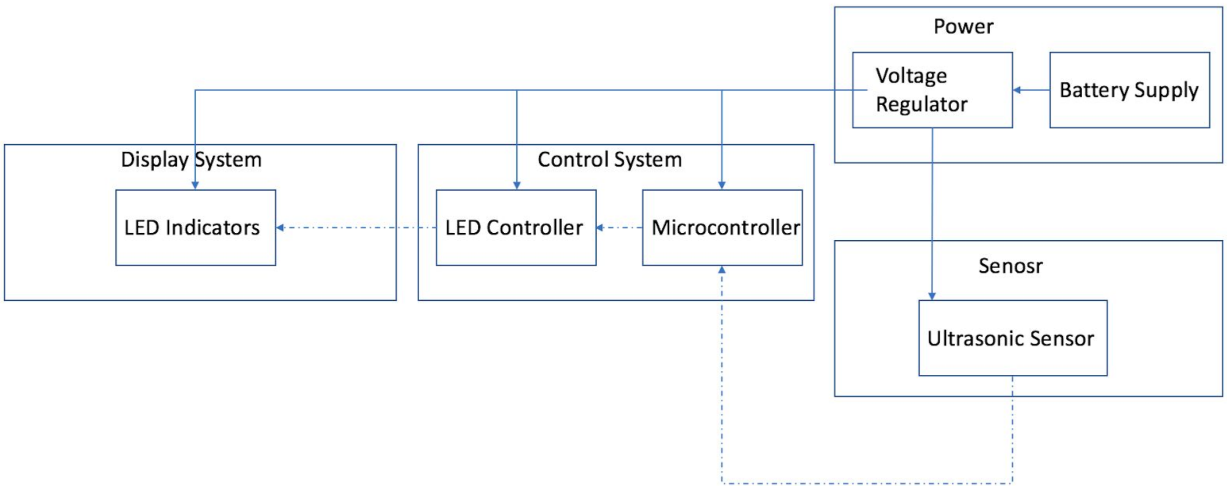
- The warning system must be able to tell the user whether the car is approaching or not by the color of the LED indicators.
- The warning system must be able to tell the user in which direction the car is approaching from behind
- The warning system must be able to withstand the vibration and winds coming from the moving bike.

2. Design and Definitions

The design would consist of 4 modules serving different purposes: The Power Module; The Control Module; The Sensor Module; The Display System. The Power module would use battery as the source and use a voltage regulator for stable input voltage level. It provides power for the rest 3 modules. The control module consist a microcontroller that would read from the Sensor Module and compute the results based on the inputs. The results then would be sent to the LED controller which will decide which LED should light up. The Sensor Module would consist 5 ultrasonic sensors that have a detecting range of 3 meters. These 5 sonar sensors would face left, right, rear, rear left and rear right respectively to detect vehicles coming from those five directions. The display module consist of five 3-color LEDS, which correspond to the five directions. It takes input from the Control module. The first picture below shows where those module would be located on a bike. The second picture below defines the 5 directions mentioned above.[4][5]



2.1 Modular Diagram:



2.2 Physical Design:

2.2.1 Power:

The power module supplies a steady 5V DC voltage to the Display System, control System and Sensor. The battery supplies a 9.6V to the voltage regulator, which in return produces a steady 5V DC voltage.

- Battery

  The battery, chosen to be Melasta 9.6v AA 1600mAh NiMH Battery Pack, provides a 9.6V voltage to the voltage regulator.

  Requirement 1: The battery must be able to provide a 7-9.6V DC voltage to the voltage regulator.

- Voltage Regulator:

  The voltage supplied by the battery would usually would drop quickly as time goes by, THe voltage regulator would be able to keep the output voltage stable at 5V.

  Requirement 1: The regulator must deliver 5V output voltage.

  Requirement 2: The min input voltage of the voltage regulator must be below 7V.

2.2.2. Control System: The control system connects sensor input with LED power output. It makes decisions based on sensors and outputs location of approaching object to LEDs.

- Microcontroller: Microcontroller contains the algorithm to decide whether there is an object approaching from behind. The algorithm can be described as:
    - Each sensor location registers presence of an object when reading decreases by certain threshold.
    - If at least one adjacent sensor has also registered a distance decrease event, mark that sensor's location and output to user LEDs.

    Requirement 1: Must continuously receive input from ultrasonic sensors.

    Requirement 2: Must continuously output inferred location if any.

    Requirement 3: Must make decision reasonably fast and do not crash.
- LED controller: A 3-color LED has 3 anodes with 1 unified cathode, hence 15 input signal needed. We will use a 4-to-16 decoder to provide input to these LEDs, with microcontroller providing digital signals as input to the decoder through GPIO.

Requirement 1: Must account for all possible LED indication combinations. Each LED is either red, green, blue or off, hence $4^5 = 1024$ possibilities.

Requirement 2: Must be controllable by input from micro-controller's GPIO.

2.2.3. Sensor: The sensor array is installed at the rear of the bike. It quantifies its proximity to nearest object, and send the value to microcontroller. The sensor array contains 5 individual ultrasonic sensors, which face the five directions (left, rear-left, rear, rear-right and right) respectively.

- Ultrasonic sensors: The ultrasonic sensor is capable of detecting proximity within a 0.6m~3m range. It continuously outputs the microseconds (us) taken of a burst of ultrasonic wave (at approx. 340 m/s, or 0.34 mm/us) to hit the object and return back to its origin. The conversion from sensor value to actual distance is thus:

$$Distance = 0.34 \times sensor\ value$$

Requirement 1: Must continuously supply time values to the microcontroller.

Requirement 2: Must provide proximity detection when objects come within vicinity of 3 meters.

2.2.4. Display: We use 5 LED 3-color (red, green, blue) lights as indicators.

- LED light (x5): Each of the 5 LEDs correspond to respective sensor locations at the back of the bike. The 3 colors indicate different levels proximity between object and the bicycle:
    - Green: The object is within 2m-3m behind the bicycle
    - Blue: The object is within 1.5m-2m behind the bicycle.
    - Red: The object is within less than 1.5m behind the bicycle.

  Requirement 1: All LED indicators must be off when the microcontroller outputs no signal.

  Requirement 2: If an object is present at one of the sensor locations, the corresponding LED light must be lit.

  Requirement 3: Multiple LEDs lit is permissible, to address a large object that occupies more than one sensor locations.

2.3. Risk Analysis:

- In real development, we might need to tune parameters of our algorithm to make more accurate inference about object's presence.
- The sensors must be installed reliably to withstand shocks and vibrations, as might happen in real cycling.
- The location of the sensors require tuning to provide optimum testing range and accuracy.

3. Ethics and Safety

3.1 Ethics

- We are responsible in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment through the whole project. This is in accordance with the Section 7 IEEE Code of Ethics [2].
- We are responsible in refraining from infractions of academic integrity, from conduct that may lead to suspicion of such infractions, and from conduct that aids others in such infractions. This is in accordance with the UIUC Student Code Part-4 $1-401(Expectations for students) [3].

- We are responsible to provide a poolproof installation guide of the blind spot warning system to our end users to avoid misplacement of sensors and display.
- We are responsible in notifying users that fully depending safety on our blind spot warning system is still a dangerous action. Our system can give warning lights for possible collisions, but it still needs bicyclists to act properly to avoid collisions.

3.2 Safety

- For safety, we will ensure at least two of our teammates in the lab when we need to work in lab and obey all regulations as suggested by Division of Research Safety.
- For safe using, we are responsible in eliminating static shock for our prototype.
- For our own safety and people on the road, we would test our bike in open space instead of on the road. We would use obstacles to simulate the real world road environment.

REFERENCE

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