A Smart Guidance System for the Visually Challenged using IOT

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Abstract – Navigation technology has evolved tremendously from the Early man following North Star to today's Google maps. However, the visually challenged people can hardly use any of these navigation technologies. Apparently, they are the ones who require navigation and assistance in everyday life. The existing system includes an electronic aid system, RFID and solely used ultrasonic sensory module. The proposed system automates the navigation for the disabled by using raspberry pi along with ultrasonic sensors and 360 degree camera technology. This system incorporates eSpeak module for text to speech conversion of data, to help the blind user hear about the upcoming obstacle. A GPS sensor is used to find the current location of the visually challenged person. There is also a weather determination system, which updates the user about upcoming weather statistics. This design is advantageous as it uses both camera and ultrasonic module to determine obstacle in real time, as well as give information about the object ahead of the user. Moreover, the system can also help in recognizing familiar faces and storing them for the user.

Index Terms – Raspberry pi, eSpeak, Ultrasonic sensor, Image sensor, Weather sensor, GPS sensor.

1. INTRODUCTION

Visual impairment is among the most common disability among mankind. According to the World health organization [1], there is about 285 million of the world's population that suffers from visual impairment. Among them, 39 million are completely blind, and an estimated 246 million suffer from low vision. In India itself, there are about 53 million visually impaired people, with 6.8 million with complete blindness.

According to another survey, there are a large number of road accidents and mishaps involving blind people. Due to low navigation facilities available and less social awareness, blind people suffer the most. The only navigation known to blind people is a stick that guides them to one place to another. For a few people, there are guide dogs or assistants[2], but they take a lot of time to train and can be used only by few people.

Sticks cannot be helpful everywhere, as in a crowded area; the stick might collide with nearby objects without any prior knowledge.

2. EXISTING SYSTEM

Technology can help in minimizing many barriers that people with visual disabilities face. These technologies are known as assistive technology (AT). Many ATs have been proposed to help the visually challenged. The following section describes existing proposals or systems to be helpful for the blind.

The blind Cane is one of the assisting tools for the visually challenged and it is important [3]. It was intended for testing the visually challenged to utilize their brain to memorize a set of objects. It aids its user to understand their surroundings but, if the user walks into a new environment, they will find it difficult to memorize the locations of the object or obstacles. The blind cane cannot detect any obstacle which is present in front of the person. There is no possibility of a practical application of this cane due to its requirement of extensive training.

The Guide Cane was designed to help the visually challenged people navigate safely and quickly among obstacles and other hazards, but it is considerably heavier than the white cane. It consists of wheels that are equipped with encoders to determine the relative motion. The servo motor, controlled by the built-in computer, can drive the wheels left and right relative to the cane. To detect obstacles, it is decked with ten ultrasonic sensors. A joystick fixed at the top handle allows the user to specify a desired direction of motion.

The Smart Cane consists of a sensor system [4]. Ultrasonic sensors detect and avoid obstacles located in front of the user. A fuzzy controller is required to determine the instructions that will be executed. It uses purely ultrasonic sensors for its operation, which can detect very short distances, and there is no knowledge about the obstacle ahead. It cannot help the user in recognizing the object in front of him.

Another Smart Cane using Radio Frequency Identification (RFID), was designed by students from Central Michigan University. RFID is used to detect objects or obstacles in front of the visually challenged person. This device is similar to a normal stick but it is equipped with a bag, worn by the person. This bag supplies electricity to the stick and informs the user through speakers inside the bag. However, this invention has several drawbacks and is only suitable for small areas. This is because it only detects the area with RFID tag otherwise this only works as a regular blind cane.

Navigation Assistance for Visually Impaired (NAVI) is also a technology for guiding the visually challenged people by use of sound and voice technology that helps them to find their way with the help of mobile systems.

Electronic Travel Aids (ETAs) are devices that warn the user with the help of some signals such as sound waves or by physical interaction with people such as vibratory patterns. This system provides an important measure to reduce accidents among blind people in common traffic areas and give away warning to them by creating a great tendency to detect objects and obstacles as blind death has become common due to their inability to see and manage situations in heavy traffic.

NAVBELT is a guidance system that uses a portable robot obstacle avoidance system. The prototype consists of ultrasonic range sensors, a computer and earphones. The disadvantage of this system is that it exclusively uses audio feedback and is very bulky for the users. Moreover, the users require extensive training to operate this system. Moreover, the end products that were created are difficult to wear, non-portable and are very costly, making them out of reach for common people [5].

3. PROPOSED SYSTEM

The proposed design makes use of a combination of both Ultrasonic Sensor and image sensor to detect the obstacles present in front of the visually challenged person. The ultrasonic sensor detects objects by sending a short ultrasonic burst and then listening for the echo. The Raspberry Pi microcontroller connected to the sensors calculates the distance from the object based on the time taken for the echo to come back.

Now, a text output is generated based on the distance calculated. This Text output is converted into an Audio Format, using the eSpeak module which is then relayed to the user using an Earphone or a Speaker. The PI Camera captures the images of the objects present in front of the user. This image is matched with the set of images stored in an SD card.

When the Raspberry Pi recognizes the image, it gives out as an audio output to the user. This system is made up of seven main components: (A) Ultrasonic Sensor, (B) Raspberry Pi, (C) Power Source, (D) Image Sensor, (E) GPS Sensor, (F) Weather Sensor and (G) Ear Phones as shown in Fig. 1.

The Ultrasonic module is used for the purpose of obstacle detection for the visually challenged person. It emits ultrasound i.e. sound frequency more than 20 kHz. Initially, a trigger pulse is given as an input to the sensor using Raspberry Pi.

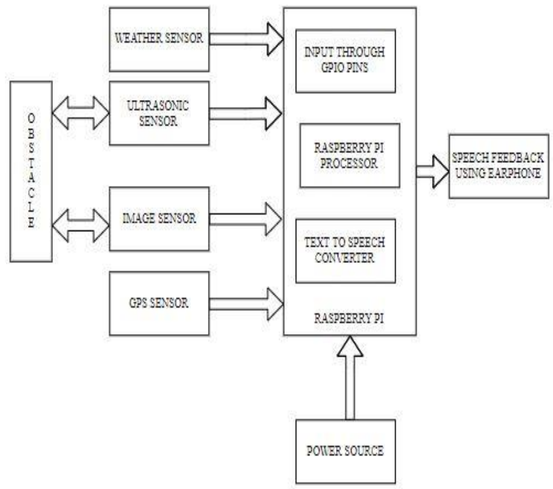

Fig.1. Block diagram of the proposed system

A. Ultrasonic sensor:

The ultrasonic sensor (fig 2) then emits a short 40 kHz ultrasonic burst signal [7][8]. This burst signal moves through the air at about 343ms-1, hits an object and then rebounds to the sensor resulting in an output pulse. The Raspberry Pi captures this output pulse. Then, using the time taken by the pulse to return back, the distance from the obstacle is calculated. The sensor consists of four pins:

(1) VCC, (2) Trigger, (3) Echo and (4) Ground as illustrated in Fig. 2.

- VCC - It is used to provide 5V power to the sensor.
- Trigger (Trig) - Takes in Input Pulse to trigger the sensor.
- Echo - It is used to receive the Output Pulse i.e.
- The echo from the object detected through ultrasonic waves.
- Ground (GND) - for earthing purpose [9].

Fig.2. An ultrasonic sensor

B. Raspberry Pi

Raspberry Pi (fig 3) belongs to the category of Single block system (SBS). Raspberry pi is a microcontroller that can be used for making iot based systems It is a credit card sized board, low cost computer. It takes input through the General Purpose Input Output (GPIO) pins, which can be attached to

LEDs, switches, analog signals and other devices. In our proposed design, the GPIO pins are connected to the ultrasonic sensor, image sensor, GPS sensor and the weather sensor. It requires a power source of 5V to be operational and a Micro SD memory card is inserted, which acts as its permanent memory. For our design Raspberry Pi 1 Model B+ is used. It contains 4 USB ports, a HDMI port, an audio jack port and an Ethernet port. The Ethernet port helps the device connect to the Internet and install required driver APIs. It has a 700 MHz single core processor and supports programming languages such as Python, Java, C, and C++ [6].

Fig.3. A Raspberry Pi

C. Image sensor:

The image sensor module [10][11][12] is a small chip which consists of a sensor that can detect images and send the relevant information to the system. The sensor uses matching algorithms and preloaded images stored in the SD card to determine the type of object the user is facing. Every color of light has its own frequency and variable attenuation, which the image sensor takes advantage of.This kind of image matching using the difference in color frequencies to determine the type of object is called RGB imaging. These lights are converted into signals or small bursts of current which are then converted into the required information I.e.; the object characteristics. Image sensors are used in electronic imaging devices of both analog and digital types, which include digital cameras, camera modules, medical imaging equipment, night vision equipment such as thermal imaging devices, radar, sonar, and others.

D. *Weather sensor:*

Weather sensor module in the system is used to determine the current weather and notify the user upon being prompted through voice command or pressing a button. The main aim of this system is to help the user be prepared for any sudden changes in the climate and also save oneself from any mishaps. The raspberry pi module allows weather sensor device to be attached to it, which can be in turn used to collect data from a web server that can return weather statistics by sending a web request. The module takes advantage of the wifi module fixed in the system. This wifi module acts as a channel for sending and receiving web requests. The web server can be hosted on any cloud website that can provide data in textual format. For example www.weewx.com; hosts open source weather determination web server. For weather determination, DS18B20 digital temperature sensor, which is also waterproof for minimal purposes. For better working, one can use raspberry pi weather station module[13].

E. *GPS:*

GPS (global positioning system) module in the system is used to guide the user to its destination on command from the user. it is a small electronic circuit that allows connecting to the Raspberry Pi microcontroller to get position and altitude, as well as speed, date and time on UTC (Universal Time Coordinated). It uses the standard NMEA protocol to transmit the position data via serial port.GPS TTL Mini is a high gain GPS Receiver. It has an entirely compact and simple design with the ultimate tracking performances. It is also ideal for plug-and-play GPS receiver module into their small form factor design as in the proposed system which requires minimal design. It can be directly connected to Microcontroller's UART [14].

4. DETECTION OF OBSTACLES AND CALCULATION OF DISTANCE

A. Obstacle Detection

Ultrasonic sensors are used for obstacle detection and calculation of the distance between the obstacle and the visually challenged person. The transmitter emits eight 40 kHz pulse, this pulse after hitting the obstacle is received back at the receiver. The ultrasonic sensor records the time taken by the emitted pulse to return back at the receiver end. The proposed algorithm implemented in Python Programming language is deployed on Raspberry Pi. This algorithm is used to calculate the distance between the obstruction and the user, by recording the time interval between the pulse sent and received.

B. Distance Calculation

To find the distance between the obstacle and the person, The Distance Formula is used:

Distance = speed * time

DO = [(Speed of Sound * Time Taken) / 2]

Where,

- DO: Distance between an obstacle and the person in meters.
- Speed of Sound: speed of sound is taken as 343 meter/sec.
- Time Taken: It is the time interval between the pulse emitted and the pulse received.
- The time taken by the pulse is twice the distance traveled; hence the equation is divided by 2.

5. OBJECT RECOGNITION

The image sensor can be used for the purpose of object recognition for the visually challenged person. The Pi camera is connected to the raspberry pi by using the flat ribbon cable. The sensor is used to capture images of people or things that are present in front of it. The images are then compared with a set of images present in the SD card. If any match is found then a speech output is given to the user by using an espeak module by using python language.

6. WORKING

The working of the blind navigation system is started when the Raspberry Pi is given power. Raspberry Pi then boots up its operating system. The ultrasonic module is used in conjunction with a pi camera to detect obstacles. The pi camera takes a picture of the obstacle and the ultrasonic module calculates the distance of the obstacle from the stick using the distance calculation formula. The picture taken by the camera is sent to the microcontroller, which is fitted with an SD card. The picture is then compared to the data stored on the SD card and identified. After the signal returns back to the receiver of the sensor as an echo, the Raspberry Pi calculates the time taken from transmitting and receiving the echo. Using this time we calculate the distance of an obstacle from the sensor. The image sensor (pi camera) also keeps capturing the objects in front of it. This captured data is compared with the data that is present in the SD card. If any match is found then a speech output of the data is given to the blind person. This helps the blind person in recognizing the obstacle in front of him. Also, the system can recognize the traffic signal and inform the user if he can cross the road or not. The GPS module detects latitude and longitude details from the cloud and feeds into the module. The microcontroller analyses this information and uses the GPS tracking system to guide the person home using voice output.

The weather sensor module also uses the weather data received from the sensitive sensor module and gives data to the user upon being prompted. The SD card can also store contacts of the user along with facial data, so it can prompt the image sensor to recognize the known faces of the user when he is being approached by one of his contacts. Every data received is in textual format. The espeak module uses this textual data to convert it into voice data. This voice data is heard by the user through earphones or wireless headphones. The following block diagram shows the entire system. (Fig 4)

Fig.4. A conceptual model of the system

7. IMPLEMENTATION

The model was implemented by using a raspberry pi 3 controller. This model was able to take up to 5 volts. To which, the GPS sensor and a pi camera were connected, along with an ultrasonic sensor. The microcontroller was connected to a computer for testing purpose, through the use of the remote desktop connection. The sd card was booted up and fitted into the microcontroller. All the above modules were installed through the raspberry pi user-interface present in the computer. For testing purpose, earphones were given to the test subject and he was made to walk around the room. While encountering an obstacle, such as a chair, the subject was able to hear it before its approach up to 15 m. whenever an obstacle was detected; the system produced a voice output which was heard by the subject as "an obstacle has been detected". The image sensor was able to detect objects within this range accurately by spelling out "chair". On being prompted, the GPS sensor was able to correctly determine the latitude and longitude of the space in which the subject was present. The weather sensor module also collected adequate and precise data and was given as voice output on being prompted by the user.

8. CONCLUSION

The goal of the system is to allow blind people to have a quality life with comfort and without any threat or difficulties. This project offers the best way for the blind to travel without any hesitation and also exclude the thought of having a disability. The ultrasonic sensor, GPS, weather report, an image sensor, together give a new pair of eyes to the blind people and help them live their life with ease and confidence. By this, we conclude that the project is indeed a new companion to the blind which can allow the blind people to live a good and wonderful life without having to regret the disability. Using advanced technologies in the upcoming years, one can improve this system to unimaginable limits and allow us to perceive the impossible. Internet of things has allowed mankind to achieve implausible feats. These can be put to use for social benefit and improvement through cutting edge technology and out of the box thinking, which in turn, can help change lives of millions of people around the globe.

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