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Path planning and obstacle detection for blind people

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ABSTRACT

In these rapidly expanding economies that evolve at a seeming pace, visually challenged have done the most of it in achieving formidable outcomes. However, limitations in mobility is a vital concern to be addressed for people with visual disability. Today's demographic scenario reveals that visually impaired count for about 1% of the gross, and 10% of whom is totally blind leading to the urgency in the invention of a real problem-solving system for the impaired. Numerous devices already subsist for the need for global navigation like GPS systems, but these do not aid for the cause of local navigation, local path organizing, and crash avoidance. The key purpose behind this project is to design an electronic travel aid which consists of a wearable tool that serves the sightless to engineer their local navigation jobs. It includes a sensory system that is under the control of the user. The primary data necessary for local navigation is map data of the indoor environment which serves as the input to an audio-based navigation system that coverts this data into audio command guiding the person to navigate to a particular location. In addition to these navigation procedures, IR sensors and ultrasonic sensors are planted in for the obstacle detection on the sides and in front respectively for collision avoidance. The output from these sensor modules is fed into an Arduino microcontroller, which grabs all the output from these sensors for further processing and ending up in generating a voice output accordingly. Local navigation and collision avoidance together serve the purpose of mobility for the sightless in indoor environments.

Keywords— *Electronic travel aid, Obstacle detection, Arduino Uno, IR sensor, Ultrasonic sensor, RF transceivers*

1. INTRODUCTION

Physiological or neurological factors can sometimes affect the visual ability of a person leading to partial or total blindness. The partial blindness is a state that arises due to lack of integration in the growth of the optic nerve or visual center of the eye, whereas total blindness is a condition resulting on account of deficiency of the visual light perception. Trained dogs and white canes come for the rescue to the blind in navigation [1], but don't much seem to be effective. There is a requisition for a system that swiftly and precisely advises the blind people in secure path planning. GPS for navigation cannot come into handy in the indoors due to the difficulty of the signals penetrating inside. The proposed tool furnishes guidance about the surroundings of the blind person to facilitate him in proceeding around without difficulties. Efforts are put in to incorporate an easy, cost-efficient and easy to use smart blind guidance system to enhance the mobility of blind and visually impaired people in a defined area.

2. OBJECTIVE

Independent traveling stands as real trouble for most of the people troubled with visual impairments. The extensive scale of tools and techniques needs to be incorporated in supporting their mobility. First of all, we need an Obstacle- sensing function in front of the blind to avoid collision against stable and mobile objects. Secondly, for indoor navigation in places like offices, malls, hospitals, etc. we need a system which will help the blind people for safe navigation in the indoor environment [3]. The objective is to develop portable equipment that will accomplish the following basic requirements in indoor mobility of a visually impaired person.

- Navigation to a particular destination.
- Obstacle detection.

The basic objective is to develop a POC type implementation of an indoor navigation and obstacle detection system, with a small number of source and destination points, which once tested for the feasibility of implementation and cost-effectiveness can then be expanded for a bigger use case.

3. PROPOSED SYSTEM

This project proposes a method of sensing the presence of static and moving obstacles. The equipment is made to be mountable on a jacket wherein two ultrasonic sensors are placed in the front and IR sensors on the right and left arms. The four sensors send a predetermined pulse, and the reflected signals are used to gather information about obstacles in the four directions, which is then fed to the Arduino. The Arduino is then used to alert the person with announcements indicating immediate obstacles around the person.

Along with the obstacle guidance, we have developed a navigational assistance technology for the blind using RF concepts. The indoor area like that of a mall or a hospital is equipped with multiple RF checkpoints and each checkpoint when visited by a person, alerts its receiver about the current location of the person, which is then used to guide the person to the destination. Arduino uses this input to create announcements for the person to reach the next checkpoint in the path to the destination. The POC implementation takes a use case of 3 checkpoints, where the user may be willing to move from any of these checkpoints to any of the other two.

3.1 Advantages of RF

- RF has different penetration through the walls of the buildings or houses based on the frequency. Hence used for radio and television transmission and for cellular mobile phone service [5].
- As RF does not require line of sight, it is the medium of alternative for many applications.
- RF modules have the flexibility to comply with any protocol for communication like Zigbee, Bluetooth, and WiFi.

4. SYSTEM ARCHITECTURE

Arduino is the pith of the system which is being interfaced with the rest of components. When the power supply is provided to the Arduino and the receiver via 9v battery and when the transmitters are supplied through the 4-5v batteries provided, the entire system will be made functionally ON and other functionalities are processed simultaneously. The RF transmitters are placed at three different check points and an RF receiver near the person. The IR sensors and the ultrasonic sensors send the inputs to the Arduino for the detection of the obstacle. Based on the data received from the sensors the Arduino sends the trigger to the speaker for the announcement. Different combinations of the paths to and from various check points are saved in the SD card. The destination has to be selected and the path will be heard in the speaker along with the detection of obstacles.

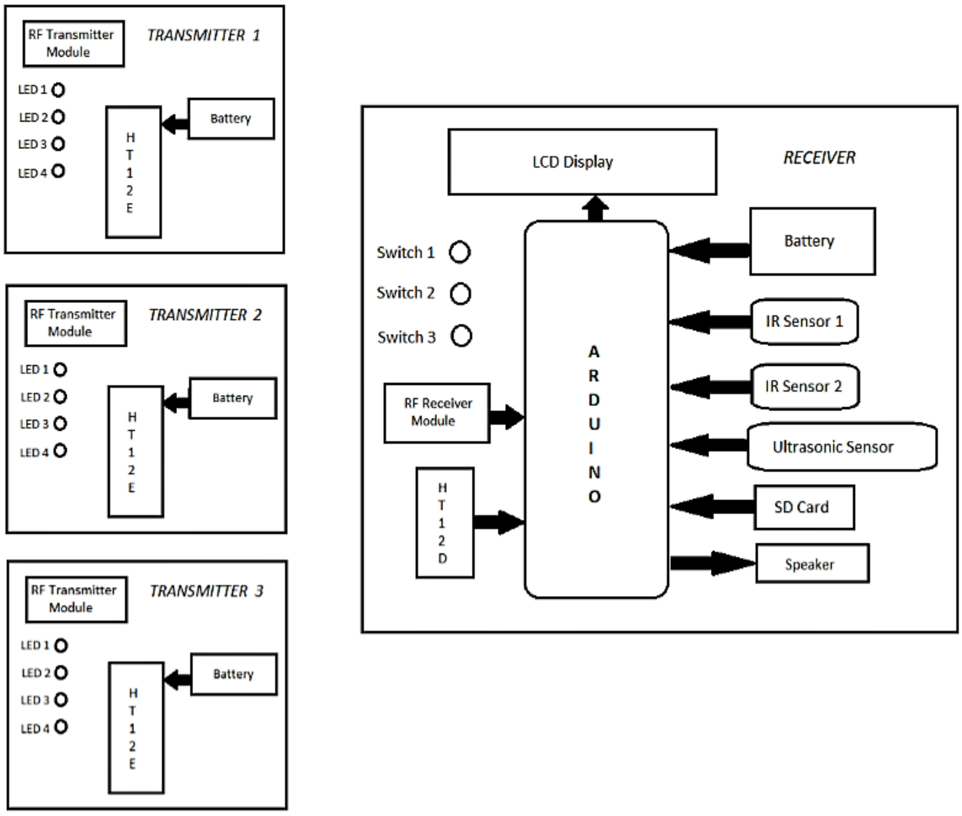

Fig. 1: Architecture of the system

4.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328.It is easier to use and is cost-effective. It can take any input like a location from GPS, light on sensors and convert it into the desired output like driving a motor, announcement on a speaker. It comprises of 14 digital input/output pins, a 16MHz crystal oscillator, 6 analog inputs, a USB connection, an ICSP header, a power jack and a reset button [2].

Fig. 2: Arduino Uno

4.2 RF Transmitter and Receiver

The RF modules are small and have the advantage of operating between 3V-12V. The operating frequency is 433 MHz. It consumes very low power as the transmitter does not use power while transmitting logic '0'. Data is transferred serially from transmitter to receiver which is interfaced using two microcontrollers. RF signals have high penetration and can travel even when there is an obstruction which is why these RF modules are preferred over other modes of communication.

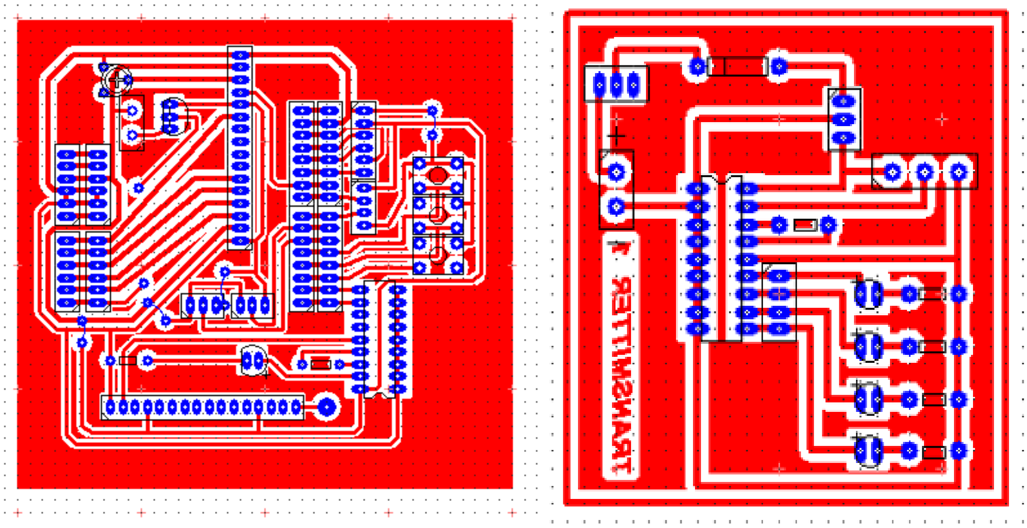

Fig. 3: Architecture of RF receiver and transmitter

4.3 Ultrasonic Sensor

This ultrasonic sensor module aids in yielding many advantages which encompass object sensor, calculating distance, motion sensors, etc[6]. The high sensitive module can be employed with microcontroller to blend with motion circuits to give birth to robotic projects. This also results in other position, distance & motion sensitive products. Eight 40 kHz square wave pulses shall be transmitted by the module and the module automatically detects whether it receives the returning signal. A high-level pulse is sent on the echo pin on noticing a signal returning. The length of this pulse is the time it took the signal from first triggering to the return echo.

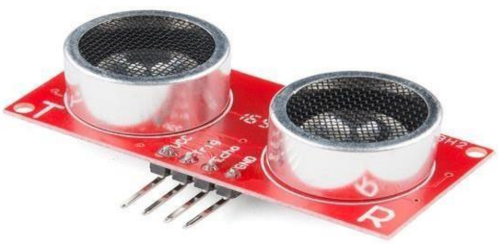

Fig. 4: Ultrasonic sensor

4.4 IR Sensors

All the macroscopic objects emit thermal radiations which are invisible to the human eye. Thermal radiations are a part of the electromagnetic spectrum with wavelength varying from 700nm to 1mm [8]. Thermal radiations can be categorized as infrared, microwave and so on, on the basis of wavelength or frequency. Hence, all the objects emit some quantity of infrared radiation which can be detected using IR sensors and used as a tool to track & detect obstacles.

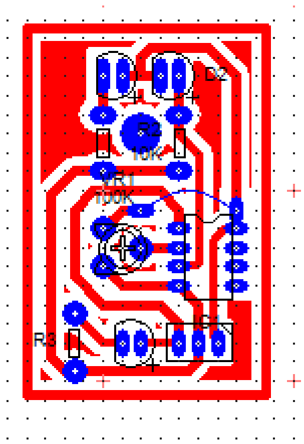

Fig. 5: Architecture of IR sensor

5. WORKING

(a) As Arduino is charged, SD card gets initialized and LCD Display immediately shows the message "SD card found", as soon as it is charged. If any problem in the circuit appears then it displays "SD card not found".
(b) After switching on the receiver, it receives the signals from the nearest transmitter.
(c) The person has to select the destination by pressing a button corresponding to any of the nearest checkpoints and upon selecting it, the path will be known to the destination and will be announced to the person for the proper guiding.

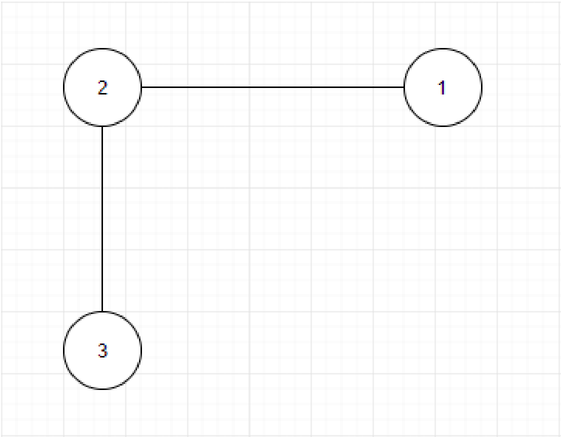

Fig. 6: Path to destination

- Suppose there are 3 checkpoints and the path between them is as shown in the above figure.
- If the person is currently at checkpoint 3 and wants to go to checkpoint 2, the path will be retrieved from the SD card showing it is the next checkpoint straight 10 meters down the path. So, announcement telling the blind person to move straight will be played.
- Whereas if he wants to move to checkpoint 1, first an announcement to reach checkpoint 2 will be played, once the receiver detects it is on checkpoint 2, a new announcement telling the person to turn right and move 10 meters will be played.
- Such a case can be expanded to a use case with multiple checkpoints.
- Even if the person misses the path and reaches a wrong check point, he will be guided towards the destination as the path from that check point to the destination is also known.

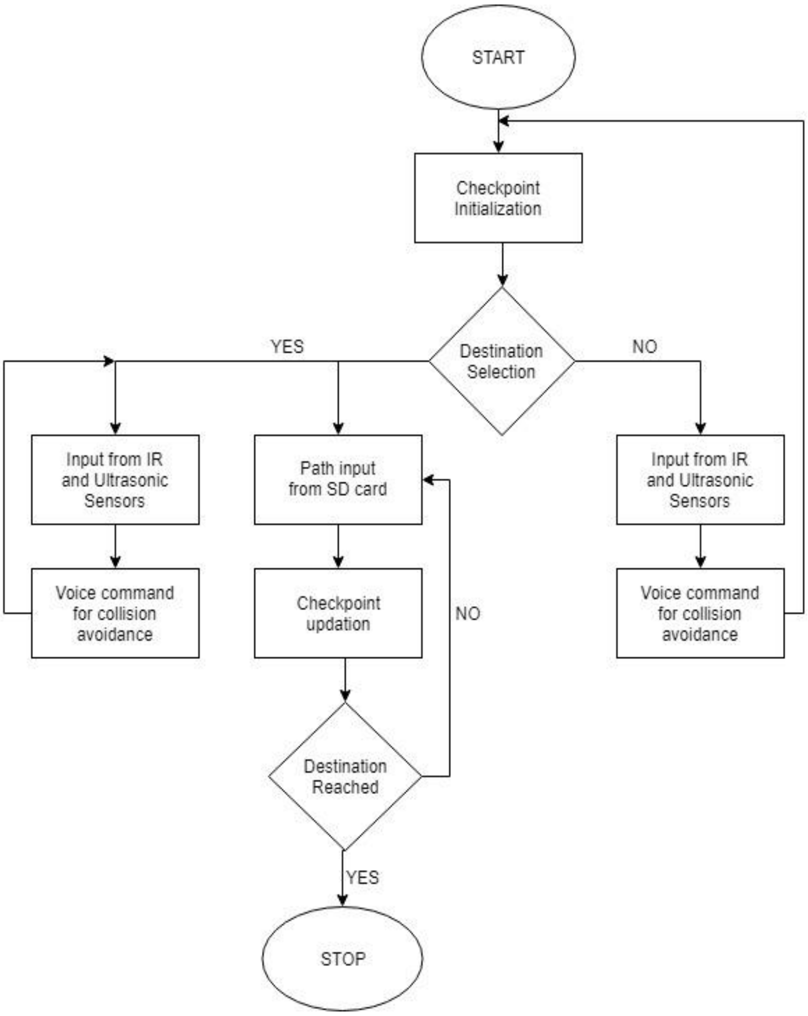

Fig. 7: Flow chart

- The Ultrasonic sensor transmits corresponding Ultrasonic waves and IR sensor can be adjusted for the distance sensitivity for the photodiode using its potentiometer.
- An ultrasonic sensor sends a fixed 40 kHz pulse, once it is triggered from an I/O pin of Arduino, and once reflected wave reaches the receiver, an echo pin goes high which then is the input to Arduino to measure the distance.
- If it senses any object in front of the person for more than 3 seconds, it considers the respective obstacle as a wall then the indication is given as "obstacle ahead within xx meters" where xx is the distance measured and if the obstacle is very close, the path is changed to the next sequential followed direction "Slightly move left or right to avoid collision".
- Simultaneously if any object is sensed by the left IR sensor's photo diode, then audio is heard as "Don't move too left" indicating that there is an obstacle in the left side.
- Similarly, if any object is sensed by the right IR sensor's photo diode, then audio is heard as "Don't move too right" indicating that there is an obstacle in the right side.
- When the RF receiver receives the signals from the selected RF transmitter through the switch, then the "Destination reached" audio is heard.

6. TESTING AND RESULTS

(a) The above setup was implemented using one ultrasonic and two IR sensors, for collision avoidance and three RF checkpoints.
(b) A person was blind folded as he entered the testing area from checkpoint 3 ten times, five times out of which, the person pressed button 2 (destination – checkpoint 2) and remaining 5 times, the person pressed button 1 for checkpoint 1.
(c) The person was able to get proper navigation inputs from his audio headphones for all of the 10 iterations, however it took some 3-4 iterations for the person to perceive obstacle avoidance inputs from the headphones properly, which suggests it takes a little 'getting used to' to properly analyze collision avoidance inputs to avoid collisions in real-time.
(d) After 3 iterations the person was able to avoid obstacles accurately and navigate to the destination precisely.

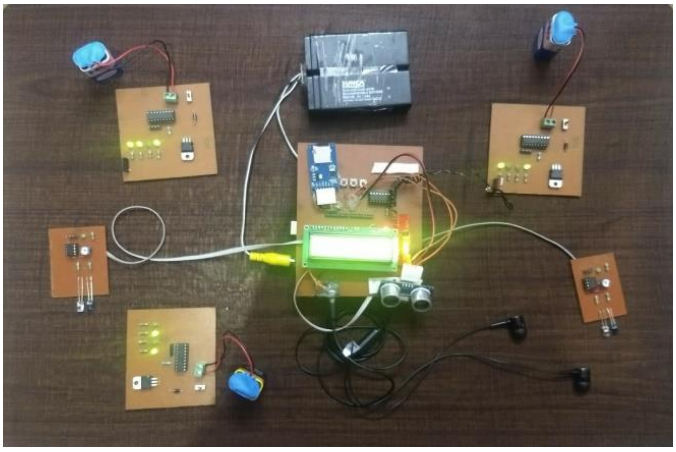

Fig. 8: Implementation of system

7. CONCLUSION

In this paper, a POC type implementation of portable equipment for obstacle detection and path planning has been proposed and a working model has been developed and tested. The system was able to detect the obstacles and avoid collision and could accurately guide the person to the destination. However, the purposeful implementation of such a system relies on the fact that the entire serving area is equipped with many checkpoints which each point serving a very small area. This will help locate the person accurately in the system and better navigation commands can be provided.

8. FUTURE SCOPE

- We observe that currently, the destination entry is implemented via a button input, however, an API based voice recognition system can be used to take voice input so that it would be easier for the person to choose the destination.
- The location information is currently gathered according to the nearest RF transmitter, but with the help of computer vision techniques can be made dynamic. Initially, the entire indoor environment will be captured in images which can then be stored in the SD card. The cameras mounted on the jacket will send real-time images to Arduino, and using computer vision techniques, the location can be identified, and the path to the destination can be dynamically identified too.
- Instead of using a visual camera image, an ultrasonic image for each and every point in the serving area can be captured using ultrasonic transmitters and receivers and stored in the SD card. Then when the person roams around, the ultrasonic transmitters and receivers on the jacket can capture the ultrasonic image of the location, and using machine learning techniques can map the current image to one of the many locations stored in SD card. Such enhancements can help the blind person avoid collisions and navigate more efficiently.

9. REFERENCES

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