Vision Esartz for the Visually Challenged

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Abstract – Blind people need some aid to feel safe while moving. Smart stick comes as a proposed solution to improve the mobility of both blind and visually impaired people. Stick solution use different technologies like ultrasonic, infrared and laser but they still have drawbacks. In this paper we propose, light weight, cheap, user friendly, fast response and low power consumption, smart stick based on infrared technology. A pair of infrared sensors can detect stair-cases and other obstacles presence in the user path, within a range of two meters. The experimental results achieve good accuracy and the stick is able to detect all of obstacles. The main objective of the project is to help blind people in moving and allowing them to perform their work easily and comfortably. In a normal cane or stick, the detection of the obstacle is done by using the sensor. But it is not efficient in the case of visually impaired persons because a blind person does not know what type of things or objects are in front of him or her. The blind person also cannot recognize the size of that object and how far he/she is from the object. So, it can be difficult for blind person to move around. The smart walking stick is integrated with Object recognition through sensors and the signal comes out mainly in the form of speech through speech unit both connected to the Arduino Uno. The sensors measure the distance between objects and the walking stick by using Ultrasonic sensors. When the objects or obstacles come in range of the ultrasonic sensor, the speech unit announces the name of obstacle in front of the stick. The smart walking stick is very useful for the visually impaired for their safety and independence from others at all times.

Index Terms – Ultrasonic sensors; Raspberry Pi; Speech unit; visually impaired.

1. INTRODUCTION

According to the WHO, about 30 million people are estimated to be permanently blind worldwide. These people are totally dependent on others. They even cannot walk on their own. There are many guidance systems for visually impaired people to navigate quickly and safely against obstacles and other hazards faced. Generally, a blind user carries a white cane or a guidance dog as their mobility aid. With the advances of modern technologies many different types of devices are available to support the mobility of blind. We have created, designed and built this device which will help blind people to walk with ease independently. As a simpler version, we have used ultrasonic sensor in this project. For better accuracy and assistance two or three sensors can be used. The main objective of this project is to develop a simple guidance system for the blind users, using sensors, and to determine whether the blind can moves safely or not.

Moving through an unknown environment becomes a real challenge when we can't rely on our own eyes. Since dynamic obstacles usually produce noise while moving, blind people develop their sense of hearing to localize them. A visionless person commonly uses a white cane or walking cane for navigation. The walking cane is a simple and purely mechanical device to detect static obstacles on the ground, uneven surfaces, holes and steps through simple tactile-force feedback. This device is light, portable, but its range is limited to its own size and is not usable for dynamic components. Another option that provides the best travel aid for the blind is the guide dogs. Based on the symbiosis between the blind owner and his dog, the training and the relationship to the animal are the keys to success. The dog is able to detect and analyze complex situations: cross walks, stairs, potential danger, know paths and more. Most of the information is passed through tactile feedback by the handle fixed on the animal.

This system presents a concept to provide a smart electronic aid for blind people. The aim of the overall system is to provide a low cost and efficient system that calculates the distance from the object to the person. In this project, embedded system plays a major role we are using the Ultrasonic sensor, Raspberry Pi, Voice synthesizer, speaker or headphone and Battery.

Ultrasonic sensors works on a principle similar to radar or sonar which evaluates attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. That signal is send to the Raspberry Pi. The voice synthesizer and speaker is used to produce the voice if the human goes out of the desired path. Battery present in the system is used to give power to all the units present in the system.

2. EXISTING SYSTEM

This section describes appropriate related works on the development of smart canes intended for visually-impaired people. According to, technology can help in reducing many barriers that people with disabilities face. These kinds of technologies are referred to as assistive technology (AT). There are many types of disabilities, including physical disabilities, hearing impaired, and visually-impaired. AT has been utilized in assisting them. However, developing an AT is expensive, making their selling price high. According to Mazo and Rodriguez the blind Cane is one of the assisting tools for the visually-impaired and it is really important. According to Herman, one of the main problems of the visually-impaired is that most of these people have lost their physical integrity. Also, they do not have confidence in themselves. When the visually-impaired walk into a new environment, they will find it difficult to memorize the locations of the object or obstacles. These examples demonstrate the difficulties of visually impaired people.

The Guide Cane is designed to help the visually-impaired users navigate safely and quickly among obstacles and other hazards. Guide Cane is used like the widely used white cane, where the user holds the Guide Cane in front of the user while walking. The Guide Cane is considerably heavier than the white cane, because it uses a servo motor. The wheels are equipped with encoders to determine the relative motion. The servo motor, controlled by the built-in computer, can steer the wheels left and right relative to the cane. To detect obstacles, the Guide Cane is equipped with ten ultrasonic sensors. A mini joystick located at the handle allows the user to specify a desired direction of motion. Guide Cane is far heavier than the ordinary white cane and also it is hard to keep because it cannot be folded. Smart Cane is one invention which was originally the creation of a common blind cane but it is equipped with a sensor system. This invention resembles Guide Cane where this invention has a number of ultrasonic sensors and servo motors. This invention is designed with the aim at helping the blind in navigating. Ultrasonic sensors need to detect and avoid obstacles or objects located in front of the user. Meanwhile the fuzzy controller is required to determine the instructions that will be executed for example to turn right, left or stop. Like Guide Cane, this invention also has a control button on the handle, and the button has four different directions. This invention has the same weaknesses as the Guide Cane where there will be a problem to save space or to place the smart cane. Besides that, cost is also a weakness in this project as it uses ultrasonic sensors and a number of servo motors. If the cost is too high, users are not able to afford for it because the average income of the visually-impaired people is relatively small.

Smart Cane has been designed by students from Central Michigan University where this invention uses Radio Frequency Identification (RFID). RFID is used to detect objects or obstacles in front of the user and detects the RFID tag that has been placed in several areas to navigate the users. This invention is just like a normal stick but is equipped with a bag, worn by the user. The bag supplies electricity power to the invention and informs the user through speakers inside the bag. For users who do not have the ability to hear, there are special gloves that will vibrate at every finger, in which different vibrations in each finger have different meanings. However, this invention has several weaknesses and is only suitable for small areas. This is because it only detects the area with RFID tag otherwise this invention only works as a regular blind cane. In addition, this invention requires a high cost if it is used in the external environment because the larger area that need to be tagged, the higher cost is needed.

Mechatronic Blind Stick is a guiding system, designed to facilitate the daily work among the visually-impaired people. This invention has many similarities with the Smart Blind Cane. In which this invention uses ultrasonic sensors and sound vibrations. However, this invention also has several weaknesses; it cannot be folded and difficult to keep. In addition, this invention is not equipped with sensors to detect the water areas.

3. PROPOSED SYSTEM

The proposed design makes use of Ultrasonic Sensor that detects objects by sending a short ultrasonic burst and then listening for the echo . The Raspberry Pi connected to the sensors calculates the distance from the object based on the time the echo took to come back. Next, based on the output the distance is calculated. The output is converted into an Audio Format, which is then relayed to the visually impaired using an Earphone or a Speaker. This system could be integrated on top of a belt, making it portable. This system is made up of four main components:

(1) Ultrasonic Sensors

(2) Raspberry Pi

(3) Power Source

(4) Earphone

1. SENSOR

The Ultrasonic Sensors belongs to a category of sensors that emits ultrasound i.e. sound of frequency more than 20 kHz. Initially, a trigger pulse is given as an input to the ultrasonic sensor using Raspberry Pi. The ultrasonic sensor then emits a short 40 kHz ultrasonic burst signal. This burst signal travels through the air at approximately 343ms-1, hits an object and then bounces back to the sensor resulting in an output pulse. This output pulse is captured by Raspberry Pi. Then using the time taken by the pulse to return back, calculate the distance from the obstacle.

The sensor consists of four pins: (1) VCC, (2) Trigger, (3) Echo and (4) Ground

1. VCC - It is used to provide 5V power to the sensor.

2. Trigger (Trig) - Takes in Input Pulse to trigger the sensor.

3. Echo - It is used to receive the Output Pulse i.e. the echo from the object detected.

4. Ground (GND) - It connects sensor to the ground.

The proposed device uses ultrasonic sensor and it can detect any object that lies on the ground, situated a distance of certain meters from the user. The minimum size of the object that can be detected should not be less than 3 cm width (or diameter). In operation a beam of ultrasound of 40 KHz frequency is transmitted at a regular interval in the forward direction. The ultrasound will be reflected from a nearby object, if any. The sensor will then detect the presence of any object that lies within that meters by detecting the reflected sound beam. The time intervals at which the transmitter will transmit ultrasound depend on the walking speed of the user.

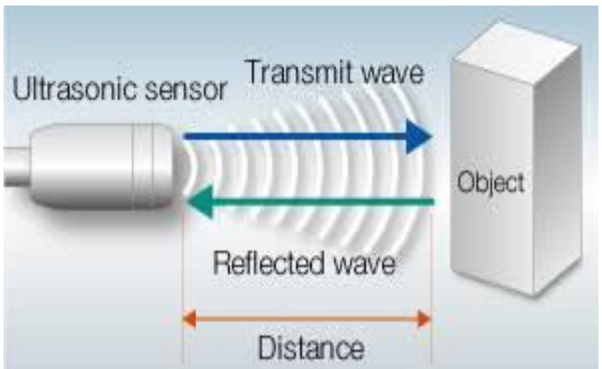

Fig 1. Ultrasonic sensor

2. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or Breadboards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

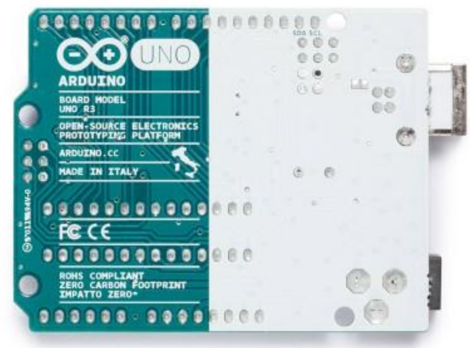

Fig 2. Arduino UNO

3. EARPHONE/SPEAKER

Earphone/Speaker is used to make the visually impaired person aware of the obstacles that are there, by telling the direction and distance from the obstacle. It is better than a buzzer since, it provides more accurate results and is more perceptive, thereby, helping the person to react more easily.

4. POWER SOURCE

This system requires a 5V power supply. We can use a battery, portable charger, micro USB or a rectifier as the input power source.

4. OBSTACLE DETECTION AND DISTANCE CALCULATION

This section explains the details on the process of obstacle detection and distance calculation.

A. Obstacle Detection

Ultrasonic sensors are used for obstacle detection and calculation of distance between the obstacle and the visually impaired person. Ultrasonic sensors are used in pair as transceivers i.e. a single sensor can both send and receive signals. The transmitter emits eight 40 kHz pulse, this pulse after hitting the obstacle is received back at the receiver. The ultrasonic sensor works on the principle of sonar i.e. it records the time taken by the emitted pulse to return back at the receiver end. Our algorithm implemented in Python programming language is deployed on Raspberry Pi. This algorithm is used to calculate the distance between the obstacle and the person, by recording the time interval between the pulse sent and pulse received. In this setup we use 3 ultrasonic sensors, which help the person to find any obstacle in left, right or front direction.

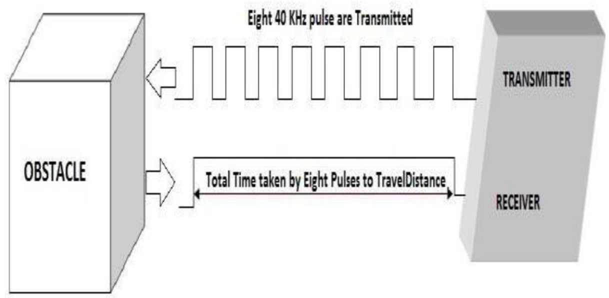

Fig 3. Working of an Ultrasonic sensor

B. Distance Calculation

To find the distance between the obstacle and the person, we use Distance

Formula: distance = speed * time

OD = {[Speed of Sound * Time Taken] / 2} (1)

Where,

OD: Distance between an obstacle and the person in meters.

Speed of Sound: We take speed of sound as 343 meter/sec.

Time Taken: It is the time interval between the pulse emitted and the pulse received.

Since, the time taken by the pulse is twice the distance travelled, we divide the equation by 2.

5. WORKING

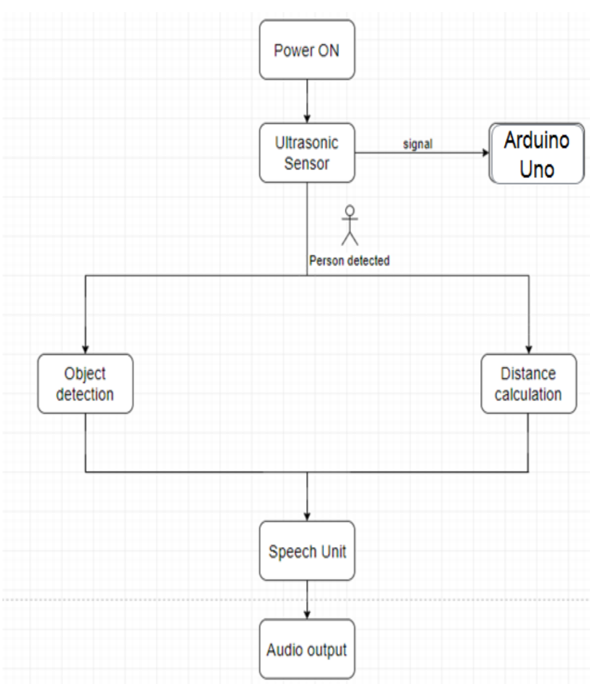

Fig 4. System Architecture

The process starts when power is supplied to the Raspberry Pi. As Raspberry Pi boots up its operating system, it triggers the ultrasonic sensor to start sending burst signal. All the sensors are triggered at approximately the same time thus, there is very less delay. 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 any of the sensors. Next, it checks if any of the distance calculated is less than the minimum distance specified i.e. 0.5m in our case. If none of the sensors have distance less than the minimum distance, the entire process starts again. However, even if one of the sensors detects distance less than 0.5m, it triggers the pre-defined conditions

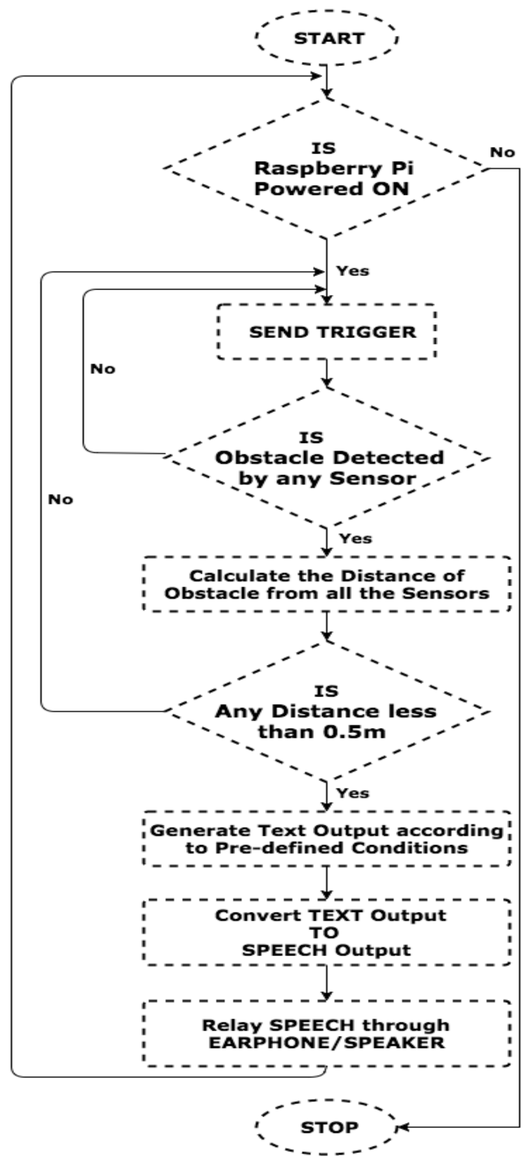

Fig 5. Flow chart

The smart walking stick is integrated with Object recognition through sensors and the signal comes out mainly in the form of speech through speech unit both connected to the Raspberry Pi. The sensors measure the distance between objects and the walking stick by using Ultrasonic sensors. Speech warning messages and the vibration motor are activated when any obstacle is detected. When the objects or obstacles come in range of the ultrasonic sensor, the speech unit announces the name of obstacle in front of the stick. The smart walking stick is very useful for the visually impaired for their safety and independence from others at all times.

6. RESULT

An electronic device is built in the form of a Raspberry Pi to detect obstacles. The device is tested, by placing various obstacles at different positions and distances from the sensors on the Pi. The system is successful in warning the user about the presence of obstacles in their path. It can detect any object within a pre-specified minimum distance in any direction. For out tests, we set the minimum distance value to 0.5m. The system announces the distance calculated in real time in meters or centimeters. For the simplicity of the user, the speech messages are stored in the form a universal language i.e. English. The distance calculated based on the receiving pulse (echo) is not hundred percent accurate, however, we take into account the worst case and thus provide with the best results to avoid the obstacle.

Object Distance and	**Sensor Reading**			**Output**
	Left	***Center***	***Right***	
5cm, left	5	0	0	Move towards right
10cm, right	0	0	10	Move towards left
10cm, in front	0	10	0	Turn left
20cm, in front	0	20	0	Turn left or right
25cm, in left right and front	25	25	25	Turn around
25cm in left right, 20cm in front	25	20	25	Turn around
35cm in left and front	35	35	0	Turn right
40cm in right and front	0	40	40	Turn left
45cm in front	0	45	0	Turn left or right
50cm in left and right	49	0	50	Move forward

Table 1. Test results of the Pi

The experiments were conducted to evaluate the performance of the proposed method. The results presented in this paper mark the beginning of our efforts to build a compact travelling aid that allows the visually impaired to negotiate everyday environment. As previously mentioned, the sensor circuits give information about the environment.

7. CONCLUSION

With the proposed architecture, if constructed with at most accuracy, the blind people will able to move from one place to another without others help. If such a system is developed, it will act as a basic platform for the generation of more such devices for the visually impaired in the future which will be cost effective. It will be real boon for the blind. The developed prototype gives good results in detecting obstacles paced at distance in front of the user. The solution developed is a moderate budget aid for the visually impaired. However minimizing cost leads to compromises in performance. It is advised that the design be improved before commercial production. Some improvements that could be made are as follows:

Increasing the range of the ultrasonic sensor and

- Implementing a technology for determining the speed of approaching obstacles. Synchronization with external memory to increase
- The number of routes stored. Synchronization with various navigation software
- Applications available on the internet so that new, un-programmed destinations can also be chosen. Provision for voice control using speech
- Recognition.

This paper proposes to develop an electronic device in the form a Raspberry Pi using a system of Raspberry Pi and various other components (sensors, earphones, etc.). It has the following features:

- A device that helps visually impaired people as walking assistance.
- Uses sensors to gather information of Obstacles.
- A device that can be used without Internet connectivity.
- A device that is cost effective, easy to use and portable.

- Adevice that notifies the user about obstacles in the form of speech.

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