FRIENDLY EYES

Senior Design 1

Initial Project Document and Group Identification

University of Central Florida

Department of Engineering and Computer Science

Group 43

Michelle Dubon	Electrical Engineering
Victor Lopes	Electrical Engineering
Manuel Parilli Nunez	Electrical Engineering
Joseph Brown	Computer Engineering

Project Narrative

Finalizing an idea for our senior design project was no easy task since we all had different focuses in mind and there was not one leader to decide for us what our project would be. Ultimately, we vetted our project ideas with our advisor and decided on a project that would divide an appropriate amount of work fit for three electrical engineers and one computer engineer. The idea we decided on was a vest that can help blind individuals detect objects around them. A variety of sensors would be attached to a vest that would detect nearby objects. The vest would have vibrational motors distributed around it that would vibrate at combinations of different frequencies and intensities when approaching obstacles or when moving objects are headed its way, and would help blind individuals navigate a space by letting the user know where not to go. An additional component would be to have a reconfigurable braille interface that would give the blind user more information about their environment such as whether there is a door or a chair in front of them. The idea came from a senior design class where the professor described a cane that vibrated in a certain direction that would tell an individual to go that certain direction.

Although our aim is to make a vest, the technology that we are aiming to make is something that our team wants to be able to integrate into different configurations. So far, there does not seem to be mass produced products that are accessible in terms of low cost, easy usability, and portability. Students attending MIT in 2017 developed a vibrating wearable to help blind individuals navigate an open space. The problem with their wearable is that it is bulky and heavy, and we would like to make a wearable that is lightweight, easily compact and storable. Although our initial idea is to make a vest, we want to make our wearable discrete, but we first want to make sure we can integrate the components into something as large as a vest. Another example of a technology similar to our idea is a navigational device that uses Google Maps made by Honda for the visually impaired that would attach to an individual's shoe and would vibrate in a certain pattern to alert an individual of what direction to go in. The problem with their idea is that it is just that for now and it won’t be available for mass consumption until March of 2023.

Project Goals

This project aims to accomplish a walking guidance system for blind people to commute easily and avoid obstacles and people in the process. Also, we plan to use a sensor that will be able to detect when the person is approaching a stair, and we want to add an emergency system so when the person falls, a message will be sent to their emergency contact. This system will initially be located on a vest that the person will use as a part of their clothing. After we have a final design, including the size of the PCB and how many components we will have in the project, we will try to create a better and more comfortable way to carry all the necessary parts. This will involve using a hat or anything similar to placing the battery, sensors, and PCB. The user will have a better connection with the equipment because instead of an extra piece of clothes that can be uncomfortable during a hot day, a hat is something less problematic and easier to carry.

Project Objectives

- Provide a walking guidance system that is affordable for users.
- Design and build a PCB that will be used as the main controller.
- Create an interface where we can use a sensor to detect obstacles, people and stairs.
- The system will provide feedback to the user by making the wearable vibrate.
- The system should be small and have a light weight because it will be on a vest and later a vest and a hat with wireless communication.
- The system should be able to fall to the ground, detect the fall to send an alert, and keep working after.
- The system is built with materials that are easy to find for mass production.
- The system should be able to detect the distance between its user and any obstacle between the range of the sensor.

Function

For the power requirements portion of this project, we will have to decide what kind of battery we will use, the power output for the battery, and how we are going to distribute power from the battery to each component of our wearable. Accurate power distribution is important to us since it will ensure that power is managed throughout the wearable for smooth operation and complete safety for the user. There are several main components that we must consider for power distribution such as the microcontroller, a variety of sensors, and a motor. It is likely that these components will have different voltage requirements from one another and will require separate power rails for this reason. Separate power rails may also be required for components with the same voltage requirements for isolation purposes. For example, we may want to isolate power going to the MCU from power going to the sensors. We will use TI WEBENCH for the power design of our PCB.

We are looking into battery supplies that are low voltage and have high current output. In order to use these types of supplies we will employ step-up and charge pump DC-DC voltage converters to raise the voltage to levels usable by our components. In order to have appropriate headroom in our power supply, we will assume the efficiency of our DC-DC converters to be a lower value than specified by TI WEBENCH. In addition to derating the efficiency of the DC-DC converters, we will also ensure that our power supply exceeds our maximum power consumption by some margin. We want to make sure that our wearable works properly and is safe to use, so appropriate power input to all components should be researched and designed with enough time and consideration. Our wearable is designed with portability in mind, so we want the battery to be easily accessible and replaceable in our design for convenience. When removed, the battery can be plugged into a charger and recharged.

After accounting for a proper power distribution, the main feature of the project relies on the utilization of different kinds of sensors to collect the data that all other subsystems will be working for. While navigating our day-to-day lives we run into a lot of different kinds of obstacles made of different materials, with different shapes and posing completely different scenarios from one to the other. Humans have the ability of devising and discerning things from other things, along with a series of characteristics such as their angling, height, and the danger it would represent as well. Since we are designing instrumentation to figure out this issue for the portion of the population that cannot do it by themselves, we will be implementing a combination of sensors to gather the necessary information for the integrated processing unit to make the decisions on how to best assist the user in his/her next steps.

We will be needing a mixture of sensors for our system to work at the expected performance level since there is a variety of technologies used in sensing equipment, and each of them yields products that are specifically made to be implemented in specific situations. For accurate range detection of most materials, we are looking into Radar and Lidar systems while evaluating the relationship between their price tags, their functionalities, and our actual needs. Special considerations will be taken regarding the performance of these technologies when presented with specific challenges, such as Lidar’s inability to accurately detect glass doors and walls or Radar's ability to deliver accurate readings of its surroundings even when conditions are not ideal like in the presence of fog.

The decision of which specific sensors to get will also be accompanied by a precedent analysis on the circuitry they need to receive their share of power and proper interfacing, the requirements it poses to maintain signal integrity all throughout the signal's path (protection from electromagnetic interference, prevention of electromagnetic radiation, transient stabilization, buffering to avoid overloads, etc.), and the technology they use to deliver acquired data to the processing unit - be it digital or analog means -. The sensor that best fits our needs must account for the needs of the processing unit, such as the protocol used to receive transmitted data (SPI, UART, I2C, etc.), and the most efficient way to use this information to produce decisions and output them in the right direction, while keeping power consumption and cost of production relatively low.

Our software will need to be capable of running on a low-power system - that is, it will require the absolute minimum amount of processing power that it can to keep power requirements and cost as low as possible. The software needs to be able to decipher data received from the sensors, using whatever transmission protocol we decide on. It must take that data and calculate what risk any nearby object has to the user (perhaps some function of object distance, direction of user travel, and speed of approach).

During the "idle" state, the sensors are constantly being polled for data. At fixed intervals objects' distances will be compared to previously stored data to detect incoming potential threats. When a collision becomes likely to occur, a trigger will be met and a signal will be sent to the corresponding motor to a specific sensor (that is, the vibration will happen from whatever direction the object is detected). The signal strength will be based upon the proximity and speed of approach of whatever object is nearby. A rapid approaching or very close object will cause a much stronger vibration to happen in that direction.

A gyroscope will also be installed that will be used in detecting a fall or other accident that could occur. As the object detection sensors are being polled, so will this gyroscope sensor. We will also store the gyroscope's data at fixed intervals to detect a sudden change in rotation on the X or Z axis, which would be indicative of a fall. When this occurs, an alert message should be sent to a contact of the user who can use stored information to assist. The best way to do this would probably be via a GSM module that would be installed with a SIM card. This module would be used to send a text message to whatever contact the user has initialized as 'in case of emergency.'

Requirement and Specifications

Hardware Requirements:

1.1	System will operate on less than 30 V.
1.2	Circuitry and wiring must be compact enough to fit in the design for the garment without difficulty.
1.3	System will be powered by a rechargeable battery and will remain turned on until battery power runs out. Battery is expected to last for at least 8 hours.
1.4	System will be able to accurately measure how far an object is from the user in a range between .3 and 12 meters.
1.5	System must produce an output in less than 2 seconds to account for objects moving at 5 mph or less (~2.24 m/s) and leave a buffer for the user's reaction time.
1.6	System will be able to accurately assess objects made from different materials to make the best decision to alert the user.
1.7	System will be able to differentiate the level of the ground to discern between heights of objects, or the presence of stairs, and the risks involved if that path is followed to produce the appropriate alert.
1.8	System will be sturdy enough to withstand the impact from a fall of less than 2 meters or crashes slower than 10 mph, and deliver proper functionality afterward.
1.9	System will be able to detect when a fall or crash occurs and offer the possibility to reach for help.
1.10	System will be made with relatively accessible components for easy fabrication.
1.11	System will contain vibrating components working with variable intensity to alert users of dangers in the current path, or within a range.

Software requirements:

2.1	Software will require minimum processing power.
2.2	Software will be well organized and documented for ease of understanding of other people.
2.3	Software will be capable of determining objects' threat level to the user.
2.4	Software will be capable of deciphering sensor inputs to determine an object's distance.
2.5	Software will be capable of controlling vibration motors to warn a user of dangerous

	objects.
2.6	Software will be able to detect sudden changes in movement indicative of a possible accident.
2.7	Software will be able to communicate in order to reach help in case of an accident

Constraints and Standards

One primary constraint for our project is that it is entirely self-funded, so our team will have to consider the cost and number of components. We will need to perform complete research on the kind of sensors we will use for this project. This is important because even though the cost is the main problem, we cannot select a sensor that will not work or do everything we plan to accomplish. That is why we are looking into Lidar technology which seems promising, but the price is above the cost of other sensors. The option we are leaning for at the moment consists on a combination of radar sensors, since they are priced much cheaper, and may suffice the needs of an alpha version prototype. Beyond the cost of our project, we think the second most important constraint is time. We want to be able to make a workable product that accomplishes all our goals by all our group members but since we all have different class schedules and work schedules, as a team we will have to hold each other accountable to accomplish individual and group goals.

Since we are expecting a battery life of about 8 hours, there will be constraints related to the cost, its power efficiency, the power distribution and power drawn by the components of the circuitry, the processing unit’s requirements and the best low-power configuration we can achieve, as well as the appeal of the battery, method of charging, maintenance, possibility for replacement, and user accessibility features. Also, because we are planning to reduce the size of the system in future revisions if possible, we may need to find different kinds of batteries to fit the requirements to place subsystems such as the sensor modules on a hat, and powering the module while keeping its overall size relatively small and accompanying the processing unit and mechanical vibrators in a full 8 hour day of use. and that it can last at least one day.

Along with the technology we choose to implement, there is a tradeoff between the range of the sensor and the time it takes the whole system to produce an output. This is because non-stationary objects in the direction or along the path of the user must be accounted for in a timely manner, leaving enough time for him to react according to the signal produced. For the preliminary design we are inclined to go with a 12-meter range which will allow a person jogging at 5 mph to be detected with ~ 5 seconds to avoid collision from the moment of detection.

As mentioned before, the decision to use a vest or vest/hat combination will significantly impact the size requirements of the elements to keep PCBs relatively small, added to the fact that it is likely that more than one PCB will be needed, due to the working nature of the system consisting of different, detached, and somewhat independent modules. The dimensions of final PCBs will be essential, along with the type of sensors and how many we will have. Because we cannot make sensors smaller, we can choose components of smaller sizes and design PCBs using both sizes to optimize all the areas possible. With that being said, we have to focus on the PCB and its enclosure design and make sure that there is proper pathing and shielding to reduce electromagnetic interference on the primary signal path. This can be from outside sources and other components within the wearable.

A final constraint related to the actual garment is that it must be able to protect all equipment and wiring from non-favorable weather. We will be testing the wearable indoors for the senior design panel and advisors, but our design should be able to withstand outdoor conditions that are most common in Florida like heavy rain and wind.

In terms of standards we must meet, we will also develop this product abiding by Americans with Disabilities Act standards. Additionally, to allow the sensors to communicate with our microcontroller, we will be using serial communication standards. In the event that we choose to use a wireless communication method for sensor to microcontroller communication, we will use Bluetooth.

Project Milestones (Both Semesters)

Senior Design 1

Number	Task	Milestone Date	Status
1	Pick Project Idea, Assign roles	8/27/2021	Completed
2	Initial Project Documentation – Divide and Conquer	9/17/2021	In Progress
3	Updated Divide and Conquer document	10/01/2021	Not Started
4	60 page draft	11/05/2021	Not Started
5	100 page draft	11/19/2021	Not Started
6	120 page Final Document	12/07/2021	Not Started
7	Breadboard testing	12/07/2021	Not Started
8	Begin ordering parts	12/07/2021	Not Started

Senior Design 2

Number	Task	Milestone Date	Status
1	Implementing Note Detection & Test Software	TBD	Not Started
2	Finish first draft of drivers	TBD	Not Started
3	Testing Parts	TBD	Not Started
4	Possible Redesign	TBD	Not Started
5	Finalized Design	TBD	Not Started
6	Final Prototype working	TBD	Not Started
7	SD Showcase	TBA	Not Started

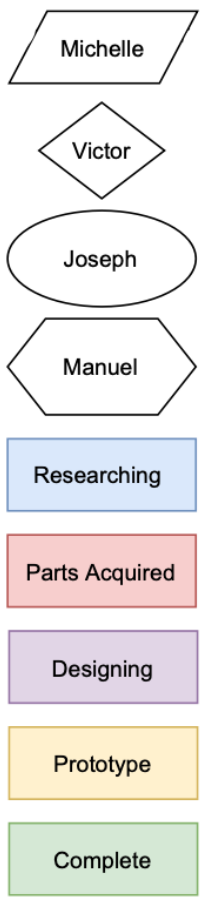
Decision Matrix

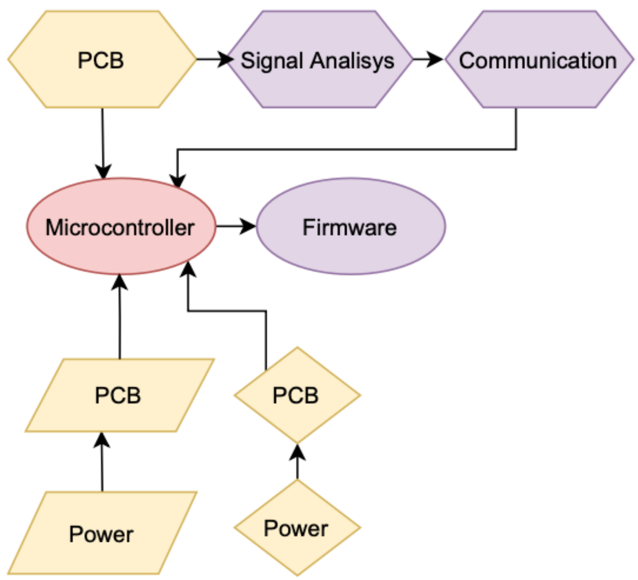
	Vest Design	**Vest and Hat Design**
Description	All components will be located on the vest. Vibrating motors on the best will vibrate at different frequencies when sensors pick up that an individual is within a certain range of objects.	The sensors for this project would be located on the hat while the rest of the components would be located on the vest. Vibrating motors on the best will vibrate at different frequencies when sensors pick up that an individual is within a certain range of objects.
Motivation	We want to help the visually impaired by helping them navigate the space around them easier. We also believe this wearable can be used for different purposes from the original intention.	We want to help the visually impaired by helping them navigate the space around them easier. We also believe this wearable can be used for different purposes from the original intention.
Stretch Goals	We would like to attach a braille pad so that individuals will know if there are specific objects in front of them like a chair or a door. We would also like to integrate an induction charger for the battery.	We would like to attach a braille pad so that individuals will know if there are specific objects in front of them like a chair or a door. Bluetooth communication for the sensors. This would enable us to have no wires from the hat to the vest. We would also like to integrate an induction charger for the battery.

Notes	All electrical and computer engineering	All electrical and computer engineering.

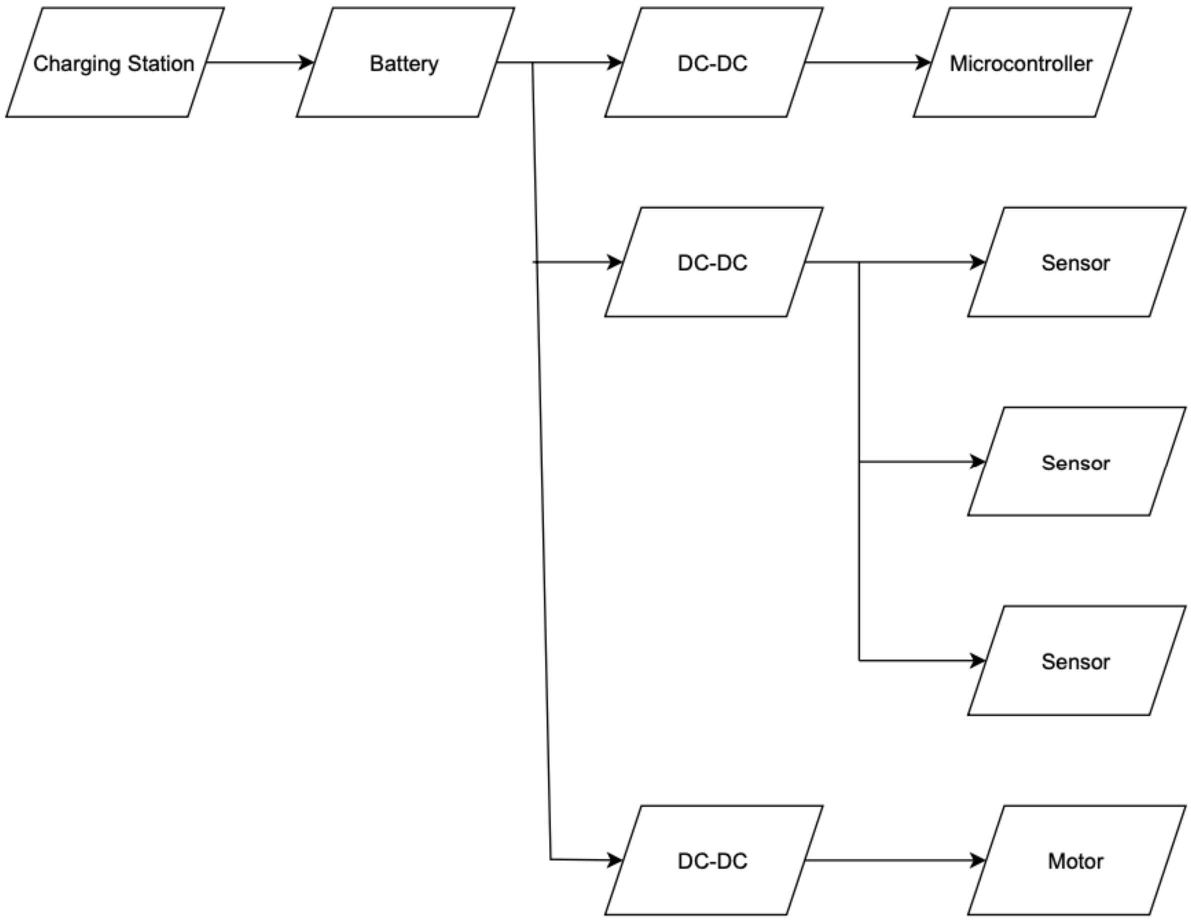
Block Diagrams

Hardware & Legend

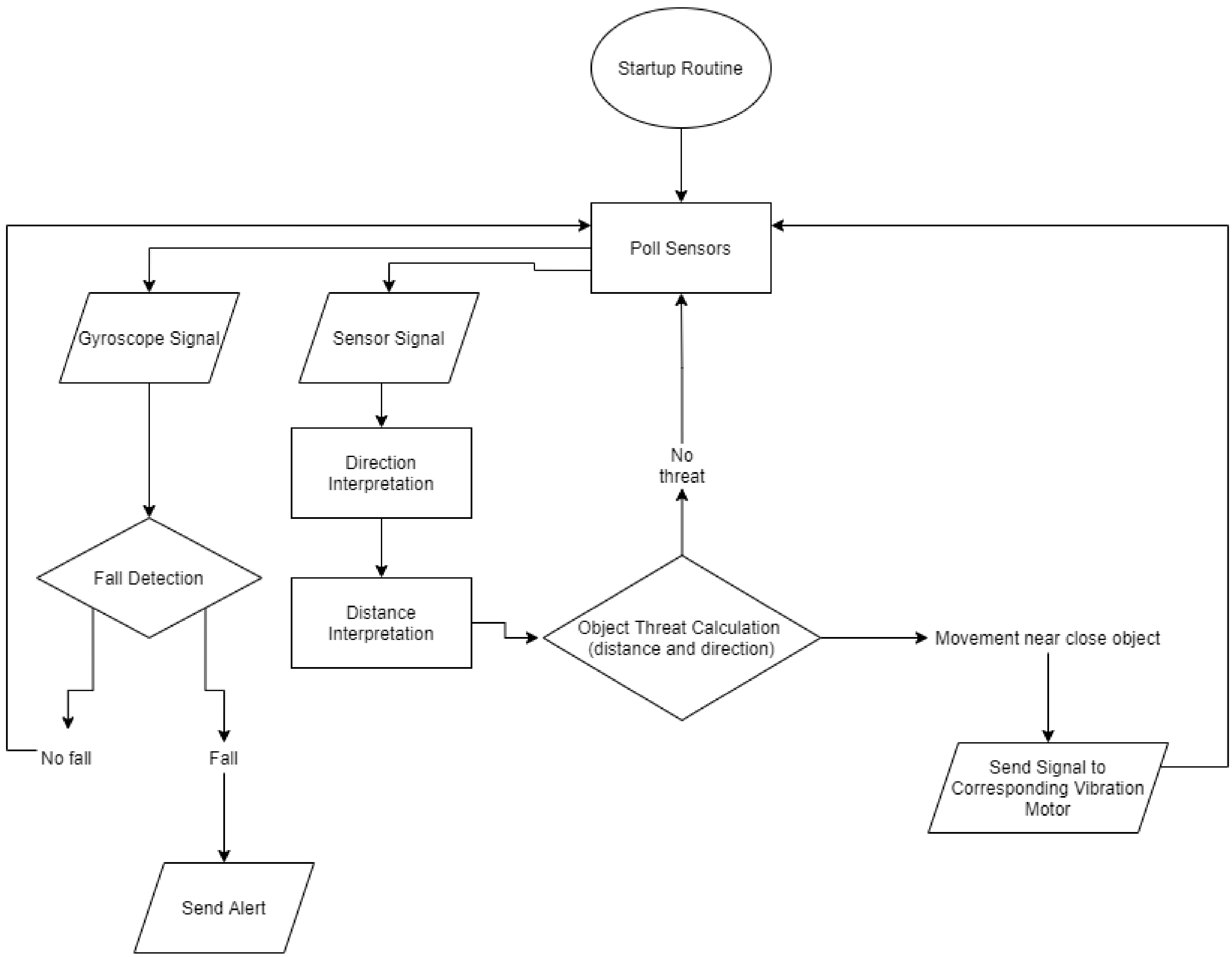




Power Diagram



Software Diagram



Expected Budget and Financing

We do not expect to get a sponsor to aid us in financing for this project so the project will be self-funded. For this reason, we hope to keep the project as low budget as possible without interfering with the functionality of the design.

Component	**Budget**
PCB	$150
Sensors	$80
Power Supply	$30
Analog-to-Digital Converter	$10
Microcontroller/microprocessor	$20
USB cable	$2
Input/output interfaces	$30
Passive components	$30
DC-DC converters	$50

Voltage regulators and active components	$50
Vest/Hat	$30
Total	$482