

E-BOOK OF EXTENDED ABSTRACT

THE 14TH INTERNATIONAL INVENTION, INNOVATION & DESIGN COMPETITION 2025



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DESIGN COMPETITION 2025

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SMART ASSISTANT FOR VISUALLY IMPAIRED NAVIGATION ON TACTILE PAVING USING ESP32

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ABSTRACT

The main challenge of visually impaired individuals is the movement from one destination to another, especially in urban environment through the public walkways. Even though the local authority has provided the tactile paving facility as the basic guidance for them, it is still lacking the capability to detect nearby obstacles and alert to the blind people. This project aims to propose a smart assistive device for visually impaired individuals to get through tactile paving walkways using ESP32 microcontroller and integrated with proximity sensors. The proof-of-concept (POC) make use the ultrasonic and infrared (IR) distance sensors to detect close obstacles. The system will be alarming to the blind people via a buzzer or speaker when the sensors detected. The suggested prototype, like wearable or handheld, will demonstrate real-time feedback that increases safety for the blinds. Light Detection and Ranging (LiDAR) is proposed to be integrated for the real-world readiness device to improve spatial accuracy. This POC serves to validate the feasibility of a low-cost, sensor-driven mobility assistant. This project has the potential to improve the quality of life for visually impaired individuals in urban environments.

Keyword: Assistive Technology, Tactile Paving, Esp32, Ultrasonic Sensor, IR Distance, Visually Impaired

1. INTRODUCTION

Visual impairment people always face challenges when walking in public walkways alone (Ramgopal & Roshini, 2020). Despite the tactile paving that guide them along safe paths being implemented in most of the city, the blind people still facing difficulties about unexpected obstacles in real-time (Toyoda & Ogata, 2023). This limitation will expose them to a dangerous situation especially in urban environments (Khan et al., 2021). To tackle this issue, we propose the development of a smart assistive system designed to enhance the function of tactile paving through digital sensing and feedback mechanisms (Lu et al., 2022, Bontula et al., 2024). The main objective of this project is to provide the POC for the visually impaired individual with a wearable or handheld device that is based on ESP32 microcontroller board for detecting the obstacles and provide real-time audio alerts. This project emphasises affordability and accessibility, ensuring the solution is practical for real-world use and scalable for future enhancements such as LiDAR and AI-based detection.

2. METHODOLOGY

2.1 System Architecture

The proposed system is built around an ESP32 microcontroller, selected for its processing capability, built-in wireless communication, and energy efficiency. Two types of proximity sensors are used in this prototype:

- a) Ultrasonic Sensor (HC-SR04) for forward distance detection.
- b) IR Distance Sensor (Sharp GP2Y0A21YK) for detecting nearby or low-profile obstacles.

Sensor data is continuously monitored, and when a predefined distance threshold is breached, the system triggers an output alert. Two output methods were tested: a passive buzzer for basic audio feedback and a mini speaker connected through a DFPlayer Mini for voice-based alerts. The prototype is powered via a rechargeable power bank and can be worn or held by the user. Future expansion will integrate LiDAR sensors for more accurate environmental scanning and potentially AI modules for object recognition. Figure 1 and Table 1 shows the wiring instructions, and the components used for the POC.

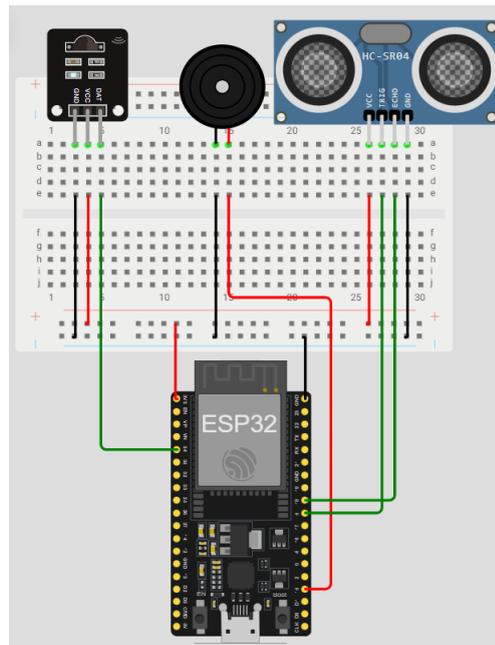


Figure 1 The POC of a smart assistive device wiring instruction.

Table 1 Components use for the POC

Category	Component	Purpose
Microcontroller	ESP32 Dev Board	Core controller for sensor reading, logic, and output
Sensors	HC-SR04 Ultrasonic Sensor	Detects frontal obstacles (up to ~3 meters)
	Sharp IR Distance Sensor	Detects nearby/low-height obstacles (~10–80 cm)
Output (Alert)	Buzzer (Active or Passive) OR DFPlayer Mini + Mini Speaker	Alerts user with beep or voice
Power	18650 Li-Ion Battery + TP4056 Charging Module OR Power Bank	Portable power supply
Others	Breadboard (for prototyping), jumper wires, switch, 3D-printed enclosure or wearable strap	For mounting, wiring, and packaging

3. FINDINGS

Preliminary testing was conducted in a controlled indoor setting simulating common pedestrian scenarios. The system successfully detected obstacles placed within 50 cm to 1 m using ultrasonic sensors and within 10–30 cm using IR sensors. Alerts were triggered within 0.5 seconds of detection. The following table summarizes sample sensor readings:

Table 2 Sample sensor readings

Distance from Object (cm)	Sensor Reading (Ultrasonic)	Sensor Reading (IR)
100	98.2	-
50	49.6	-
30	29.7	28.3
10	-	9.5

4. CONCLUSION

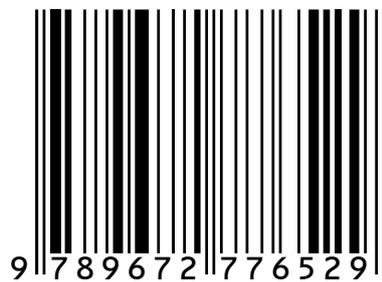
The smart assistive system for visually impaired navigation on tactile paving shows that the use of low-cost sensors and ESP32 can provide improved navigation assistance for visually impaired users. Although the tactile paving able to provide guidance for the users, this solution could enhance the safety of the visually impaired on the walkways with real-time obstacle detection and alert system. The initial design of the POC shows the feasibility of using low-cost components to provide assistive alerts. Future developments will focus on adding LiDAR and intelligent processing to improve detection and responsiveness. This project could help the visually impaired individuals feel safe and consequently could improve their quality of life in the city areas.

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