Preliminary Design Report

LED Car Proximity Sensor: A Safety Device

COSC/ECE 401

University of Tennessee-Knoxville

Knoxville, Tennessee

November 2020

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LED Car Proximity Sensor

Executive Summary

Motor vehicle crashes are estimated to be the eighth leading cause of death globally for all age groups according to the CDC. As technologies in new cars continue to advance to combat this problem, owners of older cars have had limited access to these technologies. We will create a LED Car Proximity Sensor system that will allow users to access some of the safety measures and protections of a new car without buying one.

Many car manufacturers have implemented engineering solutions in newer cars to try to lower motor vehicle crashes and deaths. These include proximity alerts for nearby vehicles or possible obstructions, ignitions that require BAC to be below a certain threshold, and back-up or parking cameras. However, many of these technologies have not seen widespread implementation and owners of new cars have had no way to access these technologies. Our project will allow consumers to implement a proximity sensor and alert system to decrease the likelihood of a motor vehicle crash without having to buy a new vehicle.

For our project, we will be looking to meet certain Engineering Characteristics: a successful proximity detection rate of at least 95%, detection capability from at least 3 feet, a brightness level of between 2,000 and 4,000 lumens that will be determined through testing, an unobtrusive design that can be implemented nearly universally, and weatherproofing.

Problem Definition and Background

By creating an easy to implement proximity system, our product could potentially save thousands of lives. According to the CDC, approximately thirty thousand Americans die every year from car accidents with an additional two million injured (Motor Vehicle Crash Deaths 2016). Using proximity sensors, the detection system will use an LED lighting system to warn people. Our product will hopefully lower the aforementioned statistic by preventing extraneous fatalities and casualties. This could be something as nondramatic as backing out of the driveway with a blind spot, to losing focus on the highway; the light from the system could provide the extra second needed to prevent disaster. As nice as this sounds, it is going to take more than words and an idea to make this product come to fruition. The constraints to be dealt with include both the technical and figuring out what needs to be fixed from the eventual testing phase.

Among the most frequent auto accidents in the U.S are merging, side-impact and rear-end collisions which occur due to distracted driving or failure to maintain a safe following distance. The LED device will provide further visual alert that will make sure to notify other drivers when they are in a risky situation. Proximity sensors are standard for most vehicles manufactured after 2016, but the sensors are only within the car, meaning that they can’t notify other vehicles around without the sensors. Blind spot monitoring systems that can be installed to vehicles who do not have the system already built in, and blind spot mirrors are examples of products that have tried to solve this problem.

While those only alert the driver with the alert system, our product would also be able to notify the other drivers who are too close to the vehicle with our product.

Requirements Specification

The final product will be a kit to install 2 proximity sensors and an LED strip to the rear of a vehicle to show by lighting or flashing when a vehicle is tailing too close behind. Two proximity sensors will be mounted to the rear bumper of the vehicle. These sensors will then be connected to a raspberry pi programmed to trigger a signal when a large vehicle is found within a certain distance to the proximity sensors. The raspberry pi will then output the signal to an LED strip or panel also mounted to the rear of the vehicle to notify the object too close to the vehicle when the object has breached the proximity distance specified.

The product is required to be functional in efficiently triggering at appropriate distance threshold. It should also be reliably charged by the vehicle's own power and simple to install on any vehicle

- Signaling: LED device should turn on when an object breaches the distance threshold
- Power: The System should be sufficiently powered by the vehicle
- Weather proof: The LED Device should be weather and climate proof to alert the surrounding drivers in heavy weather and to safely protect the customer.
- Simple: The device should be simple enough for a customer to install on their own vehicle.

The LED panel or strip should reliably signal in a viewable manner whenever an object of considerable size is within a certain distance from the rear of the vehicle. The entire device should be powered by the vehicle's electric output via a cigarette lighter or other plug in order to meet customer requirements for convenience. It is also important that we install waterproofing and insulation to all parts of the device in order for it to function reliably in all customer required environments. It is also desirable for the customer to be able to install it on their own vehicle. Therefore, the design must be simple enough to be incorporated into vehicles with minimal tool requirements or instructions.

Our project has many variable features but it also could have potential constraints including some vehicles needing extra sensors. Sensors will be placed in specific locations to detect potential collisions, but depending on the size of the vehicle additional sensors may be required to work adequately. We will offer additional sensors to those who feel their car may need or could sell kits depending on what kind of vehicle the system is going on. This will be useful in maximizing the efficiency of our product for all vehicles. When considering the design requirements and goals for this project there are a few important Engineering Characteristics that must be considered. Below is a table explaining the top characteristics and describing them as either variable or constraining in terms of the design specifications.

Engineering Characteristics	Options/Units	Significance
Number of Sensors	2-6	Variable: We have the freedom to use the most efficient placement of sensors. Larger cars may require more than smaller vehicles.
Weather proof	Weather and climate proof	Variable: It is necessary to weatherproof the LED device as this device will always be attached on a car.
LED	Placement and brightness	Variable: The placement and brightness of our LED display could have different results. We must optimize all these options for all vehicles..
Non-Obtrusive	Avoid major components of vehicle	Constraint: The device must be made in a way that it does not interfere with the anything important in the vehicle and must be placed where it is not too noticeable

These Engineering Characteristics were determined by accessing the customers needs and incorporating them into our design. It should be noted that there are other things taken into consideration for our design, the characteristics mentioned above were just a few of the most important considerations. By considering the characteristics above the overall design will meet the customer's requirements.

Technical Approach

In our final project, we are aiming to create a physical final project and/or formulating a simulation that mimics the physical device. In a physical final project, if built, the device will be able to be utilized by a car as an alert system. The device will be attachable with functioning sensors and LEDs.

The purpose of our final project is to increase safety on the road. Increase safety by being another layer of alert system. An alert system not just for the customer, but also the surrounding and nearby cars. The device will sense dangerously nearby vehicles through the proximity sensor, and then the LEDs will blink. An output that implies that a vehicle is too close. We are open in changing our design to achieve driver safety through our device. We are also open in making the device as an accessory for car hobbyists. As well as explore other realms, other than the average driver, that can utilize our designed device.

For our project, our components will each serve different purposes that are broken down as follows:

- The LED device should be bright enough to be noticeable to alert both the driver of the car the device is implemented on and the object that is approaching the

car. However, it should not be so bright that it will limit the ability for users to drive safely. We will be testing to determine a final value for this, but we are tentatively looking at between 2000 and 4000 lumens.
- The sensors should be able to pick up any object that is approaching too close to the car. It should be able to pick up the object when it begins to get too close, tentatively 5ft, and alert the system and have the LEDs light up when it is too close, tentatively 3ft.
- The Raspberry Pi will handle the I/O for the system. It will take in the data from the sensors and turn on the LEDs in the event the sensors indicate an object is too close to the sensors.

These devices need to function properly and quickly together. The ability for the sensor to pick up the object does not matter if it cannot communicate with the LEDs quickly enough for the driver to react. In addition, the LEDs must be bright enough to alert the driver or a fast response time from the LEDs will not matter. Lastly, the Raspberry Pi must correctly interpret the data from the sensors to accurately determine when the LEDs should be on or off. Even if these devices all work together and function properly, however, this will only be a solution to some causes of motor vehicle accidents. This project will primarily aim to limit accidents between two objects moving slowly towards each other, such as merging or backing up. It will not be able to stop head-on collisions or other speed accidents due to the limitations of the reaction time.

Given that human lives are on the line, it is absolutely necessary that we leave as little room for error as possible. After ensuring that our project works successfully in a controlled environment, it will need to undergo several environmental tests as well. This will involve simulating a multitude of different times of day, weather, temperature, etc. For example, we can dump water on it or have it work under a hose at nighttime. Any failures are to be immediately rectified.

Design Concepts, Evaluation and Selection

- Our final project will increase the safety of all drivers on the road. We will create a security system that alerts other drivers to prevent accidents. We are aiming to create a project and/or formulate a simulation that mimics the physical device in action.

- The deliverables that we will provide at the end of the semester/project are the following:
    - The LEDs should be bright and big enough to alert the drivers and the customer. This deliverable is possible if the LED has enough Power (wattage). Meaning, the lights will be connected to the car's electrical power systems to achieve high brightness. Our final LED might not be too bright as a prototype for our project, but can be scaled up.
    - Sensors will be used in our design to detect when nearby vehicles are dangerously close. This deliverable is important because the effectiveness of our design relies highly on the effectiveness of the sensors we use.
    - A program for the raspberry pi will be delivered in this project. The program will take in sensor

data and use that to determine if the LED lights need to lit up. This deliverable is important as the customer will not be able to make any modifications to the code. It is important to make sure that the program is written efficiently and without any bugs. A bug in our program could put customers at risk.

- An installation kit for our device should be delivered at the end of the project. This deliverable is important because the installation kit should tell our customers how to set up the sensors and LED's on any car, and is therefore critical in terms of customer convenience.
- A Raspberry pi will be used and connected to the display to govern the main operation. The process includes wiring up the display to the pi, and some coding that will generate images. A prototype of our product will likely include some codes to test if breadboard wiring has been done properly and pi is able to generate images as it's supposed to.
- The final report will be written to showcase our overall findings. Important information such as technical details of the design, requirement specification and budget will be included in the final report and can be utilized for mass production of our product.

- For prototyping the device we will make/design, we will not attach it to a vehicle and then drive it to an open road but test it in a simpler mode of transportation: bike, scooter, or even toy car. In addition to exposing the device to the elements and at an accelerating pace. For computer simulation, we will utilize LTSpice for wiring to Solidworks for physical structures, with some wiring, to showcase our design. This will improve our project by narrowing down on the workable dimensions we can make and increase durability.
- Using an LED light will make it easier to signal users if an object is nearby. Using a Raspberry Pi is convenient for us because it is relatively easy to program and relatively inexpensive for any potential clients. That being said, we will actually need to learn how to do so, but it should not take very long.

- The Business Model Canvas (BMC) is an effective tool used to consistently reevaluate the understanding of your business in nine main areas: Customer Segments, Value Propositions, Channels, Key Activities, Key resources, Key Partnerships, Revenue Streams, and Cost Structure. Each of these nine areas are specifically defined and understanding these helps you understand your business. We developed a BMC for this project in order to help us understand what our customers are looking for with our product. This in turn helps us with the design of our product. With the BMC we were also able to see what type of relationship we should have with our customers. For the most part we want our customers to trust our product enough so that they can feel comfortable knowing that when using our product they are more safe on the road. Understanding that we need to be trustworthy impacts the way we approach our design, as now we want to make sure that our product is very well tested.

- To develop this product we will have to program a raspberry pi in order to read the sensor data and determine if the LED's need to be displayed. The positioning of the sensors and LEDs will be optimized for the effectiveness of the product. For our design we will be programming a raspberry pi to control the LED's. Alternatively our design could have been an LED screen that is controlled by a phone or even a system that honks your horn automatically for you when other vehicles get too close to your own vehicle.

Project Management

- The modules we learned this semester were a big help for writing the final project.
  - Module 2 was helpful for us to identify our project goal and examine strategies to meet requirements.
  - Module 5 helped us identify the fundamental problems and challenges reviewing the Capstone Research Design Project Guidance and think critically about how to develop our skills to solve the identified issues.
  - Module 6 covered the value of the use of virtual presentations in academic and professional settings. This module can help us plan to construct our final presentation.
  - Module 7 introduced the concept of Business Model Canvas. It helped us illustrate our preliminary Business Model Canvas to identify key elements of our project.
  - Module 10 provided with the description of the requirements for the Preliminary Project Design Report which we applied to our team's report.

- As you can see in the Gantt Chart at the end of the document, the few weeks will be devoted to planning and designing. We hope to have a design before we start trying to build a prototype. Many design steps overlap as they are not completely dependent on each other. Each major will be given tasks for each assignment. For example, the EE majors will handle the power, wiring and circuitry assignments. The CS majors will handle the programming and coding involved. Many of us will be working together with other majors in assignments, however those assigned majors will take the lead. At the end of building we can test our designs and prepare for Reporting and Presentation together.
  - Example: For coding the Microcontroller at Week 3, with Emory, and Hyeseong (CS majors) on the job, they will make sure that the device will have appropriate and effective coded settings. Settings including; the amount of distance, time delays, etc. You can also see that we are looking to begin building our prototype at approximately the halfway point of our project

timeline. We are doing this in hopes that we will be able to make any necessary adjustments to our design that we may find throughout our implementation and testing processes. For the same reasons we are also looking to begin field testing with over a month left in the project. This is all done to ensure that we have flexibility in our design process.
   - At the end of the day, we aspire to provide something that can save lives; nothing is more precious. If it even saves one, this project will be worth it.

Budget

- The indoor LED screen device is approximated to $612. Our expenses include tools, software, raw materials and custom machining. Our budget is a rough estimate given our team members' knowledge of prices with references to some sources.

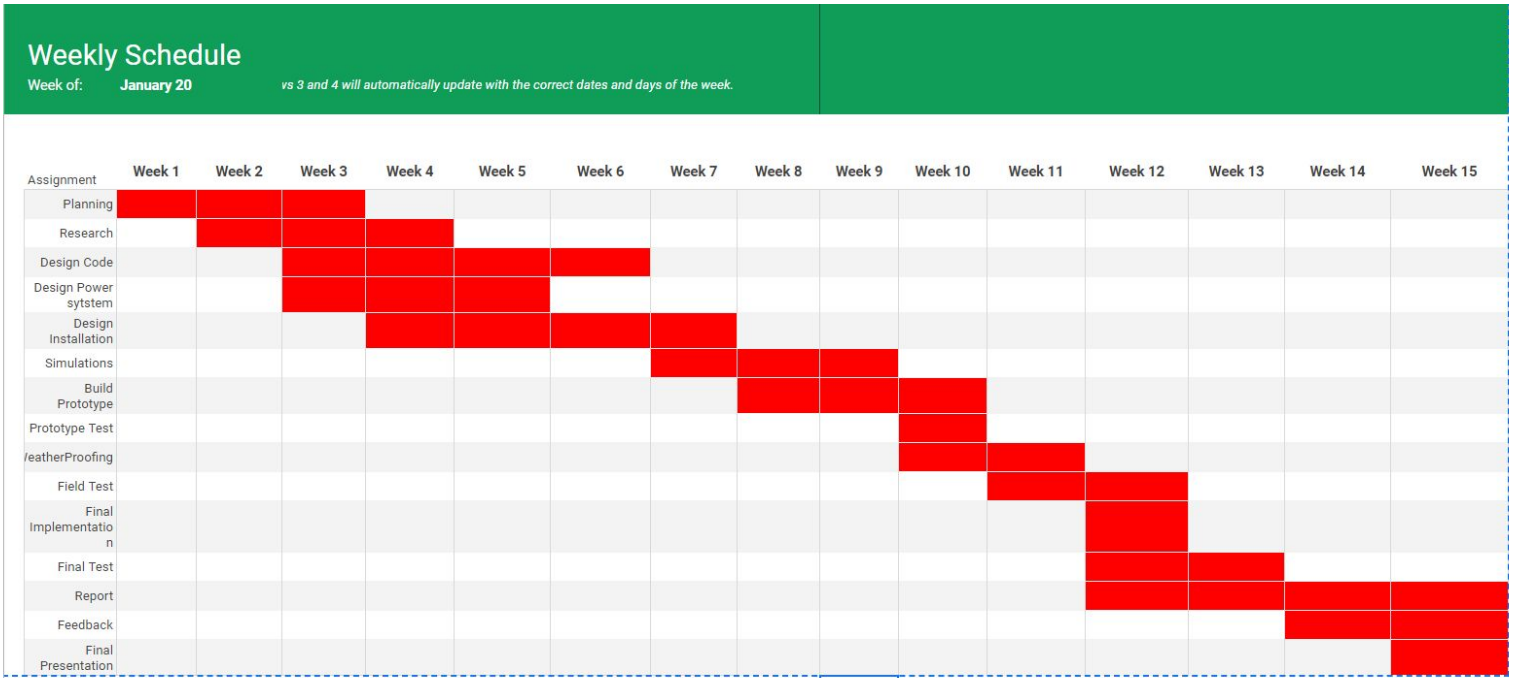
Item	Cost
CNC Rent	$200
Sheet metal	$40
Wood	$20
Drill	$150
PCB soldering	$20
KF2510	$5
Nuts/Clamp	$20
Cam programmer	$12
Thermal camera	$80
RGB LED lights	$25
Power Supply	$30
Ping pong balls for diffusing the light	$10
Total	$612

References

- Motor Vehicle Crash Deaths. (2016, July 06). Retrieved November 20, 2020, from https://www.cdc.gov/vitalsigns/motor-vehicle-safety/index.html

Appendix

- Solidworks - An engineering program. A solid modeling CAD (computer-aided design) and computer-aided engineering computer program, utilized to create models, visualize projects , and run simulations.
- LTspice - a SPICE-based analog electronic circuit simulator computer software,


Weekly Schedule
Week of: January 20
vs 3 and 4 will automatically update with the correct dates and days of the week.
Assignment
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Week 15
Planning
Research
Design Code
Design Power sytstem
Design Installation
Simulations
Build Prototype
Prototype Test
/eatherProofing
Field Test
Final Implementatio n
Final Test
Report
Feedback
Final Presentation