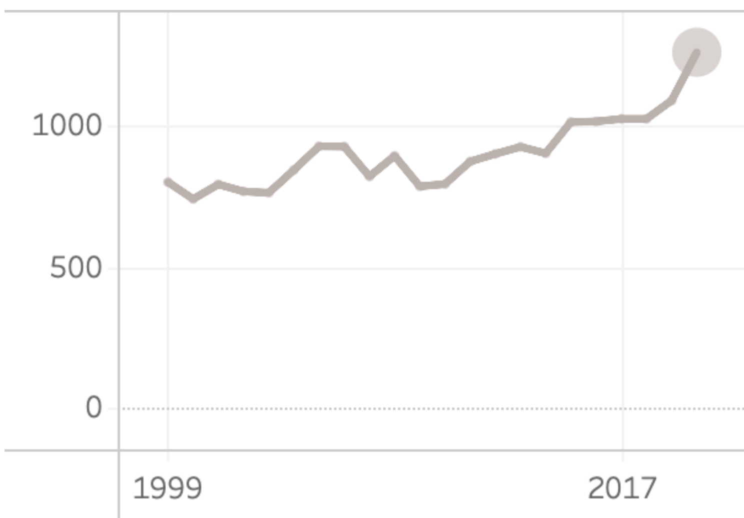
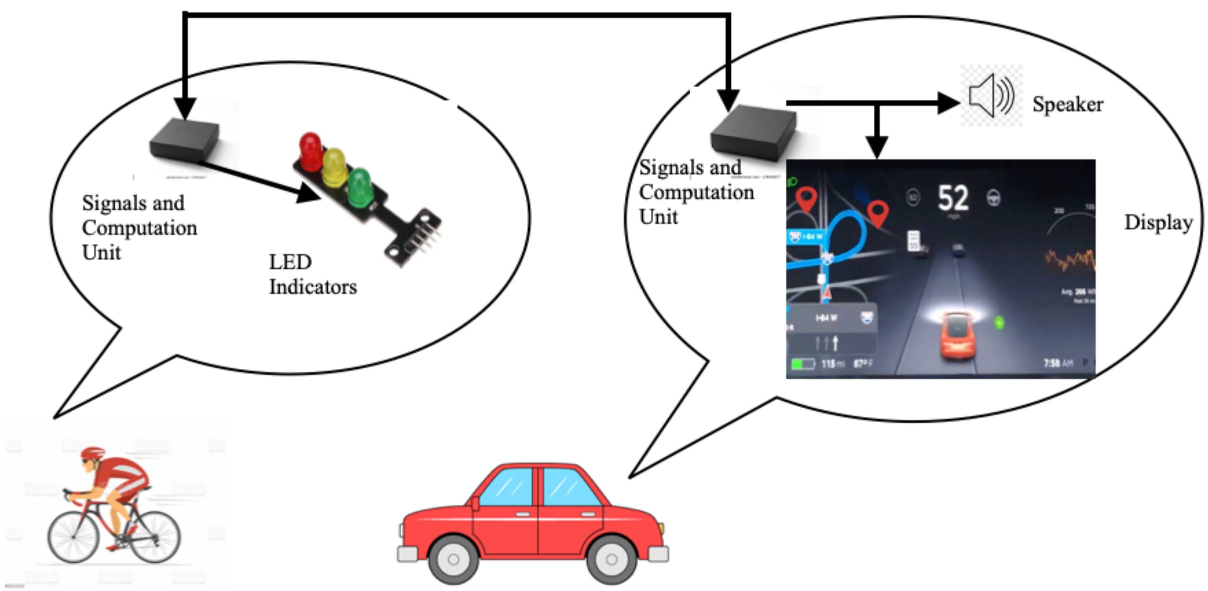
1. Introduction
    a. Problem: Each year, there are a significant number of cyclist fatalities caused by collision with a motor vehicle. In fact, there were over 1000 cyclist deaths in 2020, a 9% increase from the previous year in the US. Furthermore, according to a study on the subject, it was determined that environmental factors, (such as weather, lighting conditions, and the time of day) was intrinsically linked with the level of injury occurring from such crashes. These conditions of low visibility inevitably resulted in not only a larger proportion of accidents, but also greater severity of the injuries in question. Naturally, this also includes unavoidable accidents due to there being blind corners, as a large fraction of the collisions occur in urban areas.



From the figure left, as these accidents are clearly increasing in frequency, it is clear that none of the measures that have been taken are effectively addressing the issue. Although one might assume that camera implementation would be suitable, such an approach would be unlikely to aid in diminishing such accidents. This is due to the fact that cameras are not infallible in the aforementioned visibility conditions. As such, this leaves a large gap for an appropriate solution.

    a. Solution: In order to address the problem in question, it is clear that some form of warning is required for a vehicle driver prior to the occurrence of any unfortunate collisions. It would also be beneficial if a cyclist can be warned of a closely-approaching vehicle beforehand. The solution for the latter must be compact and clear in order to be easily understood by the cyclist. Therefore, a system of three colored LEDs (red, yellow, and green) could be jointly placed on the handlebar to indicate how far away a vehicle is, in ascending order. The aforementioned colors simply translate to near, approaching, and far respectively. Now discussing the system for the vehicle, it is important that there is a way to alert the driver on recognizing a bicycle in the vicinity (10 m). An additional method of monitoring all bicycles in a greater scope (50 m) would also be helpful. These problems can both be solved with a two-part system: one that releases a buzz-like sound upon recognizing a cyclist in a 10 m range, and another that serves as a display to depict the positions of any bicycles in the area (50 m radius). Using this system, a vehicle can be alerted about a cyclist well before actually seeing the bicycle, therefore reducing the probability of these accidents. Note: This works by uniquely identifying bicycles and cars by IDs, which will aid in the car and bicycle easily being able to identify their counterparts approaching through the emission of signals.

b. Visual Aid:
Note: The red location pins in the Display are locations of the bicycles nearby.



The pictorial representation is depicted above, with arrows indicating data (and computation results) transfer. To summarize, the Signals and Computation Unit of the bike and vehicle work in tandem, to let each other know of their respective positions, finally sending it to the LED indicators, along with the display and speaker respectively. This then informs the user according to specifications mentioned.

- High-level requirements list:

- The vehicle and bicycle should be able to detect and inform the driver/cyclist about their approaching counterpart starting from the time where the distance between them is at least 10 meters. This is to give them sufficient warning to respond to the situation.
- The vehicle and bicycle should be able to detect movement of their counterparts that are of speeds of 10 miles/hour at the minimum. This is simply a metric to start with. If the device can detect approaching vehicles at higher speeds, it would be ideal.

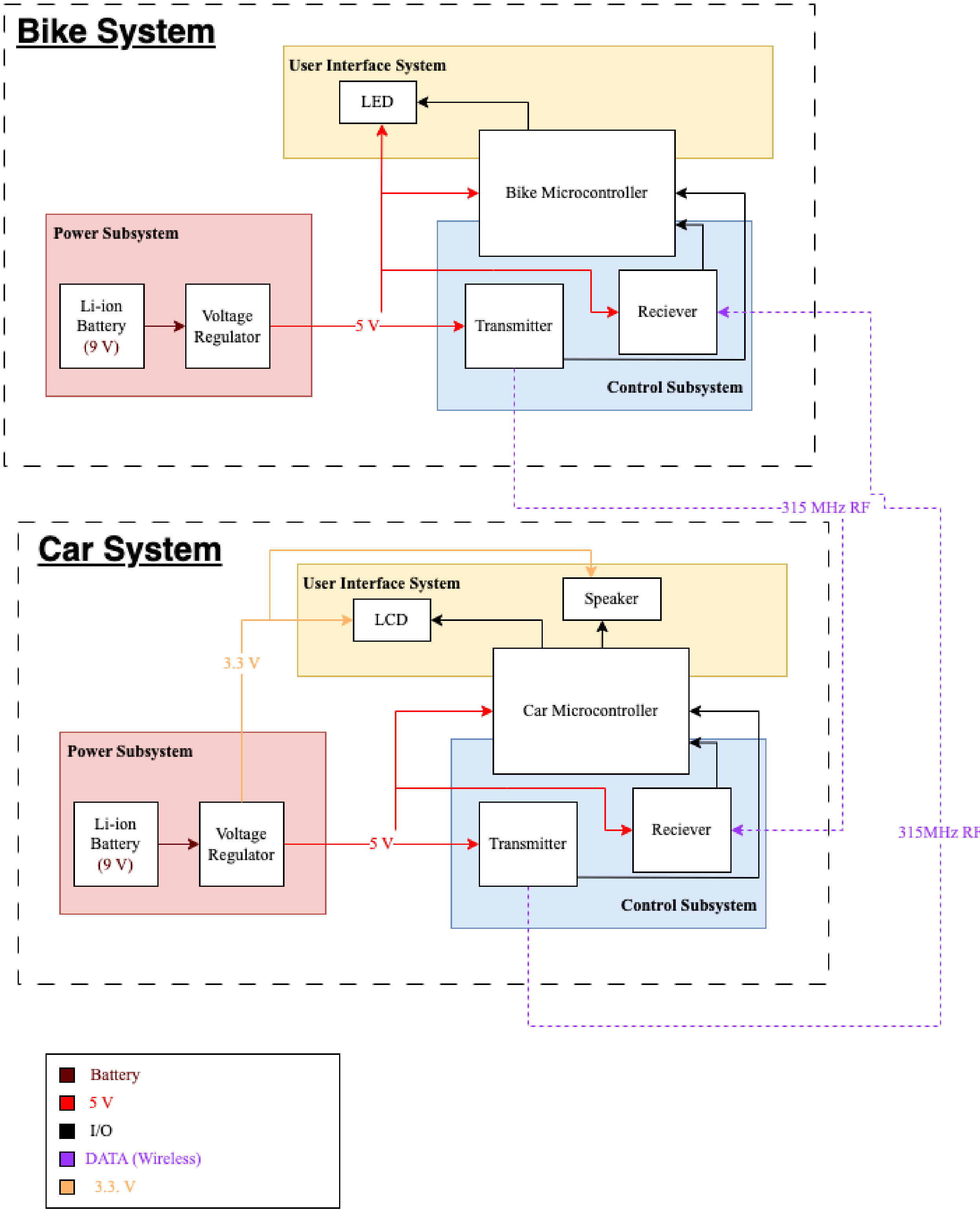
- The system should update both the bicycle and vehicle regarding their counterpart's position once every 10 ms (milliseconds). This is to ensure that both the cyclist and driver always have updated information, even in a fluid situation.

References:

https://www.iihs.org/topics/fatality-statistics/detail/bicyclists
https://injuryfacts.nsc.org/home-and-community/safety-topics/bicycle-deaths/
https://onlinelibrary.wiley.com/doi/10.1002/ajim.22849

2. Design

a. Block Design



b. Subsystem Overview and Requirements

i. Bike Device

1. Control System

a. Part: (Digi-key Part No. : 1597-114992732-ND) RF Transmitter and Receiver
b. The transmitter and accompanied circuits will generate any signals as directed by the microcontroller. The Transmitter will be powered by the battery subsystem at 5 volts.

The receiver will relay any information received at the expected frequency to the microcontroller. The Receiver will be powered by the Battery subsystem also at 5 volts. Must ensure that both transmitter and receiver work at the same frequency and at high enough power in order to fulfill the high level requirements of at least communication at 10 miles per hour and at distances of 10 meters. Communication will be done at the radio frequency of 315 MHz.

2. Battery Subsystem
    a. Part Voltage Regulator: (Digi-key Part No. : S-19214B00A-V5T2U7) Voltage Regulator

9V Lithium Ion Battery(Duracell)

    b. The Battery subsystem will power all components on the Bike PCB and Car PCB using a 9 V battery and 2 voltage regulators at 5 volts and 3.3 volts(for LEDs, LCD, and speaker). The battery subsystem must continuously operate at said voltages in order to fulfill high level requirements of communication.
3. Microcontroller
    a. Part: Digi-key Part No. :3647-ATMEGA328P-PUDIP28-ND

    b. The microcontroller will accomplish 3 main tasks. First, it will store received information from the receiver in on chip memory. Second, it will generate/output the unique bike ID and send it to the transmitter. Third, the microcontroller will verify information from the receiver and generate an appropriate confirmation message. High level requirements will be fulfilled by generating the necessary confirmation and ID signals that will be sent via the transmitter. This enables communication at various speeds and distances to fulfill high level requirements.

4. User Interface System
    a. LCD Part: Digi-key Part No. :1756-1000-ND

Speaker: Digikey : 2056-K15S-8OHM-ND
LED: panel mount LED (used in class)

    b. On the bike pcb, we expect data communication via I/O pin from the microcontroller to the LED when the signal from the Car pcb is picked up from the bike pcb's receiver. This signal will be updated every 10 ms by the microcontroller in order to fulfill high level requirements. The Car pcb will have an LCD screen and a speaker in order to alert the driver when it receives the transmitted signal from the bike pcb. The LCD display will show the approximate position of the Biker with respect to the driver and the speaker will sound a beep via signal from the microcontroller updating every 10 ms. The LCD display and speaker will be powered via 3.3 volts from the battery subsystem.

c. Tolerance Analysis
    i. An aspect of our design that poses a risk to the successful completion of this project is the LCD module. It requires a constant power supply voltage of 5 V and has an operating temperature of 70 degrees Celcuis. Since we are planning on keeping the LCD inside of an enclosure, we must ensure that the inside operating temperature of the box must be less than 70 degrees. This can be done by planning heat vent into the enclosure as well as keeping the box somewhere inside the car that will not be directly in the sunlight in case extraordinary heating occurs.

3. Ethics and Safety
    a. One of the tenets of the IEEE code of ethics is “to protect the privacy of others”. One particular concern that arises from this is that our device can be used to detect the location and a unique id for another driver/biker. This can be subverted by randomizing the id of a particular device every 24 hours to ensure user privacy.
    b. Another tenet of the IEEE code states “to hold paramount, the safety, health, and welfare of the public”. One potential concern related to this is the effects on humans from the use of EM waves in our device. According to the Federal Communications Commission, the maximum RF limit for an individual from a cell phone or similar device is 1.6 W/kg. We can use this as a benchmark during our design for both our safety and a user’s safety.