Sensor based Technologies for Visually Impaired: A Comparative Study

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ABSTRACT
Of the 37 million visually impaired people across the globe, over 15 million are from India. [1].The world today demands people to be independent, irrespective of their challenges, mentally or physically [2]. Despite an increased amount of technologies and systems designed to address the navigational requirements of the visually impaired community, current research has failed to sufficiently address the human issues associated to their design and use [3]. Sensors hold a wide scope of development, implementation and improvement in this area. Several technologies have been developed, based on sensors to meet the day to day needs of this community. But they have not proved to be very helpful due to various reasons like cost, portability etc. Therefore, before we proceed to the further developments in this area, we must closely study the Human Computer Interaction that too from the viewpoint of the visually challenged. It has been proved that visually impaired vary individually and collectively in their use of environmental context during micro- and/or macro-based navigation [15]. In this paper ,we will take a look at some technologies developed so far, their advantages and drawbacks, and thus conclude the various aspects to be focused on to give way to better technology that will help the visually impaired community. We'll also see how sensors and their technological improvement can prove to be helpful.

Keywords
Visually Impaired, Technology, obstacle, descriptive, information.

1. INTRODUCTION
Sensors have proved to be a boon giving intelligent technology a boost. Motion sensing technologies, obstacle avoidance systems, robots, weapon detectors etc. are only a few examples of application of sensors. They have in fact given way to the development of technologies for disabled people, so as to help them assist themselves without dependency on other people. A boom in assistive technologies has been encountered. Related work is in progress for technologies related with virtually disabled concepts to develop a user-friendly piece of self-help. White canes being the most popular in this context, but helpful for known destinations along familiar routes. For new or unknown destinations along unfamiliar routes (that may change dynamically) the limitations of these aids become apparent [4, 5, 6] (e.g. white canes are ineffective for detecting obstacles beyond 3-6 feet). Further, Petrie [7] describes how these mobility aids are only useful for assisting visually impaired people through the immediate environment (termed as micro-navigation), but do not facilitate the traveler in more distant environments (termed as macronavigation). With the proliferation of context-aware research and development, Electronic Travel Aids (ETAs) such as obstacle avoidance systems (e.g. Laser Cane and ultrasonic obstacle avoiders [8]) have been developed to assist visually impaired travelers for micro-navigation. Whereas, Global Positioning Systems (GPS) and Geographical Information Systems (GIS) have been/are being developed for macro navigation (e.g. MOBIC Travel Aid [6], Arkenstone system [9] & Personal Guidance System [10]).

2. NAVIGATIONAL TECHNOLOGIES FOR VISUALLY IMPAIRED:
2.1 E-Drive: This is 'a mechanism of fuzzy logic which reduces the accidents and also help the physically/visually challenged persons. The proposed system will reduce the accidents by neighboring vehicle detection, obstacle detection, controlling the vehicle speed, traffic light detection and sign board detections. All these above mentioned facilities are automated (i.e.) without any human intervention.' This system works on a set of input combinations and their consecutive outputs based on fuzzy if-then conditions. It is implemented using an ultrasonic sensor system, with a sender, a receiver, a counter with display, time reference section, electronic components and motors. The sensitivity of receiver is a function of time.[2]

Advantages	Drawbacks
No remodeling of existing vehicle is needed. Physically/visually challenged persons can ride the vehicle without others' help. The system reduces the number of accidents to great extent	The proposed system may create problems in rural areas. The speed of the vehicles is comparatively less.

Table.1

2.2 Smart Cane for Visually Impaired:
White cane can only be used to detect obstacles up to knee-level within a range of only 2-3 feet. Further, the visually challenged are unable to access the bus transport system without sighted assistance as they cannot read the route number and are unsure about the physical location of the bus and its entry/exit door. This project is aimed at developing two systems to address these problems:

(i) Cane mounted knee-above obstacle detection and warning system using ultrasound beam to enhance the horizontal and vertical detection range, and
(ii) User-triggered bus identification and homing system by using radio-frequency (RF) communication.

i. Cane Mounted Knee-Above Obstacle Detection and Warning System

The cane consists of detachable unit comprising of an ultrasonic ranger, vibrator and a microcontroller which offers a range of 3m and can detect obstacles above knee level. There are two modes of operation:

(i) *Less than 1m range*: useful while navigating within a room; and

(ii) *Greater than 1m range*: used while navigating outdoors.

ii. User-Triggered Bus Identification and Homing System

This device consists of two modules:

(i) *User Module*, carried by the user,

(ii) *Bus Module*, placed at the entry of each bus.

Once the user hears a bus approaching the bus stop, he presses the Query Button on the User Module which transmits an RF signal to all the buses in the vicinity. Each bus module responds by transmitting its route number. All numbers received are sequentially spoken out by the user module. The user selects the bus number of interest by pressing the Select Button after that number is read out. This triggers voice output of the bus number from the entry of the selected bus that acts as an auditory cue and assists the person in moving towards the gate of the bus.[11]

Advantages	Drawbacks
1. For both the systems, the projected cost of user modules is reasonable each making them suitable for developing country needs. The cost would decline substantially once these devices are mass produced. 2. In a practical setting, white canes can only be used to detect obstacles up to knee-level. Hence, potentially hazardous obstacles like protruding window panes, raised platforms and horizontal bars go undetected. ’Smart Cane’ overcome this shortcoming. Since people have different skin sensitivities there is a knob to adjust the intensity of vibrations. 3. The detection range of the white cane is restricted to 1-2 feet from the user. Certain obstacles (e.g. a moving vehicle) cannot be detected till they are dangerously close to the person. The range of ‘Smart Cane’ have been increased to 3m. 4. A fully charged battery lasts about 10 hours of constant usage before recharging.	1. Additional charger lead for charging this device would be required. 2. The system needs implementation of module in transport system too which may prove to be a tedious task.

Table .2

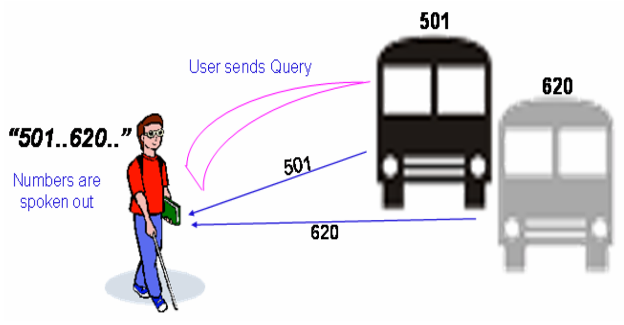

Fig. 1 User Queries

Fig1. [12] User queries all buses for route number. Numbers received are spoken out to the user. Once the user selects a particular bus, a small bulb would start flickering in the driver’s control panel (like a car indicator). This gives an indication to the driver that a person with special needs is interested in boarding the bus.

2.3 Wearable Obstacle Detection System for visually impaired People:

By this obstacle detection system for visually impaired people, User can be alerted of closed obstacles in range while traveling in their environment. The system detects the nearest obstacle via a stereoscopic sonar system and sends back vibro-tactile feedback to inform the user about its localization. The idea is to extend the senses of the user through a cyborgian interface. The components integrated are: Two sonar sensors, a microcontroller, and two vibrators.

First, the direction of the obstacle is determined by appropriate combination of vibrators on the left and right side (sensors and vibrators on either shoulder of wearable jacket). Vibration on either side means the obstacle is on that side, vibration on both sides’ means the obstacle is in front. Second, the height of the obstacle is determined by the user keeping in mind that the sensor are located on his shoulder at 60° of field of view. If the object is at shoulder height then the vibration is increasing constantly while the user is moving toward it. If the obstacle is located on the floor at sufficient distance the user will feel a vibration corresponding to the obstacle. When he’ll move towards it the vibration will stop according to the fact that the obstacle will pass below the field of view of the sensors.[12]

Advantages	Drawbacks
1. Vibrators are used from mobile phone technology. Those devices are small and light enough to be fixed on cloth without any obstruction. The electrical consumption was also a major factor in this choice. With an electrical power consumption of 0.2W at 3.5V, they can run for hours using energy from standard	1. The user approximates the distance to the obstacle and not localizes it precisely. 2. The blind angles limit the field of action of such system. 3. Another disadvantage is the occlusion of the sensor by the user’s hands. 4. One main limitation of such sonar system is in measuring the distance to

battery. They are also produced in huge amounts so their price is really low. 2. With maximum power consumption below the Watt, our system can run 3. For hours out of a single battery supply. 4. By its stereoscopic architecture, it allows positioning by telling the user from which side an obstacle is coming. 5. Each part is small enough to be fixed on the cloth which ensures the whole system is wearable. 6. It also let the user hands free for other purposes.	the “closest” obstacle in range, which could be an inconvenience when we are trying to map the environment. 5. The problem is obvious when the system is used to sense the entrance to a room. We still have obstacle from both the left and the right and it can be interpreted as a continuous wall. 6. The system still be hardwired from the sensor to the actuators via the microcontroller. Each part of the system is also mounted on hard circuit board. It will be interesting to weave directly the wires inside the textile fiber and to use semi rigid support for the mounting of the electronic components.

Table.3

IMPROVEMENTS SUGGESTED:

A main improvement that can be done to the current system will be to incorporate a set of sensors with a narrow “field of view”. Coupled with a set of vibrators all around the user body, we will be able to make him sense more precisely the topology of the environment.

Another solution to improve the wearable aspect could be to design the system as a set of independent modules that can be fixed on the cloth and communicating via wireless connection. In order to accomplish a perfectly wearable system the miniaturization should be improved on the sensors and actuators.

Those could never be, in a close future, perfectly wearable but could approximate the size of a standard button or clipper present on the most common vest.[12]

2.4 A handheld computer based Tour Guide to guide visually impaired through the exhibition

The objects used were a handheld device and a smart RFID sensor to guide the people along the EuroFlora2006 exhibition. The guide is based on PocketPC handheld devices and Radio-Frequency (RF) localization. RF sensors (IP65 compliant) were placed all over the exhibition. The guide consisted of 2 parts, one that provides general information of the exhibition and the guide; and the other that contains information of area of interest selected. When the handheld device recognizes the RF tag of interest area, the software asks the user whether to launch the description or not.[13]

Feedback received by the users-

- Some users found the long silence between two presentation activation irritating. This was managed by a message informing that user is not in his point of interest.
- Some people asked for more descriptions. Thus individual needs were not fulfilled. In short this technology is not customizable.

3. LIMITATIONS & SUGGESTIONS FOR TECHNOLOGIES DISCUSSED

The technologies are a great help but few key requirements are yet to be considered before their implementation along with few modifications.

Technology	Observation
1.Smart Cane	The system proves to be a great technology, but few improvements are required like a tech to keep the user’s hand free would be a better assist. Also the presence of the system in all bus systems of the world is needed; otherwise user may face great difficulty in foreign land. The system is a directional assistance, but gives no structural of descriptive info.
2.E-Drive	This tech is helpful in assisting the Visually impaired in driving, but it is still unclear whether the user would be assisted in reaching the destination. No such system is mentioned so as to track the way to the final destination. In addition, a tech to define multiple routes will be helpful in case one track is not functioning. Also, it gives no descriptive information and is directional. Therefore, it is more oriented for people without this disability as it will definitely decrease the count of accidents.
3.Wearable Obstacle Detection System	A Great assistance indeed. The testing of this system is done by blindfolding people, this hampers the knowledge of orientation of the visually challenged. Therefore, testing should be done again and feedback reconsidered. Again, it is a non-descriptive tech. More frequent vibration may be irritating and harmful too, and it would be better to have guiding-voice option.
4.A handheld computer based Tour Guide	This technology is a great descriptive assistance to guide the people through a limited area though. Customizable tech would be even better. Also this tech has limited area implementation. Inspired by this tech Implementation of Sensor Networks may be help in guiding the visually impaired. Though integrated with other techs to avoid shortcomings.

Table.**4**

Along with these technologies the integration of Assistive Technologies are needed for meeting the day-to-day requirements.

Human Computer Interaction:

Current research appears very technology focused, which has led to an insufficient appreciation of Human Computer

Interaction, in particular task/requirements analysis and notions of contextual interactions. In a study, Visually impaired participants on average used over 3 times more directional information, over 7 times more structural & environmental information, 6 times more numerical information (with additional types, such as using degrees for heading direction), almost 9 times more descriptive information and over 2 times more temporal/distance based information than sighted participants. Visually impaired participants mentioned words/phrases within a greater number of contextual categories on average (9.75) than sighted participants (6.33). Sensory information is paramount for navigation for visually impaired, though audio cues (sound of hospital machinery, squeaking of door opening, sound of escalators and ATMs, and sound of wind exiting a tunnel.); olfactory cues(smell of bakeries, pet shops, chemists, newsagents, chip shops, etc.) ; and sense of touch(the difference in ground textures) are important for orientation/ navigation too. A visually impaired vary individually and collectively in their use of environmental context during micro- and/or macro-based navigation. The study proved the hypothesis that each participant's contextual descriptions were unique, which indicates the need(of user) to customize information for his/her own needs. Also, differing types of visual impairments and length of impairment, may be the factors resulting in unique orientation of individuals. For instance, someone blind since birth may rely more on olfaction and hearing environmental information than someone who has restricted peripheral vision as a result of glaucoma. Considering these point, it is observed that further investigation relating to those HCI/usability issues is required. [14]

4. CONCLUSION

Current navigation systems, which are designed for sighted users, are based heavily around giving directional, numerical and textual information and give very little (if any) structural or descriptive information. HCI methods/models/frameworks need to be utilized to identify which contextual interactions are relevant and how temporal changes can influence usability. Further work in the field of HCI/usability issues is required [15]. Also, advancement in sensor technology with regard to their miniaturization, increase in field view and decrease in cost would be helpful in creating a hand free, user friendly technology. Integration of sensor technology with other technologies (like GPS and GIS) is also a integral part of navigation systems. Also keen work should be done to make the whole system cost friendly as to make it available for middle-class and poor users. Research in the field of sensor networks would help to guide the users through especial environments like exhibitions etc. and therefore this field of study holds a scope of development and improvement too.

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