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Ultrasonic Smart Stick for Visually Impaired

VARUN SHILESH[1], ABHILASH M[2], AKSHAJ SHIVARA MADHUSUDHAN[3]

[1-3]*Electronics and Instrumentation Engineering Dept., RNS Institute of Technology,* Bangalore, India

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Abstract— The Ultrasonic smart stick comes as a proposed solution to enable visually impaired persons to identify the world around. The system is designed to act as an artificial vision. The proposed system consists of four sensors: ultrasonic sensors, IR sensor, water sensor and light (LDR) sensor. It is controlled by the ESP 32 microcontroller to receive the sensor signals.

GPS navigation in the mobile can be used to guide the visually impaired in new and unfamiliar places. The user can use an earphone to listen to the navigation directions that are coming from the google voice assistant. Emergency buttons [SOS] can be provided on the stick.

***Keywords*- Visually Impaired, Smart Stick, ESP 32, Ultrasonic Sensor, GPS/GSM, Voice Assistant.**

I. INTRODUCTION

There are approximately 285 million people with visual impairment who face difficulty in interacting with their environment [1]. The life of visually impaired people is very different. They find difficulties while detecting obstacles in front of them, as a result, they can get severely injured. It may lead to humiliation and loss of confidence in themselves, also there are chances that they can get lost.

Physical movement is a challenge for visually impaired people because it can become tricky to distinguish where they are, and how to get to where they want to go. Generally, they bring a sighted family member or friend for support.

The realm of electronics is growing rapidly. Advanced electronics can be implemented in assisting the visually impaired society in various ways. Over the last decades, research has been conducted to design a good and reliable system for visually impaired persons to detect obstacles and warn them of dangerous places. There are some systems which have a few drawbacks. We conducted a survey with visually impaired people and tried to understand their requirements so as to give them a user-friendly experience.

The main objective of this research is to design and implement an intelligent, lightweight and affordable stick. In the proposed system the above-mentioned cases and requirements are taken into consideration and implementation is provided. In order to help the visually impaired in detecting the object, the proposed system makes use of ultrasonic sensors, an IR Sensor additionally, the moisture sensor will detect any water in their path [Fig.1].

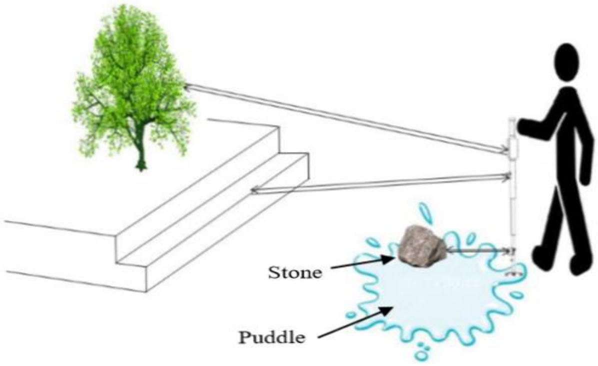

Fig. 1 Smart Stick Detecting Obstacles In front of the Blind

II. LITERATURE SURVEY

1. Sung Jae Kang, et al." Development of an Intelligent Guide-Stick for the Blind" has developed a system for sensor-based circuitry consisting of Ultrasonic Sensor and DC motors is used for detecting obstacles, the device weighs 4.0 kg's and hence can cause some inconvenience to the users. This is one major limitation.

2. B.S. Sourabh and Sachith D'Souza, India. -2015 IEEE. "Design and Implementation of Mobility Aid for the Blind People". The stick consists of an obstacle detection system as well as a navigation system. It uses the Raspberry Pi micro-controller. This increases the cost of the stick, thus making it less affordable.

We conducted a literature survey in this topic and realized that the smart stick is already a product, in some form or the other. The key factor which separates our stick from the rest is the pricing. We have used a simplistic design and

We are focusing on the low- and mid-income section of the society. Only the most useful features are implemented so as to make it extremely affordable yet effective to the common man. Another key aspect we are looking into is the lack of internet connectivity in many villages. Our device is designed in such a way that it is not dependent on Network connectivity.

III. PROPOSED SYSTEM

- **Sensors**

The selection process of the appropriate sensor depends on several factors such as cost, atmospheric condition, kind of obstacle to be detected, detection range, and the desired precision of measurements. The data is collected and represented in Table I.

TABLE I. GENERAL CHARACTERISTIC OF SOME ACTIVE SENSORS

	Laser	Infrared	Radar	Ultrasound
Principle	Transmission and reception of light wave	Transmission and reception of pulse of IR light	Transmission and reception of microwave	Transmission and reception of acoustic waves
Range	SLR: 15cm to 120cm LLR: about 10- 50 m	From 20 cm to 150 cm	about 150-200 m	From 3 cm to 10 m
Beam width	narrow	fairly thin	Depended on size of antenna	wide
Atmospheric condition	affected	affected	Affected	Not affected
Cost	Very high	Low	High	Low

SLR: short laser range, LLR: Long laser range

Ultrasonic Transducers

Ultrasonic transducers work well for close obstacles unlike the laser sensor, which are not accurate for obstacles lesser than 15 cm, the close up of the US-100 ultrasonic transducer module is as shown in [Fig. 2].

Fig.2 Ultrasonic Sensor

Moisture Sensor

A moisture sensor is located at the base of the stick to prevent any injuries that can be caused by tripping in a puddle. When the moisture sensor comes in contact with the wet surface, it produces an electrical signal which triggers the Micro-controller which in turn triggers the buzzer and vibrator for warning the user [Fig.3].

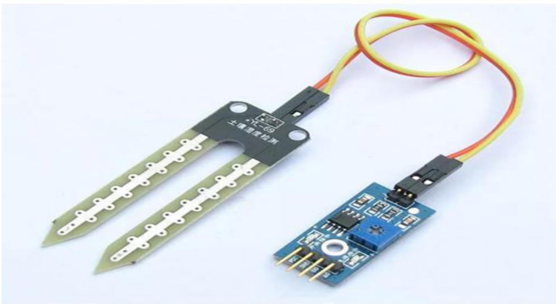

Fig.3 Moisture Sensor

IR Sensor

It is used to detect variation in the ground level such as pits, staircase, or ditches, it is placed at the lower end of the stick. After detecting the obstacles on the ground, the IR sensor will send the signal to the Micro-controller, which will notify the user regarding the presence of obstacles on the ground.

The IR sensor works on the same principle as that of the ultrasonic, except here Infrared waves are emitted by the transmitter and the rebound duration is recorded and used to calculate the distance.

IR sensors have a much smaller range as compared to the ultrasonic sensors.

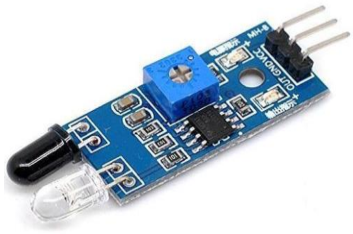

Fig.4 IR Sensor Module

Micro-Controller

The system uses the ESP 32 [Fig.5] which can control the environment by receiving input signals (Digital/Analog) and can affect its surroundings by controlling many devices such as lights and relays. The microcontroller on the board is programmed using the Arduino IDE.

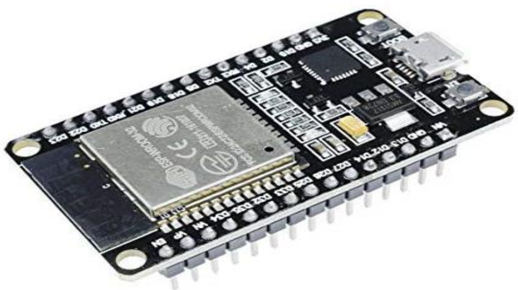

Fig.5 ESP 32 Micro-Controller

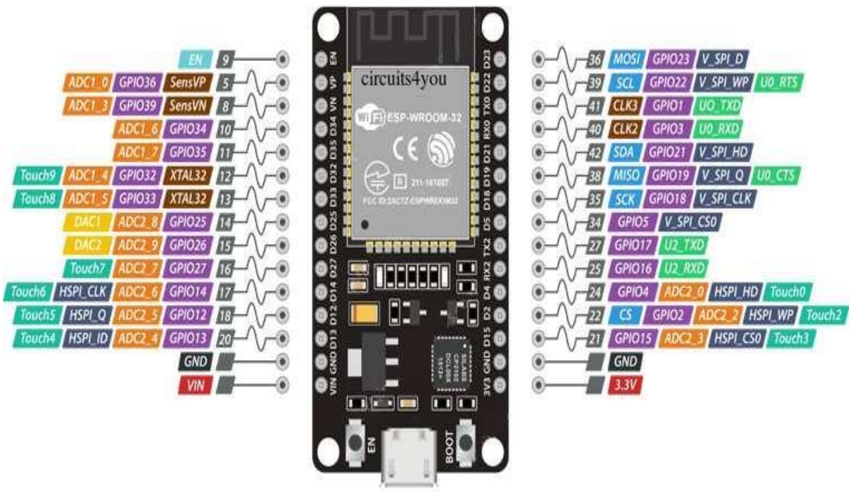

Fig.6 Schematic Circuit Diagram

- **Design**

The system has been designed such that the two ultrasonic sensors are mounted approximately one foot above the base of the stick for better precision. The IR and moisture sensor have been mounted at the bottom of the stick.

The top of the stick houses the vibrator, buzzer and the battery pack which is attached to a toggle switch. All these components are interfaced with the Micro-Controller [Fig.7]. The stick has radium stickers on the top and bottom to help while crossing the road. Emergency buttons are placed at accessible locations for easy access.

Fig. 7 Prototype of The Smart Stick

- **Working**

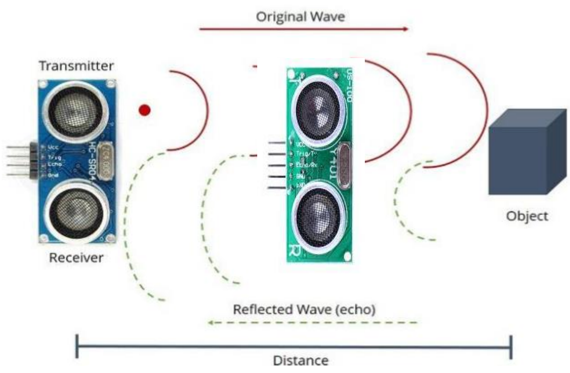

Fig. 8 Ultrasonic Sensor Sending and Receiving Signals

The ultrasonic sensor uses 40 kHz transmission signal to send and receive the pulses, the 40 kHz frequency is produced by a transmitter of two centimetres diameter; it can generate narrow beams. This is a reasonable size to be installed in the stick.

Detection using ultrasonic sensor is based on a few factors:

Time of flight (ToF)

ToF is the amount of delay between the emission of a sound and the arrival of an echo depending on the distance of an obstacle, which is directly proportional to the distance.

Beam size

Obstacle size is depending on the amount of reflected wave. Obstacles whose dimensions are larger than the beam size, all of the sound waves will be reflected to the receiver. If the obstacle size small as compared to the beam size, the part of the ultrasonic sound wave will be reflected to the receiver and the rest will be lost.

The speed at which sound travels depends on the medium it passes through. Broadly, the speed of sound is proportional to the square root of the ratio between the stiffness of the medium and its density. The speed of sound can also change with the atmospheric conditions. All obstacles reflect some part of the wave back to the receiver. The amplitude of the wave reflected is comparatively proportional to how much surface of the obstacle is available, concerning coherent reflection. Also, shape and orientation, are major factors contributing to the strength of the reflected signal [Fig.9].

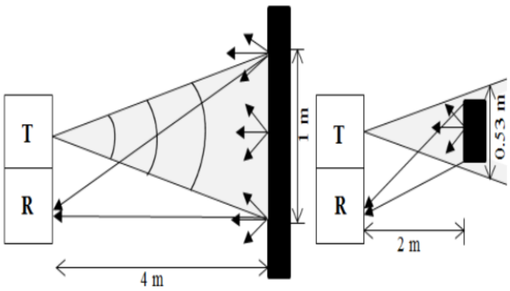

Fig. 9 Ultrasonic Sensor Detecting Obstacles

Alarm unit

This unit is very important as it informs the users of any potential hazard in the user's way. It consists of two components:

Buzzer

The buzzer typically operates in the lower portion of the audible frequency range of 20 Hz to 20 kHz. This is accomplished by transforming an electric, oscillating signal in the audible range, into mechanical energy, in the form of audible waves. The buzzer is used in this research to warn the blind person against obstacle by generating sound proportional to the distance from obstacle [Fig.10].

Vibrator

A vibrator motor is included to enhance the overall feedback for the person, who receives a warning against obstacles depending on their closeness in different forms of vibrations [Fig.11].

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Fig.10 Buzzer Fig.11 Vibrator motor

IV. RESULTS

The proposed smart stick produced good results when tested at RNSIT, Bangalore. The prototype is being developed and tested to increase its efficiency.

Applications	Number of attempts	Range	Number of successful attempts	success percentage
Holes	16	0-20 Cm	12	75%
Obstacles	16	0-60 Cm	16	100%
Puddles	12	NA	10	83.33%
Average success percentage of the tested device				86.11%

V. FUTURE IDEAS

GPS and GSM Module

In this module, through GPS and GSM the longitude and latitude of the stick is tracked, which can be sent to the emergency contact if needed. The latitude and longitude of the stick are sent as a text message. A GPS device will retrieve from the GPS system location and time information. A GPS reception needs a line of sight of four or additional GPS satellites and is subject to poor satellite signal conditions.

Global System for Mobile Communications (GSM) services are of a standard assortment of applications and options accessible to subscribers all over the world. The commonplace makes it possible to use phones constantly with different companies and services. GSM is the world's most dominant transportable commonplace.

Portable and lightweight

The results of a survey we conducted shows that the only drawback with the available smart sticks is that they are heavy and not portable. The proposed stick is intended to be very lightweight and easy to use. The stick will be made foldable to avoid any humiliation in public places.

Calling the Stick

The stick can be fitted with FM “frequency modulation” wireless communication to help the visually impaired to find the stick if it is far from him. [Fig.12] shows an RF transmitter that generates radio frequency waves in its circuits, and to this 'carrier signal', it adds the information part by modulating the carrier signal. This composite signal (carrier plus information) is then fed to an antenna. An RF sensor receiver receives the signal at the same frequency from the atmosphere, by altering the Electric and Magnetic fields from its own antenna. The receiver circuit then separates the information part of the signal from the carrier part and amplify this to a useful audio level.

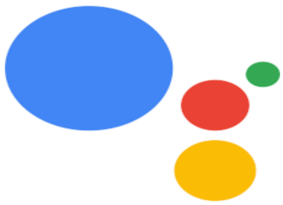
Fig.12 RF Transmitter and Receiver

AUX Earphone port

An AUX port can be provided to enable the user to listen to the commands and beeps even when he/she is in crowded places.

Google assistant

The idea is to integrate the powerful Google assistant features. The Google assistant will be able to guide the user with directions. The user will be able to give voice commands and ask questions to the google assistant software in the stick.



CONCLUSION

With the proposed architecture, if constructed with utmost precision, the visually impaired people will able to move from one place to another without other's help, which leads to increase autonomy for the visually impaired. The completely developed smart stick can be incorporated with multiple sensors which will provide additional assistance in navigating the way while walking and keep alarming the person if any sign of danger or inconvenience is detected.

At the same time global positioning system (GPS) can be linked with the voice assistant for navigation, so that person can know his current position and distance from the destination which will alert the users through voice instructions.

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