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Smart Navigation System for Visually Impaired Individual

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Abstract: *A significant number of blind and visually impaired individuals around the world frequently require assistance. In this paper, I have introduced a system designed for visually impaired people, utilizing an ESP32 microcontroller, an ultrasonic sensor, and GPS. This system detects objects and converts the information into audio signals. Various types of sensors are employed in the design, and it also includes Bluetooth functionality for audio navigation. This smart electronic aid is lightweight, user-friendly, energy-efficient, simple to operate, and easy for users to understand.*

The goal of this project is to assist visually impaired individuals in navigating independently. It is a portable solution suitable for both indoor and outdoor use. This smart electronic aid helps guide visually impaired users by detecting obstacles within its range along their path.

Keywords: ESP32 microcontroller, Ultrasonic sensor, Bluetooth and GPS

I. INTRODUCTION

According to the World Health Organization (WHO), approximately 285 million people worldwide are visually impaired. Among them, 39 million are completely blind, while 246 million have low vision. The number of blind individuals over the age of 60 is increasing by 2 million annually, leading to a rise in the demand for navigation and orientation devices. Traditionally, visually impaired individuals have relied on relatives and friends for assistance in their daily activities. Some use guide dogs, which require extensive training and are expensive to maintain. Common causes of blindness include diabetes, macular degeneration, glaucoma, congenital abnormalities, and hereditary eye diseases. Less common causes include vascular diseases, conditions affecting the retina or optic nerve (such as stroke-related ocular issues), vitamin A deficiency, retinopathy of prematurity, retinitis pigmentosa, and other congenital abnormalities.

This system detects objects and translates the detected signals into audio cues. Bluetooth is utilized for audio navigation. The stick is lightweight, user-friendly, energy-efficient, and simple to operate.

II. EXISTING SYSTEM

In the past, numerous studies have been conducted on blind sticks designed for visually impaired individuals. These sticks typically incorporate features such as object detection sensors, buzzers, vibration sensors, and GPS. Historically, visually impaired people have largely relied on family, friends, and relatives for assistance with daily tasks and activities, which is not always feasible for everyone. Many visually impaired individuals have primarily used traditional cane sticks.

III. PROPOSED SYSTEM

The proposed smart stick system incorporates various components, including an ESP32 microcontroller, radar sensor, ultrasonic sensor, speaker, Bluetooth, Wi-Fi, camera, Google Assistant, LDR sensor, vibration sensor, buzzer, water sensor, battery, and solar panel. The camera is utilized for object detection, converting the captured image into an audio signal. Navigation is facilitated for the front, left, and right sides of the stick. The LDR sensor is used to distinguish

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between daylight and nighttime conditions. The stick is powered by a 6V battery and is equipped with a solar panel for additional energy support.

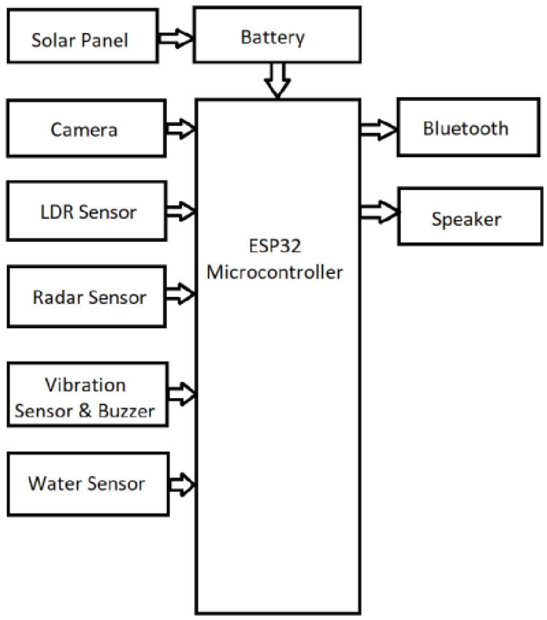

Fig.1 Block Diagram

The smart stick is designed to be user-friendly and easy to understand. Objects in the path of the visually impaired person are detected using a radar sensor, and the camera captures an image of the object. This image data is sent to the ESP32 microcontroller, where it is processed and converted into an audio signal. The audio signal is then delivered to the user via a speaker or headphones. When the user begins using the smart stick, its sensors are activated, and any objects detected by the camera are processed and transmitted to the ESP32 for further action.

IV. METHODOLOGY USED

ESP32

The ESP32 is a versatile microcontroller featuring Bluetooth, Wi-Fi, multipurpose GPIO ports, Bluetooth 4.2 with BLE, and Wi-Fi 802.11 b/g/n. It includes interfaces such as UART and PWM, as well as an integrated camera. The operating voltage is 0.5 V DC. It offers 512 KB of internal storage and 4 MB of external storage, along with an onboard TF card slot that supports 4G cards for additional storage.

Fig. 2 ESP32 Module

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Camera

The OV5640 camera module, used for object detection, features a 5MP sensor. It connects to the ESP32 to capture images with a maximum resolution of 2592 x 1944 and supports an image transfer rate of up to 60 frames per second. The module operates on a 3.3V power supply. It includes automatic image control functions such as Automatic Exposure Control (AEC), Automatic White Balance (AWB), Automatic Band Filter (ABF), and Automatic Black Level Calibration (ABLC). The data interface is an 8-bit DVP.

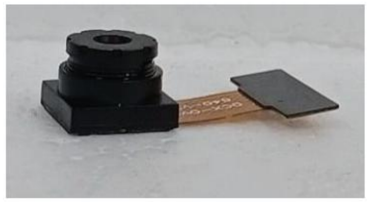

Fig. 3 OV5640 Module

RCWL – 0516

The RCWL is a Microwave Radar Sensor that serves as an alternative to the PIR motion sensor, offering a 360-degree detection area. This sensor detects movement within its range by calculating the distance to an object based on the time it takes for microwaves to return to the sensor. This data can be used to map the surrounding area.The microwave sensor is preferred for its extended coverage range and uses Microwave Doppler Radar to detect moving objects. It supports a power supply range of 4 to 28V and provides adjustable block time and detection distance. The sensor outputs a 3.3V power supply and is highly flexible for use with microcontrollers. It offers a 2-second retrigger time with motion detection and operates at a frequency of 3.2 GHz.

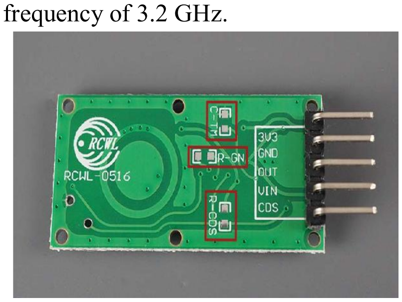

Fig. 4 RCWL 0516 Module

Vibration Sensor

When an object is detected, the signal is simultaneously converted into an audio signal. Additionally, the smart stick vibrates when an object is nearby. A vibration sensor is used in the smart stick to ensure compatibility and to measure the vibration frequency. These sensors operate by detecting the motion of an object or material through its frequency. Faster movements result in higher frequencies being detected. These frequencies can also help identify imbalances. The vibration sensor outputs a signal in the range of 4-20 mA.

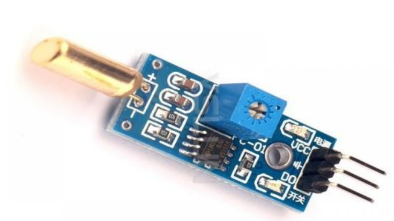

Fig.5 Vibration Sensor

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LDR Sensor

The Light Dependent Resistor (LDR), also known as a Photoresistor, is a light-sensitive device used to detect the presence or absence of light. Its resistance varies based on the amount of light falling on it. In darkness, the LDR's resistance is very high, but when exposed to light, the resistance decreases automatically. The sensor outputs a voltage of 5V and functions as an analog component. It absorbs light and converts it into an analog value ranging from 0 to 255.

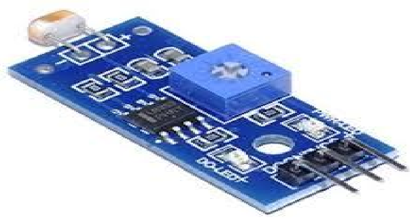

Fig.6 LDR Sensor

Water Sensor

A water sensor is employed to detect water levels and identify slippery surfaces on the path, ensuring a safe and secure route for visually impaired individuals.

Fig. 7 Water Sensor

Ultrasonic sensor

An ultrasonic sensor is integrated into our smart stick to measure the distance between the user and nearby objects. We have utilized the HC-SR04 model, known for its high accuracy. This sensor is also capable of functioning effectively in foggy weather. The HC-SR04 is a widely used ultrasonic sensor designed for non-contact distance measurement. It works by emitting an ultrasonic sound pulse and calculating the distance to an object based on the time it takes for the echo to return.

Fig. 8 Ultrasonic sensor

Speaker and Buzzer

When an object is detected, the processed signal is converted into an audio signal and transmitted to the user via speakers. A buzzer is used to alert the user about obstacles in their path. The buzzer beeps twice if an object is nearby, and it buzzes three times consecutively if the object is directly in front of the user, providing a clear warning about the obstacle.

Fig. 9 Speaker and Buzzer

Battery and Solar Panel

The smart stick is powered by a rechargeable 6V lithium polymer battery, capable of providing energy for up to 4 hours. To recharge the battery, a 6V solar panel is integrated into the stick. This solar panel absorbs sunlight and converts it into energy, ensuring the battery remains charged using renewable solar power.

Fig. 10 Battery and Solar Panel

V. CONCLUSION

The smart stick we developed is simple to use and easy to handle. Its lightweight design makes it convenient to carry anywhere. To address situations where the user forgets to recharge the battery or lacks access to a power source, we have included solar panels that automatically charge the battery using sunlight. The stick also features a navigation system that guides the user along their path.

Sensors are placed on the left, right, and front sides of the stick to detect objects and motion. Detected object signals are converted into audio signals and transmitted via Bluetooth to a speaker. A moisture sensor is included to detect water and slippery surfaces, helping to prevent accidents. Additionally, we have incorporated an emergency button that sends the user's location to designated contacts such as family, friends, or an operator.

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