Directional Driver Hazard Advisory System

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1 Introduction

1.1 Objective

Even with self driving cars on the horizon, there is still more that we can do to make driving safer with technology for human operators. In the United States, there were 35,092 fatalities and 2.44 million injuries from motor vehicle accidents in 2015 [1]. This makes it one of the leading causes of death in the United States [2]. With some of the top causes of most accidents being distracted driving, reckless driving, and hazardous conditions on the road [3], a driver can benefit from increased awareness and information about the road and nearby drivers.

Our project aims to augment driver awareness of the road by using motion data from sensors within a car to detect and directionally communicate hazards to nearby cars. This information will propagate from car to car using IR transmitters and receivers to keep drivers informed of potential advisories through audio cues. Some hazards, like rapid deceleration or hard swerves could be automatically detected which would send a propagating notification backwards to advise other drivers. In addition to those automatically detected, the passenger will be able to put up advisories for less immediate hazards, such as road obstructions, stopped cars, or accidents.

1.2 Background

Currently most new vehicles on the road today already come equipped with additional sensors to attempt to keep the driver more alert and aware of unsafe driver behavior or road conditions. Sensors like blind spot sensors, lane departure sensors [4] and backup cameras greatly help driver awareness, but are limited to the immediate area around the car. Given that hazards that can be detected by one car can affect several behind it, our system aims to propagate and share information to ensure all drivers are aware.

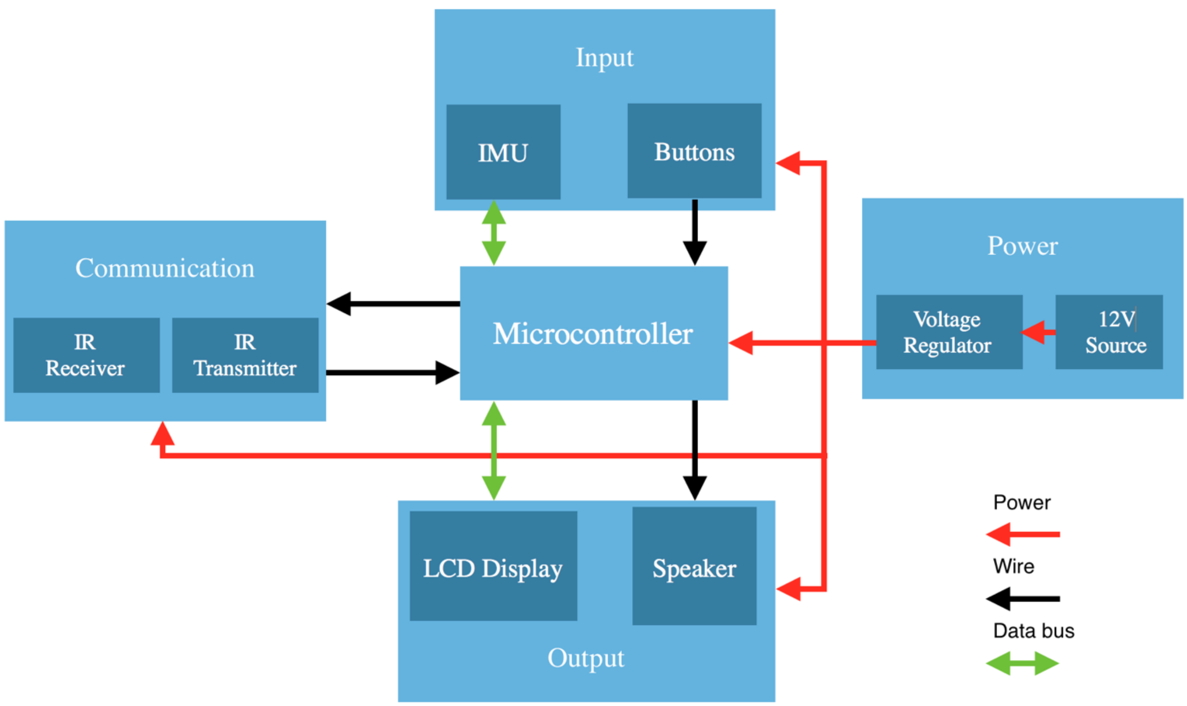
Other technologies that work to provide a similar sharing of information are mobile apps like Waze and CB radio (an old-school approach). Our system differentiates itself in that it will respond to hazards automatically, unlike Waze which is meant to be used by a passenger who manually enters it. Also, our system is directional, meaning a notification will be propagated directionally as to only notify drivers who would be affected by that notification. It is also worth noting that because every system can communicate with any another system independently, it requires no internet connection or backend system to operate.

1.3 High-Level Requirements

- System must be able to transmit/receive full messages over IR at ranges of at least 100ft.
- System must be able to detect sudden/severe deceleration or swerves. (Roughly deceleration of at most 60 feet/s^2 [5])
- System must be able to notify user of a received message through output from the speaker/screen within 1 second of message validation.

2 Design

We decided to compartmentalize our project into functional components. Each block represents an individual function, contributing in a different way to the goal of the project. The Input block represents the two user inputs to our system: passenger button inputs, and IMU readings. The output block represents the two ways in which we will communicate with the driver and passenger: the speaker and LCD. The communication block represents communication between devices. Each component is controlled by a microcontroller. Finally, the power block provides suitable power to each block.



2.1 Communication

2.1.1 IR Receiver

We would like to use IR as our communication medium to limit communication to the car in front of or behind the sender. Each car would have an IR receiver in the front of the car to receive messages. The receiver would be connected to the microcontroller through a single input pin to relay message data. Current is estimated at ~10mA for each IR receiver.

- *Requirement 1: must receive a message at least 100ft.*

- *Requirement 2: must work with a 3.3V or 5V power source*
- *Requirement 3: must have field of view of less than 180°*

2.1.2 IR Transmitter

We would like to use IR as our communication medium to limit communication to the car in front of or behind the sender. Each car would have an IR transmitter mounted near the rear of the car to send messages. The transmitter will be a high-power IR LED which will either be powered by the microcontroller or a MOSFET. We will use an asymmetric double-convex lens to narrow the LEDs beam for better range. The package will consist of a PVC pipe with the lens at one end and the LED at the other. When broadcasting, we will spam messages for a few seconds to account for potential data loss. For example, if we spam a message 15 times in 1 second, only one of those packets needs to be received for the message to be successfully received, so we are comfortable relatively high packet loss rate. We are expecting our messages to be roughly 16 bits wide (4 bits for a message ID, 4 bits for a time to live, and the remaining bits for the message. Current is estimated at ~100mA for each IR transmitter.

- *Requirement 1: must transmit a message at least 100ft.*
- *Requirement 2: must work with a 3.3V or 5V power source.*
- *Requirement 3: must maintain at most a 60% packet lost rate.*

2.2 Input

2.2.1 User Input Buttons

A strip of roughly 5 buttons will be needed, each with a message mapped to it, so that the user can put up less immediate advisories. These will either be wired directly to the microcontroller or to a binary encoder if we are short on pins. We do not need any sort of hardware debouncing, any debouncing should be able to be done in software.

- *Requirement 1: must be clearly labeled.*
- *Requirement 2: must be laid out in such a way as to be easily distinguished from each other.*

2.2.2 Inertial Measurement Unit (IMU)

An IMU will be used to detect rapid deceleration to trigger automatic messages. The IMU will be powered by the 3.3V or 5V source and wired to the microcontroller using 2 pins for I2C. Current is estimated at ~4mA for the IMU.

- *Requirement 1: must be able to measure acceleration in at least two axes.*
- *Requirement 2: must be able to measure acceleration/deceleration from +60 feet/s^2 to -60 feet/s^2 with a resolution of 0.1 feet/s^2 [5].*
- *Requirement 3: must be able to communicate on I2C interface.*

2.3 Microcontroller

A low power microcontroller will be needed to control the screen, send and receive messages, play audio cues, and interface with the IMU. Current is estimated at ~100mA for the microcontroller.

- *Requirement 1: must have sufficient IO pins to talk to 5 IR receivers, 1 LED, an I2C bus (2 pins), 5 buttons (3 pins), speaker (1 pin), and display (5 pins) (16 total).*
- *Requirement 2: must PWM for at least 2 pins.*
- *Requirement 3: must work with a 3.3V or 5V power source.*

2.4 Output

2.4.1 LCD Display

For low priority advisories (ones that do not have a dedicated sound cue), a small (~1-2 inch) display will be used to display them to the driver. Messages will be pre-determined and stored on the microcontroller. Current is estimated at ~500mA for the LCD and backlight.

- *Requirement 1: must be larger than 1”*
- *Requirement 2: must have at least 2 colors.*
- *Requirement 3: must have at least 64*64 resolution.*

2.4.2 Speaker

A speaker will be used to provide sound cues during a hazardous situation. It will be driven by the microcontroller, which will play a fixed single tone which will be specified by the microcontroller (No storage necessary).

- *Requirement 1: must be at least 90 dB.*
- *Requirement 2: must be able to produce tone between 1kHz to 15 kHz.*
- *Requirement 3: must work with a 3.3V or 5V power source.*

2.5 Power

2.5.1 Power Source

The device will be powered from the car's 12V source, brought down to 5V or 3V (depending on our choice of microcontroller). Our estimated maximum power consumption is 1A (500mA for the LCD and backlight, 4mA for the IMU, 10mA for each IR receiver, 100mA for each IR transmitter, 100mA for the microcontroller).

- *Requirement 1: must be compatible with cigarette lighter receptacle.*
- *Requirement 2: must be able to supply 1A+/-.5A of current*

2.5.2 Voltage Regulators

We will be using a linear regulator to bring down the 12V dc voltage from the source to 5 or 3V.

- *Requirement 1: must output 5V or 3V.*

2.6 Risk Analysis

The most significant risk to the completion of our project will be IR communication. One problem that we foresee are the conditions in which the IR will need to travel. Since we will be communicating outdoors in sunlight, we are expecting some level of data loss which we will consider when implementing our communication algorithm (Ex. At least one reliability).

Another consideration is the range of the IR communication, which considering highway driving will need to be at least ~100ft. To boost IR range, we will be using techniques used in outdoor laser tag systems, which should allow us to broadcast at long enough distances for communication to be effective on the at distances found on most highways. These techniques include using high powered IR LEDs, symmetrical lenses to focus the LED’s light, and multiple IR receivers to increase the size of our target for receiving which will compensate for the narrowed cone of light as a result of using optics on the LEDs.

3 Safety and Ethics

The main potential safety hazard with our project is driver distraction. To mitigate this risk, our system will be designed in such a way to not add any user interaction more distracting then what is currently outfitted on a car dashboard. For the manual hazard entry, the buttons are placed so that only a passenger in the front seat can interact with it, preventing the driver from taking his/her eyes off the road or otherwise getting distracted. We will still give the driver some feedback in the form of audio cues in the event of an emergency, but the cues will conform to audio design patterns used in existing driver safety systems (such as blind spot sensors) in the event of an emergency.

Another potential risk factor is IR radiation. Though some IR sources such as IR lasers can cause damage to the eyes, we will be using IR LEDs which, per semiconductor manufacturer Vishay Intertechnology Inc., “nearly all LEDs are far below the Exempt limits” [6] so to mitigate this risk, we need to make sure the IR LEDs we purchase are safe.

Our safety risks and mitigations follow the IEEE code of ethics first point, “to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment” [7]. We believe that the benefits provided through increased driver awareness outweigh the potential risk of driver distraction given our distraction mitigation techniques.

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