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Voice and GPS Based Navigation System for Visually Challenged People Walking in a Campus

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Abstract— One of the most important problems for the blind is navigation. They mostly use canes to avoid obstacles or often depend on someone to move to a particular location. Though there are a few strategies like echo location for humans that would help the blind to navigate though it requires a lot of practice and is difficult to master.This research paper is mainly focused on implementing a navigation system for the blind which can be used around a campus. We proposed a system which uses Raspberry Pi that will allow the blind to navigate within a campus or through any closed area without assistance. The problem with many other navigation system is that they use a client server model and require an active internet connection to work with. In case of our proposed system, it learns as you walk which prevents the need for an internet connection. One big advantage of this system is that it doesn't use any mobile phone and the entire kit is embedded in a walking stick which eases the usage.

Keywords— Blind Navigation, Global Positioning System (GPS), Obstacle Detection

I. INTRODUCTION

According to the World Health Organization (WHO), there are 285 million blind people [6] all around the world, of which 39 million are completely blind and the rest have low vision. More than 90% of the people live in a low-income condition [9] and so they won't be able to offer for eye transplantations.

There are many types of blindness. A person is said to be normal or legally blind if he has a visual acuity of 200 [10], which means he can see an object or a person who is 200 feet away, clearly. Complete blindness is the phenomenon where the person has lost his complete vision. The other types of blindness include color blindness, night blindness etc., Color blindness, technically called as Dyschromatopsia [8], is the inability of a person to distinguish between the various colors. The most common form of color blindness is the red green color blindness where the person will not be able to easily distinguish between red and green color. Night blindness is another type of blindness where the person will have difficulties viewing in dim light and during the night.

Being blind, the biggest problem is navigation.They have difficulties in navigation even in common areas.To improve their quality of life we have designed a system that allows the blind to navigate in common areas easily. Using this system, the person can easily navigate within a campus or a pre defined area without any hassle.

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II. RELATED WORK

There is a lot of research going on in making the navigation simple for the visually impaired and blind people. The biggest problem comes when the navigation is outdoor which involves handling various factors like traffic traffic and road rules. Indoor navigation is quite simple compared to outdoor as it has lesser problems to deal with.

AnushreeHarsur and Chitra M from Bangalore, proposed a navigation system [1] which is mainly used for the navigation of the blind people in outdoor environments. It uses embedded C for obtaining GPS data and python for obstacle detection. The destination address is taken as input through a microphone from the user and it is then looked after in the database to get the latitude and the longitude details. The database has to be predefined with the latitude and longitude of the given address for this system to work. The route query module is then used to find the route from the current location of the user to the required destination. This system deals with outdoor navigation but it doesn't have any component which maintains the safety of the person.

Another proposal made by SomnathKoley and Ravi Mishra [2] was also used for the navigation for the blind in outdoor environment. Once the system is powered on there are two options. In the first option the user can register a new location and in the second option the user can navigate to his destination. While registering for a new route the user has to move through the route and during any deviation in the route the user has to use a joystick and has to move it in the required direction to register the deviation. While navigation the user has to choose the second option and then key in the required destination through the microphone. The database will be searched for the location and if found the user will be navigated. This system just like the previous one used no component that ensures the safety of the person in an outdoor environment.

In order to overcome the difficulties in outdoor navigation system for the blind, YogendraRavle proposed a system [3] that uses cameras for obstacle detection instead of ultrasonic sensor. This kind of a system would increase the accuracy in obstacle detection as the ultrasonic sensor would indicate even

the slightest thing in its path as an obstacle, say, a leaf. One of the major disadvantage of this system was the number of sensors used. It used a large number of sensors which increases the complexity of the system, increases the cost and makes it difficult to carry.

Another problem with outdoor navigation is the exact direction in which the person should move. There maybe situations in which the person may have to take a very slight right turn and there are high chances of misleading the person into a completely different route. In case of indoor navigation system this may not be an issue as there is no chance of the person being lost in an unknown place. In order to overcome this difficulty for outdoor navigation system Jack M. Loomis, Reginal G. Golledge and Roberta L. Klatzky [4] proposed a system in which the position of the person is calculated based on the position, velocity and acceleration of the person. To increase the accuracy, they have implemented acoustic virtual display which keeps track of the head movements of the person. The person would usually be facing in the direction in which he moves, and so by tracking the head movement if the user turns his head in a wrong direction he would be alerted.

For indoor navigation system, one could easily use RFID tags for making the system simple. Karen Duarte proposed a system [5] using the same concept. The system includes various modules like, the voice module, information module, location module and the route module. This system is mainly used for navigation inside public buildings. When the user turns of the system in a public place the nearby RFID tags would be detected, and the information from the tags would be extracted to find the name and the coordinates of the place. The user would be asked for the place where he should navigate to and depending on the user input the route module would prepare a route to the destination and navigate the person. The major drawback of this system is obviously the installation of the RFID tags.

A few systems use the internet for the same purpose. Such devices provide a great deal of accuracy and are highly reliable, the only disadvantage being the requirement of an active internet connection. Ari Virtanen and Sami Koskinen [6] proposed a system that uses the internet for the navigation of the blind. In their proposed system they designed a new concept called the Unbroken Trip Chain which provides the visually impaired people with information like trip planning, finding the entrance to a railway station, finding a seat on the train and much more. The system uses a local information server that contains the data like speech recognizer, command interpreter and uses the internet for finding information like route planning, weather report and news. This system proposed by them can act as an all in one kit for the visually impaired people.

Security is one of the most important problem that has to be handled with care in case of navigation systems. A few proposed systems deal exclusively with security and obstacle detection. ioCane, a system proposed by Ben Leduc and Halley Profita [7], was built to exclusively to deal with security problems faced by the visually impaired people. They built a mobile application for both iOS and Android which will be connected to a board embedded on a walking stick fitted with ultrasonic sensors all around. The ultrasonic sensors will be used for finding the proximity and the height of the obstacle present in front of the person. Once the ultrasonic sensor senses an obstacle an haptic feedback will be sent to the phone which will alert the user. One of the biggest advantage of this system is that it is wireless and seamlessly integrates with both iOS and Android with just the installation of an application.

Aswathy VR, Dilraj and Sethuraman Rao proposed a system that is based on the concept of RFID tags [8]. Their proposed system used the RFID transmitter, RFID receiver along with a mobile phone and a Bluetooth modem as a communication link between the RFID receiver and the mobile phone. The RFID tags will be placed at particular positions inside a building. When the user is near a RFID transmitter, the RFID receiver will receive the information and it is then transmitted to the user's mobile Bluetooth module. The RFID transmitter in this system, transmits the information with a higher transmission power so that the interference with other signals is reduced. A summary of all the related work mentioned in this section is given in the Table I.

TABLE I. Summary of Related Work

S. No.	Paper Name	Tools Used	Advantages	Disadvantages
1.	Voice Operated Outdoor Navigation System for Visually Impaired Persons [1]	ARM Processor	• No internet required	• Not compact • Presence of joystick reduces ease of use • Only one ultrasonic sensor, makes it unsafe in outdoor environments.
2.	Innovative wearable navigation device for the blind using Raspberry Pi [2]	Raspberry Pi	• Uses camera for more accurate obstacle detection	• Usage of many number of sensors makes the system more complex. • Use of buzzer disturbs environment.
3.	Voice based navigation system for the blind using Ultrasonic Sensor [3]	Raspberry Pi	• Multilingual • Low production cost	• Exact equality of GPS coordinates is checked which may seldom happen.
4.	Navigation system for the blind : Auditory Display Modes and Guidance [4]	Inertial Sensor, Velocity Detector, Geographic Information System.	• High Accuracy • Wrong directions not possible because of virtual display.	• Costly • Too Heavy (11.4 Kg) • Location identifiers have to be placed in the environment in order for way-finding algorithm to work.
5.	Information and Assisted Navigation System for Blind People [5]	Mobile Phone and RFID Tags.	• Extremely efficient for navigation in public buildings. • The system works on a mobile phone and so it is more portable.	• RFID's have to be placed in all locations.

6.	Navigation and Guidance system for the Visually impaired [6]	NOPPA Pocket PC and Bluetooth GPS Receiver.	• Produces all sorts of information, such as, weather, interested areas, location of free seats on a train etc.,	• Requires internet for many of it's applications.
7.	A Smart-Phone and SensorAugmented Mobility Aid for the Blind [7]	Smart Phone and Ultrasonic sensors.	• Wireless communication between phone and kit.	• Requires a mobile phone.
8.	RF Based Talking Signage For Blind Navigation [8]	RFID Tags	• It is based on RFID tags and so it is much efficient in areas installed with RFID Tags.	• Usage of two hardware components involves communication issue problems.

III. PROPOSED SYSTEM ARCHITECTURE

In this proposed work, we have designed a system as shown in Figure 3, that allows the blind to navigate without any form of assistance within a campus. We need to make sure that the system doesn't provide too many information that confuses the person. The system will have all the predefined routes of a particular locality, and when the person tries to navigate to any area within that locality he will be initially asked for the destination name. The user will have to give the names of both from and to locations as an audio input. The corresponding route from the database will be retrieved and he will be navigated depending on that data.

The major factor that was considered during the design of the system was cost and affordability. More than 90% of the blind being unemployed the system had to cheap and affordable to make it useful for the bigger mass. So we built a system with the very affordable components available. The system is based on Raspberry Pi Model 2B. The following chapter describes the various modules used in the system

IV. MODULES OF THE PROPOSED SYSTEM

The following are the various modules involved in the operation of the system.

- Data Preparation
- Obstacle Detection
- Navigation

A. Data Preparation

The data preparation module is the core module of the system which is used for preparing the latitude and longitude coordinates of the deviation in a particular route. The flow of the data preparation is as shown in Figure 1. In this module the user will be asked to walk through the path through which he has to navigate. The GPS module is used to obtain the latitude and longitude coordinates. When there is any deviation in the path the user has to give an audio input which says the direction in which the path is deviated i.e., left or right. The coordinates of every deviation is stored in the database as rows. Once the user reaches the destination he has to give an audio input saying that the destination has been reached. The user has to use this module first to prepare the path only after which he can navigate through it

B. Obstacle Detection

One of the major factors that was considered during the design of the system was the safety of the system. Though this system deals with navigation inside a particular campus, still it has to deal with safety problems. In this system we use an ultrasonic sensor to detect the obstacles in front of a user. We start a clock while the audio waves are transmitted and we stop it when we receive them back (i.e., when the output of the receiver is high). The time difference between the transmission and reception is calculated and it's substituted in the formula distance = time * speed, where speed is the speed of sound. If the distance is less than a particular value we alert the user about the obstacle in front of him.

C. Navigation

This is the key module of the system and the reason why a person would use this system. The work flow of the navigation module is as show in Figure 1. The user will be initially asked for the name of the from and to locations. The system would search the database for the presence of the route. If it is not found in the database an error message would be given to the user. If found, directions are given to the user for movement. The GPS module is used continuously obtain the latitude and longitude coordinates. When the user gets near any deviation he will be alerted with an audio message to move in that particular direction. Once the user crosses a particular deviation, the database record pointer is incremented to point to the next deviation. Geo fencing mechanism is used to find if the user has neared the coordinates of the deviation

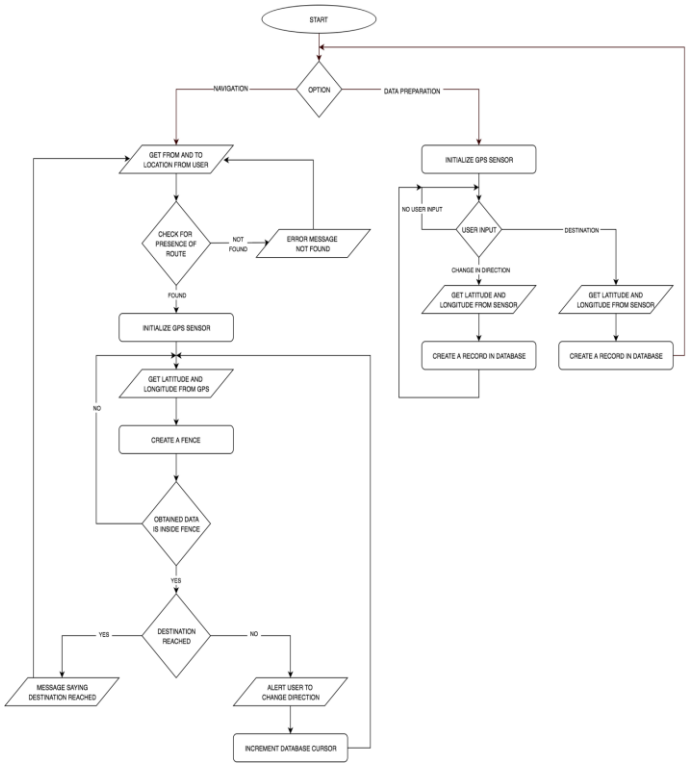

Figure 1 Data Preparation and Navigation Flow Chart

V. GEO FENCING

Latitude and Longitude coordinates are very precise. 1 degree change in longitude occurs for every 49 miles. So it is tough to determine if two sets of latitude and longitude coordinates are very close to each other, say at a distance of 1 meter from each other. Geo Fencing is a universally used mechanism to determine if one set of latitude and longitude coordinates is near another set of coordinates.

In this mechanism, as shown in Figure 2, a rectangle, a circle or a polygon is created around both the set of coordinates. If a rectangle is created, then we would be having the coordinates of all the four corners of the rectangle.Consider a rectangle is created and the first set of coordinates are taken as reference, we then take all the four corners of another set and check if any one of these four set of coordinates is within the reference rectangle.

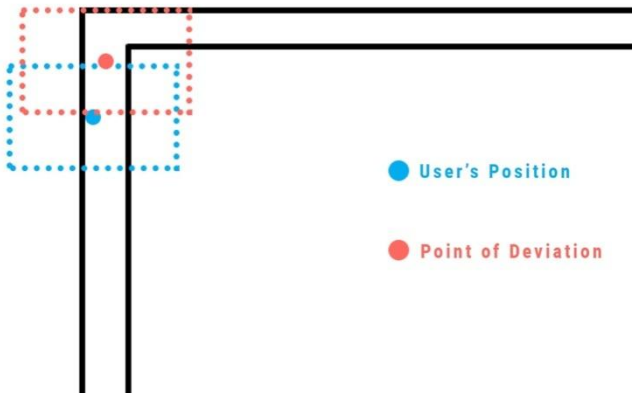

Figure 2 Geo Fencing

If yes, then the second set of coordinates is within the area of the first set of coordinates. We use this mechanism in our system to find if the user has reached near any of the deviations in his path

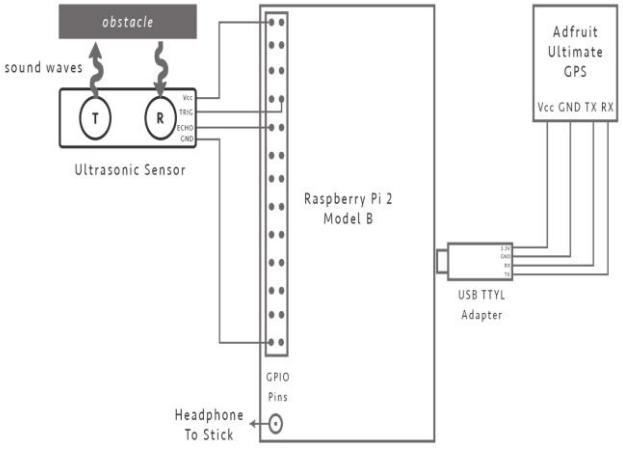

Figure 3 Architecture of Proposed System

VI. CONCLUSION AND FUTURE WORK

According to India Today, India is the country with the largest population of blind or the visually impaired [11]. Though India is home for the largest population of blind, there is not yet a system that would help the blind to navigate without any assistance. So we built a system that would help for the navigation of the blind without any assistance, at least within a localized area. Our system still is in it's starting stage and needs a lot of work and refinements before it can be used publicly. A few of the drawbacks of our system is that it would suffer from poor GPS signals in indoor locations within a campus. Our future work lies on improving the system's accuracy in indoor locations inside a campus. The usage of internet will bring a lot of advantages with only one con, the internet connection itself. In future we will try to use internet to download all the necessary content for a localized area like weather report, nearby interesting areas etc., beforehand so that it can be used later. Currently this system can be used in a small scale within a particular campus which is well defined.

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