Senior Design Team 02
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Houston, TX 77004
October 26, 2018

Dr. Contreras-Vidal
UH Department of Electrical and Computer Engineering
4800 Calhoun Road
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Dear Dr. Contreras-Vidal,

I am proposing the Electronic cane for the blind for the senior design project on behalf of team-2, Vivek Patel, Francisco Sorto Lemus, Josh Young, and Samuel Aragon under the guidance of Project Manager Dr. Steven Pei. In this report, I will briefly go over the purpose of the project, problem and need, analysis, project timeline, etc. Our team will first interview visually impaired people and figure out their problems as well as their needs. Based on this information, we will analyze the project deliverables. set the project goal and create a timeline.

Sincerely,

Vivek N. Patel

Electronic Cane for the Blind

ECE 4336-Senior Design II

Written Report II

October 4, 2018

Facilitator

Dr. Steven Pei

Project Sponsor

Dr. Contreras-Vidal

Team 2

Team Members

Joshua Young

Vivek Patel

Samuel Aragon

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Abstract

The members of the present Capstone project are working on a device that will address the problems and needs that blind and visually impaired individuals face when walking indoors and outdoors due to falls and trip hazards. We have conducted research on the visually impaired community to understand the problems and needs to be addressed in this project and have analyzed data from the interviews to start the design of the device. This report will be written to explain the design of an advanced electronic cane for blind and visually impaired users. The electronic cane will guide the visually impaired user indoors and may assist their mobile outdoors by utilizing embedded sensors to recognize obstacles both at ground level and overhead and determine its distance from the user to alert accordingly about its position by both an audible signal and vibration sequences at the handle We will design the electronic cane to work with the Raspberry pi 3 because of its low power composition, small size, versatility of functions and high-performance capabilities. The capstone project will be sponsored by the department of Electrical and computer Engineering. The main challenges of this capstone project are design of the device to be able to solve the actual needs of the users within the initial budget proposed by the team and accomplishing the deadlines given by the department of Electrical and Computer Engineering.

Background

According to the National Federation of blind it is estimated that 10 million Americans are blind or visually impaired. Each year this number is increased by 75,000 more people becoming blind or visually impaired due to illnesses and old age. The loss of vision represents a huge drawback for the quality of life of the individual by losing their freedom and independence to do certain things that were normal before. Those who suffer from blindness face challenges every day and some of the daily tasks of a person can become a hazard and injure the individual, for this reason the blind has required traditionally to have assistance either by another person or a walking aid dog for their everyday tasks. We will focus on the challenge of getting mobility of the individual becoming independent again by embedding electronics, software and controls to the traditional blind cane.

Project Description

To be able to build the electronic cane we have focused our attention into the real problems and needs of potential users contacting blind and visually impaired organizations to interview some of their members and research their needs. The interviews were conducted in person, by phone and online messaging. The interviewees mentioned they mostly used the traditional cane and very few of them use the walking aid dog to mobile and none of the interviewees have used any kind of electronic devices for the visually impaired available in the market right now mostly because of the price tag on the device being too high. The results from this research are that what they need is a device designed to help them mobile inside unfamiliar buildings such as offices and hospitals and outside to be able to walk on the bench. It is worth mentioning that almost all of them mentioned they don't need any type of help within their own house.

This paper was written to explain the sponsors and managers the design and progress of the electronic cane that we will follow to meet all the needs of the potential users by keeping in mind economic and time constraints of the project. The design features will be described in the following pages with a detailed explanation of component capabilities, estimated cost and technical incorporation into the device.

The project constraints have been analyzed and the risks of issues arising during the project have been assessed. We have designed a back up plan for those risks identified which will help keep our timelines and specifications of the device under control in case any of these foreseeable situations arise.

Goal

The goal for the electronic cane is to deliver a device capable of detecting objects, signaling audible cues, and alerting via vibrational feedback while the user is outside of his or her home.

The electronic cane will feature an infrared sensor, called the HC-SR04 Ultrasonic Range Sensor, whose purpose is to accurately identify nearby objects and people within 400 cm. The Ultrasonic Range Sensor allows the visually impaired to navigate safely inside of buildings and hospitals with the help of audible and vibrational accessories.

The cane uses an audible and vibrational device that alerts its users of any potential dangers on the pathway. The audible device will be loud enough to also inform nearby people they are near a user with a cane who is visually impaired. The vibration device is included as an extra precaution to users who are not able to hear the audio signal. Whenever the Ultrasonic sensor detects a hazardous obstacle, the electronic cane performs vibrational feedback which allows the user to stay safely walk around any object.

Overview Diagram

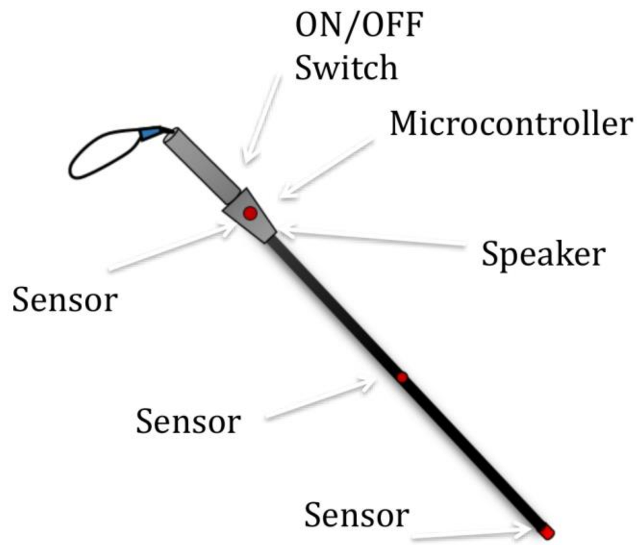

Figure 1: Overview Diagram for the electronic cane

Figure 1 shows the prototype of the electronic cane proposed by our team. The cane will feature the Raspberry Pi 3 model B+, four infrared sensors, an audio speaker, and a long-lasting battery pack.

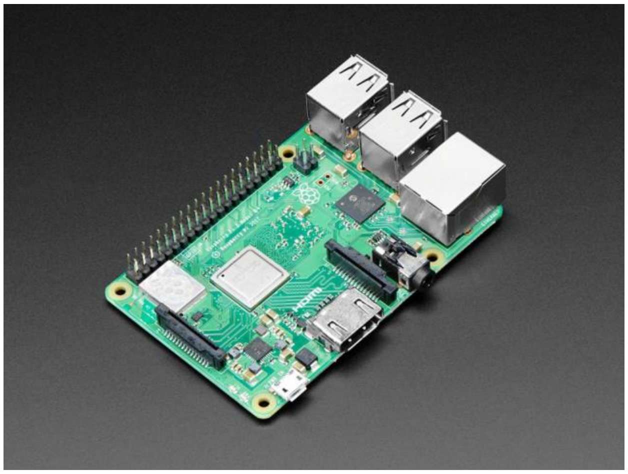

Figure 2: Raspberry Pi 3 Model B+ microcomputer

Figure 2 shows the Raspberry Pi 3 Model B+ microcomputer. The Raspberry Pi 3 is affordable at a price of $89.99 USD and provides a high level of connectivity, capabilities and device management for general purpose users as well as high level applications. It is programmable using C language and python.

Figure 3: HC-SR04 Ultrasonic Range Sensor

Figure 3 shows the Ultrasonic sensors that will be used in this project. The HC-SR04 Sensor can identify objects between 2cm to 400cm We will use these sensors to accurately measure the distance to the objects from the users. The expected price is $8 for each sensor.

Terminal Objective

The device will be able to indicate the user about obstacles in the way and will have functionality detecting special obstacles such as walls, stairs and overhead objects. When the user turns on the electronic cane, the Ultrasonic Sensors will measure the distance between the object up front and the user. The device will classify the objects and distances and will notify the user about the distance of the object and the specific action the individual needs to take by generating vibrations on the handle for ground level obstacles and it will generate audio alerts for overhead objects and elevation changes. If all sensors read, an algorithm will activate to let the user know about a special obstacle wall by generating an audio signal. The cane will be able to differentiate between walls, stairs, and elevation changes. This lets the user know accordingly by audio signals.

Goal Analysis

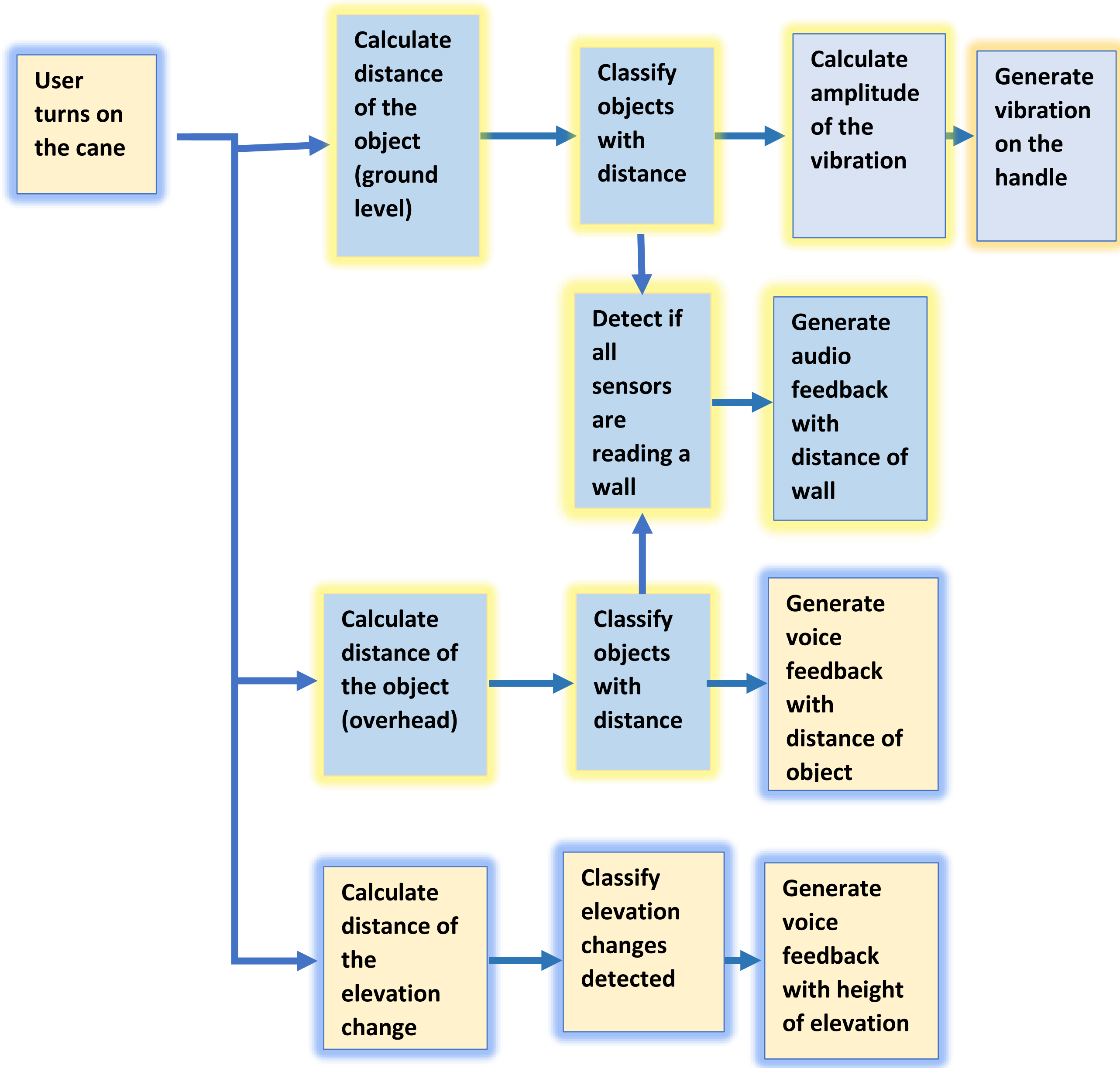

Figure 4: Goal Analysis Diagram

Figure 4 shows the distribution of work for the fall semester. Boxes in blue background indicate parts of the Goal that have already been completed or parts of the goal that have already been met. Each one of these goals will be combined into the Cane chassis to complete the goal of the semester.

Team Members

In this project all members come from different backgrounds of electrical and computer engineering courses and we have decided to allocate each one of us according to what we have more knowledge on. Each team member will oversee tasks that fall more in the expertise and knowledge of the member, but all members will collaborate with each task. Joshua Young oversees software development and debugging, Vivek Patel in charge of power management, battery features and power economy of the device, and Francisco Sorto and Samuel Aragon will be working on the electronics and controls of the device.

Constraints

It is imperative to use a High-Level programming language for the Raspberry Pi 3 that will process the data as fast as possible. We have decided to use C and Python programming languages since these languages are known by every team member.

Another constraint involves getting an accurate reading from ultrasonic sensors to minimize the error of the alerts given to the user, for this we will use the best electronics and the hardware available within the budget. The sensors that will be used have a limited efficiency when the reading area of the object in front is not flat or is being held at an angle of more than 20 degrees. We have decided we will overcome this difficulty by implementing good commands on the Program running the cane instead of increasing the price and the power consumption of the cane several times by using more expensive and bigger ultrasonic sensors.

Last, but not least is the power of the device which needs to be delivered by a rechargeable battery able to last several hours of operation. The Pi and the several sensors and vibration motors embedded into the cane will draw considerable power from the battery and getting a compact battery able to drive the cane for hours is very difficult. We have decided to make the device capable of recharging by a small solar panel on the go, this brings the constraint of getting a panel that is good enough to provide a considerable amount of energy to the cane.

Standards

Our project uses the International Organization for Standardization, which is the most respected developer of standards in the world. The ISO/AWI 21856 is used to assist products for people with disabilities; most of its assistance involving general requirements and test methods. Its technical committee for this standard is ISO/TC 173. The ISO/TC 173 standardizes the field of assistive product and related services to help compensate those with disabilities. The status of ISO/AWI 21856 is currently under development and once the standard is released, we will review the cane features and specs to comply with the standard.

Specifications

Referring to Figure 1, we have the Specifications of the device we are designing. The device's operations need to be intuitive to users used to the old traditional cane for the switch to be as smooth as possible. This includes being light weighted at the same time as having all the functionality proposed for the project. For the project goal to be successful it needs to have the following specs:

- Three Ultrasonic sensors working with an audio alert for obstacles and trip hazards. The three sensors will be facing to the front of the cane and will help the Microprocessor measure the distance to the objects in front of it. With this distance information the Microprocessor will alert the user of obstacles by using vibrations on the handle and audible signals.
- Vibration on handle to signal obstacles to give the sense of space to the user. The vibrator on the handle will have a varying amplitude inversely proportional to the distance read by the sensors.
- Able to detect objects up to 8 feet of distance within a measurement accuracy of 1%. To have precise alerts to the user the reading on the sensors must be accurate. The location, direction and software of the Ultrasonic sensors will be maximized to achieve this goal.

- Lightweight device: Any user should be able to hold it with one hand. The expected weight of the device is to be approximately two pounds. To achieve this, only small electronics will be used.
- Rechargeable battery able to recharge with embedded solar panel and wall outlet. Using high level electronics requires substantial power delivery, so we plan to use a high-quality battery capable of supplying the power and be able to last at least 3 hours on a full charge. To help achieve this goal a small solar receiver will be added to recharge the battery on the go.

Test Methodology

To ensure we meet the specifications of the device. These specifications are clearly explained in the Specifications section of this report. The testing of these specifications will be developed as follow:

Accuracy of sensors will be tested against the different objects at various distance. Sensors are mounted on the cane at the different distance and angle to ensure the slanted objects' distance are measured correctly. The actual distance of the object to the sensor will be measured and compared to the value obtained from the Ultrasonic sensor. Using this test for all sensors mounted on the cane only errors of less than 1% will be accepted.

The battery will be tested with an ammeter to ensure it delivers 2.0 amperes and it will also be drained using the cane for a continuous time. A work time of 3 hours is expected. Then with a small solar panel mounted around the cane to charge the battery with its rating capacity will do the same test to rate how much is the battery life extended when exposed to the sunlight.

Measure amplitude of vibrations using an oscilloscope in the Microprocessor output. The vibrator is tested with the different objects and distances to make sure the vibrator amplitudes is inversely proportional to the distances of the object. The PWM used to vibrate will show on the screen of the oscilloscope and for objects at the same distances pulses duty cycle times need to be within 2% of error.

The cane will be weighed to ensure it is light enough to carry around. We will weight all the parts of the cane and ensure most of the weight is centered close to the handle to make it easier to move around. We will deliver information of where its center mass is located.

Patents

A government grants an inventor a property right; therefore, only rightful inventor is permitted to make, sell, or import the invention in the US. The patent is issued by the Patent and Trademark Office. The patent is valid for 20 years within the US, US territories, and US possessions. Below is the description of the latest three patent which is related to **our prototype product**.

Patent I: Smart Mobility Assistance Device

The patent is filed by AT&T Intellectual Property I, L.P. in Atlanta, GA on June 14th,2017. The application number is 15/622,096 and the Family ID is 63685385. The present disclosure describes a device, computer-readable medium, and method for providing smart mobility assistance. The set of sensors is to monitor an area surrounding a user of a mobility assistance device. The processor is to detect a hazard in the surrounding area, based on the monitoring. The first set of feedback mechanisms is to provide the user with an alert that notifies the user of the hazard. The communication device is to send a notification to a third party informing the third party of the hazard.

Patent II: System for Guiding Blind and Method Thereof

The patent is filed by Inventec (Pudong) Technology Corporation in Shanghai, CN on June, 14th, 2017. The application number is 15/622983 and the Family ID is 58893532. The present disclosure illustrates a system for guiding a blind and method thereof. In the system, a portable device is electrically coupled to a walking aid device, the walking aid device generates an obstacle signal when detecting an obstacle, an obstacle determination module may determine an obstacle width and a distance from the obstacle in accordance with the obstacle signal, and a route planning module may generate a dodging route according to the obstacle width, the obstacle distance and a user step size loaded previously. As a result, the system and the method are able to let user know about information of the front obstacle, and may achieve the effect of dodging the front obstacle safely.

Patent III: Method and Device for Visually Impaired Assistance

The patent is filed by VasuYantra Corp in Milpitas, CA on January 20th, 2017. The application number is 15/411,837 and the family ID is 60022636. A device, system, and method of assistance for visually impaired users. The system comprises a plurality of video cameras, often head mounted, computer processors and associated support devices and algorithms configured for computer vision, and a user worn haptic band comprising a plurality (two or more) of distantly spaced haptic transducers. This haptic band is worn such that user's hands are free for other tasks. The system uses its video camera, depth processing algorithms, and object recognition algorithms (hardware and/or software based) to identify a limited number of navigationally important objects. The spatial locations of each object deemed important is output to the user by varying output to the haptic transducers accordingly. The system is configured to identify and report objects as generic objects, identified objects, and potential obstacle objects. The system can also optionally provide audio information pertaining to these objects as well.

Progress

Following the proposed timeline schedule there is an actual update of each task if the project which is shown in Table 1. The table is divided in color coded boxes that indicate the correspondent task and week date deadline for the task. The green indicates within planned schedule for the task. Blue box indicates the task has already completed. The yellow boxes indicate extension of deadline for the task due to delays in design and parts orders. The red indicates a late start of the task.

Table 1. Timeline update by task. The table is divided in color coded boxes that indicate the correspondent task and week date deadline for the task. The green indicates within planned schedule for the task. Blue box indicates the task has already completed. The yellow boxes indicate extension of deadline for the task due to delays in design and parts orders. The red indicates a late start of the task.

Task	8/31/18	9/7/18	9/14/18	9/21/18	9/28/18	10/5/18	10/12/18	10/19/18	10/26/18	11/2/18	11/9/18	11/16/18	11/23/18	11/30/18	12/7/18
Selection of battery model															
Selection of Microprocessor model															
IR sensor model selection															
IR sensors coding															
Selected materials and parts orders															
Design of battery location															
IR sensor location design															
Vibration device selection and design															
Selected materials and parts orders															
Assemble first prototype															
Selected materials and parts orders															
Build final prototype															
Presentations and demonstration of final prototype															

Budget

The initial proposed budget is $US300 which will be sponsor by Faculty and team members. Table 2 describes the project's budget utilization. Its divided into actual spending, which describes what we have already spent in parts; and projected spending which allow us to project what the expected price of the parts we are yet to buy is.

Table 2. Budget utilization of the project.

Description	Projected	Actual
Raspberry Pi Model 3 B+ Kit	$100.00	$97.41
Cane chassis	$25.00	$3.67
Wires	$20.00	$8.65
IR Sensors	$45.00	$28.56
Vibration motor	$10.00	$15.00
LED miscellaneous	$10.00	$5.00
Ultrasonic sensor	$20.00	$18.00
Speaker with amplifier module	$25.00	$0.00
Solar panel	$20.00	$0.00
Battery	$20.00	$45.00
Miscellaneous	$0.00	$31.00
Total	$295.00	$252.29

Figure 5 describes a comparison of the budget vs the projected spending of the device.

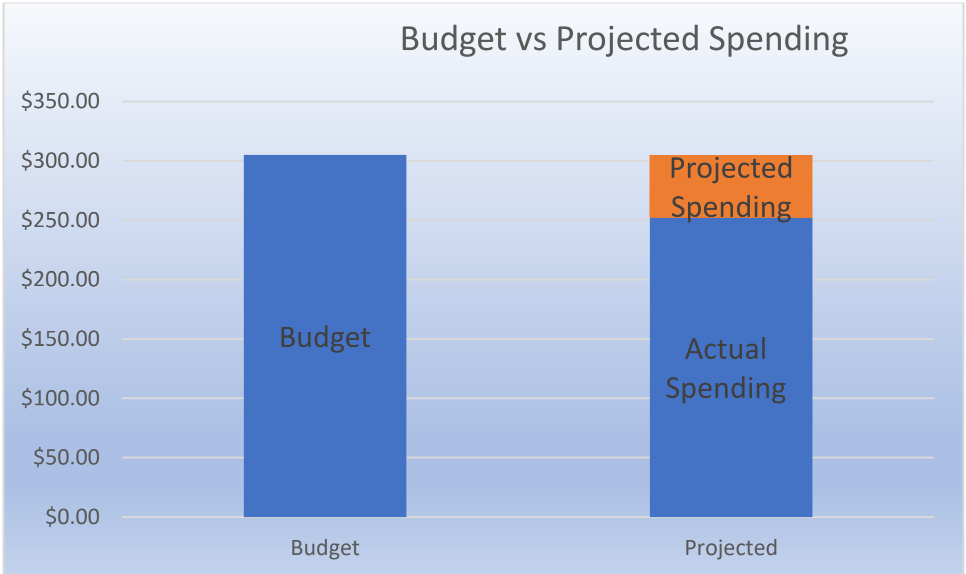

Figure 5. Comparison of budget and resources already spent.

Risk Management

1. The Raspberry Pi 3 Model B+ is prone to circuit malfunctioning during the debugging and testing phase because is very sensitive to voltage spikes. Any voltage over 3.3V in the pins could result in damage of the device, this becomes a serious problem because some of the devices we are going to use have 5V feedback to the microprocessor. We will use voltage divider circuits to protect the Raspberry Pi from voltages dangerous to the board.
2. During the first trials of the IR sensors intended to be used to measure distance we found that it had a lot of errors measuring distances for objects even slightly at an angle. We have switched our range sensors for the HC-SR04 Ultrasonic sensors due to them having better accuracy on objects at different shapes and angles of action. The accuracy of these new sensors has been tested to be within 1% for different objects at distances of 2.5 meters or less. During the testing we also found that these Ultrasonic sensors consume less power than the old IR sensors we were intending to use which comes as an added benefit from using them.
3. We have found in our research that a small solar panel will not have any significant benefits such as extending the battery life. This feature of the device will be dropped and will be reconsidered in the future if a small solar panel able to fit on top of the electronic cane handle with meaningful extension of the battery life is made available in the market.
4. While trying to integrate the speaker to the cane microprocessor we found that the model we used does not support PWM, which is used for the vibrator motors, and audio signals at the same time. This is because it uses the same hardware, so only one can be used at a time. To prevent this issue from setting us back in the timeline we had decided to go with our back up plan to be later introduced once a new model of the Raspberry Pi is made available with compatibility for PWM and audio stereo port at the same time.

Backup Plan

1. The Raspberry Pi 3 Model B+ is prone to circuit malfunctioning during the debugging and testing phase because is very sensitive to voltage spikes. Our team has set aside an extra Raspberry Pi device to ensure we do not waste time waiting for it to come in the mail. This is to avoid delays during our development phase and stay on track given the time we have available. The microprocessor itself has a cost of $30 which will fit in our budget as a reasonable expense on insurance because the schedule is very tight.
2. We have used the HC-SR04 Ultrasonic sensor which is able to have more accurate readings on different surfaces. This device is also within budget and the board will be able to process the data in a timeline manner.
3. We believe the rechargeable battery can deliver what we need so it won't affect the functionality of the device. The solar panel feature has been dropped from the device since we saw no benefit from having it on the cane due to its smalls size, if another solar panel capable of meaningful improvement in the battery life is made available in the market we will reconsider using it on the cane.
4. We have faced one design constraint from the Raspberry Pi and this is not being able to work PWM ports and audio feedback through the jack at the same time. We have decided we will wait for a new model of the Raspberry Pi to come in the market that is able to do both tasks at the same time to think on including it in the cane. We have decided to do away of this problem by using two buzzers to replace the audio signal of objects in front of the of until voice feedback is included in the project.

Summary

Many aspects of the project such as its objective, goal, overview diagram, terminal objective, schedule, budget, and division of labor have been discussed throughout this report. The electronic cane for the blind objective is to improve the quality of life of the visually impaired by giving them back their freedom, independence, and individuality. These objectives will only be reach by listening to the needs of the potential users and inclusion of the solutions to their problems into the features of the device. Such objectives need to be developed keeping in mind the constraints of time and budget for the project.

We have used risk management to decide on the issues we have found with the components which made us switch from using IR sensors to Ultrasonic sensors which have better capabilities and consume less power.

The specifications and goals of the device have been defined such as Three Ultrasonic sensors working with an audio alert for obstacles and trip hazards, vibration on handle to signal obstacles to give the sense of space to the user, able to detect objects up to 8 feet of distance within a measurement accuracy of 1%, being a lightweight device and a rechargeable battery.

The device is in its first development phase with the distance sensors already being operational. The vibrators have been added to the output of the microprocessor and its response has been very satisfying. We have successfully used the information of the sensors to have the vibrators respond inversely to the distance of object in front of it.

The project is also still within budget although more than half of the budget has been spent on parts already, but the estimated cost of the project is five dollars below the initial budget. We expect to be able to meet this constraint by the end of the project.

References

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