ECE 445

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Project Proposal

Auto-Brake Bicycle

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Introduction

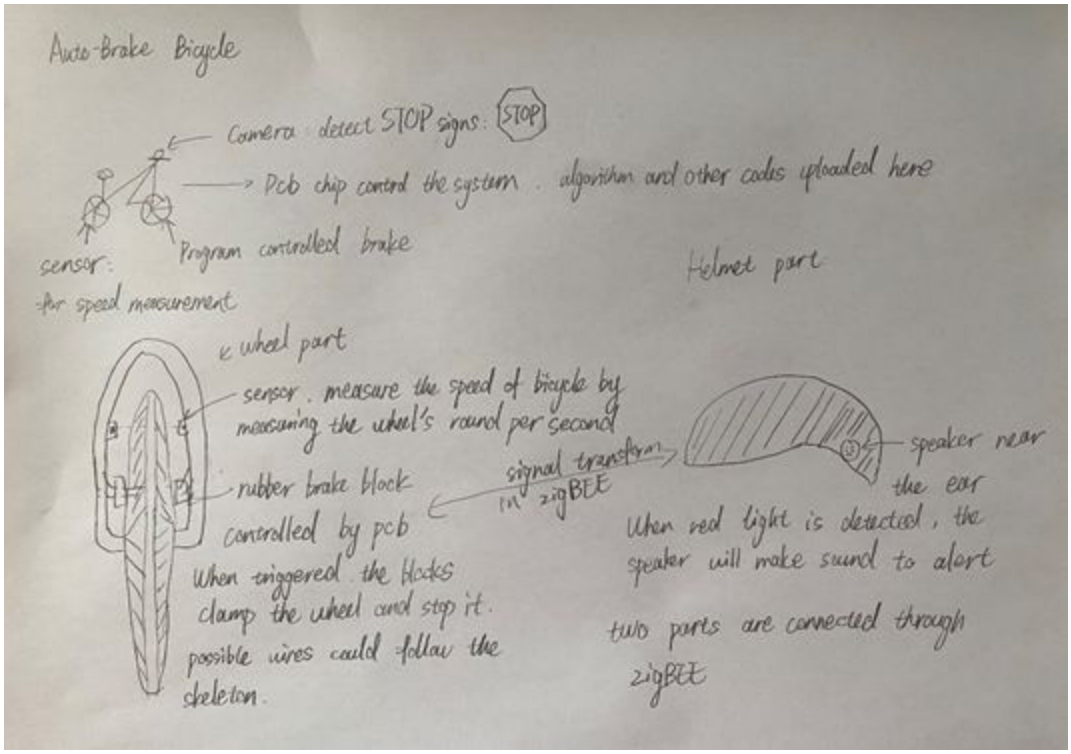
Objective

The starting point of this project is the contrast between the availability of bicycle and the constraint for anyone to ride it. As one of the most popular traffic methods in the world, anyone could spend an afternoon to learn how to ride it. However, there is almost no limitation or qualification for someone to ride the bicycle on the motorway, which means a greenhand who just learned how to ride this afternoon could risk his/her life on the motorway this evening.

Background

Even for now, the classification of bicycles is still uncertain and unsafe. Bicycles are not cataloged as a vehicle, for sure. It is neither cataloged as a passenger since it still uses the motorway. In other words, anyone can ride a bicycle onto the motorway without system training of traffic law and ethics. This is dangerous because we cannot track all the bicycles and their riders through license plates, which makes it impossible to punish all the violators. Thus, we would like to build an automatic system that would stop the bicycles when a STOP sign is detected to prevent the violation of STOP signs. Because the violation of STOP sign is the most common and dangerous behavior that could happen to bicycle riders.

Physical Design

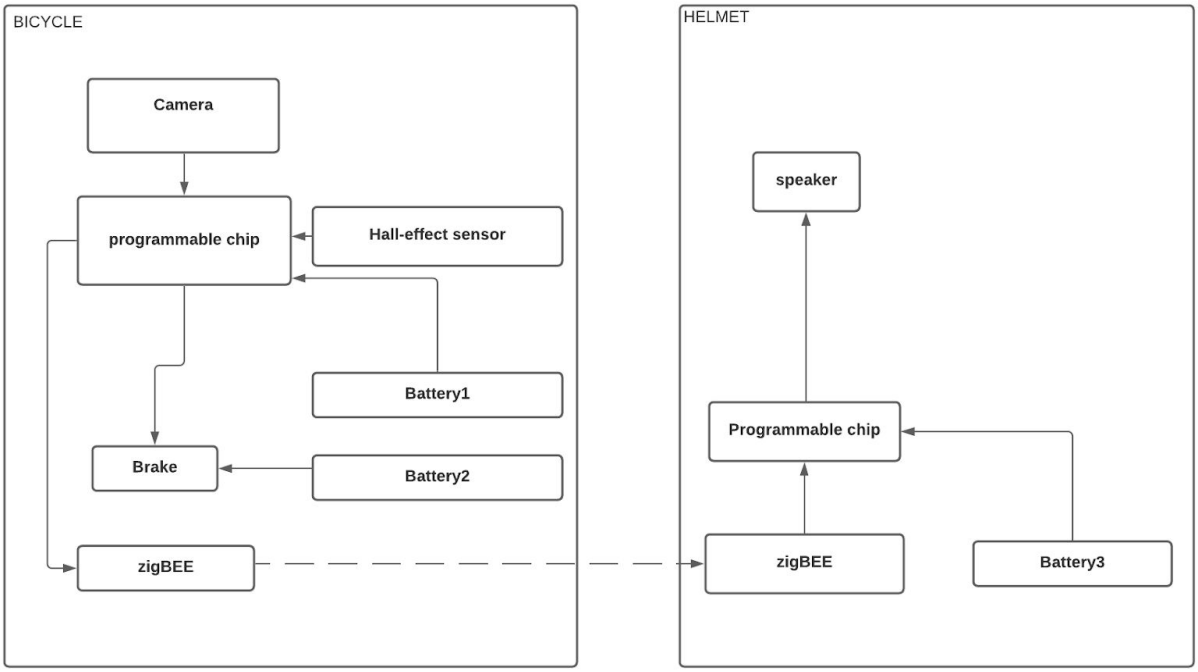


High Level Requirements

- The project must be able to detect a STOP sign within proper distance.
- 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.

Design

Block Diagram



The project of auto-brake bicycle can be splitted 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 (*zigbee alliance*, 2020). We plan to use a camera module and use 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 warn people about it. 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 driver did not take action after hearing the reminder, the auto brake will be triggered.

Bicycle Part

- ***Camera***

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.

- ***Programmable chip1***

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 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***

A large torque servo will be triggered to push the bicycle brake based on instructions given by the micro-controller.

Requirement1: The sevo must be powerful enough to push the brake. The exact torque depends on the brake.

- ***Power Supply***

The power supply contains two batteries, one for the servo and one for the microcontroller.

Requirement1: The battery for the servo must supply at least 1A at 10V consistently.

Requirement2: The battery for the microcontroller should give 5V power supply.

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.

Risk Analysis

One risk 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.