



GUIDEYE: INTELLIGENT NAVIGATION SYSTEM FOR THE BLIND USING IOT

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Abstract: The problem of navigation assistance for visually impaired people is still a challenge due to the lack of environmental awareness and the high probability of encountering obstacles during navigation. Existing navigation aids like white canes are only limited to providing basic assistance and cannot detect obstacles at varying heights and distances. This paper proposes the design and implementation of a Smart Blind Stick, which is based on IoT technology and aims to help visually impaired people by enhancing their safe navigation and communication during emergencies. In this proposed system, an ESP32 module, ultrasonic sensors, and a servo motor are used to detect obstacles in different directions, i.e., left, front, and right, whereas another ultrasonic sensor is used at the bottom of the stick to detect obstacles at low levels. The system constantly monitors the environment and provides instant feedback using a buzzer alert system. This helps the user recognize the location of the obstacles. In addition to this, the system communicates with a mobile application using Bluetooth technology. This mobile application provides voice-based alerts for the direction of the obstacle. The mobile application also includes a GPS-based emergency alert system, which helps the user send their location to caregivers using Telegram and SMS by pressing a button. This provides double assurance of emergency alerting even when the internet connection is limited. The proposed solution incorporates low-cost hardware components, wireless communication, and mobile application support to design a practical and user-friendly assistive system. Experimental evaluation of the proposed system has shown that obstacles within a predetermined range can be successfully identified and alerted to prevent accidents. The proposed Smart Blind Stick is portable, cost-effective, and easy to use, making it a viable solution to improve the safety and mobility of visually impaired people in real-world environments.

Index Terms - Smart Blind Stick, Internet of Things (IoT), Assistive Technology, ESP32 Microcontroller, Ultrasonic Sensors, Obstacle Detection, Servo Motor, Bluetooth Communication, GPS Location Tracking, Emergency Alert System, Mobile Application.

I. INTRODUCTION

The visually impaired face many challenges when trying to navigate their environment. This is due to the lack of visual perception and environmental awareness. Independent mobility plays a crucial role in the daily lives of visually impaired people. However, the existence of barriers like walls, cars, stairs, and uneven surfaces presents a big challenge. The conventional white cane provides some assistance to the visually impaired by detecting obstacles that are in direct contact with the ground. However, this device fails to detect obstacles at varying heights and distances. This leads to difficulties experienced by the visually impaired when trying to navigate unfamiliar environments.

The problem identified by this work is the lack of an efficient, affordable, and intelligent navigation system that can provide obstacle detection as well as emergency communication services. The safe and independent movement of visually impaired people plays a crucial role in improving their quality of life. Therefore, there is a need to develop technologies that can improve the lives of visually impaired people.

For instance, existing devices such as white canes and guide dogs have their own limitations. While white canes cannot sense obstacles above ground level, guide dogs require extensive training and maintenance. Even though there are electronic assistive devices, most of them are expensive, complex, and do not support modern communication services such as mobile applications. Some of these devices do not offer effective ways of sharing the location of the user in case of an emergency.

To overcome the drawbacks of the existing blind sticks, this project proposes the concept of a smart blind stick using Internet of Things (IoT) technology. In this smart blind stick, the system consists of an ESP32 microcontroller, ultrasonic sensors, and a servo motor. The blind stick can detect obstacles in different directions, namely left, front, and right. In addition to this, the blind stick also has a sensor located at the bottom to detect obstacles that are low in height. The system also has a buzzer for providing alerts to the blind person and a Bluetooth connection to the mobile application for voice-based alerts. In addition to this, the system also has a GPS-based emergency alert system that helps the blind person to share their location using Telegram and SMS.

The purpose of this work is to create a cost-effective, portable, and reliable assistive navigation system that improves the ability to detect obstacles and has efficient emergency communication for the visually impaired.

II. SYSTEM ARCHITECTURE

The proposed Smart Blind Stick system follows a modular architecture designed for efficient obstacle detection, real-time processing, and reliable communication. The architecture consists of four major layers: Sensing Layer, Processing Layer, Communication Layer, and Application Layer.

A. Sensing Layer

The sensing layer is the part of the robot that collects the environmental information from the surroundings. It is composed of ultrasonic sensors attached to the stick, which help to detect obstacles from different directions, e.g., from the left, front, and right of the robot. There is also a bottom ultrasonic sensor to detect small obstacles or holes, as well as a push button for emergency alerts.

B. Processing Layer

The processing layer is done using the ESP32 microcontroller, which serves as the core control unit of the entire system. This microcontroller processes the data it receives from the sensors and determines the existence and direction of the obstacles. The microcontroller also controls the servo motor in the scanning process. Based on the processed data, the microcontroller activates the buzzer and sends the data to the mobile application.

C. Communication Layer

This layer facilitates communication between the hardware system and the mobile application. Bluetooth communication is used for this purpose. The ESP32 sends information related to obstacle detection to the mobile application. This layer provides real-time and reliable communication between the stick and the mobile application.

D. Application Layer

The application layer comprises the mobile application, which is developed using the MIT App Inventor platform. The application provides voice alerts on the direction of the obstacles and the status of the system. In addition, the application has a GPS-based emergency alert system, which helps users send their location to the caregiver through Telegram and SMS services. This layer increases the level of user interaction and safety through proper communication.

III. IMPLEMENTATION

A. Obstacle Detection Module

The obstacle detection module is the part of the system that is used to detect the objects in the path of the user. The system uses ultrasonic sensors that are fixed on a servo motor to scan the surroundings in different directions, i.e., left, front, and right, etc. The servo motor rotates the sensors to a certain degree to cover a wider area of detection. The bottom ultrasonic sensor is also used to detect low-level obstacles or pits in the path of the user.

B. Alert and Feedback Module

The alert module provides real-time feedback to the user based on detected obstacles. When an obstacle is detected within a predefined range, the system activates a buzzer to generate audio alerts. Additionally, the ESP32 sends data to the mobile application via Bluetooth, where voice alerts are generated to indicate the direction of the obstacle (left, front, or right). This dual alert system enhances user awareness and safety.

C. Communication and Mobile Application Module

The communication module enables interaction between the smart stick and the mobile application. The ESP32 uses Bluetooth communication to transmit obstacle data to the mobile device. The mobile application, developed using MIT App Inventor, processes this data and provides voice feedback to the user. The application also retrieves GPS location data from the mobile device.

D. Emergency Alert System

The system includes an emergency alert feature triggered by a push button on the stick. A single press sends an automatic alert through Telegram, including the user's current GPS location. Long press triggers an SMS alert as a backup communication method. This dual alert mechanism ensures reliable communication during emergencies.

E. Emergency Alert System

All the hardware devices, like sensors, ESP32, buzzer, and servo motor, are integrated on the PCB and fixed on the walking cane. The complete device is compact, portable, and energy-efficient, which makes it easy to use for visually impaired people.

IV. RESULTS

The proposed Smart Blind Stick system was evaluated based on its obstacle detection capability, system responsiveness, reliability of communication, and emergency alert features. The system was tested under various environmental conditions to ascertain its precision and real-time response.

A. Performance Metrics

The system was also efficient in terms of real-time response. The ultrasonic sensors were efficient in detecting obstacles within a range of 50 cm. The response time was also minimal. The servo motor was efficient in scanning between 0° and 180° to detect obstacles in a specific direction. The response time of the system in detecting obstacles and generating signals was observed to be within a time of less than 1 second. The Bluetooth communication between the ESP32 and the mobile app was efficient.

B. Detection Accuracy

The obstacle detection system was able to detect obstacles in the left, front, and right directions based on the servo position. The bottom sensor was also effective in detecting low-level obstacles and pits within a range of 20 cm. The system was also consistent in its results in normal conditions, both indoor and outdoor. It is estimated that the accuracy of the system is about 90-95%.

C. System Efficiency

The integration of hardware and mobile application improved the efficiency of the system. The buzzer and mobile voice alerts gave instant feedback, thus reducing the possibility of collisions. The emergency alert system successfully sent GPS location via Telegram automatically and SMS alert as a backup. The system reduced the need for assistance and improved user independence.

Table 1 Performance evaluation summary

Metric	Value	Description
Obstacle Detection Range	Up to 50 cm	Effective detection distance
Bottom Sensor Range	Up to 20 cm	Pit/low obstacle detection
System Response Time	< 1 sec	Detection to alert time
Bluetooth Communication	Stable	Real-time data transfer
Detection Accuracy	~90–95%	Obstacle identification accuracy
Telegram Alert	Successful	Automatic alert delivery
SMS Alert	Successful	Backup emergency alert

C. Comparison with Existing Systems

The proposed Smart Blind Stick has better performance compared to other assistive devices and traditional devices used for guiding visually impaired people. The proposed Smart Blind Stick has better performance compared to other assistive devices and traditional devices used for guiding visually impaired people. Unlike other traditional devices such as white canes that can only sense obstacles on the ground, the proposed Smart Blind Stick can sense obstacles from all sides (left, front, right, and below) through ultrasonic sensors and servo scanning. Unlike other assistive devices for visually impaired people, such as electronic blind sticks that can only sense obstacles in one direction, the proposed Smart Blind Stick has better performance compared to other assistive devices and traditional devices used for guiding visually impaired people. The proposed Smart Blind Stick has better performance compared to other assistive devices and traditional devices used for guiding visually impaired people. Furthermore, the provision of an emergency alert system that uses both Telegram and SMS provides an advantage over existing assistive technologies that do not provide an emergency alert system or provide an emergency alert system that is dependent on the internet. This is because SMS can function even without an internet connection. Overall, the proposed assistive technology provides an advantage in terms of cost-effectiveness, portability, usability, safety, real-time navigation, and emergency communication over existing assistive technologies.

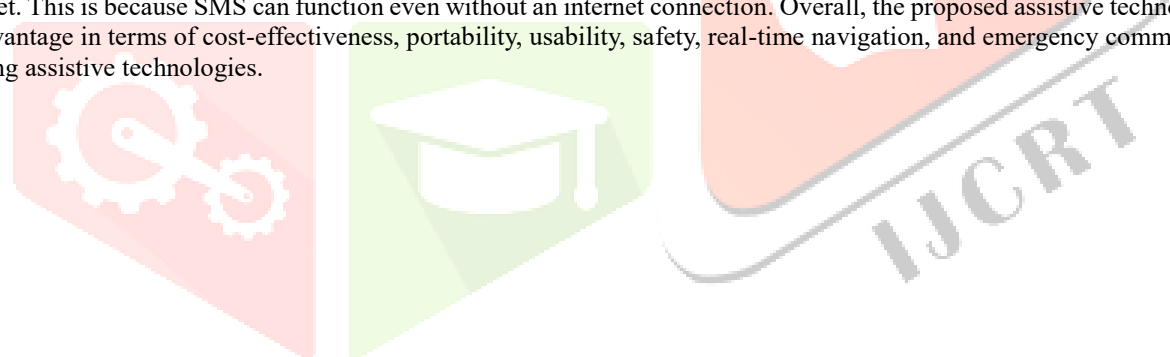




Figure 1.0: Smart Blind Stick

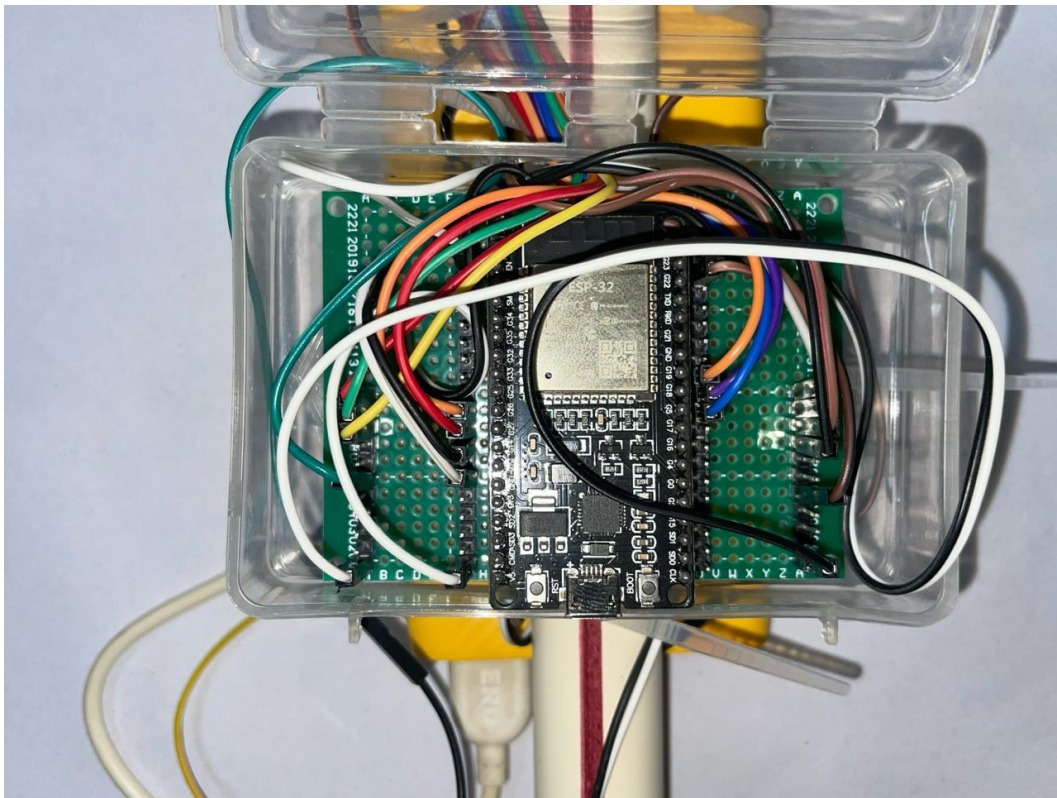


Figure 1.1: Processing Unit

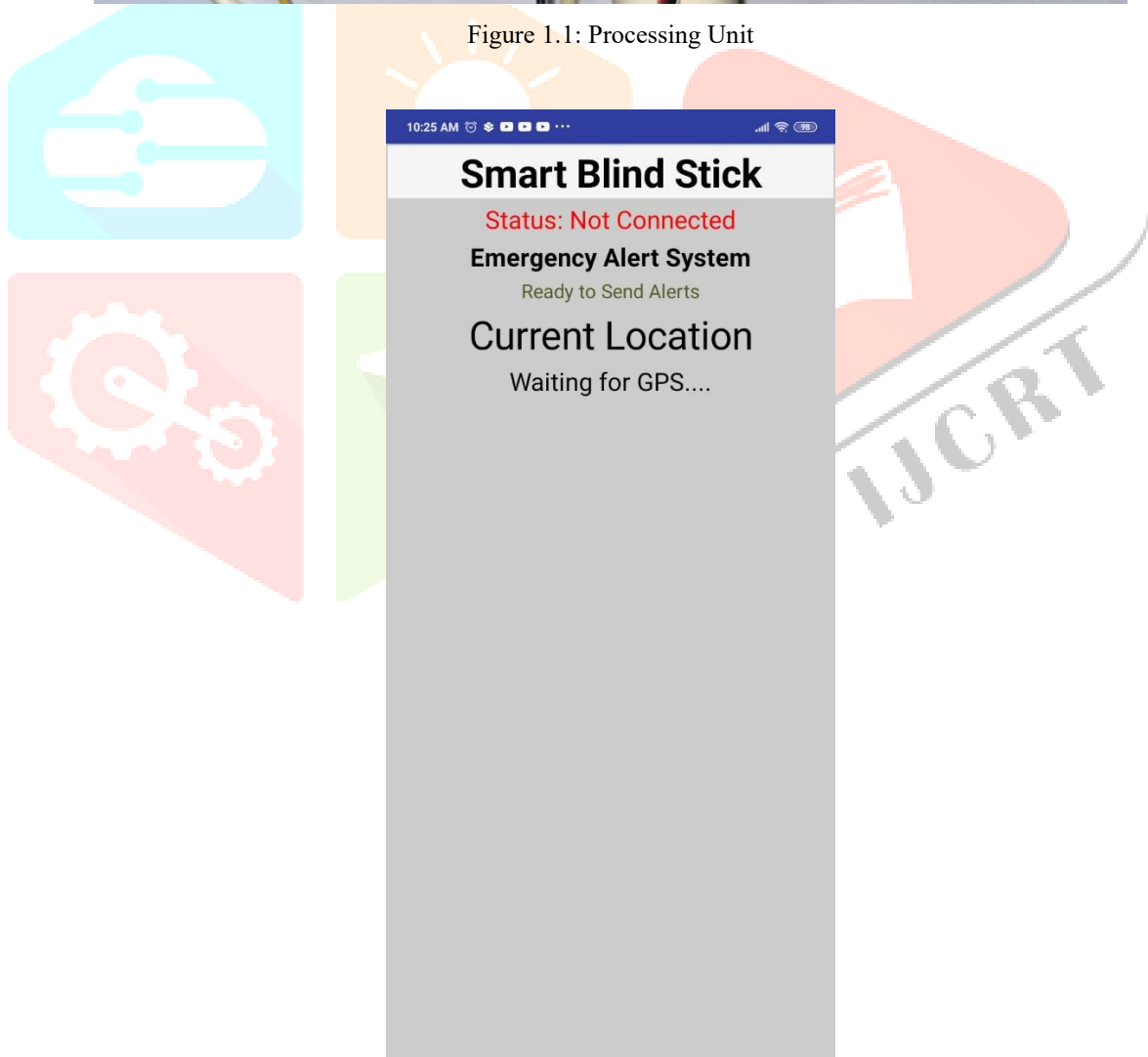


Figure 1.2: Smart Blind Stick when not connected to APP

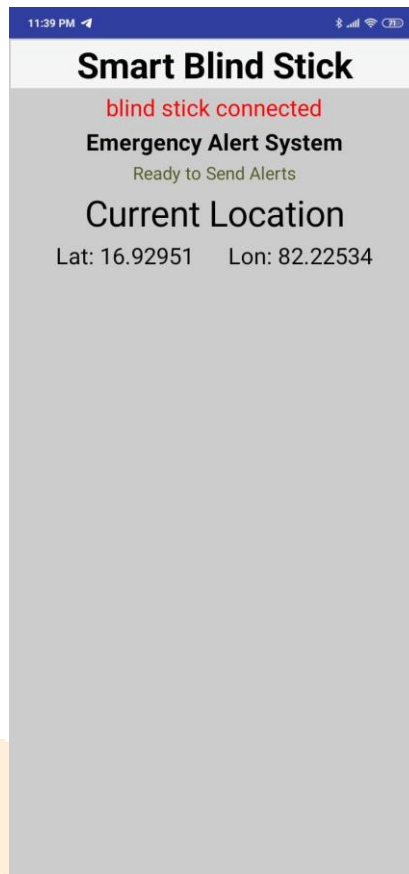


Figure 1.3: Smart Blind Stick when connected to APP



Figure 1.4: Telegram alert messaging

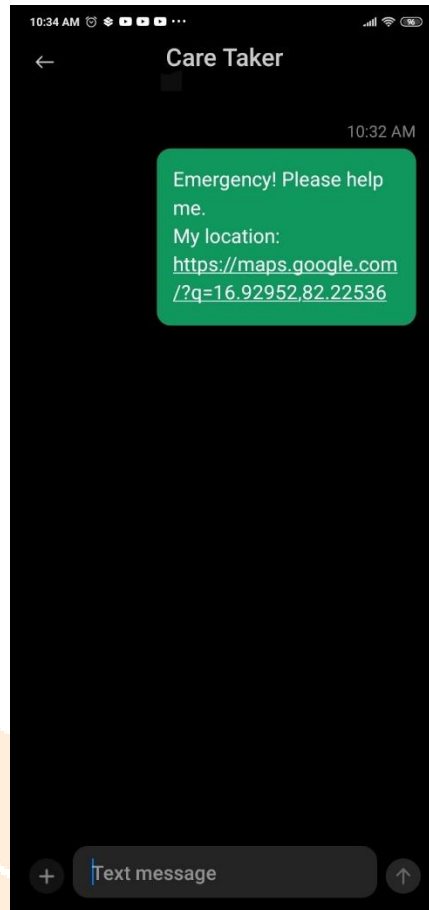


Figure 1.5: SMS alert messaging

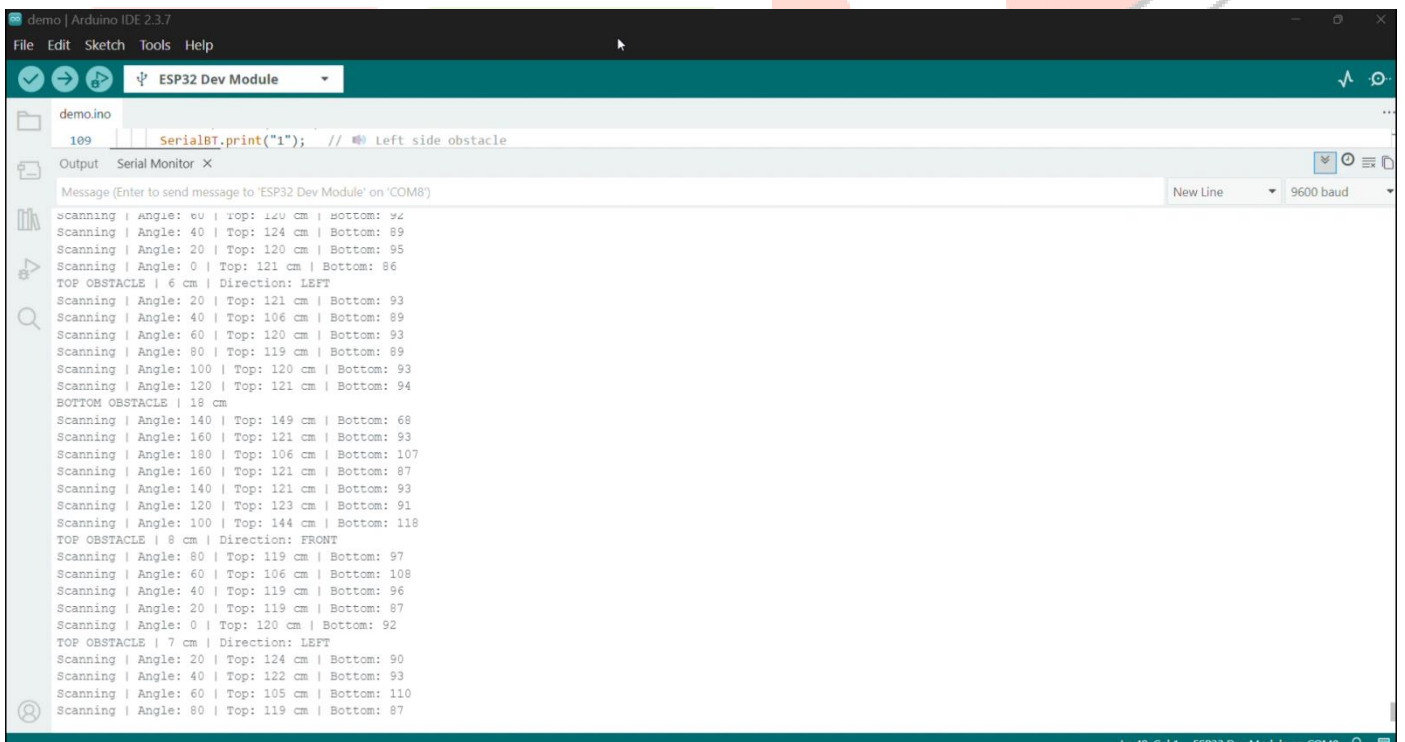


Figure 1.6: Outputs of the device in serial monitor

V. CONCLUSION

The project involved the design and implementation of a smart blind stick for the visually impaired to enable safe navigation using IoT technology. The project was successful in integrating the ultrasonic sensors, ESP32, and servo motor to enable the detection of obstacles from different directions, including the left, front, right, and below the device. The device enables the user to be aware of the surroundings using a buzzer and a mobile app-based voice message.

The project entailed the creation of a smart blind stick for the visually impaired to help them navigate through their environment using IoT technology. The project was successful in incorporating the ultrasonic sensors, ESP32, and the servo motor to help detect obstacles coming from different directions, either from the left, front, right, and below the blind stick. This device helps the user to be aware of their surroundings using a buzzer and voice message sent through a mobile application.

The project required the development of a smart blind stick for the visually impaired, which will assist them in moving around their environment with the help of IoT technology. The project was successful in the integration of the ultrasonic sensors, ESP32, and the servo motor, which will assist in the detection of obstacles coming from various directions, either from the left, front, right, and below the blind stick. The device will assist the user in being aware of their environment through the buzzer and the voice message sent through the mobile application.

The project involved the creation of a smart blind stick for the visually impaired. This blind stick will help the visually impaired navigate their environment with the aid of IoT technology. The project was a success in terms of the integration of the ultrasonic sensors, ESP32, and the servo motor, which will help in the detection of obstacles coming from different directions, either from the left, front, right, and below the blind stick. This will help the blind stick user become aware of their environment using the buzzer and voice message sent by the mobile application.

ACKNOWLEDGMENT

We gratefully acknowledge the support and guidance provided by the Department of CSE - AIML at Aditya College of Engineering & Technology (A). We extend our sincere appreciation to the institution authorities for providing the necessary resources and infrastructure for this research. We also thank our peers and mentors who provided valuable feedback during the development and evaluation phases of this project.

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