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Navigation Assistance for Visually Challenged People

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Abstract - *This paper presents an obstacle detection and routing solution for visually impaired people. The technologies like voice based assistance, ultrasonic based assistance, camera based assistance and transplantation of real eyes with robotic eyes which can capable enough to plot the real image over patient retina using some biomedical technologies are developed for visually challenged people for navigation assistance. Creating a fusion of sensing technology and voice based guidance system which could give better result than individual technology. The system consists of the following functional components: (1) a module for determining the traveler's position and orientation in space, (2) a module for obstacle detection and (3) the user interface. By using this technology, it is possible to assist a visually impaired person to navigate through an unfamiliar indoor environment. By adding an audio guide to this system blind people are able to perceive their environment in more detail and navigate to their desired point of interest without depending on others. It increases their spatial awareness, independence and self-confidence, all at once.*

Key Words: Sensing technology, Robotic eyes, Ultrasonic based assistance

1. INTRODUCTION

The biggest challenge for a person with physical limitation such as the visually impaired individuals, senior citizens or partially or completely blind individuals is to navigate independently and perform their routine schedule independently. Particularly, visually impaired individuals can't navigate and perform their basic day-to-day activities, without the support of other individuals or without using any other artificial support aid such as white cane, sensors or a watch dog. When people navigate from one place to another, they make use of several different inputs which is not possible in case of the visually impaired. Our goal is to develop a system to guide the visually impaired people to navigate comfortably any avoiding obstacle collision. Research in this field has increased tremendously over the years. Different methods are used for obstacle detection and avoidance. Our main objective is to make a compact, self-sufficient system that will permit these blind people to travel through an environment. Different methods are used for obstacle detection and avoidance. A Smart vision prototype is proposed by which is a local navigation aid for the blind and visually impaired people for identifying paths, sidewalks corridors as well as provides obstacle avoidance both indoor and outdoor locations. It needs a stereo camera worn at chest height, a portable computer and a small speaker carried to fulfill the requirements of this navigation system. Another pedestrian navigation system called Drishti is a wireless system which also uses wearable computers, voice recognition and synthesis, wireless networks, Geographic Information System (GIS) and Global positioning system (GPS). Another digital navigation system for the blind called the Smart Walker uses a digital radio, GPS, headphones, a blind keyboard and a walker for detecting changes in the terrain while walking and warning during dangerous situations. The Eye Walker is a low-cost, ultra-light computer vision device for users with mobility problems, which could be clipped on a standard walker. It warns the users of potentially risky situations or help to locate a few particular objects, under widely varying illumination conditions.

This voice based route navigation system can provide solution to this problem. This System is based on embedded system and provides navigation instructions to the user by giving audio instructions through speaker which is connected to raspberry pi using a USB jack. This navigation system will detect an obstacle using HC-SR 04 ultrasonic sensor and guide blind person by providing an audio instruction through 3.5 mm speakers. It is our conviction that advances in innovations could help and encourage these blind people in their regular operations. This work goes for giving the route to blind persons, by designing a cost – effective and more flexible navigation system. Here we are developing a navigation system that makes use of sounds in order to provide navigation instruction to the user. The conversion of speech into a text is done by Google API. Route navigation is taken care by a Raspberry pi. The user can include the location by talking into a microphone connected to raspberry pi. The whole system is mounted to a pack that sits on the client waist. It is light and convenient and it doesn't obstruct any of the client's detects while it is being utilized.

Indoor navigation deals with navigation within buildings. Because GPS reception is normally non-existent. Contrary to GPS, however, they also enable you to determine the actual floor level. Most applications require an "indoor routing" functionality that guides people precisely through a building using an indoor navigation app and in this way, automatically determines their position - very similar to the navigation systems that we use in our cars. A typical application is turn-by-turn navigation in an app (displaying directions on a digital map) used for train stations, airports, shopping centers and museums. This kind of application can

also include many other useful services. However, indoor navigation is not possible without automatic positioning - for example, when a digital building map is integrated into a website or in a digital signage system (multi-touch kiosk/interactive terminal). The automatic positioning inside a closed environment is done using Artificial intelligence(AI).

Artificial intelligence is the field of computer science that tries to blur the line between human and machine operation. The field of AI research defines itself as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of success at some goal. Colloquially, the term "artificial intelligence" is applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving". AI programs can absorb new modifications by putting highly independent pieces of information together. Hence you can modify even a minute piece of information of program without affecting its structure.

Most applications of Artificial Intelligence utilize an expert system to find solution of a problem. In artificial intelligence, an expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, represented mainly as if–then rules rather than through conventional procedural code. At implementation level an Expert system is a piece of software which uses databases of expert knowledge to offer advice or make decisions to a problem in its specified domain.

Theoretical results in machine learning mainly deal with a type of inductive learning called supervised learning. In supervised learning, an algorithm is given samples that are labeled in some useful way. The algorithm takes these previously labeled samples and uses them to induce a classifier. This classifier is a function that assigns labels to samples including the samples that have never been previously seen by the algorithm. The goal of the supervised learning algorithm is to optimize some measure of performance such as minimizing the number of mistakes made on new samples.

2. METHODOLOGY

Users on entering a location which has implemented the proposed system, will get an alert in their device. The only control that the user can access is a big button in the center of the device. On pressing the button, the ai system activities and provides the user with current location information with accuracy up to 1m. The always on walking assistant system equipped with multiple ultrasonic sensors will enable the user to walk everywhere without worrying about hitting obstacles. These sensors can detect obstacles in 3 directions and accurately measure its distance from user within a range of 40 cm to 4m.

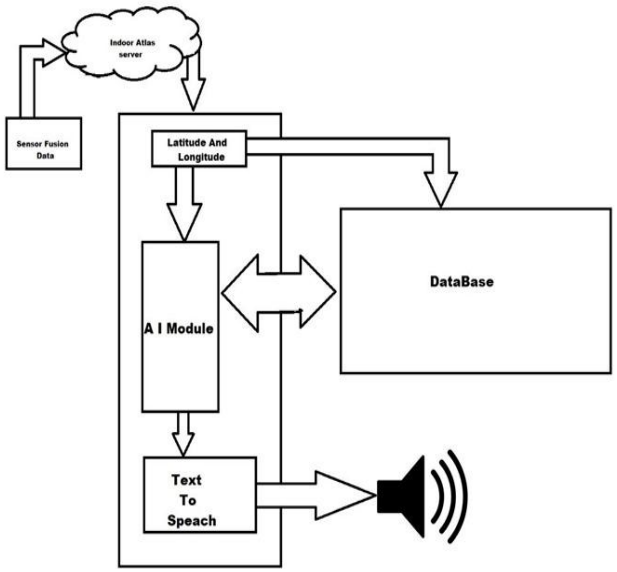

Figure 2.1: Block diagram of navigation assistant

Prerequisites for implementing this system includes

- ✓ Mapping the target area
  Mapping is the process of creating a blueprint of the building in which the system has to be implemented. It also involves the collection of sensor fusion data at various points in the map so that this information can be used to create a relation between location and sensor readings. The points where we collect sample sensor data are called waypoints. The more the number of waypoints the more accurate the system will work. An efficient mapping can provide indoor location information such as latitude and longitude with an accuracy of up to 1m. Considering the fact that the accuracy of GPS is about 8m, this is 8 times better than current generation GPS technology.

  In order to map a location, we first create a blueprint containing all the necessary structural information such as the rooms, staircase, walkable area, restricted area... Then we'll align the map with a real digital map such as google map to get an approximate latitude longitude range. We name the map and floor id. Then we select random waypoints in the map and collect sensor data at that position as well as at regions that comes between two waypoints by walking between them. All this information is stored on to indoor atlas server so that whenever we request the server with sensor data it can provide us with some latitude and longitude information.

- ✓ Installing and Calibrating Target Devices
  The end user system of this project contains two entities one obstacle detection wearable that gives

three directional obstacle sense and android based positioning system. Both these system works extensively on the basis of sensor data. All manufactured sensor will have some precision error so in order to avoid the effect of such errors on the result the compass, accelerometer gyro and other sensors must be calibrated. This has to be done only once for every unit.

The installation includes both attaching the head strap in a comfortable position for the user as well as installing the android app which does the positioning and navigation part. Since the obstacle detection sensor is always powered on it must be provided with a charged battery unit.

Basic working of the proposed system consists of the following steps:

1. Sensor Data Collection and Sensor fusion
2. Sending the data to IA server via API calls
3. Waiting for response and handling it
4. Retrieving latitude and Longitude
5. Passing Information to AI
6. Write backing new results
7. Parallel obstacle detection
8. Text to Speech output

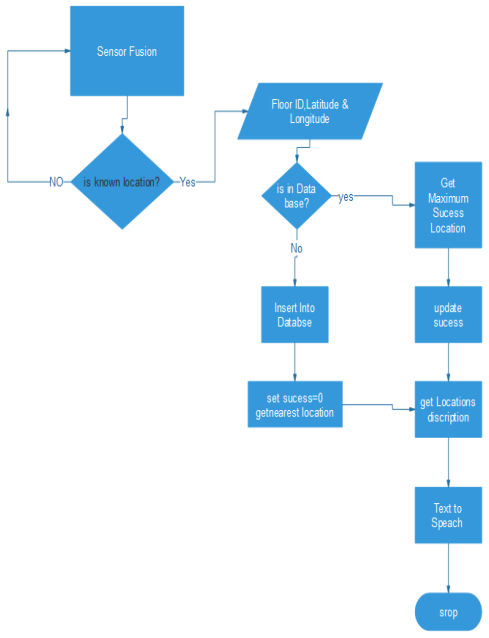

Figure 2.2: Flow chart of AI module

1. Sensor Data Collection and Sensor fusion
The android application make use of the android hardware APIs to collect the sensor data from accelerometer, gyro and Compass sensors. These raw sensor data are passed on to an encoder provided by indoor atlas SDK this is considered similar to as that of key in a key value pair. This encoded information is used to accurately find user location information.

2. Sending the data to IA server via API calls
These encoded key value is stored in an internal variable and is passed to indoor atlas servers as instance of IALocation class through asynchronous API calls. Use of async functions enables UI thread to perform normally even when background data transfer takes place. The authentication of users at server side is done by making use of a secret code and its key. This information must be explicitly declared in apps manifest

3. Waiting for response and handling it
Whenever user enters a mapped location a java callback listener onLocationChanged is called. This method takes an argument as object of IALocation class. This object consist of all the re-quired information to identify the users current location information. The IALocationListner Class is responsible for handling events like resume, Exit location, Change floor...

4. Retrieving latitude and Longitude
In our application, we focus mainly on getting latitude and longitude information from the Indoor atlas services. This information are available as data members of IALocation object which we received from IA callback. So, in order to access them we use the get methods of the class. The location.getlatitude() and location.getlongitude() functions will return location informations with up to 9 digit precision. These precision is responsible for the high positional accuracy of the system.

5. Passing Information to AI
The received latitude and longitude data are given to the AI module. The Ai system tries to build an expert system from previous knowledge which is present in its database. The database is implemented using Sqlite in android and contains two tables. One in which it stores all the basic room information like room name, description, approximate corner latitude and longitude.

This table has to be filled at the initialization time this is done by training the AI system at the Implementation time. Every time a new Room is added to the system this training must be repeated for the Room
The second table used for actual AI processing, it consists of a Latitude Longitude pair and a success rate indicator.
Whenever a new room is added updateDB is called which insert the values into the first table

When we try to train the system, the AI will recommend you a check in location if it is true the user have to press yes at that time success rate is increased in AI table
On receiving the latitude and longitude info from IA module the AI will check the AI table and select the closest latitude longitude combination with maximum success.

6. Write backing new results
The advantage of using Artificial Intelligence is that it learns from its use case and be-comes efficient over time. In order to do that it must save results and inference from its every usage. For this purpose, we use one of the table from the SQLite database. The AI table is used for this purpose. Every time a location is identified the AI system will write back the latitude longitude combination to AI table with its success rate. If the pair is not already in database it is inserted and success rate is set to 0. If the pair is already in database the success rate is incremented. This is one of the important step in AI design.

7. Parallel obstacle detection
From the moment, the user puts on the headset the obstacle detection starts and it will last till he removes the headset from his head. The headset uses three ultrasonic sensors which are placed slightly angled to each other and has a range of 270 degree. Each ultrasonic sensor is connected to a single master board powered by a raspberry pi 2 b. The raspberry pi monitors each sensor in real time and if an obstacle is found at any point the raspberry pi will detect its approximate location by analyzing result from other two sensors and it finds the distance to collision using sensor data. These information is passed on to the user as audio signals.
The distance to the object is found by calculating speed of sound, time difference between sound wave release and reflection received.

8. Text to Speech output
Speech output is the only mode of user interaction in this system. So, it is given one of the highest priority. This system has two independent output generators, one from the mobile application and other from obstacle detection unit. Both of these systems uses text to speech capabilities of their respective platform to produce efficient speech output to the user. The sound data from both raspberry pi and smartphone are taken from the 3.5mm audio jack and are multiplexed into a regular earphone unit.

3. CONCLUSIONS

The developed system efficiently ensures the following:

- ✓ It makes visually impaired people capable of moving to his/her willing place safely without seeking help from others.
- ✓ While reaching to the destination the system detects obstacles on their way.
- ✓ Helps them to do their day-to-day work with ease.
- ✓ AI implemented on this system accurately locate their current position.
- ✓ Alternate paths are successfully generated when an obstacle is detected or when the user got lost.

The overall aim of the proposed system is to construct and design a portable, simple, less costly device that will help visually impaired people to move in unfamiliar environment. Proposed system is designed considering usefulness of all ages, user friendliness and does need pre-training of the AI. In this proposed system, more attention is paid to sensor fusion based indoor navigation, obstacle detection using Ultrasonic sensors, minimizing the amount of infrastructure. Moreover, the primary objective of this system is to design a cost effective and easier to handle device for visually impaired people.

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