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Prototype Design and Development in Assistive Mobility Solution for the Visually Impaired using IOT

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ABSTRACT

In this paper, we have introduced an elaborate assistive mobility aid system for visually impaired individuals. In this system, a visually impaired individual is aided through a networked system comprising mainly an android device and ultrasonic sensors. The phone is placed in the individual's pocket and the sensors are fitted at the individual's feet and temple. The visually impaired individual, or 'user' for further reference, is guided through the environment through English voice guidance produced by the application as per the current position of the user and the relative position of obstacles in the line of the user's path. The user can navigate around the app using voice commands. The app is made accessible using aural feedback. Navigation is supported using GPS with Google Maps (GPS is only applicable in outdoor navigation). Obstacle detection is done using ultrasonic sensors; the aggregate results of the readings are conveyed to the user through aural feedback. Location data and location history is uploaded and synced with a remote server at regular intervals to allow guardians and/or loved ones keep track of the user's whereabouts. A panic feature is interposed among the features which will send an SOS message with last recorded location attached to an ICE contact and also place a call to the same.
Keywords: Visual Impairment, Mobility Aid, Assistive Technology, Location Tracking, Android Application, Navigation, Ultrasonic Sensors.

I. INTRODUCTION

According to a global survey report on visual impairment around the world by WHO in 2010, there were estimated over 285 million visually impaired people in the world. Of the 285 million, 13.7% are blind and 86.3% ie. 246 million people have low vision. And on a further note, 21.9% of the world's visually impaired are from India, whereas 26.5% are from China.[1] Given a look at the numbers, it is clear there is a populace that can be served to fulfil a need. Most of the impaired are found to be in developing nations, over a wide range of ages. These individuals are hindered from a normal life and wages. A innovative step towards accessibility and portability would make life easier and, furthermore, a lot more interesting. There have been many aids developed with this goal in mind, like the smart stick[2] with transducers and lasers fitted on a white cane to identify hindrances and obstacles, and there will furthermore be many more developments in the days to come. But here is our take on the problem. This is a solution for improving the mobility of visually impaired persons. Albeit the consequent goal is to improve the lives of the blind, for practical purposes, this system will gratify low vision individuals more than it would for the total blind. This is a system where the visually impaired user can achieve better mobility despite his/her impairment with little to no help from another person. Mobility is described by Emerson Foulke as "The ability to travel safely, comfortably, gracefully, and independently, referred to hereafter by the single term "mobility," is a factor of importance in the life of a blind individual." [3] The term 'blindness' is qualitative, and it describes the clinical condition where the individual has total vision loss: that is no light perception. It could also describe certain individuals who have very low to negligible vision. Moreover, the term 'visual impairment' is also a qualitative term used to describe loss of vision that is a consequence to various diseases that affect parts of the eye at an organ level. 'Low vision' is a description of lesser degree of vision.

II. LITERATURE REVIEW

Prior to the genesis of this paper, we have studied various papers, and works of diverse authors, to infer from them, draw inspiration and purpose to improve our own. Here are the most influential research papers that we draw our reference from, presented in Table 1.

Table 1

S.No	Reference Paper	Inference	Advantages	Disadvantages
1	Design and Development of a Prototype Rehabilitative Shoes and Spectacles for the Blind[4]	This paper addresses a prototype, smart rehabilitative shoes and spectacles, designed and developed to facilitate safe navigation and mobility of blind individuals.	Obstacle Detection, Vibration alerts, Ergonomic Design	None so far
2	Automated Mobility and Orientation System for Blind or Partially Sighted People	The traditional white cane was fitted with a GSM-GPS module for location sensing and ultrasonic sensors for detecting obstacles.	Obstacle Detection, Location Sensing	Excessive physical weight
3	Android Assistant EyeMate for Blind and Blind Tracker [13]	A blind assistive and tracking embedded system is presented. The blind person is guided through Bengali/English voice commands generated by the application according to the obstacle position.	GPS and Navigation, Voice Commands, Voice initiated phone call	System fails to perform in certain situations involving elevations
4	Smart Walker	The Smart Walker is an apparatus designed to overcome the demerits of using a cane, and at the same time monitoring the health stats of the user. The entire system is interfaced with an Android device.	Takes care of balance, monitor's health stats such as heart rate and blood pressure, has obstacle detection sensors, results can be monitored on the android device	Trouble concerning the different interfaces and wiring challenges. The system is bulky, it may increase mobility along a linear path, but would fail in other situations.

In 2012, Abu-Faraj et al. presented a paper on a prototype mobility system which implements ultrasonic sensors and vibrating motors mounted on shoes and spectacles[4]. We chose this paper as the foundation of our work. In 2013, Abdel Ilah Nour Alshbatat, from Jordan, decided to improve upon the traditional white cane by affixing a GPS-GSM module to it. The module would help in locating the blind individual [5]. Md. Siddiqur Rahman Tanveer, in 2015, designed an impressive all round system which aids the blind individual in navigating around the city[6]. Greg Olmschenk et al. developed a crowd assisted navigation system where the blind individual is guided by an online community [7]. The system is implemented as an mobile application, which is brilliant, as in today's world mobile phones are becoming more smart and ubiquitous day by day.

Table 2

Sr.	Feature	Description
1	Obstacle detection	Detect nearby obstacles that are ahead, at head level, and at ground level and indicate their approximate locations and distances without causing sensory overload.
2	Warn of impending Obstacles	Reliably locate and warn of impending potholes, low obstacles, step-downs and step-ups.
3	Guidance around obstacles	Guide the traveller around impending obstacles.
4	Ergonomically designed	Offer voice and/or tactile feedback of traveller's present location. Capable of voice input operation and/or have tactually distinct push buttons.
5	Wayfinding	Able to monitor the traveller's present location and indicate the direction toward the destination.
6	Route recall	Be able to remember a previous route and warn of changes in the environment due to construction or other blockages.
7	Operational flexibility	Reliably function in a variety of settings, that is, outdoors, indoors, stairways, elevators, and cluttered open spaces.
8	User friendliness	Be portable, rugged, fail-safe, and affordable for a blind user.
9	Cosmesis	Be perceived by potential users as cosmetically acceptable and comfortable to use in terms of size, styling, obtrusiveness, and attractiveness.
10	Good battery life	Have rechargeable batteries that can last for at least 6 h per charge.

For system design and ergonomics we peruse Szteo's research in REHABILITATION ENGINEERING and ASSISTIVE TECHNOLOGY from 2012 who emphasises that despite all technological implements can make accomplishing tasks easier, technology alone cannot mitigate all the difficulties that accompany a disability; and that the technology affects people with the same disability in different ways since the attention to process information they receive real-time require thought to make sound decisions [7]. Szeto also describes an ideal mobility method in a selection [8]; which is adapted and presented in Table 2. Furthermore, for more insight into some impressive adaptive technologies developed so far for the blind, Velázquez, compiled his research in these technologies in 2010; We see work done on devices that can be mounted on the head, feet, fingertips, belt, etc[9]. Another mobility system we encountered was the Smart Walker: a visually impaired individual can utilize the contraption and move around in a controlled domain, such as a house; the user is likewise equipped for being monitored remotely for a sense of safety and security as somebody is always there to respond to need [10]. A voice acknowledgment security process is utilized by a team in their work for the visually impaired clients [11]. Unique characteristic samples of the client's voice are isolated and used for comparison at authentication time; it also uses Google Maps API to guide the user in mobility. Regarding the safety of the individual we read the work of Yarrabothu et Thota[12], although their system is SMS based, we consider the idea of transmitting location history at regular intervals as they did, but to an online server instead. TTS (Text to Speech) is utilized as a part of framework to provide navigation through voice to the visually impaired person and it makes use of Google Maps to utilize its rich map data.

III. MOTIVATION

Our paramount objective throughout this venture was the drive to fabricate something that helped the outwardly weakened populace of this developing nation, considering the large numbers thereof [1], by consolidating ubiquitous technological innovations into their lives. We needed to actualize an answer to this need keeping in mind the end goal to make it moderate and efficient for the overall visually impaired population. The possibility of a simple shoe becoming smart ignited in our brains after we saw the recent ascent in ubiquitous wearable devices. That in conjuncture with the expanding accessibility and reach of the Internet and commodity smart phones, persuaded us that we could actually, join handhelds, wearable's and the Internet to fabricate a framework that can at the very least improve the lives of individuals to explore the world around them in a viable route without hindering their present way of life. Furthermore, we needed this framework to have features that would allow the visually impaired individual's beloved ones to monitor him/her remotely. We started out with the following intentions for our goal:

- ✓ Use information given by sensors in the wearable to caution the individual about any obstacles on current heading.
- ✓ Connect the wearable to an Android device wirelessly using Bluetooth, so that the said Android device may process the information collected by sensors.
- ✓ Design an arrangement which wouldn't hinder the individual from his regular life.
- ✓ Make the arrangement economical.
- ✓ Build-on and overcome any shortcomings of previous works.

IV. PROPOSED SYSTEM DESIGN

A. Hardware Design

The shoes are mounted with ultrasonic sensors. Sensors are place on the medial, central, and lateral aspects of the front of the shoe. Sensors are also placed at the temple by mounting it on spectacles. These sensors can detect obstacles situated at different levels. The sensors are connected to an Arduino board which also includes a Bluetooth module connected to it. The Bluetooth module is used to interface and send messages to the android phone wherein the app, to guide the user, is installed. The board is mounted with ultrasonic sensors to find obstacles in the path of the visually impaired individual. To recognize the position and vicinity of the visually impaired individual, and for navigation, we depend on Global Positioning System (GPS). The application proposed in this paper utilizes TTS and Google Maps API so as to furnish routing with voice guidance. This recommended framework utilizes a Smartphone which is ubiquitous, and is genuinely modest and gives a simpler versatility. The hardware to be used is to be designed to be ergonomic and minimal. It is desired to have something lightweight and sturdy. We need it to be portable.

B. Android App Design

The android app is installed on the user's phone. And it is required to have the following design specifications and features:

1. Design Specifications:

- Single tap to speak selection
- Double tap to confirm selection
- High Contrast UI
- Colour-blind friendly
- Differentiable and clear font
- Large font

2. Features:

- Feedback when obstacle is detected
- GPS
- Live tracking
- Voice input and output
- Call a cab/driver button
- Emergency call/SMS button

C. Remote Server And Database

We need a server to store the location of the visually impaired individual into a remote database. The latitude and longitude, essentially the coordinates, along with timestamps. This is essential for the guardians to retrieve this information. We need to implement a remote server to establish connection with the remote database. The database would be used to hold coordinates data received from the visually impaired person. The server needs to be actively running to provide round the clock service. This server is also an essential part to this system. The interaction between the said remote server and android phone application can be done using JSON, a lightweight data-interchange format.

D. Guardian Android App/Web Portal For Monitoring

A web interface or Android app will be used to pass queries to the database to send requests for current location and location history of the blind individual. It will retrieve the specific results. The web interface will be used to display the results retrieved from the database, and display them as required on a Google Maps outline.

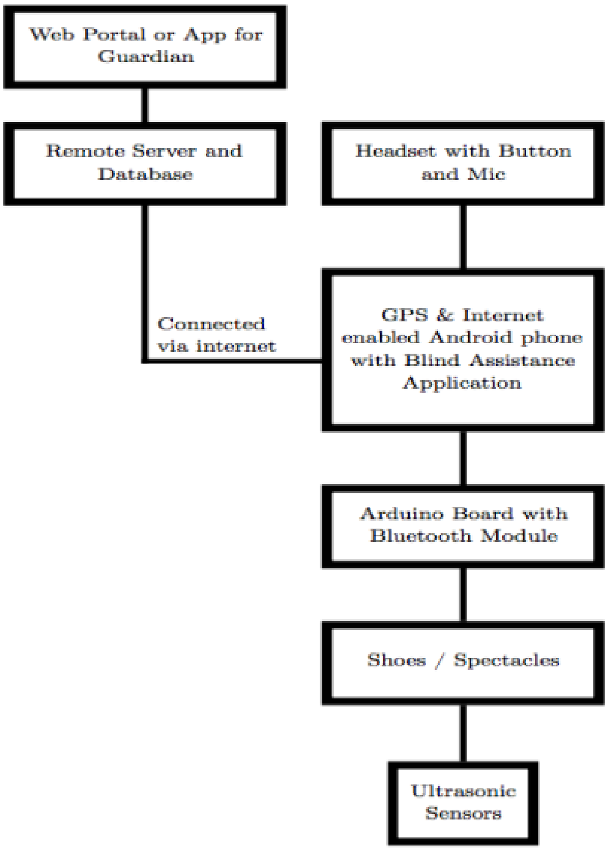

Figure 1. Architecture of proposed system

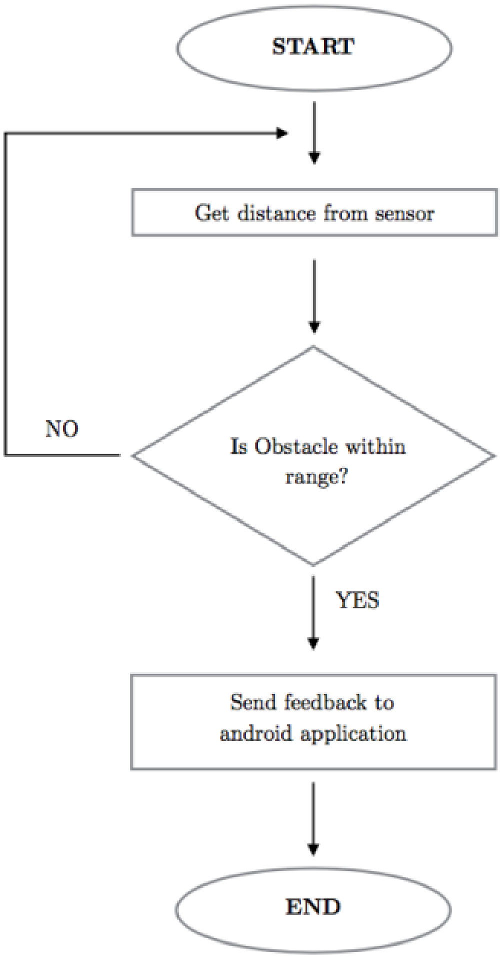

Figure 2. Flowchart for proposed system

V. TECHNICAL IMPLEMENTATION

The proposed framework has hardware sensors, an Android phone, GPS and an online framework fit together for helping the visually impaired individual in the following ways:

A. Obstacle Detection

The function of detecting obstacles along the path is to be done by ultrasonic sensors. The working of ultrasonic sensors is truly simple yet brilliant. The sensor compromises of a transmitter and receiver; the transmitter sends off pulses of ultrasonic sound, and the receiver picks up reflections. The time interval is measured and the distance is determined. These sensors are connected to a Arduino Uno board. In the model, we use Bluetooth as a means to send data about the detected obstacle along the path to the android device. A Bluetooth module, HC-05, is mounted to the board to transmit data readings of obstacle location to the android application

B. Navigation Using Android Phone

An android phone is one of the most ubiquitous technology available today. It has most commonly required sensors, pre-installed from the manufacturer, such as GPS. The android phone will have installed onto it the guidance application for the visually impaired individual. The app is interfaced with the hardware module using Bluetooth. It receives the obstacle position data from the Arduino board and also provides navigation. The phone will receive commands from the visually impaired person through voice commands.

C. Tracking And Visually Impaired Individuals

A web interface or android app will be used by the guardian to find the location history and current location of the visually impaired individual. Server and android application interaction will be done. We postulated multiple ultrasonic sensors, a few are mounted on each foot and one is mounted at the forehead, on a pair of spectacles. The sensors mounted on the shoes identify obstacles in the left, in the right, and those in front of the visually impaired individual and the sensor mounted on the temple attempts to detect obstacles at the head level. An ultrasonic sensor can also be mounted near the belt, to detect various gradients. With an intent to alarm the visually impaired individual about the position of an incoming obstacle, the phone is utilized to send aural feedback or voice feedback to the user alarming him or her of the obstacle ahead. Furthermore, these are associated with an Arduino board. In this framework a Bluetooth module HC-05 is utilized to send the information about the area of distinguished question the android application. The Bluetooth module is extremely shoddy, yet simple to interface with the micro-controller and android phone. So we utilized this module to provide communication between the equipment module and the android application. We executed both, in light of the fact that when the visually impaired individual strolls under the open sky then GPS satellites give a rather precise result however GPS will be weakened by the tall structures, trees and within the building and the underground. So hence GPS can't be utilized constantly, and the network supplier is to be utilized when GPS supplier is inaccessible.

Since visually impaired individual does not think much about the android interface, we have built up our application in a manner that the visually impaired individual can control the application including but not limited to utilizing his/her voice. In the design of the framework, the visually impaired individual does not have to touch the telephone to give voice commands - he/she simply needs to press the headset catch and can give the voice order effortlessly. The app is meant to track the current location and whereabouts of the individual. The app allows us to receive the coordinates of the present area of the visually impaired individual from the server. And thus export these coordinates to discover the visually impaired person’s position in Google Maps. Along these lines we can, without much of a stretch, find the visually impaired individual in the event that he/she is lost and safeguard him/her quickly.

VI. FUTURE SCOPE

The system is made to better the mobility of a visually impaired individual. In the future scope of this system, navigation could be supported using GPS with Google Maps and also with Crowd Assistance. Crowd assistance is made possible using a camera phone and volunteers over the world who would help the user navigate in scenarios where the computational devices fail. Although it is subject to availability, volunteers can access the video stream which is live-casted from the user's camera phone and offer guidance though pre-recorded aural (and visual clues for low vision users) or simply through a phone call. Furthermore, voice recognition, which is a way for identifying, understanding and processing voice signals into information or data, can also be explored. There are a diverse variety of validation components which we have accessible to us today which can be implemented, if required, to provide a level of voice identification, security, and personalization.

VII. CONCLUSION

We began with the goal to create a aid which would enable visually impaired persons to move more conveniently and navigate to places they desired. The final product of our work is a device capable of guiding the visually impaired along a route and also features a design integrating the setup with the Internet. This enables guardians to monitor the impaired individual online. The framework has been tried through a few experiments. This assistive gadget powered by an android device is significantly valuable to a visually impaired individual to move without the assistance of others and can look for help in a crisis through an emergency phone call. The application also keeps a record of location history on an online server which is accessible through an application on the guardian’s phone.

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