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# A Survey on Navigation Assistance for Visually Impaired using Haptic and Audio Feedback

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**ABSTRACT:** This paper proposes a system to help visually impaired users navigate their environment in a safe and efficient way. Here we primarily make use of the principle of echolocation to detect obstacles in the environment and to send real time feedback to the user so as to avoid them. Echolocation involves computation of distance through the use of ultrasonic sound waves. There are numerous examples of successful implementation of this approach both in nature (bats) as well as by humans (SONAR systems). In order to enhance the performance of the system and with it the user experience we provide two kinds of feedback to the user, i.e Haptic feedback (vibrations) and audio (voice-based) feedback to notify the user of nearby obstacles.

**KEYWORDS**: Navigation, Arduino, Obstacle Detection, Haptic Feedback, Audio Interface

## I. INTRODUCTION

Visually Impaired people have to face lots of difficulties as they go about their daily lives. This includes the problem of navigating through the environment effectively avoiding obstacles. This dictates the need to have a system which assists the user in detecting and avoiding surrounding obstacles.

Presently, simple walking cane is the most used system and is rather primitive as it can detect only those obstacles present at a low height. Also it does not inform the user about the distance of an obstacle outside the cane's reach. Our goal is to create an efficient, cost-effective device with smartphone integration which would extend the user's reach while reducing the dependence on judgment and intuition as it detects and reports obstacles in the vicinity, thus guiding the user.

The system will deploy ultrasonic range finders to detect obstacles by echolocation, controlled by an arduino board. Arduino controller being the backbone would also interface with low-power vibration motors to provide haptic feedback to the user. The system would interface with an android app to provide additional functionalities and processing capabilities such as real-time audio feedback, GPS functions etc.

## II. RELATED WORK

### *A. VISION SUBSTITUTION SYSTEMS*

A sensory substitution system leverages use of other senses of the visually impaired in order to indicate presence of obstacles in the surroundings. The idea is, that we see with the brain, not the eyes [7].Current Systems employ following technologies:-

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1. A widely used system is the SonicGuide [3]. It uses ultrasound signals to detect obstacles in user's environment. It then uses an audio signal of varying frequency to indicate proximity of user from the obstacle. It provides efficient navigation, however, a sufficient amount of training is required to decrypt the signal.
2. The Sonic Pathfinder [3] is much like the SonicGuide. However, it pre-processes the audio signal so that user can understand it easily. Although it does not interfere much with environmental sounds, training is still required.
3. UltraCane [5] has the appearance of a normal cane and uses the concept of echolocation that is used by bats and dolphins in order to measure distance between user and obstacles. It gives haptic feedback in the form of vibrating buttons placed on the handle.
4. MiniGuide [6] also uses concept of echolocation. Here the device is held in the hands of the use like a flashlight. The ultrasound beam hits the obstacle and vibrates at a frequency indicating proximity of obstacle.
5. The GuideCane [4] is a small robot on wheels which is held by the visually impaired like a cane. The user pushes it in front so that the robot scans the area with ultrasound and detects a path without obstacles. The robot, which is on wheels is then used to guide the user along the chosen path.The user perceives the movement of the GuideCane and is able to navigate effectively.

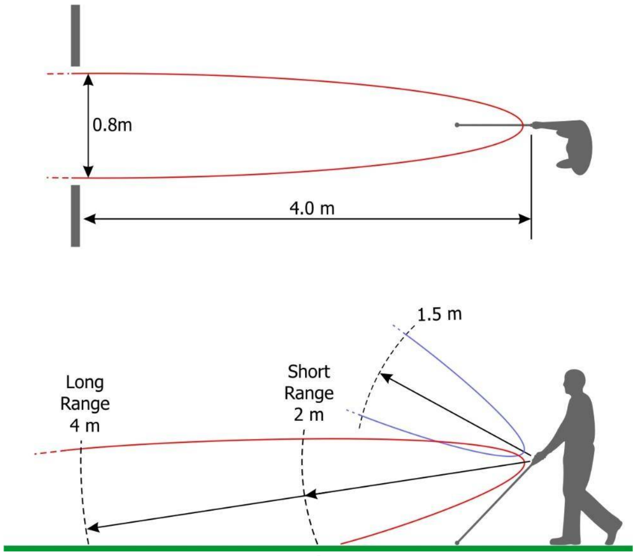

Fig. 1. Ultra Cane

***B. ANDROID APPLICATION DEVELOPMENT FOR VISUALLY IMPAIRED***

Apps with aesthetically pleasing interfaces make up most of the android ecosystem. Conventionally apps for any smartphone platform are intended to be operated with the standard touch screen interface making them rather inconvenient for the differently abled.

A good amount of work has been done in the past on making smartphones more accessible to everyone by various application vendors. Google for instance has developed android accessibility service to enable interactions with the phone without the need of visual feedback.

Following are some of the Apps/Softwares [7] in this domain :-

1. Google TalkBack: TalkBack is a part of the Android Accessibility Service. It is an application which simply narrates each and every operation which the user performs on the phone. The user is thus able to understand his/her interaction with the phone at each step. It is also capable of reading aloud text messages as well as any on-screen item selected by the user. It thus makes an android phone a whole lot accessible to visually impaired/visually impaired users as they can keep track of their actions easily. TalkBack is available on every android phone and can be enabled through settings. It is actively being developed and updated by google.

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2. IDEAL Accessibility Installer: IDEAL is the complete package which installs all features of google's Android Accessibility program. This includes three major app i.e TalkBack, KickBack, SoundBack collectively known as TKS. These apps as mentioned earlier allow the user to interact with the normal interface of a smartphone but doing away with the need of visual reception and feedback. That being said, they allow a visually impaired user to seamlessly interact with the phone by supplementing the interactions with audio and vibration feedback wherever possible.
Most of these apps are executing in the background, allowing them to effectively communicate and interact with the interfaces of other apps.

### *C.HUMAN COMPUTER INTERACTION FOR VISUALLY IMPAIRED*

Earlier the approach followed was aimed at enabling visually impaired users to access user interfaces at the same level as that of their sighted counterparts. However, currently prevalent Graphical User Interfaces (GUI's) heavily rely on graphics that cannot be easily translated to a form that is understandable to the visually impaired. Refreshable braille displays and speech synthesizers cannot create an accurate representation of GUI objects and the complex relationships that exist between them. For example, websites contain a plethora of information where headings may be repeated and every image might not have an equivalent text representation. The elimination of redundant information and representation of salient points is a problem that should be taken into account while developing custom interfaces for the blind.

Alternative to refreshable braille displays following are the custom interfaces [8] that have been developed recently for aiding the visually impaired with touch-screen devices.

1. One Finger Scan: This is similar to conventional touch-screen interfaces where a user simply slides up or down the screen to scroll through lists of items. However in order to make the interaction independent of visual feedback, it is supplemented with voice based replies from the system telling the current item selected. This is primarily used in google TalkBack as mentioned earlier.
2. Second-Finger Tap selection: Due to the precision required for selecting an item on the screen by means of a finger tap, an alternative approach for the visually impaired involving two fingers can be used. Here, while scrolling when a user has an item under the finger, the system reads it name aloud. Now without removing the first finger, a second finger can be used to tap anywhere on the screen, which results into selection of the item under the first finger.
3. Flick: In this approach, the user can simply flick on the screen with a single finger in any direction. The directions of the flick motion can be associated with different operations of the application.
4. L-Select: This can be used for selection of items in hierarchical menus. Here the user moves his finger up and down to browse through the menu, receiving audio feedback from the system. Once the user arrives on an item of interest the finger can simply be moved horizontally to the right to make the selection.
5. Double tap: A simple Double-tap with a single finger can be used to denote basic interactions such as playing music, receiving calls and so on.

## III. PROPOSED SYSTEM

Our proposed system will provide dual notifications in the form of haptic and audio feedback so that the visually impaired people can navigate freely. Ultrasonic range finders, which work on the principle of echolocation will be used to measure distance of obstacle from the user. These ultrasonic sensors [2] will provide input to a micro-controller. There will be two forms of output:-

1. Micro-servo motors will take input from Arduino micro-controller [2] and give output to user in the form of vibrations. The intensity of vibrations will vary in proportion to proximity of obstacle. If the obstacle is very close, vibrations will be more intense. Milder vibrations will indicate an obstacle that is further away.
2. An android based application will take input from microcontroller and give audio feedback to user in terms of a predefined distance metric. The application will have a simplistic User Interface and include an audio bank of pre-recorded instructions. For example, if an obstacle is 2 meters away, it will tell the user that the obstacle is 5 steps away.

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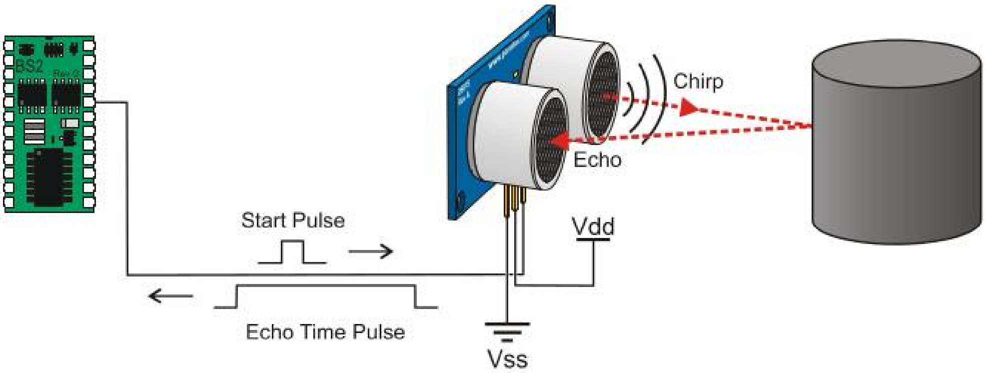


Fig. 2. Ultrasonic Distance Finders

### *A. SYSTEM ARCHITECTURE*

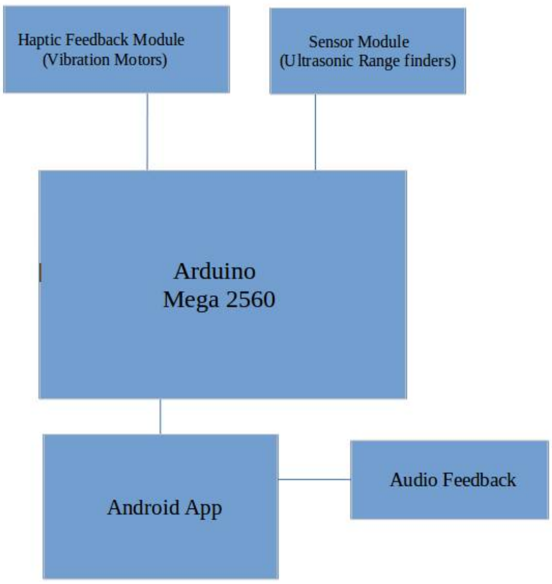


Fig. 3. System Architecture

The modules in our system are:-

1. Micro-Controller Module: It is responsible for interfacing with the sensors and other components hence controlling their operations. We intend to use the Arduino Mega 2560 as it is both cost-effective and suitable for high-end projects. Arduino micro-controllers can be interfaced with a smartphone with the help of a bluetooth module.
2. Sensor Module: This consists of ultrasonic range finders which using echolocation, can typically detect obstacles within a range of a few meters. These sensors would be interfaced with the micro-controller. The device being hand-mounted allows the sensors to detect obstacles in any direction as per the user's requirement.
3. Haptic Feedback Module: Haptic feedback makes use of the sense of touch inherent in the human biology. Micro-servo motors can be used to give mild vibrations to the user. The intensity of vibrations varies according to the proximity of the obstacle.

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4. Audio Feedback Module: Along with real-time haptic feedback our system will provide voice-based instructions to the user. Audio feedback is easier to comprehend and is more effective in guiding the user. The module consists of an audio bank with pre-recorded instructions which will form a part of the android app.
5. Android App: The app will allow the system to provide audio feedback to the user and will feature other basic functions for controlling the system. It will have a simplistic voice-based interface and will be bound to a key on the phone for ease of startup.

## IV. CONCLUSION AND FUTURE WORK

This review paper presented the inherent difficulties involved in designing an efficient and cost effective device to enable the visually impaired to navigate successfully. The device should be wearable and enable the user to carry out daily activities without any impediments. The visually impaired will not accept any device which is cumbersome to use or is poorly designed. Future designers should acknowledge these facts and use them as a challenge to build better devices.

In the future we plan to combine our system with VANET(Vehicular Adhoc Network) system that will enable the device worn by a visually impaired person to establish communication with vehicles. The driver of the vehicle will be notified about the current location of the visually impaired person and can therefore adjust the speed of his vehicle accordingly.

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