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Internet of Things Assisted Intelligent Walking Stick for Visually Impaired People to Identify Obstacles

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Abstract — Those who are blind or have low vision have a far more difficult time travelling independently. There have been attempts to address the needs of the visually handicapped, but the problems that these solutions have failed to address have persisted. To help the visually impaired with everyday navigation and recognizing persons around them, the project proposes a novel concept for a smart blind stick equipped with a facial recognition technology. A smart blind stick, equipped with many sensors, will be developed as part of this project to assist the visually impaired. The specially-designed stick can detect potential dangers such as stairs, water, vibration, and fire, and it can then notify the visually impaired individual of these threats through haptic and auditory input. A blind person's loved ones may be immediately notified of any assistance needs with the Stick's "help me" button, and the device's Internet of Things (IoT) modem allows for real-time position tracking. An on-board camera allows the blind person to capture images of obstacles as they arise, classify them using object recognition and deep learning, and then get audio cues to let them know what they're up against. The proposed method establishes a connection to a server in the cloud by means of Internet of Things protocols and an Android web application.

Keywords: *Arduino UNO; Ultrasonic Sensor; Obstacles; Visually Impaired; Blind; Walking Stick; Internet of Things.*

1. Introduction

Visually impaired people have a harder time interacting with and perceiving their surroundings. A person with visual impairments has trouble making physical touch with their environment, moving about, and recognizing potential barriers [1]. Therefore, travelling from one place to another might be quite a hassle. Without the help of loved ones or friends, those who are visually impaired would be unable to get from one location to another independently [2][3]. Therefore, they rely on their family for everything, both materially and emotionally.

There are a lot of systems out there that assist the visually impaired, but they all have their limits. Researchers have been attempting to comprehend their needs and create a solution to assist them for decades [4]. In further research, the "Smart Stick" proved to be an indispensable tool for the visually impaired, providing them with the necessary information to navigate safely and avoid hazards [5][6]. Although aluminium cane has recently replaced wood cane, the former was the standard material for blind canes. Unfortunately, this walking stick won't be able to help the visually impaired keep their independence as we go farther into the contemporary day and the age of automation. Installing ultrasonic sensors at crucial locations allows the proposed SBS to identify possible obstacles. It also has sensors that may identify potential roadblocks for the user. By communicating with an Arduino-programmed microcontroller, the aforementioned sensors establish a connection to the security system.

The user is notified of obstacles with a vibrator and a buzzer by the alarm system. You may take this battery-operated device with you anywhere you go. The reliability of the equipment's results is assured by its meticulous construction. A smart stick allows the visually impaired to more easily traverse their environment, take part in social events, and become self-sufficient. In both public and private settings, it notifies the user with an automated switch that may be activated by voice command [7]. Using the Vilo Jones algorithm and an Arduino, the suggested solution intends to provide a visually impaired individual with a real-time electronic gadget. A state-of-the-art approach to rapid object recognition, Viola Jones can operate at a frame rate of up to fifteen frames per second. It has the capability to detect things in real-time, which was previously unheard of. This apparatus has a built-in camera that can identify both interior and outdoor impediments [8]. Equipped with an ultrasonic sensor, the smart blind stick can determine the distances between various objects and itself [9]. When an impediment in the path of the smart blind stick comes within range, the microcontroller will activate the speaker or earphones attached to the stick to play the name of the thing. Because of its small weight and excellent detecting capabilities, the smart blind stick is a joy to travel with [10]. The range, however, is constrained by its own size. As a result of using this device, people who are visually impaired are able to move about more freely, travel more easily, and achieve more physical and financial independence. To those who are visually blind, an easy-to-use navigational gadget is like a guide who fills them in on their surroundings.

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The instrument has a plethora of built-in algorithms and programs that tell you the status of whatever is around, such as if something is solid or fluid, and how far away it is from the user. Using components such as a speaker, a raspberry pi, a water sensor, an ultrasonic sensor, and a speech playback board, the suggested system offers a comprehensive view. In order to measure the surface distance between various Internet of Things (IoT) devices and mobile devices with minimal mistakes, this study suggests a new popular technology called Bluetooth Low Energy, or BLE. In this study, we utilize Bluetooth Low Energy (BLE), a protocol that is well-suited for close-range, low-power connection. In order to fix some mistakes gathered from various environmental conditions, some Internet of Things devices feature self-correcting capabilities. Bluetooth Low Energy (BLE) is the most reliable wireless connection standard for short-distance communication. There are certain similarities between Wi-Fi and BLE in terms of their capacity to enable inter-device communication. The intended use cases of BLE place a premium on battery life rather than rapid data transmission rates. Due to the tiny amount of data that has to be sent to a visitor's smartphone, Bluetooth LE certified beacons save power without sacrificing efficiency. The whole Bluetooth BLE communication system makes use of 40 frequency channels; spaced 2MHz apart, to improve data transmission speeds while reducing battery consumption. We may find a variety of permanent and portable tools and procedures in our environment. In contrast to the fixed sensors, appliances, smart TVs, etc., that are used in homes and offices, wearable devices like smart watches and smartphones are lightweight and simple to take around. Because it can offer proximity between the transmitter and receiver and has very low power consumption—much less than the latest version of Bluetooth—BLE is one of the most trusted technologies among IoT devices. As a popular technology, it is still utilized in our smartphones today.

1.1. Objectives

The use of a blind stick allows the visually impaired to more easily move about in crowded public spaces. The blind individual is required to clear the path ahead of him by adjusting the stick. For a blind individual, the stick represents information about obstacles and the necessity to modify their course when they encounter them. The purpose of the smart blind stick is to help the visually impaired individual see more clearly the way ahead. A few of ultrasonic sensors and a camera allow us to do this. With the use of a camera, the cane can identify when a blind person is getting close to a barrier. The purpose of the smart blind stick is to help the visually impaired individual see more clearly the way ahead. A few of ultrasonic sensors and a camera allow us to do this. With the use of a camera, the cane can identify when a blind person is getting close to a barrier. The data is obtained from an Android device when the impediment is recognized and analyzed.

Over Bluetooth ear buds, the blind individual receives spoken instructions based on the received data, which represents the identified impediment. For the purpose of detecting impediments on each side, the stick is equipped with ultrasonic sensors. Because of this, we are able to educate the blind person more effectively on how to safely avoid the barrier. An Arduino UNO is used to manipulate the data of the ultrasonic sensors. Our goal is to develop a more effective and user-friendly navigation system for the visually impaired by utilizing the data collected by these technologies. With the use of this stick, they are able to become more independent. Prioritizing comfort and safety, the system is also economical.

1.2. System Applications

The proposed work's primary requirements and uses are as follows.

- Orientation in indoor as well as outdoor settings is possible with this technology.
- An extra layer of security can be provided by constantly monitoring the whereabouts of a blind individual.
- Uses vibration warnings and verbal output to notify the blind individual of impending danger.

2. Related Study

It is extremely difficult for a blind person to locate a lost stick and much more difficult for them to identify the existence of impediments [11] while they are going from one area to another. As a result, the smart stick is an advocated approach to assisting the vision impaired in their daily lives independently. In this study, we offered an ultrasonic sensor-equipped blind stick as a potential remedy for the visually impaired. This device can detect barriers up to four meters away, and it can detect even closer dangers in front of visually impaired persons using an infrared sensor. As a result, the user may pinpoint the precise position of the smart stick using the buzzer, thanks to the radio frequency transmitter and receiver. Upon detection of an obstruction, the smart stick's vibration motor is triggered, causing it to vibrate. The Arduino UNO serves as the controller in this approach. The branch can detect any obstacles that the user may encounter. In addition to being easy to handle and fold, the smart stick is user-friendly, responsive, lightweight, and has extremely low battery usage [11].

All these new innovations and technology are making the planet feel small [12]. As we have seen in recent years, people all around the globe are embracing technology to

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boost their productivity and influence. As a generation committed to making a greater impact through technology, this research study aims to suggest an automated model for the blind stick that the visually impaired use. The goal is to create a more inclusive and accessible environment for the blind community. By including the required sensors and the Arduino UNO microcontroller, this model has been produced effectively using the notion of the Internet of Things [IoT] [12].

As with many other problems, blindness is beyond the control of people [13]. It robs people of the chance to see the world's vibrant visual splendour. When individuals have so many obstacles in their daily lives just to do the most fundamental things, missing out on nature's beauty becomes one of their least concerns. Getting about, whether on foot, in a car, or on a train, is a major challenge for them. In order to accomplish so, they constantly need human help. However, there are instances when individuals are left powerless because no one is willing to lend them a hand. Their self-assurance takes a nosedive due to their dependence. They have long relied on the traditional cane stick to navigate, which they use to touch and poke at obstructions. They and others are put in harm's way because of how often this happens. We chose to help these disabled people by developing a tech-based solution because we live in a tech-driven world. "Smart Stick" is what we name it [13]. It is a tool that detects barriers in the user's path and provides guidance accordingly. Using a network of sensors built inside it, it will detect and eliminate any and all roadblocks. In order to alert the user of impending obstacles, the microcontroller will gather relevant data and transmit it via vibrations. It is a practical aid that will be of great use to the visually impaired [13].

The daily lives of visually impaired individuals (VCPs) are fraught with challenges [14]. They lack self-assurance in strange situations since they often have to rely on other people. As a result, we offer a tool in this study that might assist them identify impediments and puddles. A walking stick and apps developed for the Android platform make up this system. A Raspberry Pi and programmable interface controller (PIC) serve as the walking stick's control kernel. It also includes sensors, a GPS module, and components that provide alerts. The VCP is alerted by vibrations or a buzzer based on the identified impediment, which is done via sensors. With the use of an app, parents can keep tabs on where their VCP is at all times thanks to the GPS module. In case of an emergency, the VCP may quickly contact loved ones using an emergency app or by shaking the phone or pressing the power button four times in five seconds [14]. With fewer parts, we were able to create a gadget that is easy to use, lightweight, and packed with useful functionality. With this technology, VCPs will be able to live independently (with protection) to a certain degree, which will boost their confidence in an unfamiliar setting [14].

Millions of individuals throughout the globe are either blind or severely visually handicapped [15]. When they are in an unfamiliar place, they can only rely on other humans or trained animals to help them navigate. The standard walking stick is inadequate for the guiding and safety needs of the visually impaired. A smart cane that can sense and indicate the elements of its surrounding environment is the main subject of this article, which is written with the purpose of assisting visually impaired persons. The suggested smart cane is equipped with two ultrasonic sensors that measure the distance between the cane and any obstacles, whether they are fixed or dangling. An alarm will be sounded by the actuator if the obstacle's descent is within a 2-meter threshold. In addition to obstacle detection, the design incorporates a camera module ESP-32 to capture the picture of moving objects or people. In order to reduce processing time and capture images of moving objects or people, the PIR sensor sends an enable signal to the camera module. Furthermore, in the event of an emergency, it informs the blind person and their loved ones about the surrounding area. The smart cane's power requirements and implementation cost are detailed in order to create a stick with a built-in camera [15].

3. Methodology

As things stood, the blind relied on white canes, and dogs quickly became synonymous with the ability to guide the visually impaired. Using a white cane to navigate stairs or streets is a major challenge for the visually impaired. In subsequent attempts, a remote sensor was added to the cane in an effort to enhance it. White canes are the most common kind of handheld mobility assistance.

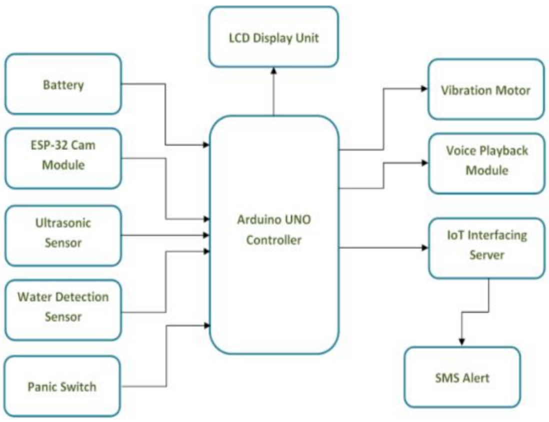

Fig.1: Block Diagram

The majority of them are collapsible and height-adjustable. The individual may "scan" the road ahead in about a swing-like motion. Canine Direction: A guide dog

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is a canine that has had extensive training to help the visually impaired avoid obstacles and follow predetermined routes; however, it will not often aid with way finding unless the route is well-known. Previous studies in this area have had some constraints, such as the following: the system is designed to be affordable for visually impaired individuals, and reducing costs often comes at the expense of performance. Figure 1 below shows the schematic of the method that has been suggested.

There are two parts to this system, and they are the blind stick and the head unit. Utilizing an ultrasonic sensor, we outfit the blind stick. Objects at a certain distance can be located with its help for the visually impaired. To determine how deep the blind walking region is, a conductivity sensor is utilized. In this apparatus, an Arduino controller is employed. Figure 2 shows the perspective of the Arduino controller used in the suggested strategy.

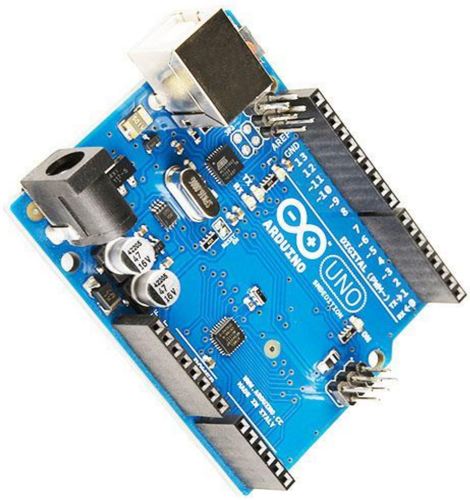

Fig.2: Arduino UNO

Sensor data is received by the controller, which then vocally speaks with visually impaired people. Another part of the headset that we use is the microcontroller. Through the use of a speech processor and speaker, the controller will proclaim information. A caregiver may see the user's real-time location using the system's Internet of Things (IoT) capabilities on a server in the cloud; all they need is the user's credentials to access the server from any computer or smartphone. To protect the privacy of the visually impaired user, each person involved has their own unique set of credentials, and only those with whom the visually impaired user feels safe sharing them can do so. A smartphone app that can find the blind stick and alert a guardian of the user's current whereabouts in the event of a crisis and ESP32-CAM control unit Also, the parent's registered Telegram app will receive the picture shot by the ESPCAM32. Figure 3 shows the perspective of the LCD display used in the suggested method.

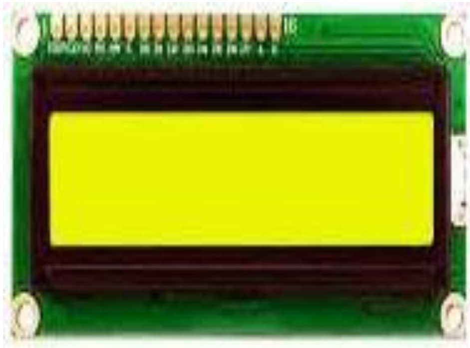

Fig.3: LCD Display

The following figure, Fig-4 represents the view of Water Identification Sensor utilized over the proposed approach and the following figure, Fig-5 represents the view of Ultrasonic Sensor.

Fig.4: Water Identification Sensor

Fig.5: Ultrasonic Sensor

The following figures, Fig-6, Fig-7 and Fig-8 represent the view of Vibration Motor, Voice board and ESP-32 Cam Module utilized over the proposed approach.

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Fig.6: Vibration Motor

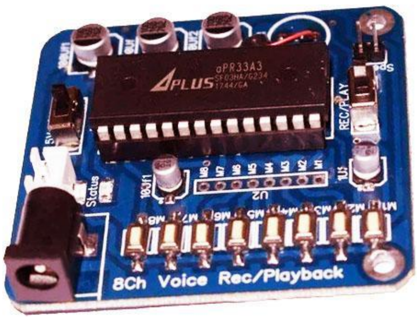

Fig.7: Voice Module

Fig.8: ESP-32 Cam Module

A transmitter and a receiver are the two main components of this suggested system. A battery or other power source is unique to each device. All of the components receive their power from it. Our controller is an Arduino. It features twenty-eight pins. We resemble a blind stick and are equipped with four ultrasonic sensors. Objects at a certain distance can be located with its help for the visually impaired. A conductivity sensor measures the water level in the area where visually impaired individuals walk. They link to ports A0–A5 on the ultrasonic sensor's controller. Port 10 on the controller is where the conductivity sensor is connected. The controller receives data from all of the sensors and uses it to increase a threshold value, which the blind people may then hear as an alarm. Connected to the voice processing unit are the controllers 2 and 3 pins. Speakers use it to announce the information.

4. Result and Discussions

Some of the problems with earlier smart blind sticks include an inability to determine the object's condition, such as whether it is solid or liquid. When tested with a arduino microcontroller and an Electronic Travelling Aid (ETA), several blind sticks failed to accurately measure the distance from the visually impaired person to the target. In light of these concerns, we have upgraded the blind stick to a newer model that uses Viola Jones's algorithm and flexible Internet of Things devices to provide precise distance calculations and item status updates. An Arduino UNO, Bluetooth, soil moisture meter, and three ultrasonic sensors are all part of the blind stick's equipment. Aside from keeping tabs on the user's surroundings, the Smart Blind Stick's built-in sensors may identify any hazards in the user's way. The hardware configuration of the suggested approach is shown in Fig. 9, which includes the following components: an LCD display, an ultrasonic sensor, a water sensor, a vibration motor, an Arduino UNO, and an ESP8266.

Fig.9: Proposed Hardware Prototypical Model

The following figures, Fig-10 and Fig-11 represents the view of proposed Internet of Things (IoT) login portal and the view of Location Details obtained from the hardware unit.

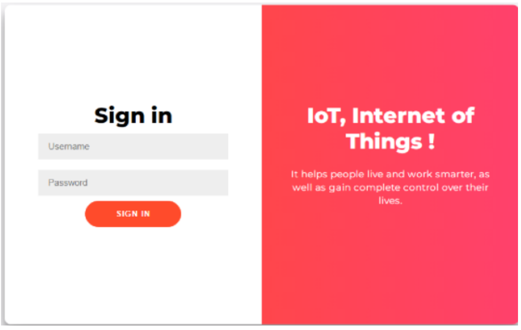

Fig.10: IoT Login Portal

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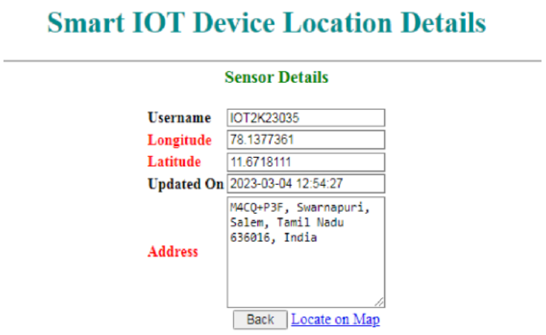

Fig.11: Location Details

5. Conclusion and Future Scope

People who are visually blind typically rely on canines or sticks to help them navigate everyday tasks securely. As technology has progressed, assistive sensors have been included onto contemporary sticks to help users recognize objects and navigate their surroundings. In order to aid the visually handicapped, this study introduces a smart stick with obstacle detection and identification capabilities. Thanks to its many features—including obstacle identification and acknowledgment, water pool identification, sound communications, tactile input, live location communication, and a panic signal for emergency assistance through SMS—the suggested IoT-enabled smart stick with barriers detection could allow the visually impaired to venture out into the world independently. In addition, the suggested smart stick detects obstacles in the user's vicinity using ultrasonic sensors and camera modules, and then uses earphones and vibration motors linked to the controller to provide feedback. It is completely autonomous and requires no user input. Both the obstacle detection and recognition mode and the obstacle detection mode with longer battery life and additional accessibility features, respectively, are beneficial. At any point along the route, the visually impaired individual can get information on the obstacles ahead thanks to the system's continuous operation. So, the sight impaired may go about their day-to-day lives with ease and confidence thanks to this clever stick; they won't have to worry about tripping over obstacles or hurting themselves.

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