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Smart Navigation System Assistance for Visually Impaired People

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***Abstract*— In this paper, we have proposed a system for visually impaired people using an ESP32 microcontroller, Radar sensor, Ultrasonic sensor, and GPS. This proposed system detects the object and converts it into an audio signal. We have used different types of sensors. It also contains Bluetooth for audio navigation. This smart stick is user-friendly, light in weight, low power consumption, easy to use, and easy to understand for the user.**

This project aims towards helping visually impaired people so they can roam around independently. It is portable in use in any environment. It is a smart stick that guides the user by sensing the obstacles in the range of the stick on the path of the user. The vibration and buzzer sensor which is placed on the stick notifies the user about the hurdles or objects which are on the path of the user.

Keywords— ESP32 Microcontroller; Machine learning, GPS, image to audio Bluetooth, google assistance, and Alexa.

I. INTRODUCTION

In the past, Visually Impaired People were always dependent on their relatives and friends for assistance or guidance in their daily chores and routine. There are also trained dogs to assist the visually impaired person which is not always affordable to the user. They have to sense the things around them and they also need a strong smell sensation in order to observe what is happening around them and in their surroundings. They also need to have strong memory to remember these small details and routes which they use on a daily basis and routine. If sometimes they get distracted on their way to a certain place or fail to remember the details, this might put them in huge trouble. Hence, the objective of this smart stick is to be affordable to the user as well as be handy in every environment. The common cause of blindness is Diabetes, Macular degeneration, Glaucoma, Congenital Abnormalities, and Hereditary diseases of the eye. Less common symptoms of blindness include Vascular Disease, Retina or Optic Nerve including Stroke Ocular, Vitamin A deficiency, Premature Retinopathy, Retinitis Pigmentosa, and congenital abnormalities. This stick is also useful for partially blind people or people with temporary blindness. The causes of permanent blindness are different from the symptoms of temporary blindness. The people who lose their vision suddenly are more symptomatic of blindness as compared to the people who lose their eyesight over the years.

The system contains an ESP32 cam model Microcontroller, Ultrasonic Sensors Vibration Sensor, LDR Sensor, and Radar Sensor. This system provides object detection and converts the detected signal into an audio signal. We have used Bluetooth for audio navigation. This stick is user-friendly, light in weight has low power consumption, and is easy to use. In case of battery discharge, we are also adding solar panels to the stick to charge the battery of the stick. These solar panels are useful when the user forgets to charge the battery or is not in a favourable position to charge the battery.

The paper contains the Proposed System, Methodology, Component features, Software, Working of the stick, Result, and Conclusion.

II. EXISTING SYSTEM

As seen in the past, there are various studies done on the blind stick for visually impaired people. These blind sticks mainly consist of object detection sensors, buzzers, vibration sensors, and GPS. Over the years, blind people were mostly dependent on their family, friends, and relatives for their daily chores and work which is not always accessible for everyone. The blind people mostly used cane sticks,

III. PROPOSED SYSTEM

The proposed system for the stick consists of various components such as ESP32, Radar Sensor, Ultrasonic Sensor, Speaker, Bluetooth, Wi-Fi, Camera, Google Assistance, LDR sensor, Vibration sensor and Buzzer, Water Sensor, Battery, and Solar Panel. The camera is used for object detection and the detected object image is then converted into the image to an audio signal. The navigation is done for the front side, left side, and right side of the stick. The LDR sensor is used to sense daylight and night. The smart stick is powered by a battery of 6V and also consists of Solar Panel. One of the main features of the stick is an Emergency Button. As shown in the following block diagram fig.1.

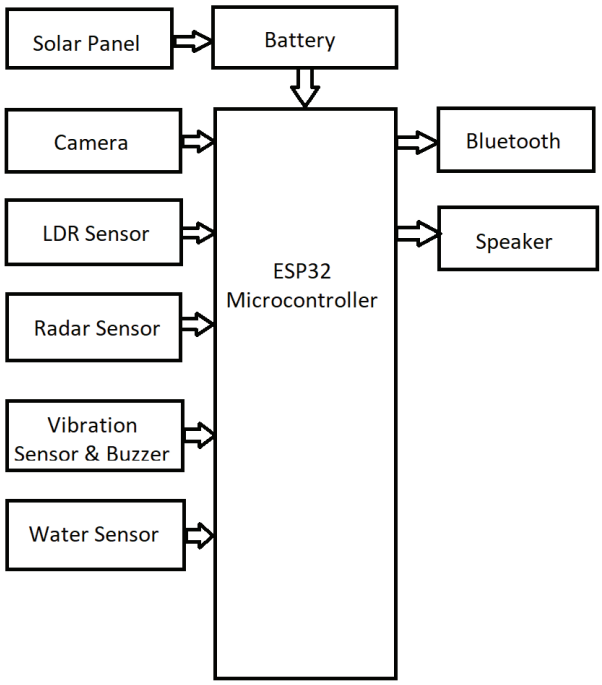

Fig. 1. Block Diagram of Proposed System

IV. METHODOLOGY USED

A. ESP32

ESP32 is a microcontroller. It has various features like Bluetooth, Wi-Fi, multipurpose GPIO ports, Bluetooth 4.2 with BLE, Wi-Fi 802.11 b/g/n, UART, and PW/M interfaces. It has an integrated camera. The required voltage is 0.5 V DC. It has 512kb of internal storage and external 4MB. On board TF card slot and support 4G card for storage.

The main reason for choosing ESP32 is that it reduces the cost. It is portable in use in any environment. As shown in fig.

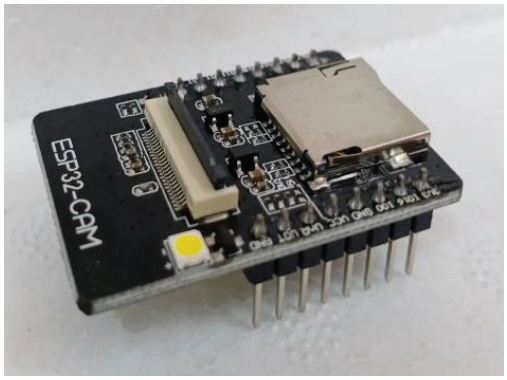

Fig. 2. ESP32 Module

B. RCWL – 0516

RCWL is a Microwave Radar Sensor. It is an alternative source to the PIR motion sensor and 360-degree detection area. This sensor detects the movements within the detection range. We have used a microwave sensor because it has a higher coverage range.

This sensor uses a Microwave Doppler Radar to detect moving objects. It also handles power supply from 4 to 28V. It has adjustable block time and distance, a 3.3V output power supply. This is a flexible sensor module used with a microcontroller. It gives 2 sec retriggers with motion, the required frequency 3.2 GHz.

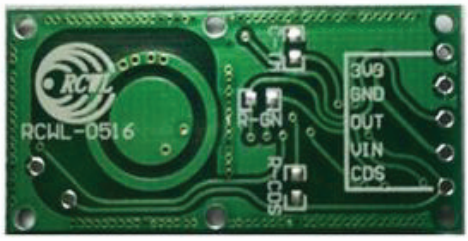

Fig. 3. RCWL 0516 Module

C. Camera

The camera module which is used for object detection is OV5640. This camera consists of a 5MP camera. The camera module is connected to ESP32 to capture the image with a max resolution of 2592 x 1944 and the image transfer rate is up to 60 frames per second. It requires a 3.3V current. It has automatic image control functions such as AEC, AWB, ABF, ABLC, etc. It has a data interface of DVP 8-bit.

Fig. 4. OV5640 Module

D. LDR sensor

The Light Dependent Register also known as a Photoresistor is the light-sensitive device used to detect the presence of light or absence of light. In the dark, the resistance of the sensor is very high but when the LDR sensor is exposed to light, the resistance drops automatically. The output of LDR is 5V. It is an Analog component. This register absorbs light and converts it into an analog value that lies between 0 – 255.

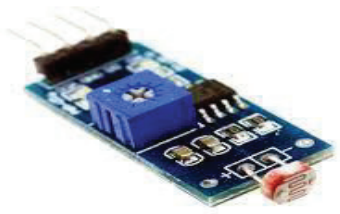

Fig. 5. LDR

E. Vibration Sensor

When the object is detected, the signal is converted into an audio signal at the same time. Our smart stick starts vibrating when the object is near the smart stick. We used this sensor for compatibility, vibration sensor measures the frequency of vibration in a smart stick. These frequencies can be used to detect imbalances. The output of the vibration sensor is 4-20 mA.

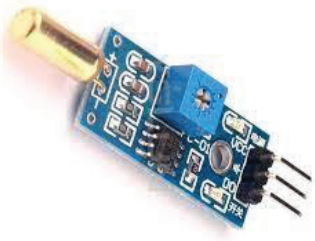

Fig. 6. Vibration Sensor

F. *Ultrasonic sensor*

An Ultrasonic sensor is used in our smart stick to measure the distance between the object and the user. We have used the HC-SR04 model, it has a high accuracy rate. This sensor has the probability of working in foggy weather.

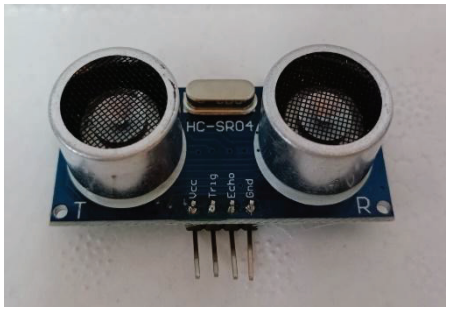

Fig. 7. Ultrasonic Sensor HC-SR04 Module

G. *Battery and Solar Panel*

The battery which we are using to power our smart stick is a rechargeable 6V lithium polymer battery. It has the capacity to power the stick for 4 hrs.

Solar panels are panels that are designed to absorb the sun's rays as a source of energy for generating electricity or heating. The solar panel used in the stick is a 6V panel. This solar panel will recharge the battery using the sun's rays.

Fig. 8. Solar Panel and Battery

H. *Water Sensor*

A water sensor is used to detect the level of water and to detect the slippery surfaces on the path of blind people to provide them with a harmless and fearless path.

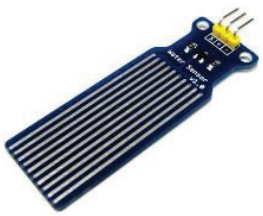

Fig. 9. Water Sensor

I. *Speaker and Buzzer*

After the object detection, the processed signal is converted into an audio signal which is transmitted to the user through the speakers

The Buzzer is used to notify the user about the objects which are on the user's path. The buzzer beep 2 times if the object is near to the user and if the object is exactly in front of the user then the buzzer buzzes 3 times in a row signaling the user about the object.

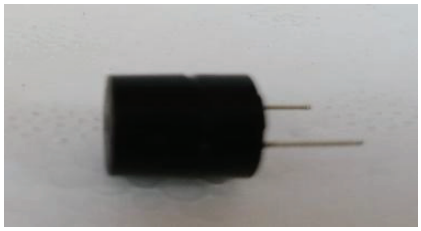

Fig. 10. Buzzer

J. *Software*

The whole idea of the smart stick comes into existence with the help of the programming language Python. The programming language Python is flexible to use in the current state of technology.

We have used Arduino IDE for the programming of the smart stick; it is an open-source platform that is compatible to program with ESP32- cam board. The software is created for the object detection is done using the Arduino IDE.

We have also added the feature of Google Assistance and Alexa which will be there for the assistance of the user in any situation.

V. WORKING

The working of the stick is in such a way that is it easy to understand for the user. The object on the path of the blind person is detected using the Radar sensor and the image of the object is captured by the camera. The captured image data is transferred to the microcontroller ESP32 and the detected image signal is converted into an audio signal. This audio signal is then transferred to the visually impaired person using the source of the speaker/ headphone. When the blind person starts using the smart stick, the sensors on the stick are activated. The objects which are captured using the camera, these captured data are sent to the ESP32.

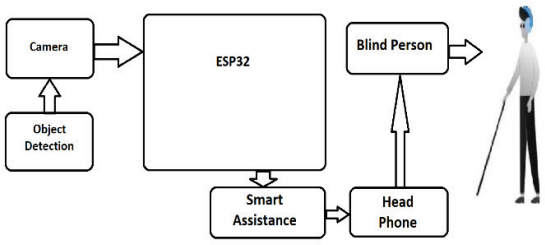

Fig. 11. Working of the Smart Stick

VI. FEATURES

- This smart stick detects the object in front of the stick and the detected object transfer into an audio signal.
- Radar Sensor detects the motion of the moving object.
- The LDR sensor is used to detect daylight and night to alert the user about the time changes
- Vibration Sensor which sends alerts to the user of detected objects, and hurdles.
- There is a GPS/GSM for tracking the live location of the person.
- There is also Google assistance and Alexa for the assistance of the blind person.
- The water sensor for detection of water.
- Solar panel for recharging the battery using sunlight.

VII. RESULT

In this paper, a proposed system has been implemented to provide the visually impaired person with smart assistance. It has been implemented using ESP32, and the movement of the moving object is also detected. Google Assistance is also provided to assist the blind person. This stick is user-friendly, lightweight, and cost-efficient.

The main of this project is to detect the object in the path of the user. The following figures show a group of people, a monitor, car, bike, chair, potted plant, and sofa which are some examples detected using our smart blind stick and also the stick can detect more than 30-40 objects and these detected objects are converted into an audio signal. We have also provided solar panel for charging the battery continuously, the main motive is to keep the battery charged. The moisture sensor is added to sense the water on the path of the user. The buzzer and vibration sensor are used to indicate the hurdles and objects to the blind person on the path.

Fig 12.5 shows multiple object detection done in a single frame.

As given in table no.1 our proposed system outperforms the existing systems thus giving a higher accuracy rate than that of the existing systems.

Fig. 12. Group of People Detection image.

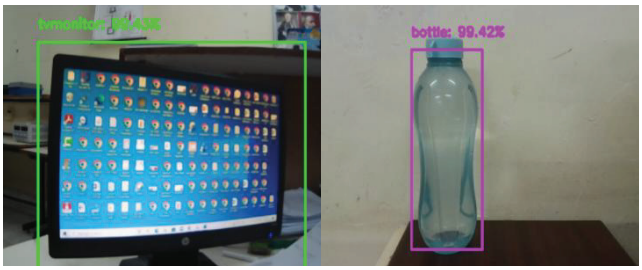

Fig. 12.(a) Tv monitor and Bottle Detection image.

Fig. 12.(b) Car and Chair Detection image.

Fig. 12.(c) Motorbike and Potted plant Detection image.

Fig. 12.(d) Sofa Detection image.

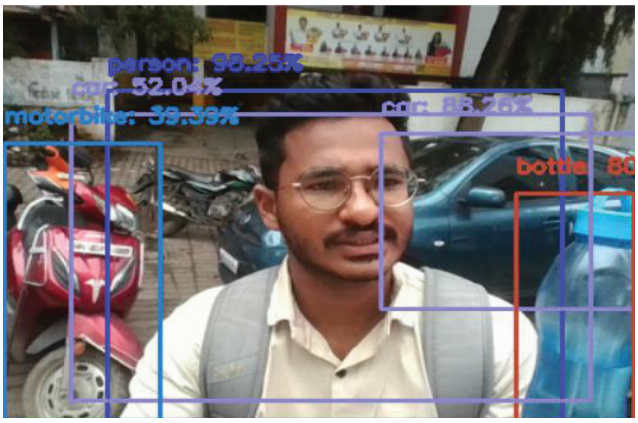

Fig. 12.(e) Multiple Objects Detection image.

VIII. CONCLUSION

The Smart Stick which we have created is easier to understand and handle. The stick has low weight which makes it efficient to carry anywhere. We have also added Solar Panels to charge the battery in case the user forgets to recharge the battery or is unable to find a power supply. The

solar panel keeps charging the battery automatically using sunlight. Our smart stick does real-time object detection; hence the smart stick detects the motion of the moving objects on the path of the user. The stick has the feature of navigation which guides the user about his path. The stick has a sensor on the left, right, and front sides of the stick for object detection and detection of motion. The detected object signal is converted into an audio signal and transmitted through Bluetooth to the speaker. The moisture sensor is used to detect water, and slippery surfaces to protect the user from accidents. We have also added an emergency button for sending the notification of the user's location to the operator, family, or friends.

TABLE I. COMPARISON BETWEEN EXISTING SYSTEM AND PROPOSED SYSTEM.

Sr no.	Project name	Accuracy
1	Blind Navigation System Using Artificial Intelligence [1]	85% - 95%
2	Smart Machine Learning System for Blind Assistance [2]	80%
3	AI-based Pilot System for Visually Impaired People [4]	41% - 90%
4	Our device	93% – 98%

As given in the table above, the existing system and our proposed system are compared with object detection accuracy. As compared to the previously existing system [1] the accuracy of the respected project is 85% - 90% while our smart stick outperforms the existing system giving the accuracy ranging between 93% to 98%. While other papers [2],[4] are also outperformed by our smart stick.

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