DISHA : An Indoor Navigation System for the Visually Challenged

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***Abstract*— In this paper we outline the design for an indoor navigation system for the visually impaired. Our long-term goal is for a portable, self-contained system that will allow visually impaired individuals to travel through familiar and unfamiliar environments without the assistance of guides. The system, as it exists now, consists of the following functional components: (1) assistance for determining the user's position and orientation in the building, (2) a detailed map of the interior of the building, and (3) the user interface. By pressing keys on his/her mobile unit, directions concerning position, orientation and navigation can be obtained by the portable system that can prompt them acoustically over a text-to-speech engine.**

I. Introduction

According to a WHO study [1] in 2002, there were more than 161 million people with visual disabilities. More than 90% of them live in developing countries and most of them are below poverty line.

Among the many challenges faced by the visually challenged persons are the constraints of independent mobility and navigation which stem from hazards in an unfamiliar indoor environment. Finding their location and the path to some other location inside the building can be quite a daunting task, especially when the environment is unfamiliar. The objective is to make them independent in this regard. Although several attempts have been made at making such systems, not many have been successfully deployed. Moreover, all systems currently in use are very expensive for the end-user (USD 200 onwards) and are therefore unsuitable for use in developing countries.

Our system, on the other hand, is extremely cost-efficient (INR 2000 or less), easily scalable and user-friendly as it does not require the user to wear any complicated belts, sensors or any other gear. It includes setting up a mesh network of Zigbee nodes [2] in the building for calculation of the users position, a bi-axial geomagnetic sensor to determine users orientation, a keyboard for the user to make queries, a voice-feedback system and a micro-controller to control them all and do the processing.

II. System Design

The system can be broadly divided into the following four parts

A. Positioning

The system uses a Zigbee-based location engine developed by Texas Instruments [3]. ZigBee (IEEE-802.15.4) is a low-cost, wireless mesh networking standard specially suited for embedded applications requiring low power consumption. The system employs a mesh network of Zigbee Nodes (henceforth called Reference Nodes) deployed at various locations inside the building such that at every point inside the building there are at least three Reference nodes within range. The user carries a similar Zigbee node (henceforth called Blind node) as part of the system.

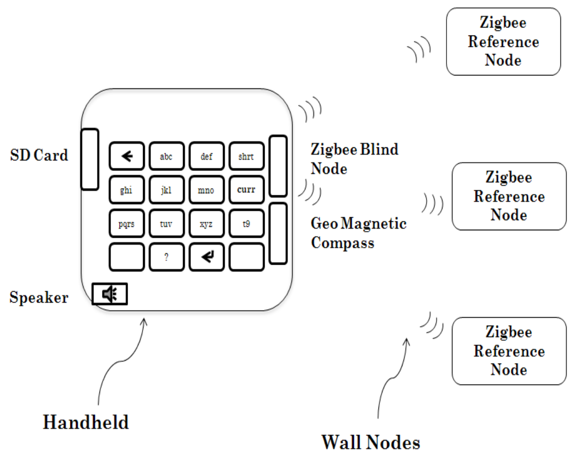

Fig. 1. Schematic Diagram

The Reference nodes can be hard coded with their co-ordinates with respect to a pre-defined coordinate system. The Blind node uses RSSI(Received Signal Strength Indication) values of the radio signal from the reference nodes. These RSSI values are a measure of the power received, and hence the distance, and along with the trilateration technique [4] can be used to calculate the coordinates of the Blind Node. The system works equally well for buildings having multiple floors.

B. Orientation

The system uses a bi-axial geo-magnetic sensor [5] to calculate the orientation of the user with respect to the corridor and guide him/her accordingly.

C. Navigation

The system contains a map file of the building (stored in an SD card on the system). The building information is stored in the form of an undirected graph-

- Each node either represents an access point or the meeting point of two corridors
- There exists an edge between two nodes iff there is a direct path (no node in between) between the two nodes

The file stores the graph as an adjacency list of nodes represented by their coordinates and edge weights. The edge weights assume importance because all paths are not equally preferred by the visually impaired. For example, a user may prefer to use the elevator instead of stairs even though the latter may give a shorter path.

The system uses the Dijkstra's algorithm to find the best possible path from the users current location to the destination location that the user has queried for.

The map file for each building can be transferred to the system whenever the user enters a new building using the Zigbee Nodes themselves.

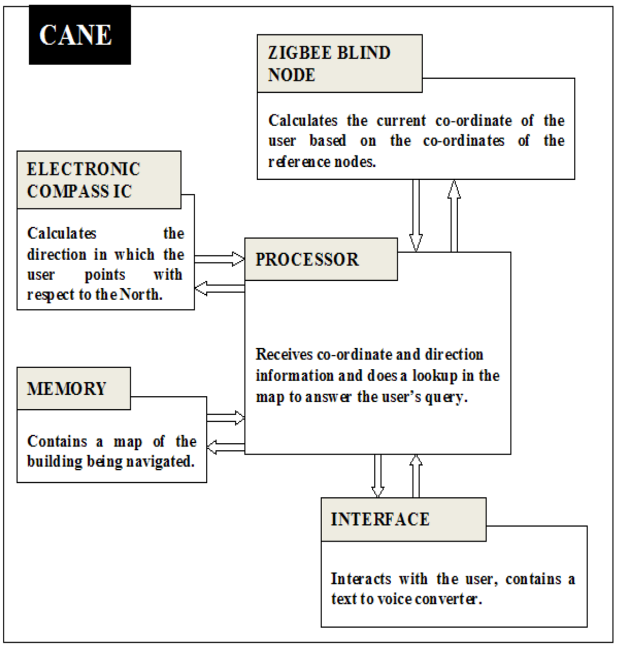

Fig. 2. Block Diagram

D. User Interface

The user interface comprises a 4x4 alphanumeric keyboard with the following modes

- Shortcut
  In this mode each of the keys represent a location commonly queried by the user. For example, elevator, rest room, exit door are some commonly queried destinations.
- Alphabet
  In this mode the user can enter the destination name using the alphanumeric keys. Each of the keys has a voice feedback so that the user knows what he/she has entered.
- Predictive text
  The system also implements a voice feedback predictive text mode. The user enters a prefix of the required destination and the system provides him with all destinations with that prefix from which he can select the appropriate one.
- Current Location
  The user can also query his location inside the building using this mode

The system generates sound output using a text to speech engine, made using a 10-bit DAC(Digital to Analog Converter) and 16 KHz sampling rate. The sound files for output are stored on the memory card.

III. Status

The system is in the Design stage. The design, development and testing of all individual components has been done successfully and has yielded encouraging results. The componenets are currently being assembled into a prototype.

IV. Conclusions

The system offers a portable, low cost and user friendly solution to problems of mobility faced by the visually handicapped. It is technically and economically feasible and can be a real boon for all visually handicapped individuals especially those living in developing countries. The system is based on a state of the art, robust technology and therefore has the potential to develop as a de facto standard for all future building construction.

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