BIUST Research and Innovation Symposium 2017 (RDAIS 2017)
Botswana International University of Science and Technology
Palapye, Botswana, 12-14 June 2017
ISSN: 2521-229X
ISBN: 978-99968-0-608-7

An Exploration of Navigation Technologies for Visually Challenged Students at a University

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***Abstract*— Education is an important aspect of individual life and key to the region's development. Education of disabled people has long been regarded as an area of concern. Visually disabled people struggle with a myriad of challenges for education. These challenges can be attributed to the absence of an enabling environment. The environment should provide them with proper facilities to get the education and also tools to navigate without any discomfort. Navigation in an unfamiliar environment is the common problem faced by visually impaired people.**

Earlier navigation in an outdoor environment was a challenge for visually disabled. With introduction of technologies like GPS (Global positioning system) it is no longer a challenging task. A GPS voice enabled smart phone will be able to do turn-by-turn navigation. A small application, Google Maps[2] with GPS Tracker on your mobile uploads your GPS position periodically over either General Packet Radio Service (GPRS) or 3G, which updates your position on a moving Google Map. GPS locates and identifies major landmarks encountered by the users and typically do not work indoors. There should be a technology to overcome this problem of indoor navigation for visually impaired. This paper studies the different technologies available for outdoor navigation, the pros and cons of each technology and proposes an ideal/best fit solution for indoor navigation in an environment like a University.

Keywords*— *Global positioning system (GPS), General Packet Radio Service (GPRS), wireless fidelity (Wi-Fi)

I. INTRODUCTION (*HEADING 1*)

Education is an important aspect of individual life and key to the region's development. Educating disabled people has long been regarded as an area of concern. According to world health organization (WHO) it is estimated that 19 million children are visually impaired. Among them 12 million children are visually impaired due to refractive errors, a condition that could be easily diagnosed and corrected and 1.4 million are irreversibly blind for the rest of their lives and need visual rehabilitation interventions for a full psychological and personal development. [1]

Securing the future of the visually disabled is a critical challenge for the society. Providing higher education can serve as an important gateway to secure the future of disabled as it creates valuable employment opportunities. In spite of hundreds of universities, thousands of colleges the number of low vision students getting education has not been on par growth. The lack of enrollment can be attributed to many factors like lack of access technology, lack of encouragement and the major inhibition can be the inability to navigate the physical campus. Navigation in an unfamiliar environment is the common problem faced by visually impaired people. Existing systems do not provide active guidance or are bulky, expensive and hence are not socially apt.

Earlier navigation on roads for blind without human assistance was a challenge, but with introduction of technologies like GPS it's no longer a challenging task. A GPS voice enabled smart phone will be able to do turn-by-turn navigation. Google Maps with GPS Tracker shows your physical position in real-time on a moving Google Map. A small application on your mobile uploads your GPS position periodically over either GPRS or 3G, which updates your position on a moving Google Map. GPS is a global positioning system [2]. Using a GPS it is easy to navigate the outdoor environments but the short coming is it locates and identifies major landmarks encountered by the users and typically they do not work indoors. GPS is suitable for outdoor navigation only, due to the need for line of sight access to satellites. There should be technology to overcome this problem of indoor navigation for visually impaired. The present paper focuses on the challenges of indoor navigation and proposes a solution.

Objectives of the paper are

- To study the existing literature on outdoor and indoor navigation technologies for blind.
- Identify how the outdoor navigation is different from indoor navigation.
- Propose a solution for indoor navigation which is similar to outdoor navigation.

II. LITERATURE SURVEY

There are many existing assistive tools available which supports a visually disabled person to navigate the physical campus like, Long cane, which is a walking tool used to support independent travel or to identify for others that the person is visually challenged. Another tool is the digital talking compass which is a directional device that announces the directions through an audio output. [3] But these technologies don't suffice the requirement. A more advanced technology and tools should be provided to assist the blind.

ISSN: 2521-229X
ISBN: 978-99968-0-608-7

The proposed model for Indoor navigation for university campus has come from the extensive study carried out on existing literature on outdoor/outdoor navigation technologies. Several studies were carried out on outdoor navigation for visually disabled. Development of a navigation tool for blind can be divided into two sub problems, location detection and object detection. Different studies and experiments were conducted using different technologies to find a solution for these problems. Some of them are outlined in Table 1 and Table 2.

A. *Outdoor Navigation*

For outdoor navigation Google developed a mobile application called Google Maps Navigation which works on Android/IOS OS and integrates Google Maps. The application provides turn-by-turn voice based instructions to reach the destination provided the mobile has an internet connection. The mobile application uploads your GPS position periodically over either GPRS or 3G, which updates your position on a moving Google Map. [2] GPS is a global positioning system. Figure1 explains the working of GPS. [4]

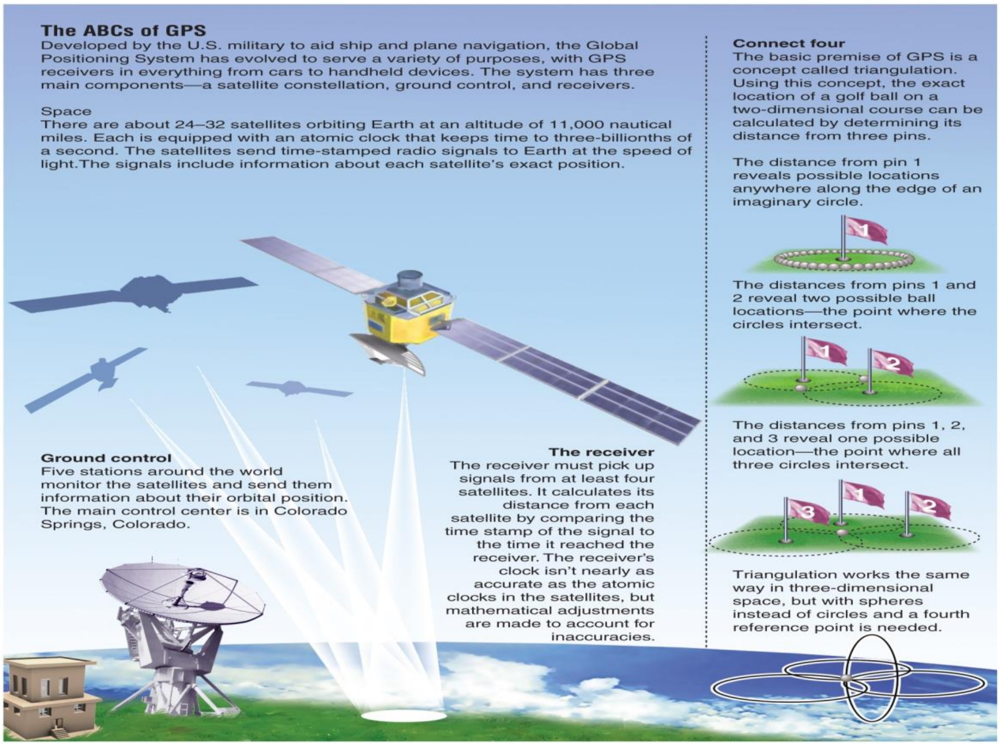

Fig 1: How GPS works
Adapted from: [4]

III. Methodology

Developing an Indoor Navigation System involves three steps,

- First step is to develop a web application like Google maps which works on an android phone for Indoor environment. It should read and analyze the maps of the Indoor locations like building and malls.
- Second step is developing and linking location recognition system like GPS to this Android application
- Third step is to develop an object sensing/detection system which should be attached to the user.

Integration of these three will aid the blind to navigate in an indoor environment. The system should be able to do the landmark identification with path based guidance in the indoor environments like Universities, Malls, and Hospitals.

The proposed system is a more advanced system which can be used to navigate within the university. For location detection and path navigation, the proposed system uses two main components, Hand Unit (Android Mobile which has the voice based user module installed. It acts as the interface) and Wall Units, WIFI Access points for getting the location coordinates..

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For obstacle identification, A walking cane with ultrasonic sensors will be used.

The University campus will span acres of land and consists of many buildings as shown in fig 2. The difference between outdoor and indoor navigation is that in indoor navigation there will be static obstacles like gates, walls, dustbins and stairs. The visually disabled should keep in mind all these obstacles and navigate. The system should facilitate with proper information about the obstacles and also the landmarks in each building. Tactile Feedback (Buzzer or vibrator also audio output) is ideal solution to alert about obstacles. The system uses the floor maps for navigation of building

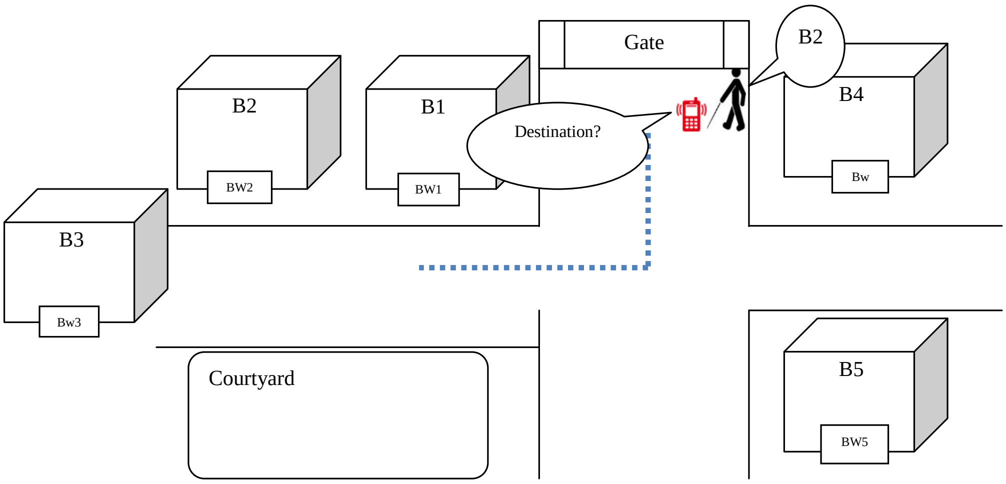

Fig 2: Campus View of the University

The user crosses the Entrance gate and the application in the handheld device will load blue print of the whole campus. The maps of the campus are stored as AutoCAD files in a spatial database. The DB should be integrated with the mobile application. This integration helps to find the way to the destination with turn-by-turn spoken directions as you move along the map also disclosing encountered landmarks information.

Wall unit (Wi-Fi access points) is fixed to all the main locations of the campus. Calculation of location is done using the received signal strength from Wi-Fi access points (a minimum of 3) to wireless access device. Each building will have wall units fixed. The units are placed such that there is no interference between the signals sent by two units. A wall unit is the WIFI access point which will locate the position of the handheld receiver by using a triangulation method similar to GPS.

Generally, people observe, follow and keep track of the landmarks while travelling an unknown place. When people navigate through the same place for the second time, they will keep track of the landmarks and ensure that the route is correct. If landmarks are not seen, then it can be understood that the chosen path is wrong. For a blind person it is not feasible to see observe and follow the landmarks while travelling so a voice based application should prompt the landmarks to ensure he is on right path.

The person navigates the campus with the assistance of the hand unit which will prompt voice based messages about the landmarks that are being crossed. After entering the destination building, the hand unit will be loaded with the blue print of the plan of each floor. That floor map is opened along with the landmarks of that floor. Whenever the person crosses that landmark the mobile will give a voice based prompt that he is crossing that land mark.

Person's location coordinates are calculated by the received signal strength from WIFI access point using triangulation method similar to GPS [5]. After receiving the location information from the access point the application should be able to find the nearest land mark and would be able to identify the distance from present location to the nearest landmark and should give the audio output of that information.

The application in the hand unit will guide the students in situations where they have queries in reaching the destination building. All the FAQ or scenarios will be saved in the DB. The application will mine the answers for the queries from the DB. Sample Voice based questions asked by the Application:

Scenario:

Q: Where is the student library?

S: In Building 1

Q: How to go building 1

S: Where are you?

Q: I m near main gate

S: Go straight 10 steps, then turn to your right you will be getting a signal from Building 1 Wall unit.

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The System starts by establishing the connection with Main Entrance Unit. The voice will be enabled and there is a possibility if series of voice based communicatons between the user and mobile application. once the user decides his destination tha application will periodically get the user to confirm the presence of landmarks, the buildings he will cross until, he reaches the destination building. After he reaches his destination building, the particular building wall unit will help in reaching the final destination (the particular room or department he wants to go in that particular building. If you are in one building and want to know about something in another department then application will give audio commands and assist you in knowing where it is and how to go back to the landmark points. These are considered as FAQ and saved in a DB. The FAQ DB will be updated with new queries periodically. Once the person reaches the destination building the wall units will navigate the person to the destination place. For obstacle identification, ultrasonic sensors are attached to the walking stick of the blind person. Ultrasonic technology detects obstacles and other objects that are located in front of the user's path produces tones which can be heard by the person.

IV. Limitations and Future scope:

Proposed system will work with university whose layout is saved in DB. It will work with a different university. Future system can be made as a dynamic system, which can take a blueprint of any building with landmarks marked and give the voice based directions to the person. The person speed is fixed in the present system. An average walking speed of the blind person is taken as fixed in the present system. New technologies implemented in the mobiles are able to capture the acceleration of the person which will be introduced into the application in later versions. The scope of the system can be increased and can be made as an ideal system which will take the blue print of buildings and gives voice based instructions to navigate that building to the user.

The proposed system is restricted to only one route from one source to one destination. There is nothing like shortest route or longest route. There will be only one possible route between the source and destination. The average step length and average speed of blind person is considered be a constant number and work on it.

TABLE I. Outdoor Navigation Applications

Application Description	Location Detection Technology	Obstacle Detection Technology	Special Features	citation
Capstone research project is a prototype using technologies like SONAR, GPS, Cloud communication, light sensing and pulse sensing.	Skylab GPS module and WIFI	SONAR sensors (buzzer)	Cost effective, Interoperable	[6]
A navigation system that uses GPS, image database like Google street view image processing and shape recognition algortihms	GPS and Image processing	Shape recognition algorithm: RBRC (Retrieval Based on Rotation-invariant Classification).	Texture and Colour analysis of scene	[7]
Tyflos system uses a pair of glasses, a vision cameras mounted on the glasses, a laser range scanner, a microphone, a portable computer, ear speaker, and the communication system	GPS	Tyflos system carries two vision cameras and captures images from the surrounding 3-D environment, then it converts these images into verbal descriptions for each image into a verbal communication with the user	Laser Range scanner attached to vision cameras to take 3D images.	[8]
A Navigation assistant using RFID technology and ultrasonic sensors	The RFID reader matches with the information specified to that ID and a voice signal is generated. Wireless RF links is placed in the Bluetooth device/ headphone for voice guidance	ultrasonic Sensor Unit interfaced with microcontroller which is inter-linked to a vibrator that would be activated when nearing obstacles.	Reliable system for indoor and outdoor way finding and proximity sensing for visually impaired	[9]
Drishti, An Integrated Indoor/Outdoor Navigation System uses a precise position measurement system, a wireless connection, a wearable computer, and a vocal communication interface.	DGPS differential global positioning systems (outdoor).	The user can get vocal prompts to avoid possible obstacles and step-by-step walking guidance to move about in an indoor environment.	It can be used for both indoors and outdoors with in-door location measurements accuracy of 22 cm.	[10]
A wearable portable electronic travel aid, Bluetooth headset to receive audio inputs, five HC-SR04 ultrasonic sensors, Raspberry Pi 2 computer that controls the ultrasonic sensors and translates the data from their output into commands heard by the user through Bluetooth headset.	GPS	HC-SR04 ultrasonic sensor. ultrasonic sensors to survey the scene, the trigger and echo pins are responsible giving distance measurements that are read by the sensor.	low-powered, easily portable, low-cost, and still effective	[11]
Walking Assistant System with Vibrotactile Indication and Voice Prompts	GPS and speech recognition modules are used for navigation. wireless headset to	Kinect cameras and ultrasonic sensors, vibrating stimulus actuated by vibration belt		[12]

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	receive the audio			
Silicon eyes: GPS: GSM based navigation assistant GSM module for sending SMS of location coordinates to another phone for help in emergency.	GPS	SONAR	System allows blind people to enter notes and control device operation via Braille capacitive touch keypad provides Object color information using 24-bit color sensor.	[13]

TABLE II. INDOOR NAVIGATION APPLICATIONS

Application Description	Location Detection Technology	Obstacle Detection Technology	Special Features	Citation
RoboCart for navigation in grocery stores	Laser range finding and RFID tags, RFID reader, Camera	Laptop with a path planner stores the Declarative knowledge of the environment which gives instructions to avoid obstacles	Audio guided, Macro navigation in a store	[14]
Indoor self positioning systems which uses RFID, Bluetooth , FLC (flourescent light communication), a photosensor on users shoulder and PDA personal digital assistant.	A photo sensor put on the user's shoulder catches the signals from the fluorescent lights and the PDA will transmit the information to the blind person. RFID instruments are used to augment the FLC model for more precise location data	NA	Audio guided, Knowing precise details of their destination by visually impaired and also general population.	[15]
RFID based navigation assistant	RFID reader module with an integrated ZigBee transceiver for transmitting the tag's information.	NA	Feasible and reliable	[16]
Drishti: An Integrated Indoor/Outdoor Navigation System uses a precise position measurement system, a wireless connection, a wearable computer, and a vocal communication interface.	An OEM ultrasound positioning system is used to provide precise indoor location measurements (indoors).	The user can get vocal prompts to avoid possible obstacles and step-by-step walking guidance to move about in an indoor environment.	Audio guided , It can be used for both indoors and outdoors with in-door location measurements accuracy of 22 cm.	[10]
A compact portable navigation system (mobile push cart) for navigation in home that integrates wireless communication technologies, path planning, sensors and other technologies.	wireless mesh network, ZigBee based localization engine technique that continuously updates the server with the user location	proximity sensors enable detaction of obstacles	A digital compass located in the push mobile cart enables the system to identify the user orientation.	[17]
A pair of glasses with RGB camera, ultrasonic sensors, radio frequency signal receivers, accelerometer, gyroscope, magnetometer, voice recognition device, microphone, and bone conduction headset to naviagate in indoors	Mapping of Radio frequency markers and visual markers using pattern recognition algorithms	ultrasonic perception of barriers	Audio guided, low cost, wearable device which chooses optimal route while navigating	[18]

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