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A Straight Forward Solution for Visually Impaired using Smart Assistive Navigation and Accessibility System

M. Nalini, R. Gayathiri

Abstract—This paper presents a Smart Assistive solution for the navigation and accessibility needs of visually impaired people. Using advances in inexpensive location mapping through GPS and navigation through various open source mapping platforms, real time assistive navigation is possible for visually impaired people. This paper also presents a solution for sensing the surroundings through a naive technology called 'Bluetooth Low Energy' to relay short messages about the surroundings.

Keywords—mobility; accessibility; gps; bluetooth; navigation

I. INTRODUCTION

Navigation is the process of determining the current location, destination and an effective route to reach the destination. The history of navigation was all about directing sea vessels (ships) through the seas using various techniques such as the direction of winds, staying within the sight of lands or using the position of the constellation of stars. All of these methods rely on one of our most important abilities, the sight. There are now many navigation systems for people who have the ability to see. But an effective solution for visually impaired people to explore the world is still not realized.

As of October 2017, 253 million people live with visual impairment, ranging from moderate to complete blindness [1]. The primary means of mobility include long canes, guide dogs and echolocation. The effectiveness and feasibility of these methods hinder the mobility of these people to a large extent. With the current developing landscape of urban cities, it is only becoming worse.

This leads to a demand for a personal, smart navigation system adapted for the current urban landscape, and also be effective and feasible than the current solutions.

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* Correspondence Author

Dr. M. Nalini*, Department of Electronics and Instrumentation Engineering, Sri Sairam Engineering College, Chennai, India. Email: nalini.ei@sairam.edu.in

R. Gayathiri, Department of Electronics and Instrumentation Engineering, Sri Sairam Engineering College, Chennai, India. Email: nalini.ei@sairam.edu.in

II. EXISTING SYSTEMS

The existing accessibility systems for the visually impaired people include walking sticks with obstacle avoidance and location tracking. The existing systems do not incorporate discovery and smart features to make a completely all-in-one accessibility system.

III. PROPOSED SYSTEM

The proposed Smart Assistive Navigation & Accessibility System (SANAS) will focus primarily on navigation and mobility, while also providing important accessibility features to mitigate the common obstacles and issues during the course of navigation.

The prototype is of the form of a walking stick with necessary sensors and controllers inbuilt for ease of use. The solution is aimed to be cheap and intended to be updated continuously for new features and improvements.

The solution also includes additional supporting apps/trackers for remote monitoring and emergency assistance.

IV. FEATURES

A. Obstacle Avoidance

The system consists of ultrasonic sensors fitted at the end of the stick to detect any obstacles on the path and alert the user to take a different course. It will provide haptic feedback to alert the user.

B. Point to Point Directions

Provides complete direction instructions with turn-by-turn navigation for over 100 million places of interests. Supports different modes of transit like walking, bus, train.

C. Assistance for Public Transportation & Places

With the use of Bluetooth Low Energy, the system provides real time information about nearby places and public transport vehicles like buses and trains, their arrival, their number and other important information.

D. Simple Image Recognition using Machine Learning

The system will be able to classify the objects to let the user know about it. It also provides novel ways to alert them of potential thieves and hazards.

E. Emergency Alert System

The system will provide an emergency switch to alert important relatives or guardian in case of danger or help.

F. Smart Assistant

The system would incorporate a smart digital assistant for helping the user with common queries and tasks. It may include setting up alarms, appointments or booking tickets, shopping, controlling the home and many other digital tasks.

G. Exploration

The system would provides exploration tools to get places in proximity to the user, such as opened shops, pharmacies, hospitals, etc.

V. INNOVATIONS

- Using Bluetooth Low Energy technology to relay short messages about the surroundings to get information about them. For e.g, a bus can be fitted with a BLE beacon that transmits its route number so that nearby user devices can detect it and inform the user about it.
- Uses Machine Learning to classify the objects on-the-go like currency notes and inform the denomination to the user.
- Integration of a smart digital assistant like Google Assistant for basic queries and tasks.
- Uses Natural Language Processing for understanding the user queries to execute tasks and actions.

VI. BLOCK DIAGRAM

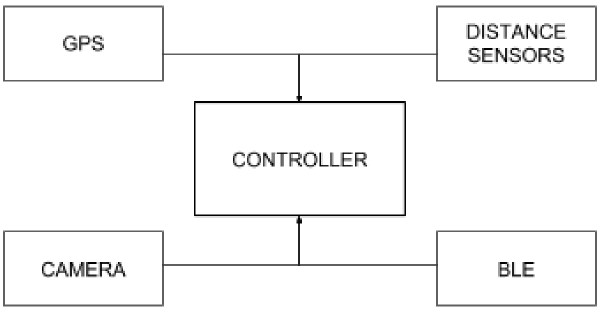

Fig.1. Basic block diagram of the proposed system

VII. WORKING

A. Obstacle Avoidance

Obstacle Avoidance is accomplished by using an array of sensors fitted on the tail end of the stick. These are distance sesnors which calculate the distance to the nearest object. It works on the principle of time of flight of the signal between the transmitter and the receiver. The selection of sensors are based on the following factors:

a) Range: The optimum range depends on the Preferred Walking Speed (PWS) of the person. For a person with high PWS, the range should be high so as to have sufficient time to alter the course, and for a person with low PWS, the range need not be high.
The optimum range will be in the span of 2 to 3m

b) Coverage (Width): The coverage of the sensor is the maximum area that it can detect within its range. This decides the number of sensors to be fitted in an array to obtain the desired coverage for different environments.

c) Size: The sensor has to be small enough to be fitted into a stick with a diameter of about 2 to 3 cm.

d) Cost: Cost to performance ratio is taken into account to develop a cost-efficient product for the masses.

Table I shows a comparison between the paramters of two commercial distance sensors.

The sensor will continuously monitor for any obstacles in the direction of walking and alert the person using haptic feedback in the handle of the stick. An array of haptic devices can be used to indicate the position of the obstacle. The intensity of the haptic vibration is varied to indicate the proximity of the obstacle. ie If the obstacle is nearer, the intensity of the vibration will be higher and if the obstacle is farther, the intensity will be lower.

TABLE I. SENSORS COMPARISON

Parameters	***IR Sensor (SHARP GP2Y0A21YKOF)***	***Ultrasonic Sensor (HC SR-04)***
Range	10 - 80 cm	2cm - 4m
Coverage	75 deg	30 deg
Frequency	353 THz	40 KHz
Cost	750 INR	130 INR

B. Navigation

The system will be able to navigate the person from his/her current location to the desired destination. The system would use a combination of Global Positioning System (GPS) and Geo location for obtaining location coordinates with both accuracy and coverage. GPS would be used outdoors during actual navigation to get accurate coordinates. Geo location is used when the person is indoors where GPS is not available, as a fallback.

The system will use either open source or commercial navigation services like Open Street Map, Map Box or Google Maps to obtain the directions to the destination.

Turn-by-turn directions are given by actively tracking the position of the user and comparing the waypoints with the directions obtained for the navigation service and giving out the next instruction.

C. Bluetooth

Bluetooth Low Energy (BLE), previously known as Bluetooth Smart is a new network protocol with low power consumption. It is used to implement "Beacons" which are simple devices that broadcasts small data within a small range. The data to be transmitted can be programmed.

This technology can be used to detect surrounding objects and places. The data transmitted by the beacon can be received by a client device which then decodes it provide useful information about the beacon and its associated place or object.

For instance, the beacon can be fixed to a public transport bus, with data about its route number and waypoints. When the bus is in the vicinity of the person, their device will receive the message and inform the person about it.

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BLE has a range greater than 100m and 1-2 Mbit/s data rate. The power consumption is as low as 0.01 - 0.5 W.

When several beacons are available, in order to distinguish them or sort them on the basis of their proximity to the user, the Received Signal Strength Indication (RSSI) data of the beacon message is used. It is an indication of how strong the signal is in terms of decibels. The beacon nearest to the user would generally have a high signal strength compared to the beacon further away from the user.

The basic components are a transmitter (beacon) and a receiver. A cheap and effective beacon would be Gimbal Proximity Beacon Series 10, with a range of 50 m and battery life of 4 months [3].

The system can detect common beacon formats like Google's Eddystone format and Apple's iBeacon format, so it can detect existing beacons.

D. Image Recognition

Image Recognition is used to classify essential day to day objects such as currency, tools and text to relay it to the person. This is done on device using Tensor flow, a Machine Learning library, which is trained with sample data. The Tensor flow model is then stored on the device and is fed with captured image to classify it or extract text from it.

E. Emergency Alert System

The emergency alert system is a simple system to alert the user's desired contact for help along with the current location. The message will be sent either through standard SMS or through any messaging platform of choice. This will also log the location of the user in real time to a cloud database which can be viewed by the user's selected contact using a dedicated cross platform app.

F. Assistant

The emergency alert system is a simple system to alert the user's desired contact for help along with the current location. The message will be sent either through standard SMS or through any messaging platform of choice. This will also log the location of the user in real time to a cloud database which can be viewed by the user's selected contact using a dedicated cross platform app.

VIII. FLOW OF OPERATION

The different features may be separately invoke and their general flow of operation for different use cases are discussed below:

A. Navigation

1) Invocation: The user initiates a navigation session through the press of a dedicated button. The user will be intimated of the session start through haptic feedback.
2) Input: The user says the desired destination to navigate. Optionally, the mode of transportation can also be given. The different modes of transportation are
   a) Walking (default)
   b) Public Transport
   c) Taxi / Cab
3) Directions Fetch: The given destination and the current location are sent to a navigation service to obtain the directions.
4) Actual Navigation: The directions will be given to the user step-by-step by tracking their location every interval and comparing with the coordinates of each leg of the route.
5) End: When the user reaches the destination, he/she is intimated and the session is closed.

B. Image Classification

1) Invocation: The user invokes the classifier using a press of a button or through voice. He/she is then intimated of the session.
2) Mode Selection: The user selects one of the available modes. They include:
   a) Object Classification
   b) Text-to-Speech
   c) Face Recognition
   d) Currency Calculation
3) Capture: The user is then intimated to place the object/sample in front of the camera and is notified if the capture was successful. If not, he is advised to move the sample around until the capture is successful.
4) Processing: The capture image is then fed to a local Machine Learning model or a cloud service to obtain the tags and associated data.
5) Response: The obtained data is then informed to the user and the session is ended.

C. Bluetooth LE

1) *Invocation:* The user initiates a exploration session through a dedicated button or through voice input.
2) *Session:* Once the session is started, bluetooth is turned on and it actively listens for any BLE messages and relays it to the user through voice.
3) *End:* The session is stopped through a button press or through voice.

D. Emergency Alert System

1) Invocation: The user initiates an emergency session through a dedicated button or through voice command. Optionally, a confirmation can be prompted.
2) Transmission: The GPS is turned on and the user's current location is sent through GSM or other messaging service to one or more selected contacts. This is sent in intervals.
3) End: The emergency session will end only when a sequence of button presses are made.

E. Assistant

1) Invocation: The assistant can be invoked either through button or active voice detection.
2) Session: The assistant will be active until the session is stopped. It would require an active network connection to work, yet a fallback offline assistant can be provided for emergency usages.

3) End: The assistant can be stopped using a button or through voice command.

IX. TOOLS AND SOFTWARES

A. Controller

The main controller used for the processes is a Raspberry Pi 3. It has Bluetooth 4.0 and can power other components.

B. Assistant

The digital assistant will be powered by Google Assistant and Dialog flow.

C. Obstacle Avoidance

Arduino is used to interface with the ultrasonic sensors. Two HC SR-04 sensors are used to detect obstacles from the two directions.

D. Tracker

The tracker is a web application built with Java script and Firebase. The web application is live at https://mukilane.github.io/sws-tracker/

X. RESULTS

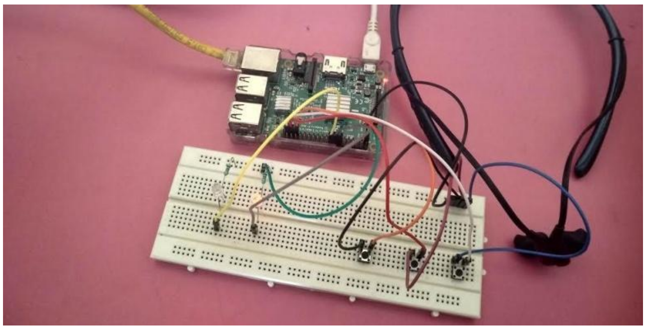

Fig. 1.Proto type of main controller along with handle

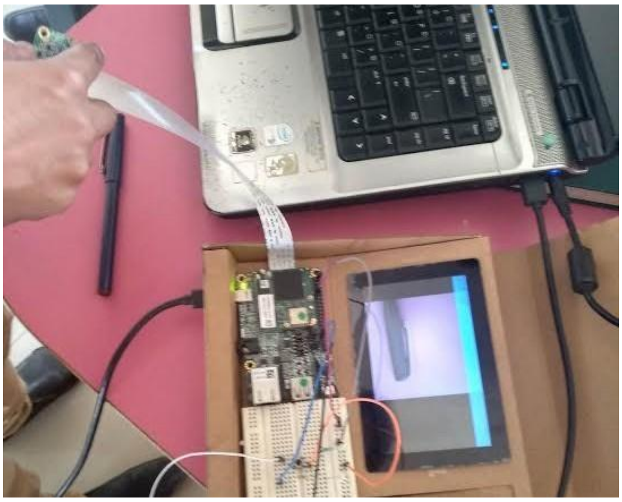

Fig 2. Working of image recognition with display

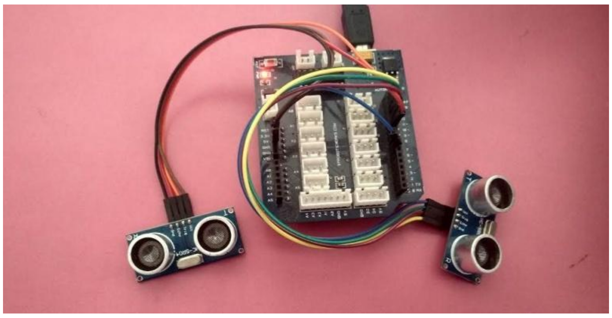

Fig 3.Two ultrasonic sensors for obstacle avoidance

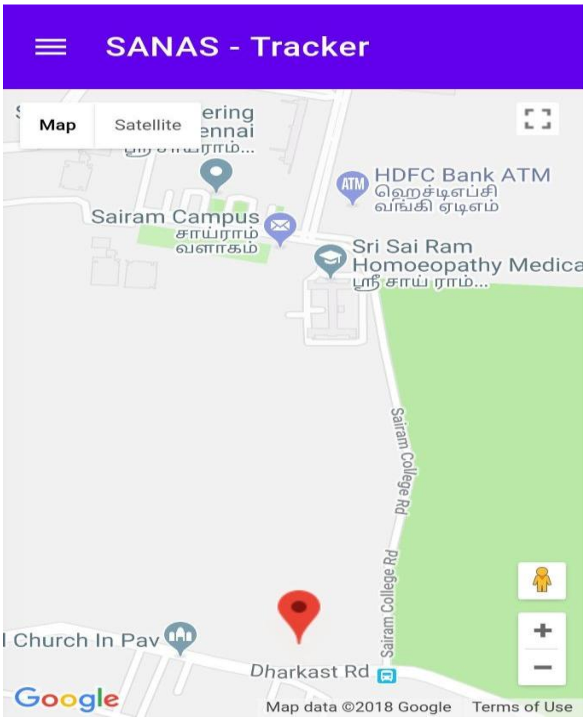

Fig.4. Companion app showing the current location of the person

CONCLUSION

Thus the accessibilty and navigation needs of the visually impaired are satisified using the existing and new technologies to provide a robust and easy tool with cost efficiency and simplicity.

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AUTHORS PROFILE

Dr. M. Nalini completed Ph.D in 2019. She has published technical papers in 11 international/national conferences. Her areas of interests are Soft Computing, VLSI, and Biomedical Instrumentation Engineering.

R. Gayathiri received her M. E in 2005 . She has published technical papers in 5 international/national conferences her areas of interests are Soft Computing, Instrumentation, Medical Electronics and Biomedical Instrumentation Engineering.

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