Vehicle Detection Cane

Team 42 - ECE445 - Spring 2020 - Design Document

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1. Introduction

1.1 Objective

In 2016, pedestrian fatalities accounted for 16% of all traffic fatalities [1]. Those who are severely visually impaired are more susceptible to being involved in a traffic accident as they are not able to see oncoming traffic. Instead they either have a guide dog or rely on using a cane and their hearing to determine if an area is safe to walk. Gas fueled vehicles make a loud noise when driving by, but electric vehicles are virtually silent. With electric vehicles becoming more common it becomes more difficult for blind people to navigate as they cannot easily determine if a street is safe to cross.

Our solution for determining if an area is safe to walk is a battery-powered cane attachment that detects and alerts the user when a vehicle is passing in front of them. When activated by pressing a button, it uses a radar sensor to determine if there are cars or other fast moving vehicles in front of the user and alerts the user with vibration if it is not safe to walk.

1.2 Background

In an article by The Telegraph [2] on how a visually impaired woman was narrowly saved by a pedestrian from being hit by an electric vehicle, she mentioned that even her guide dog failed to recognise the car since there was no noise or fumes from the exhaust. This incident has really impacted her confidence of walking outdoors alone. This is just one of the many stories and electric cars are now viewed as a hazard for the visually impaired. There have been a number of solutions proposed to solve this problem. One of which is making the electric cars emit a warning sound [3]. This hasn't been implemented yet and might also be expensive to incorporate in the cars. Our solution is designed for visually impaired people to protect themselves from electric cars and give them more autonomy.

1.3 High-Level Requirements List

1. Device is able to detect relevant incoming vehicles up to at least 25m in front of the user.

2. Device is able to be powered for at least four hours on standby mode.

3. The device is able to be easily operated by a visually impaired user.

2. Design

2.1 Block Diagram

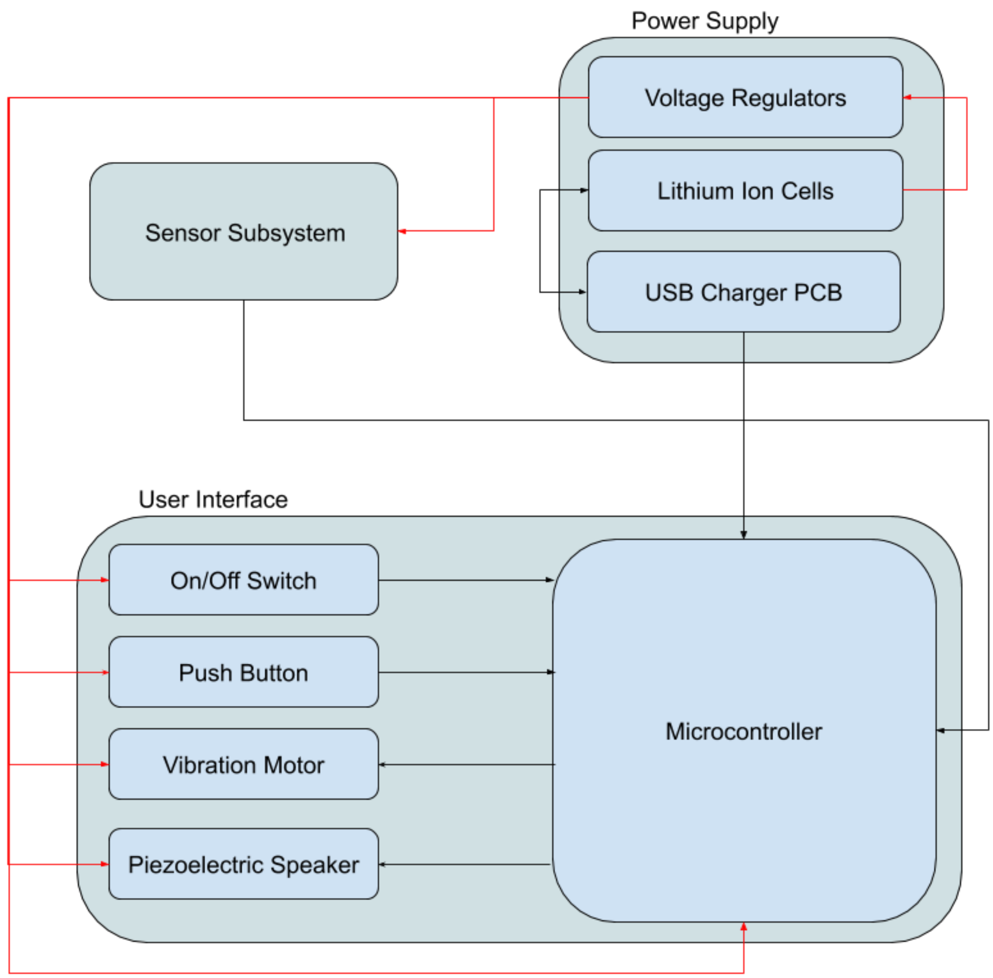

Fig 1: Block Diagram

Our design has three main subsystems for successful operation: a sensor subsystem, the power supply, as well as the user interface. The sensor subsystem is responsible for sensing incoming vehicles and processing the data received from the sensor to determine if there is an incoming vehicle. The power supply ensures that the system can be continuously powered for four hours while in standby mode. The user interface allows the user to activate the sensor and receive feedback on vehicle detection and the battery state through a vibration motor and piezoelectric speaker. Additionally, the user interface detects the low battery state and reports it to the user. To interface between the three subsystems we use a microcontroller to process all of the signals and direct them to the correct feedback output.

2.2 Physical Design

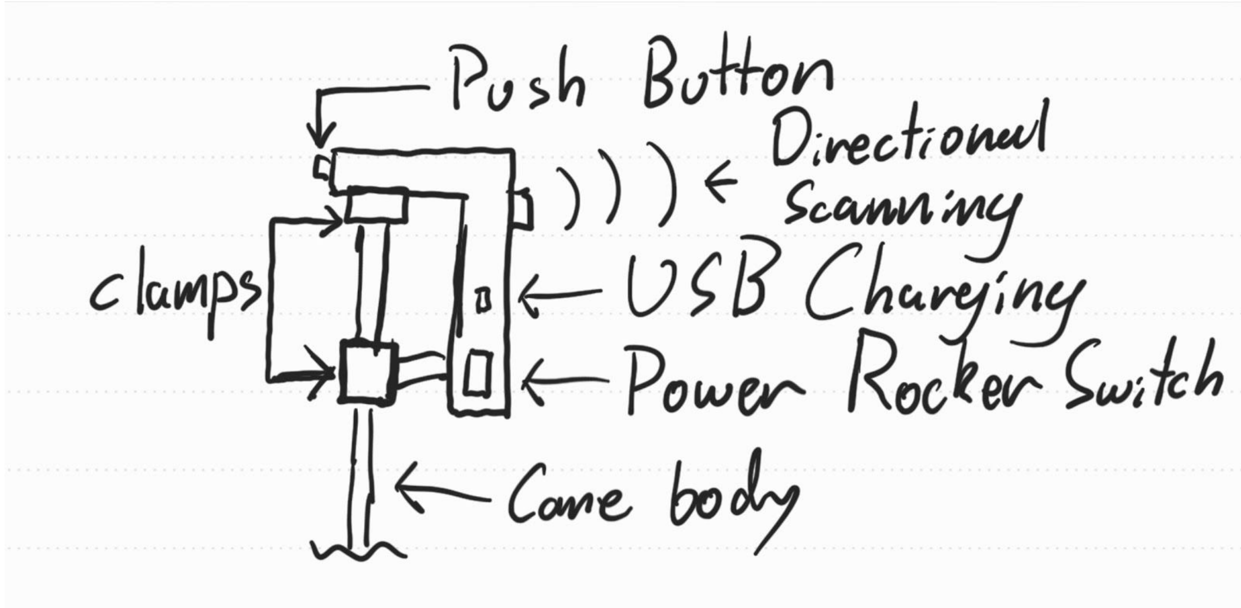

Fig 2: Physical Design

The system is designed to attach to the handle of a cane using clamps. The main body is detached from the cane shaft to allow it to be gripped the same during normal operation. The push button needs to be easily accessible during scanning, so it is positioned at the rear near the user's thumb. The push button's location also serves as a physical reference to aid in aiming the scanner.

2.3 Functional Overview

2.3.1 Sensor Subsystem

The sensor subsystem is responsible for using the doppler effect to identify moving vehicles. This technology has been in development in recent years for use in fully and partially autonomous cars. By emitting high frequency microwave "chirps" (above 77GHz) and "listening" for reflections off of objects, their general location and speed (the doppler effect) can be determined. Further processing can be performed to get more data on the object such as size and certain material characteristics (useful for differentiating between cars and other moving objects like people). An integrated automotive radar IC (which includes a transceiver, DSP, and microcontroller), will be used to emit and analyze radar data, and communicate the presence of moving vehicles to the user interface subsystem.

2.3.2 User Interface Subsystem

The radar sensor lacks the ability to interface with motors, speakers, and buttons, so a user interface microcontroller will be responsible handling them. This microcontroller will communicate with the sensor subsystem through I2C and an appropriate I2C logic level shifter. This microcontroller will interface with a push button, rocker switch, piezoelectric speaker, and vibration motor to communicate information to the user and receive input. Each component's function is as follows:

- Push button: enable radar scanning when held
- Rocker switch: turn the device on and off
- Piezoelectric speaker: alert the user of low remaining battery
- Vibration motor: vibrate when moving vehicles are detected in front of the device

2.3.3 Power Subsystem

The power system is responsible for providing set voltages to the other subsystems. 1.2v, 1.3v, 1.8v, and 3.3v are required by the sensor subsystem and 5v is required by the user interface subsystem. The power is provided by rechargeable battery cells which can be charged via USB.

2.4 Block Requirements

2.4.1 Sensor Subsystem

The sensor subsystem enables the device to detect moving vehicles. This will be accomplished using the AWR1843, and integrated radar transceiver, microcontroller, and DSP. The AWR1843 IC will communicate over I2C with the user interface microcontroller, to know when to scan and trigger vibration feedback.

Requirement	**Verification**
The device detects cars travelling at and above 10mph under 25m away.	Program an arduino to mirror I2C data over a serial connection to a laptop and probe the I2C debug pins with it. On an empty stretch of road mark a spot 25m away from a designated scanning spot on the side of the road. Drive the car at 10mph over the spot while scanning with the device from the side of the road. I2C data on the laptop should include a VIBRATE_ON message and a corresponding VIBRATE_OFF message. Repeat at 5mph

	increments up to 45mph.
The device does not detect people.	Program an arduino to mirror I2C data over a serial connection to a laptop and probe the I2C debug pins with it. In an empty area with no obstacles within 25m, have a person walk in front of the sensor while it is scanning at 5m, 10m, 15m, 20m, and 25m. I2C data on the laptop should not include a VIBRATE_ON message. Repeat at 5mph increments up to 45mph.

2.4.2 User Interface

The user interface consists of a switch to turn the device on and off, a button to toggle the haptic feedback, and the audio and haptic feedback module through a piezoelectric speaker and a vibration motor. The speaker must be able to play three different tones to signal the device turning on, turning off, and when low battery is detected.

Requirement	**Verification**
The push button triggers the microcontroller to send SCAN_ON and SCAN_OFF messages to the radar sensor.	Program an arduino to mirror I2C data over a serial connection to a PC and probe the I2C debug pins with it. Then push the button.
When the battery voltage is read to be less than 10%, the speaker periodically beeps.	Use a benchtop power supply in place of the battery cells. Set the voltage to simulate 10% charge. The device should beep periodically.
VIBRATION_ON and VIBRATION_OFF messages sent over I2C trigger the vibration motor.	Program an arduino to send a VIBRATION_ON message over I2C, wait 5 seconds, and send a VIBRATION_OFF message. Attach the arduino to the I2C debug pins and check if the motor turns on and then off.
When the battery voltage is read to be less than 10% the device does not scan.	Use a benchtop power supply in place of the battery cells. Set the voltage to simulate 10% charge. Program an arduino to mirror I2C data over a serial connection to a PC and probe the I2C debug pins with it. Pressing the button should not generate SCAN_ON messages.

2.4.3 Power Supply

The system will run off two 3.7v 18650 lithium ion cells running in series. A usb charger pcb (boards sometimes used for making portable phone chargers) will allow the cells to be charged with a usb cable. Voltage regulators will be used to produce the other voltages (1.2v, 1.3v, 1.8v, 3.3v, and 5v). A USB charger PCB will allow the cells to be charged with a USB cable.

Requirement	Verification
All voltage levels remain within 10% of their expected values during a scan.	Use a benchtop multimeter to probe the output of each linear regulator and measure the voltage during a scan.
When plugged into USB, the cells are charged.	Drain the batteries until the cells reach roughly 3.3v. When the device is plugged in, the cell voltages should begin rising.
The battery lasts at least 4 hours when not scanning.	Fully charge the battery, then time how long it takes to begin beeping.

2.5 Risk Analysis

The sensor subsystem definitely poses the greatest risk to successful completion of the project. Since if the sensor fails to detect a moving car from a distance of 25m, our main goal of the project wouldn't be achieved.

User-interface block and power subsystem should be able to work well together with the sensor subsystem to give the right inputs to the user. Since, false positives would make our product less reliable and affect the success of our project.

Also since this attachment will be on the cane, it needs to be able to work through all weather conditions which is why we have to make sure to cover our electrical components to avoid any system failure.

2.6 Tolerance Analysis

Radar sensor

- Antenna directional emission sims
- Math on doppler velocity accuracy
- Math on object size accuracy (maybe)

Power Subsystem

- Math on estimated battery life

3. Cost and Schedule

3.1 Cost Analysis

Item	Part # or Manufacturer	Count	Price
Radar Sensor	AWR1843	1	36.43
I2C Logic level shifter		1	
1.2v linear regulator		1	
1.3v linear regulator		1	
1.8v linear regulator		1	
3.3v linear regulator		1	
5v linear regulator		1	
18650 cells		4	
18650 cell holder		2	
18650 usb charger		1	
Microcontroller		1	
Vibration Motor		1	
piezoelectric speaker		1	
rocker switch		1	

push button		1	
Radar sensor programmer		1	

3.2 Schedule

Week	Neva	Aditi	Nick
2/24	Complete Design Document		
	Initial conversation with machine shop		Research antenna design
	Purchase radar sensor	Research microcontroller to use	Component List
3/02	PCB Design and order		
	Purchase Components		
	Power Subsystem Testing		
3/09	Solder		
	I2C debugging	Microcontroller Programming	Radar Testing
3/16	Spring Break		
3/23	Radar Testing and Debugging		
	Finalize Machine Shop Design		
3/30	Radar Testing and Debugging		
4/6	Radar Testing and Debugging		
	Final Assembly, Report, and Presentation		
4/13	Final Report and Presentation		
4/20	Mock Demo		
4/27	Demonstration		
5/4	Final Presentation		

4. Ethics and Safety

There are a few safety hazards that must be taken into consideration with our product. As an electrical device designed to be used outdoors, the device will be subject to conditions such as potential water damage or being accidentally stepped on. We'll need to make sure the electrical component is well covered so no water leaks are possible.

We are using a battery to power all our other subsystems so we need to make sure that the power subsystem is safe and doesn't harm the product or the user.

Since our product caters to the need of visually impaired, we must be realistic in stating claims about the features and success of the product, in accordance with IEEE Code of Ethics #3: 'to be honest and realistic in stating claims or estimates based on available data' [4].

For the success of this product we will make sure we consider all the constructive criticism and suggestion on improving the performance which adheres to the IEEE Code of Ethics #7: 'to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others' [4].

5. Citations and References

[1] NHTSA, "Travel Safety Facts", 2018 [Online]. Available: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812493. [Accessed: 13-Feb-2020]

[2] M. Write, 'Electric cars are 'silent killers' visually-impaired woman warns after near miss', *The Telegraph,* 2019. [Online]. Available: https://www.telegraph.co.uk/news/2019/11/20/electric-cars-silent-killers-visually-impaired-woman-warns-near/. [Accessed: 13-Feb-2020].

[3] SINTEF, 'Electric cars are a hazard for blind people', *Phys.org*, 2018. [Online]. Available: https://phys.org/news/2018-10-electric-cars-hazard-people.html. [Accessed: 13-Feb-2020].

[4] IEEE, "IEEE Code of Ethics", 2020. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html/. [Accessed: 13-Feb-2020].