Autobrake Bicycle

Team50: Taiqing Ling (taiqing2), Gary Gong (boyangg2), Weichen Qi (wqi4)

ECE445 Project Proposal - Spring 2021

TA: Xihang Wu

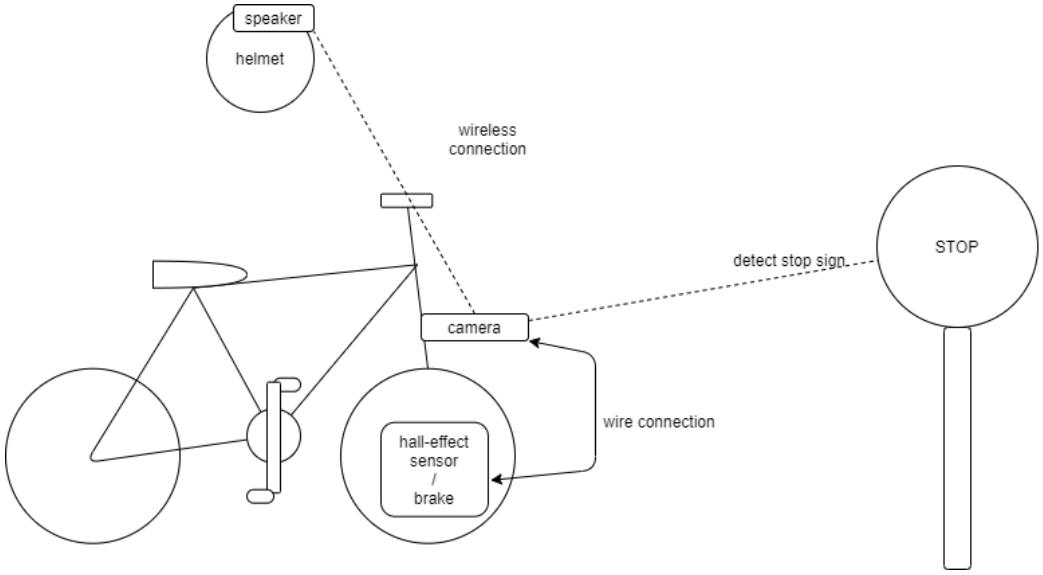
1 Introduction

1.1 Problem and Solution Overview

Currently, the traffic laws for bicycles are often incomprehensive and, therefore, potentially unsafe. In 2018, 857 people in the United States died in bicycle accidents. That number was the highest since 1990. In 2016, about 71% of deaths due to bicycle accidents occurred in urban areas and 30% occurred at intersections. It was recommended that all bicyclists should wear a helmet but no state has so far announced such a law to rule that, which caused the tragedies.

Furthermore, as one of the important methods of transportation in the world, the bicycle has never acquired equal attention to its development as other vehicles, like the car and the motorcycle. While autonomous driving has become a mainstream in the development of vehicles, many cars have installed intelligent driving assistance like lane-keeping, blind-spot detector, auto-parking. Motorcycles also have riding assistance products. All these products help avoid traffic accidents and therefore protect drivers and riders. However, similar kinds of products are barely seen on bicycles. With an aim to protect bicyclists, we decided to create a riding assist for bicycles and thus to lower the risk of a bicycle accident at crossing roads. In this project, we plan to build an autobrake system that will force the bicycle to stop at STOP signs. The STOP sign is such an important traffic signal that anyone who learns to drive will be taught about rules relevant to it. Bicyclists, however, do not need a license to ride legally and thus may lack such kind of safety awareness. This project will therefore help solving this problem by first, reminding the cyclist about the STOP sign and second, forcing the brake if no action is the cyclist does not take any action to slow down. The product should be easy to install and have an affordable price.

1.2 Physical Design



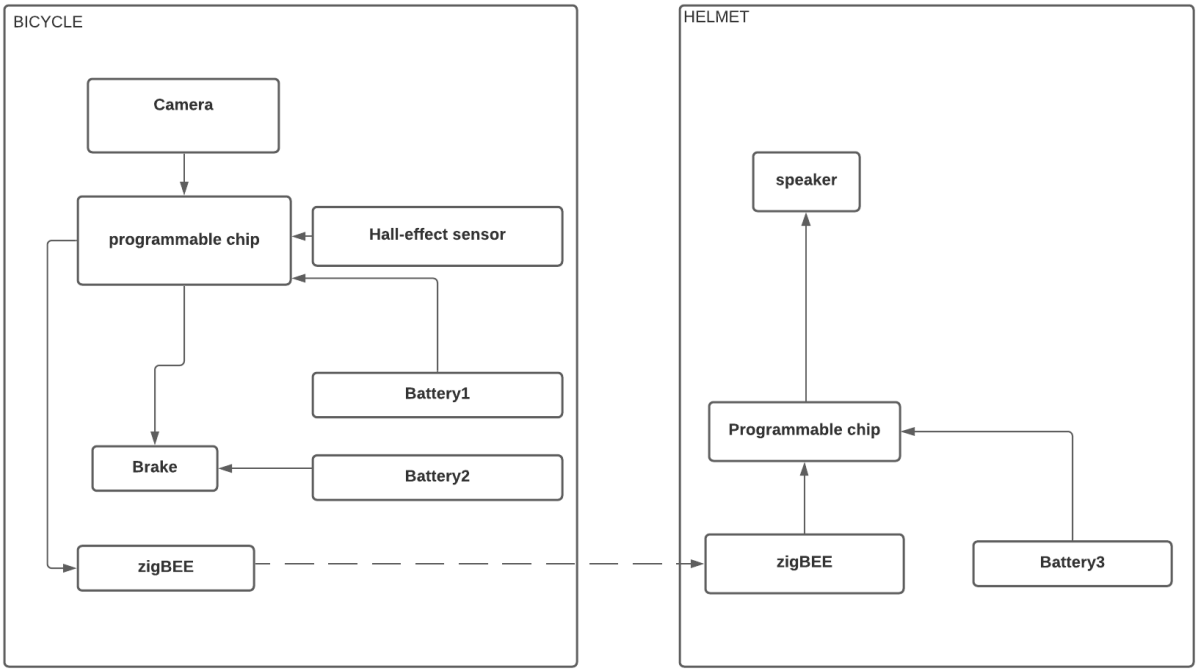
We will install a camera module as an ‘eye’ on the bicycle to capture frontier images as well as a hall-effect sensor on the wheel for speed measurement. These two sensors are wired and will be wireless connected to the speaker on the helmet. Once the camera detects a STOP sign, the speaker will generate warning sounds as a reminder. Then, when the STOP sign is closed enough, if still no action has been taken by the bicyclist, in which case the speed of the bicycle is not slowing down, the autobrake will be triggered to force the bicycle to stop.

1.3 High-Level Requirements

- The project must be able to detect a STOP sign successfully.
- The wireless connection must be built successfully so that the speaker on the helmet rings properly.
- Based on the speed, the brake must be activated properly within a threshold distance.

2 Design

2.1 Block Diagram



The autobrake bicycle project is split into two parts: the detection and braking system on the bicycle and the warning system on the helmet. These two parts will be wireless connected with zigBEE module, which can have a transmission distance of 10 meters even with the lowest power supply. We plan to use a camera module OV7670 and the 'template match' algorithm to detect a STOP sign. We can also determine the distance of detection by adjusting the size of convolution kernels. It does not need to accurately measure how many meters the STOP sign is away from the bicycle. It only needs to determine a threshold distance for triggering autobrake. We will do several tests to adjust the kernel size so that the threshold is set reasonably. Once a STOP sign is detected, it will send a signal to the helmet, and the speaker will remind the cyclist about the STOP sign. We will also measure the speed of the bicycle so that if the speed is higher than some value while the STOP sign is closed enough, which means the cyclist did not take action after hearing the reminder, the autobrake will be triggered.

Bicycle Part

- ***Camera OV7670***

The camera module will be installed in the front of the bicycle to capture real time images.

- ***Hall-effect sensor***

The hall-effect sensor will be installed on the wheel. It will detect rotations and compute the speed of the bicycle.

- ***Microcontroller: ATmega328***

This is a microcontroller on the bicycle that receives image information from the camera and speed data from the hall-effect sensor and performs relative operations.

Requirement1: It will use multi-scaling template match algorithm to determine whether there is a STOP sign captured by the camera

Requirement2: It will activate the brake system properly based on the distance to the STOP sign and the speed of the bicycle.

- ***zigBEE***

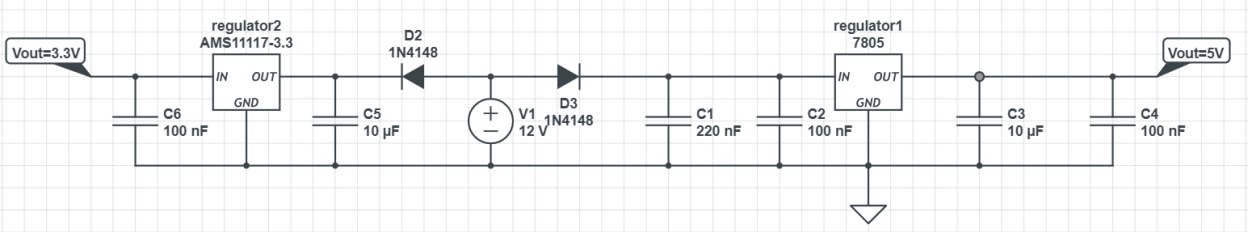
A transmitter that is wireless connected with the receiver on the helmet.

Requirement1: It should be able to build stable and consistent wireless connections.

- ***Brake***

ROB-11965 servo will be able to generate a torque 5~6kg*cm at 4.8~6V input voltages. It will be used to push the brake.

- ***Power Supply***



The power supply shown in Fig above will provide 3.3V and 5V power steadily all the time. The 3.3V power supply will be used as input voltages to the OV7670 camera module and XBEEs while the 5V supply will be used to power the ATmega328 chip and trigger the ROB-11965 servo.

Helmet Part

- ***Speaker***

It will generate warning sounds to remind people that a STOP sign is detected.

- ***zigBEE***

A receiver that is wireless connected with the transmitter on the bicycle.

Requirement1: It should be able to build stable and consistent wireless connections.

- ***Programmable chip2***

The microcontroller on the helmet. It should read signals from zigBEE and activate the speaker properly.

Tolerance Analysis

One challenge of our project is that the detection of the STOP sign and the distance measurements are solely dependent on the image processing algorithm. Considering that almost all STOP signs look exactly the same, instead of introducing a machine learning model, we plan to 'use multi-scale template match' to complete this task. We will first set a STOP sign image as our template and use K-means to analyze its color features. Then we will traverse the video image with multi-scale sliding windows to see if at some point there is a match. Whenever there is a match, the code will determine whether this STOP sign is at a safe distance away based on the sliding window, because intuitively the larger the sliding window, the closer it is. However, we need to do several road tests to determine a threshold window size. Additionally, the efficiency of the algorithm is a concern. In order to make the detection as sensitive as possible, we need to make the algorithm efficient enough to avoid time lag.

Another risk of our project is about the physical design and possibility of the automatic bicycle brake. In real life the brake is controlled by riders' hands thus adjustable. In our project, we would like to stop the bicycle using prepared program thus the force we used on the brake is important and hard to measure, because it is affected by the speed of bike, emergency distance, and even the rider's weight. The power of that brake is also a challenge, for now we are considering using battery, advanced design may change to the power from stepping on the pedals, ie a internal energy circulation system. We have not learned about the pcb so far so we are considering using Arduino as an interface and transport the signal using zigBEE. We will reconsider the risk of utilizing pcb for our project in the future.

Ethics and Safety

Our project is only an assistant for helping riders identify stop signs when they do not notice the potential danger, which could help avoid accidents in a large context. However, the project is not auto driving related. Therefore, the user still needs to take the responsibility for riding carefully when using this project. With this project, the user is still required to obey the traffic laws himself. The project is aimed to lower the risk for bicycle riders instead of letting bicycle riders ride with lower precaution. The safety issue is stated in the link below. For ethics, there is low potential that this project will be misused accidentally or intentionally. When we design and test for this product, we will also obey all the traffic laws, and make the testing in a very safe environment to avoid breaches of ethics.

References:

zigbee alliance. (2020). zigbee alliance. Retrieved 2 17, 2021, from https://zigbeealliance.org/zigbee-faq/#:~:text=Transmission%20distances%20range%20from%2010,in%20the%202.4GHz%20band.

apakizerasc, Author: "Safety Tips For Sharing The Road: Cyclists And Drivers." *" Safety Tips For Sharing The Road: Cyclists And Drivers*, blog.americansafetycouncil.com/safety-tips-for-sharing-the-road-cyclists-and-drivers/#:~:text=Safety%20Tips%20For%20Bicyclists&text=A%20stop%20sign%2C%20lane%20rules,riding%20bicycles%20on%20the%20road.

https://www.autoblog.com/2020/05/04/cyclist-traffic-death-tracking-outside-magazine/#:~:text=Tracking%20news%20databases%20and%20local,trains%20during%20the%20coronavirus%20pandemic.

https://pennygeeks.com/legal-resources/statistics/bicycle-accidents/#:~:text=Almost%20467%2C000%20individuals%20were%20hurt,reaching%20nearly%20820%20in%202015.