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HOWARD UNIVERSITY

Department of Electrical and Computer Engineering
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Senior Design Project:

Blind Assist: Project Proposal

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1. Introduction

1.1 Objective of the project

The aim of this project is to propose a portable device, designed for visually impaired individuals to assist them with getting around. Unlike most commercially available assistive devices, this device should provide directions to locations and alert the user of obstacles in their path.

1.2 Background of the project

The project was born by the team's intent to participate in the 2011 Cornell Cup competition. The competition required each team to design a system that innovatively used embedded technology. We considered the number of visually impaired individuals in the world and decided it was a worthwhile project to create an assistive device for visually impaired individuals.

2. Problem

2.1 Problem formulation

There are over 284 million people who are visually impaired and there are over 39 million people who are totally blind [1]. The lack of visual capabilities has limited these individuals from completely perceiving their immediate surroundings which has potential safety concerns and also lowers their quality of life since they must rely on some sort of aid to get around. Currently, in order for visually impaired individuals to get around, they rely on walking canes, guide dogs, and/or personal human aids for assistance. While these walking canes and guide dogs may allow the individual to get around independently, they each have a common drawback. These aids lack the intelligence to provide directions to unvisited locations and cannot completely warn individuals of obstruent objects in their vicinity. A human aid provides this intelligence but makes the visually impaired individual very dependent on the human aid.

A good solution will be a device that is portable and is able to provide directions to new locations and alert the user of obstacles in their path when the user is walking. For the purpose of this project, we streamlined the problem defined above to assisting blind individuals with getting around outdoors. We believe a project like this will create the case for further investment in creating smarter electronic devices to assist visually impaired individuals with getting around. By smarter we mean that the device is able to provide directions to unvisited locations, while ensuring safe navigation. Additionally, the device is not intended to replace the use of walking canes or guide dogs.

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2.2 Problem definition

Design a portable device for visually impaired individuals that will provide direction to new locations and alert the user of obstacles in their path during outdoor navigation.

2.3 Design Requirements

Design Requirements – Blind Assist

The constraints imposed on this project require that our proposed design must meet the Following requirements:

1. Overall Function:
    a. Should alert user of impeding obstacles while walking.
    b. Should direct users using GPS to desired locations.
2. Performance:
    a. Should take no longer than 3 minutes to boot up from a full shutdown to fully operational mode
    b. Should be able to identify an obstacle with an area larger than 18 in^2
    c. Should alert user when obstacle is at a distance of at least 3 feet
    d. Should operate when user is walking a maximum of 3 feet per second
    e. Should not issue warning if the turn signal is activated.
    f. Should direct users within 50 feet of their destination.
    g. Should find GPS signal within 1 minute of initialization.
3. Aesthetics:
    a. Should weigh less than 5 lbs
    b. Main system should fit within a 12 x 8 x 4 in dimension
3. Compliance:
    a. Blind Assist must meet all of the following regulations
        The FCC rules and regulations part 24 (As regards GSM modem for internet access)
        ADA regulations (Entire system)
        FCC Hearing Aid Compatibility (HAC) Regulations for Wireless devices (Bluetooth Earpiece)
        FCC regulations on Specific Absorption Rate (SAR) of electronic devices (GSM Modem, Bluetooth Earpiece, Electromagnetic Radiation from the Intel Atom Board)
4. User-System Interface:
    a. System should include vibration modules rated at 1.5V/10mA .
    b. System should issue an audible and/or haptic warning when the obstacle is within 3 feet.
    c. System should issue warnings to denote status of system (idle/seized/loading).
5. Power:
    a. Should operate for 5 hours of continuous use
    b. Should be able to fully charge from nil within 3 hours
    c. Battery should last 48hours on stand by

3. Current Status of Art

Assisting devices for the blind have been around for a while, but it wasn't until recently with the advancement of semiconductor technology that these devices really started to take off. Though there are many devices that help the visually impaired, these devices often only serve one purpose.

3.1 Available devices

Trekker- Talking GPS - Trekker introduces a GPS system for the visually impaired. The Trekker Breeze is a handheld talking GPS that can be controlled with one hand. It verbally announces the names of streets, intersections, and landmarks as you walk. This device is supposed to allow you greater freedom and the independence of having to stop and ask a passerby to know where you are. The Breeze also quickly becomes familiar with new routes that you travel. They also have a feature that allows you to easily retrace your steps if you get lost, with the addition of a simple push button.

Kapten Plus Voice Activated GPS- the Kapten Plus is a GPS unit for the visually impaired. It features high-performance GPS along with free navigation modes that provide real time voice description of what's around you. It has automatic speech recognition that allows you to control the device just through your voice. It also features a multitransport navigation mode that differentiates between pedestrian, bike, motorbike, and car modes. The Kapten also features a voice-controlled FM radio and MP3 player.

WuFu - The WuFu is a proximity measuring device. This device makes use of ultrasonic distance measurements. It uses ultrasonic sensors that sense obstacles in front of the user. It then sends a signal to motors attached to the wrists of the wearer that vibrate, alerting the user of an obstacle.

HandGuide –Talking Solutions gives us a system Uses high-tech, infrared sensors to detect objects within four feet. It offers a choice of two modes to detect objects and provide a sense of their distance. Audio modes uses pitch variation and vibration mode uses vibration variations.

3.2 Drawback on available devices

All the devices mentioned above work great at one task. A few devices provide GPS directions and the others sense impeding obstacles but none of them both provide GPS directions and alert the user of obstacles in their path.

4. Solution Approach

4.1 Solution Description and Expectation

Our proposed solution approach is to design a mobile embedded device that will help visually impaired individuals with their independent mobility. The device will direct them to and from specified locations (mall, grocery store etc.), and alert the user of any potential obstructions in their path. A technological approach would be useful because access to internet and GPS will help increase their independence by helping them get to locations they don't normally travel to.

When visually impaired individuals are travelling alone, they rely on walking canes and audio cues to avoid obstructions, our device will supplement these means, providing a safer traveling environment. Our proposed solution will be lightweight and easy to travel with. The device would allow blind individuals to consider going to new locations without personal aides therefore giving them a feeling of more independence.

4.1 Primary Solution

The blind assist project will be the integration of sensors (ultrasonic sensors, Bluetooth, etc), GSM internet, GPS, and the ATOM processor. After we integrate all the hardware we will create a software function that translates information gathered by the hardware into directions and obstacle alerts. The device will not analyze and identify objects within the field of view of the user. The device will not be designed to replace any human senses. For example the device will not use a camera to describe a scene to the user as if to replace sight.

For our solution implementation the atom processor will be the focal point of our design. It will constantly receive three core pieces of information from various sensors. The three pieces of information are distance of an object from the user, user request for directions, and request for date and time. The atom processor will use various functions illustrated in Figure 2 in order to generate four outputs. The four outputs are; verbal turn by turn directions, confirmation of voice request, obstacle alert, and verbal date and time response. Internet and GPS are two major enabling resources whose resources are called upon by various function, this is also illustrated in Figure 2.

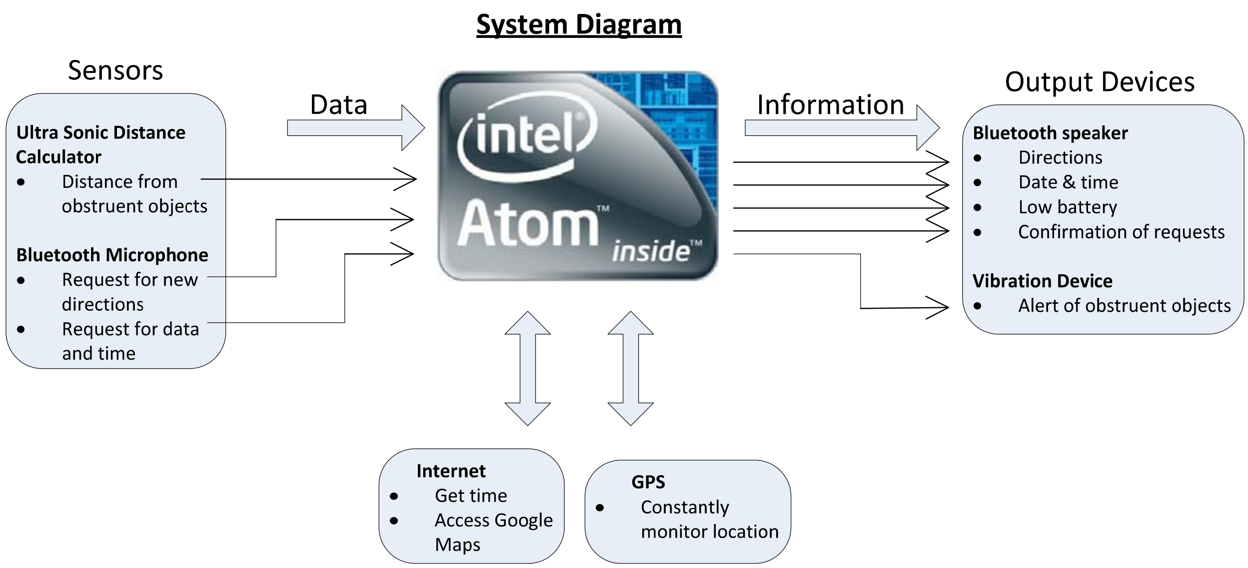

Figure 1: System Diagram showing system inputs, outputs and enabling devices

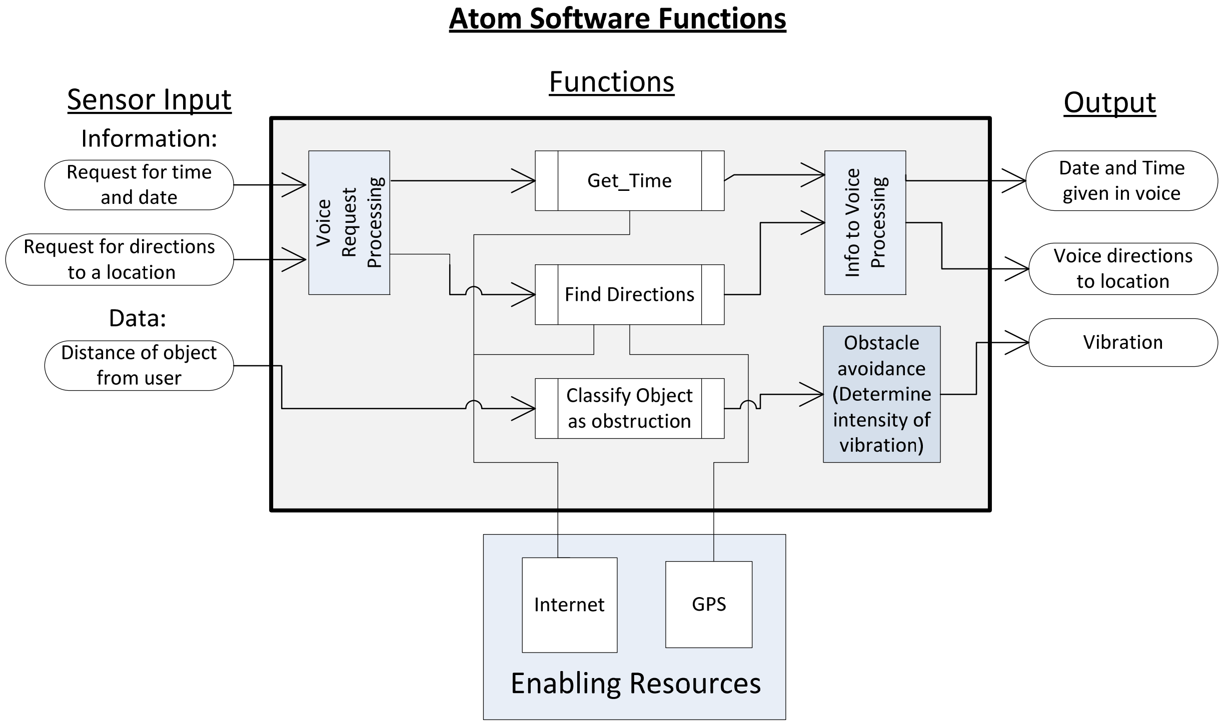

Figure 2: Atom Software functions showing how inputs are processed and enabling resources

At the Cornell Cup Expo we plan to blindfold a user and have them ask for directions to one of five predetermined locations within ten minute walking distance of the expo center. At least one team member will walk with the user to ensure their safety.

4.1.1 User-Device communication

Our system will include a Bluetooth transceiver as shown in figure 1. It is through this transceiver that the user will make request for directions to a location or request for date & time. The device will process the request as shown in figure 2 and then communicate the response on directions or date & time through the Bluetooth transceiver.

For object avoidance, we will be using vibrating modules that will be located on the user's wrists. Once an object is determined as an obstacle, the obstacle avoidance function as shown in figure 2 will determine the location and intensity of vibrations. The vibrating patterns, intensity and their meanings will be determined by the type of vibrating modules available.

4.2 Scenario Considerations

1. Very small obstacles (rope)
   With regards to small obstacles, at this time we have specified in our design requirement that for obstacle alert, the device must alert the user of obstacles with width of 3inches or more

2. Loss of GPS and or internet signal
   In a situation of loss of signal, the device must alert the user that GPS signals are unavailable

4.3 Testing and Verification Plan

Most testing will be done as blindfolded tests as mentioned earlier. However during the implementation phase rigorous component testing will be done before we begin system integration. Below are some tests and expectations for the device:

***Function*-Test**	**Expectations**
***Identification of drop zones/ topography change* – test a curb**	• Alert when change in height is 5 inches or more • Alert must give user 1 second to respond
***Upcoming hazard alert* – push a chair with wheels to the user**	• Alert user once upcoming object is 3ft away • Alert must show urgency as object comes closer – i.e increase intensity
***Direction to location* – While outside, user will request direction to a specific address**	• Device should provide directions to the location • Bring user within 40ft of the location
Power	• Battery should last at least 5 hours on continuous use • Standby power should be 2 days
Portability	• Main device should weigh less than 5lbs • Main device must be less than 12 x 8 x 4 inches
***Obstacle alert* – user walks toward a stationary chair**	• Device must alert user of an obstacle once within 3ft of the obstacle

4.4 Alternative Technologies/Components

1. Object avoidance sensor
   Rather than using one sensor, we could use a combination of sensors (e.g ultrasonic sensors and infrared sensors) and even have particular sensors for certain tasks – like ultrasonic sensors could be used for obstacle alert while infrared could be used to identify change in heights.
2. Bluetooth vibrating modules
   We could use tones or pulses on the Bluetooth transceiver instead of the vibrating modules.
3. Bluetooth transceiver
   Rather than having a Bluetooth transceiver, we could put microphones and speakers on the device itself or on the vibrating modules

5. Roles and Deliverables

5.1 Roles

While each team member is responsible for every part of the project and its success, to ensure we work effectively as a team, Durodola will work as the Project Manager, Urquhart will be the Technical Specialist and Simms will be in charge of Documentation, Correspondence and serve as Technical Assistant

5.2 Deliverables

We expect to have a working prototype of the device by mid-April 2012. The device is expected to be portable, provide directions to locations and alert users of obstacles in their paths

6. Project Management

6.1 Solution Implementation Plan

Below is how we intend on implementing our solution

- Learn about Intel Atom processor
- Divide system into functional blocks – obstacle avoidance, directions to locations, user-device communication
- Develop functional blocks and test components
- Do system integration, testing and modification

6.2 Timeline & Milestones

Milestone	**Scheduled Date**
Initial Proposal	September 28, 2011
Written Proposals: Version I	October 4, 2011
Written Proposals: Version II	October 12, 2011
Final Proposal Presentation	October 2011
Evaluation/Selection of Design	October 2011
Final Proposal Presentation	November 2011
Final Written Proposal	December 2011
Learn about atom processor	December 2011
Plan and develop functional blocks	December/ January 2012
Order components and test components	January 2012
Begin System integration	February 2012
Complete system integration	March 2012
Test device and modify	April 2012
Project Presentation – EECE day and Intel Competition	May 2012

6.3 Resources & Budget

Item	Cost
Intel Atom Board	$200 (supplied)
High quality sonar ranger	$40
Vibrtion Modules	$20 (4 units)
GPS Receiver	$40
GSM Transceiver	$50
Assembly Components	$200
Total	**$430**

7. Conclusion

According to the National Federation of the Blind, “The real problem of blindness … is the misunderstanding [of their surrounding]”. As a solution to this issue, this team proposes a device that assists the blind in navigating their surroundings. The device will function as a GPS guidance and obstacle avoidance system. We can offer this functionality through components including a sonar sensor, GPS receiver, and an Internet modem. Our avoidance system will use sonar to detect objects to protect users from collisions with obstacles. The sonar sensor will be connected to a microcontroller that sends data back to the Tunnel Creek Board for processing. The system will then send a command to the user alerting them of upcoming obstacles. There are no widely available devices that take advantage of sonar in order to protect users in this fashion. The guidance system will bring GPS functionality to persons whom were previously denied access due to the nature of their disability. Users will send voice commands (i.e. “Go to Address”) to the Bluetooth transceiver which relays the command to software on our Atom Board. Our software gets data from the internet modem and GPS receiver and returns navigational instructions.

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[patent] http://www.patentstorm.us/patents/5687136.html

9. Appendix

9.1 Feasibility of Project

We determined that our solution was feasible by first looking at the individual functions that our device must complete in order to meet the challenge definition. After analyzing some of these functions we looked at the device as a whole. Some individual functions we looked at were object detection, distance calculation using sensors (ultrasonic & Infrared IR), and speech recognition. We also created a timeline that will keep us on track for our deadlines, and it also has built in time for unexpected issues that will occur. Time has also been allotted in research periods to account for background research.

We have three concerns; our ability to identify objects real time, the accuracy of GPS destinations, and the accuracy of voice commands. We believe that these functions are a majority of the feasibility because without these functions we would not be able to complete the proposed solution.

There could be a potential problem with real time object detection for the purpose of avoidance. We would have to identify an object as an obstruction, not only alerting the users of an object presence but now we must adjust the directions to account for the object. Even with this potential concern we believe this is feasible, using a technology like sonar. We are aware that there are industries that use sonar for object detection and distance calculation. There is a particular patent that exemplifies this concept in application that utilizes an array of ultrasonic sensors to detect obstacles in the users' path [patent]. We also explored the concept of distance calculations using sonar in Appendix B.

A limitation of GPS is that it has an accuracy deviation of 3 meter of your location .Therefore there is inherent error with GPS. With the close proximity of city addresses, this can lead to error in arrival at the destination.

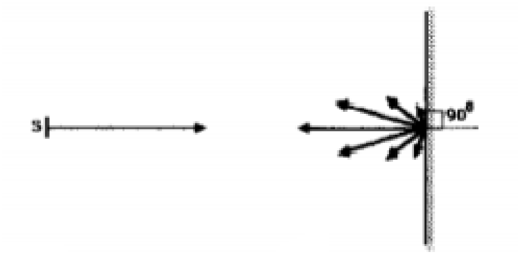
Since the user will give voice commands to the device there will be issues with assuring that the intended information is received correctly, accuracy of speech to text greatly depends on the software algorithm. In order to mitigate this error we will repeat the received command or request to the user. Therefore we will find the best tradeoff between accuracy of the speech to text algorithm and ease of implementation. Word error rate can be used as a quantitative analysis of the accuracy of speech recognition systems.

The last aspect of feasibility that needs to be analyzed is the system integration of our major functions. We believe that atom development kit easily lends itself to be a system integrator because it has the processing power to complete the functions and make software based decisions. We have also identified that interfacing a key component like internet would be straightforward. For example we could use a USB GSM internet adapter to bring internet to our kit. In closing developing a blind assistant device is definitely feasible as long as we stick to our timeline, so that if/when we run into an unexpected issue we will have enough time to work through it and still deliver our product to the Cornell Cup expo.

9.2 Distance calculation using Sonar

A Sonar sensor emits a sonic pulse and then waits for the returned echo reflecting off an object. The pulse is emitted by a transducer which converts between electrical, mechanical, and sonic energy. The time between the sent pulse and the returned echo is used to calculate distance.

Distance = Elapsed-Time x Speed-Of-Sound /2



Ultrasonic range measurements suffer from some fundamental drawbacks which limit its usefulness and accuracy in using it for navigation. These disadvantages are not related to a specific model or manufacture but limited by the nature of their wavelengths and materials interactions. From figure 6, the reflections of the sound waves on a smooth surface perpendicular to the wave's direction results in full reflection of the sound waves back to the unit. [7]

Figure 6: Sound waves reflected from a flat surface.

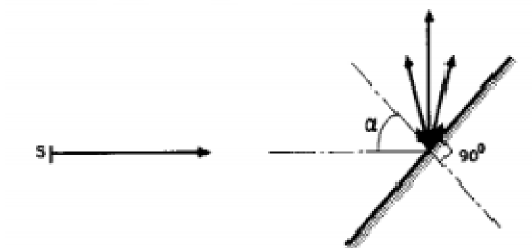


Figure 7: Sound waves reflected from an angled surface.

From figure 7, the reflected sound waves are not fully received by the receiver when the angle is too large. Only a portion of the sound energy is returned resulting in a false negative. Also, the material of objects my effect the sensors' accuracy in detection. Low density materials with irregular surfaces tend to absorb a lot of the energy off from the sound waves resulting in another false negative.

Additionally, there are many effects that the medium of air has on the waves of ultrasonic sensors. The humidity and temperature also affect the propagation of sound waves in air. For humidity, the addition of tiny water molecules actually increases the velocity of sound waves by about 4 ft/s due to the change in density of the air. The Doppler Effect also affects sound waves. As the sound source approaches the listener its frequency increases, and as the source moves away from the listener the frequency decreases [8]. However for navigation purposes these differences are noted yet negligible.