Voice Assisted Navigation System for the Blind

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Abstract— **The visually impaired are at a considerable disadvantage because they often lack the information for avoiding obstacles and hazards in their path. They have very little information on self- velocity, objects, direction— which is essential for travel. Previously developed navigation systems use costly equipment which is often not affordable by the common blind community. The navigation systems available are heavy and very complicated to operate. This research has been aimed at design and development of a smart and intelligent cane which helps in navigation for the visually impaired people. The navigator system designed will detect an object or obstacle using ultrasonic sensors and gives audio instructions for guidance. The signals from the ultrasound sensor are processed by a microcontroller in order to identify sudden changes in the ground gradient and/or an obstacle in front. The algorithm developed gives a suitable audio instruction depending on the duration of ultrasound travel which in turn is made available by an mp3 module associated with the system. This work presents a new prototype of navigation system on a cane which can be used as a travel aid for blind people. The product developed is light in weight, hence, does not cause fatigue to the user. This project is developed by keeping in view the affordability and reliability. An obstacle as close as 4cm can be detected by this module. A resolution of 15cm of obstacle distance has been designed and achieved. This system can also detect potholes on the path.**

Keywords— **Ultrasonic sensor, navigation, mp3 module, ATmega16, visually impaired, obstacle sensing**

I. INTRODUCTION

Human way of travelling consists of two specific components: sensing of the environment for obstructions to travel (e.g., obstacles and hazards) and navigating to outlying destinations beyond the detectable environment. Methods of updating position and orientation can be classified on the basis of kinematic order. Position-based navigation is computed using external signals which indicate the traveller's position and orientation (often in association with an external or internal map). Velocity-based navigation relies on external signals indicating the traveller's velocity; displacement and direction change from the origin of travel are computed by integrating the velocity vector. Acceleration- based navigation is computed by the double integration of the traveller's linear and gyratory accelerations to obtain displacement and direction change from the origin of travel, but with no external signals required [1].

With 7.8 million blind people in India, the country has 20 per cent of the 39 million blind populations across the world**.** Currently most blind people rely on people, pets and canes to find their way in buildings and other places alike [2]. This can be a hassle for both the visually impaired person as well as others. Conventional navigational systems in the indoor environment are expensive and its manufacturing is time consuming. This work aims at designing a cost-effective and more flexible navigation system for the visually impaired. One of the earlier approaches has been to install location identifiers throughout the environments travelled by blind persons to assist the travel by tracking the blind person. Instead, developers have designed identifiers that can be remotely sensed by the blind traveller using appropriate equipment. One such system being deployed in demonstration projects is 'Talking Signs' (Crandall, Gerry, and Alden, 1993; Loughborough, 1979). In this system, infrared transmitters are installed throughout the travel surroundings (e.g., railway station or airport). These highly direction-sensitive transmitters continuously transmit digital speech signals to the blind person indicating what obstacle is at the location of the transmitter (e.g., pillar); within a range of 15 m or 40 m (depending upon battery size), a blind traveller with an infrared receiver can receive the signal from the transmitter and hear the audio utterance; directional localization of the transmitter is possible by aligning the hand-held receiver to obtain maximum signal strength from the transmitter.

Sunita Ram et Al. [3] designed the "People sensor," which uses pyroelectric and ultrasonic sensors to find and discern between human and non-human obstructions in the detection path. The system also measures the distance between the user and obstacles. Another work by John Zelek [4] is on an innovative technology, "the logical extension of the walking cane," which allows visually handicapped individuals to use tactile feedback in their perceivable environment.

There are many ways to determine the location and orientation of the user and provide routes. 'Metranaut' [5], developed by Asim Smailagic and Richard Martin, is a new wearable computer system that uses a bar code reader for input information and position from a series of bar code labels placed at strategically important places to guide visitors of CMU's campus. A. R. Golding and N. Lesh [6] detect the user's positional information by using inexpensive, wearable sensors that include a fluorescent light detector, a temperature sensor, 3D accelerometer and a 3D magnetometer, , that do not require modifications in the environment at all. Loomis was one of the first people to propose the idea using DGPS with an FM correction data receiver for the stable determination of the location of the traveler [7]. A similar work is done by Hideo Makino[8] et al. Other works that use GPS to find the user's location are MoBic [9] and a work by Bruce Thomas, etc. [10]. BrailleNote GPS is another commercially available blind navigation tool. It allows the user to know nearby location names and the distance to destination along the travel. The location of the user is ascertained by computer vision techniques. From the registered images, based on straight-line features, the landmark lines are transferred onto an unregistered image by image-to-image matching to get accurate position for real world images taken by the camera later [11,12]. This approach is thought to be applicable to landscape environments.

The Drishti system provides its users the layout of the indoor facility, and gives him/her an extensive picture of what the environment is like. As the user walks around, the system ensures travel safety by employing timely obstacle prompting. Another feature of this system is that it can also communicate with the user and answer varied contextual awareness questions on demand. Because GPS is not available indoors, and because the requirements of measurement error change, the Drishti system switches to a different location tracking technology: ultrasonic positioning service, which provides a high precision measurement scale, for indoor use and prompts the user with the indoor room layout [13]

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II. METHOD OF IMPLEMENTATION

Fig 1 shows the different components used. The ultrasonic sensor is used for obstacle detection and distance sensing. The microcontroller controls the sending and reception of the signals to the other components. The mp3 module plays the required distance clip into the headphones. It uses an SD card as memory for storing the recorded clips.

The prototype is designed to sense an obstacle within 1.8m. It uses ultrasonic sensors, a memory chip, a microcontroller and headphones. The prototype is designed to sense an obstacle within 1.8m. It uses ultrasonic sensors, a memory chip, a microcontroller and headphones.

A. *Ultrasonic sensor:*

The advantages of ultrasonic sensing is its outstanding capability to probe inside objects non-destructively because ultrasound can propagate through any kind of media including solids, liquids and gases except vacuum. In typical ultrasonic sensing the ultrasonic waves travel in a medium and are often focused on detecting objects so that useful reflection based on the interaction of ultrasonic energy with the objects are acquired as ultrasonic signals that are in form of waves.

Ultrasound waves are generated by piezoelectric crystals. Piezoelectric means "pressure electric" effect. When an electric current is applied to a quartz crystal, its shape changes with polarity. Ultrasonic ranging and detecting devices use high-frequency sound waves to detect the presence of an object and its range. The systems either measure the echo reflection of the sound from objects or detect the interruption of the sound beam as the objects pass between the transmitter and receiver.

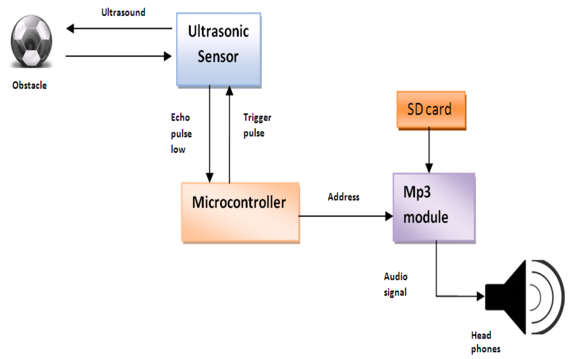

Fig. 1: Block diagram of Voice Assisted Navigation System for The Blind

An ultrasonic wave moves at a velocity (the wave velocity) that is determined by the material properties and shape of the medium, and occasionally the frequency. Also, one can understand that no ultrasonic wave propagates in vacuum because there are no vibrating particles present there.

The ultrasonic sensor used in the project is HC-SR04. It has 4 pins-VCC, Trigger, Echo and ground. When the ultrasonic is triggered by a pulse sent to the trigger pin (min. 10 milli second pulse width), it sends a burst of 8 ultrasonic waves through the transmitter and automatically makes the echo pin to go high as shown in fig. 2. The ultrasonic waves reflected from an obstacle are picked by the receiver and the echo pin goes low. The duration for which the echo pin was high is proportional to the distance of the obstacle. The distance is calculated using the formula:

Distance = time for which the echo pin was high * speed of ultrasonic wave in air

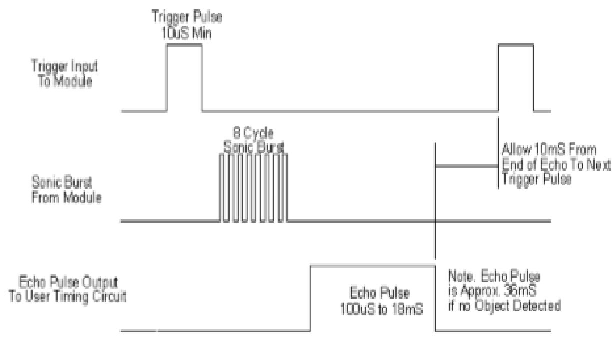

Fig. 2: Timing diagram of the HC-SR04

The status of the echo pin is constantly monitored. The exact time of echo pin being high is measured and corresponding count value is registered in a microcontroller. The counting process is associated with the clock speed of the microcontroller and is suitably calibrated for the increments of the distance to be measured. This is to fix the resolution of the prototype.

B. *Mp3 module:*

The mp3 module used in the project is WTM-SD version 1.3. The chip can operate with a SD card (max. 2GB) in 4 modes: mp3 mode, key mode, parallel mode, SPI mode.

The mode incorporated in our project is parallel mode due to the following reasons:

1) A lot of audio clips (up to 32) can be accessed in this mode unlike the key mode (6 clips) and mp3 mode (1 clip).
2) The serial peripheral interface mode demands complex circuitry including a MAX 232, which is not necessary for the working of the prototype.

The procedure for configuring the mp3 module in parallel interface mode is as follows:

1) A folder named ‘advert01’ is created.
2) All of voice clips are put into this folder. Files name in folder must be 000.mp3, 001.mp3, 002.mp3, 003.mp3 ... 031.mp3 and so on.
3) If we want choose Standard mode (mp3 mode) or key mode or parallel mode, a new “.txt” file in ‘advert01’ folder is created, and then opened. The numbers 1 or 2 or 3 (1 means standard mode (mp3 mode), 2 means key mode, 3 means parallel mode) is written in the text file. Next, the file is saved and exited. Finally, this file is renamed as “cof.mp3” [6]

The count value so obtained from the microcontroller is sent to an mp3 module which has an SD card having pre-recorded audio clips stored in it. Depending on the count value, the address to be accessed is sent to the suitable pins of the mp3 module.

The SBT pin is used to trigger the mp3 module by active low signal (min. 10 milli second pulse width). The clip plays after the SBT pin goes high as shown in the control timing diagram.

TABLE 1: Pins and their functions in parallel mode

PINS	P01	P02	P03	P04	P05	P06
Function	SBT	A0	A1	A2	A3	A4

The address is sent to the mp3 module through the pins P02-P06 on the mp3 module as per table 1. The address sending port (port D as in the program) is made low entirely (8 bits of the port) for 2 milli seconds as shown in the timing diagram in fig. 3. Then the address is sent through the same port to the mp3 module. At the same time, the SBT pin is made low to indicate to the mp3 module that an address is being sent to it. The SBT pin is then made low for a minimum of 10 milli seconds. The mp3 module has 3 LEDs- Power, SD and Busy. At the moment of powering on, the power LED glows. When there is an SD card fit into the card slot, the SD LED glows.

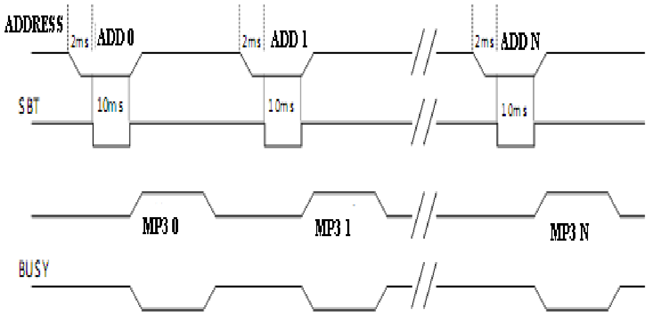

Fig. 3: Timing diagram of Mp3 module

The mp3 file is fetched according to this particular address received. Then the SBT pin is made high. At the time the mp3 file fetched by the mp3 module from the SD card is played. There is an LED on the module which represents that it is busy playing the clip. When the clip is played, the busy LED glows. The process is repeated for every trigger pulse sent to the ultrasonic sensor. The above figure shows the status of the Busy LED of the mp3 module.

The clip is played in to headphones (L, R and GND pins of the mp3 module). Continuous signals (count values in the form of address signals) are sent and accordingly clips are played.

The distance (D) travelled by any object is given by product of speed (S) and time (T) as shown in (1).

$$D = S*T \tag{1}$$

In the case of ultrasonic sensor the time of travel of the ultrasound is the time taken by signal to travel from sensor to object and back to sensor, i.e. the total time corresponds to twice the distance. Hence actual time of travel, t = (T/2), where T is the total time of travel

Consider an example of T= 3.28ms

Assuming speed of ultrasound is equal to 340 m/s (metres per second) in air

Substituting,

$$D = S \times (T/2) \tag{2}$$
$$= (340\ \text{m/s}) \times ((3.28)/2\ \text{ms})$$
$$=0.557\ \text{meters}$$

Hence from the Eq. (2) it can be inferred that the width or the state of the echo pin being high corresponds to the distance at which obstacle is located. By knowing this basic function of ultrasonic sensor and the response of echo pin, the microcontroller is designed to sense the echo pin status and initiate mp3 module to play respective audio file.

C. *Depth sensing:*

The concept behind depth sensing is similar to obstacle detection except that there is only two possible condition that is to be detected i.e., depth (pot hole) and gradients. Using suitable program the sudden change in level roads varying abruptly over 30 cm is sensed.

The basic logic applied is that it keeps track of the count value being measured and the measured value is continuously compared with previous value. Depending upon the comparison results, the microcontroller sends suitable address to the mp3 module. The mp3 module plays the particular audio file which informs the user whether it is up gradient or down gradient.

Consider an example where the previous value is X and the measured value is Y. If the measured value Y>X and (Y-X) =2 then level is down gradient, because a change in count value of 2 corresponds to a change of 15*2=30 cm in distance vertically. If the measured value Y<X and (X-Y) =2 the level is up gradient, because a change in count value of 2 corresponds to a change of 15*2=30 cm in distance vertically.

III. PROGRAMMING

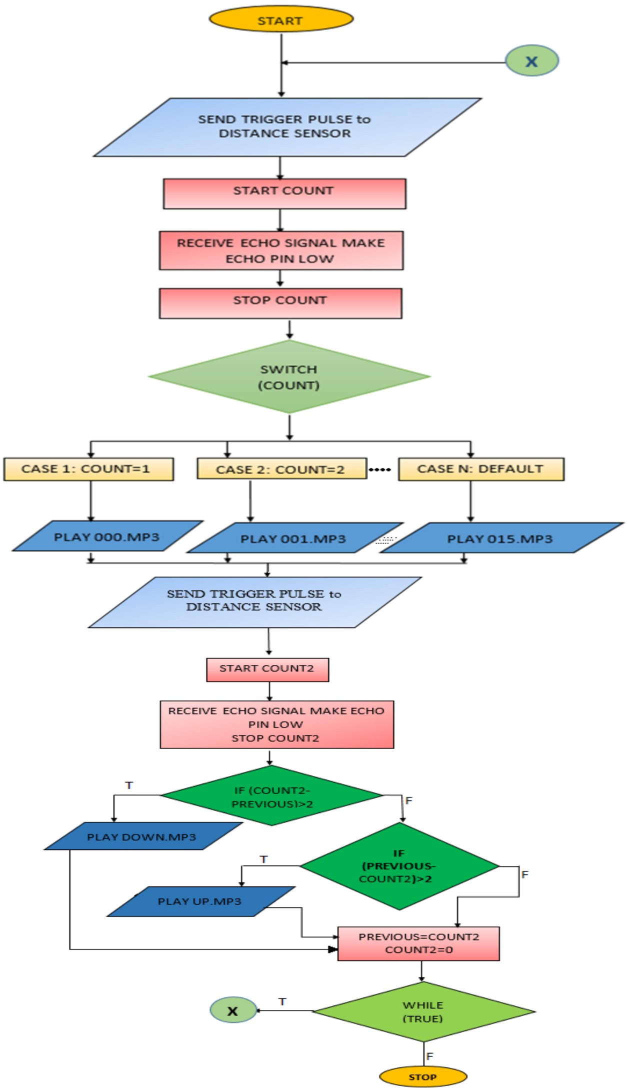

Fig. 4: Flowchart for obstacle sensing

IV. RESULTS AND EVALUATION

The following waveforms were obtained on a digital signal oscilloscope during interfacing the ultrasonic sensor with the microcontroller.

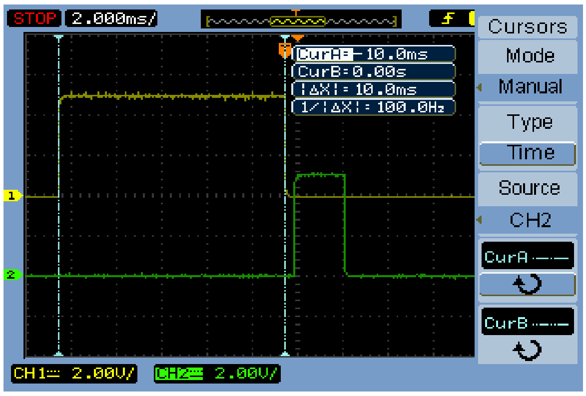

Fig. 5: Trigger and echo pulses

The yellow line in the fig. 5 denotes the trigger pin status. In the figure, it can be seen that the trigger pulse is of 10 milli second pulse width. The green line indicates the status of the echo pin. The time for which the echo pin is high depends on the distance of the obstacle from the sensor.

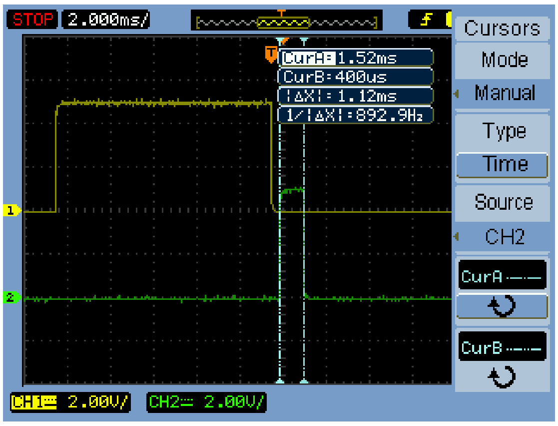

Fig. 6: Echo pin status for the distance of 20 cm

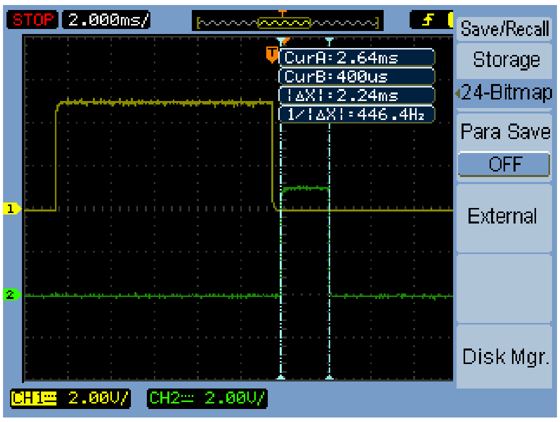

Fig. 7: Echo pin status for the distance of 40 cm

The fig. 6 and 7 show the status of the echo pin for a sample distance of 20cm and 40cm respectively.

After the trigger pin goes low, the ultrasonic sensor sends a burst of 8 ultrasonic waves. Then the echo pin goes high automatically. The time for which the ultrasonic sensor sends the ultrasound waves is observed as a delay between the 2 pulses in the figure. It is observed to be constant irrespective of the distance of the obstacle sensed and equal to 400 micro seconds.

V. Conclusion and Future Scope

This work presents a prototype of a navigation system that helps the visually impaired to move in both indoor and outdoor environments. This system is designed to be completely self-sustainable and rely as little as possible on virtual mapping methods. It is powered by an on-board power source and allows the user to sense objects in their environment.

Obstacle is sensed from ultrasonic sensor and an audio is played depending on the distance of travel of ultrasound. An obstacle as close as 4cm can be detected by the module. With a resolution of 15cm of obstacle distance, a suitable audio instruction is given to the blind user. The navigator satisfactorily plays an appropriate audio into the headphones which corresponds to the distance of obstacle from the user.

Change in the ground gradients has been tackled easily as the sensors process the sharp change in ground level and intimates the user about the same. This proposed system can be mass-produced as the system is inexpensive. The system is implemented on the cane to provide a safer feeling to the blind. The project can be improvised by the use of wireless LAN connections which supports the use of GPS. This helps the user to navigate more accurately and effectively as a GPS module can actuate the position using GPS co-ordinates.

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