UKR Journal of Multidisciplinary Studies (UKRJMS)
Homepage: https://ukrpublisher.com/ukrjms/
Email: submit.ukrpublisher@gmail.com
Volume 2, Issue 4, 2026
ISSN: 3049-432X (Online)

A Smart Cane with Integrated Alert and GPS Navigation System for Enhanced Mobility of Visually Impaired Individuals

Jullie Marie R. Ordaniza[1], Fatimah Sherfa M. Arjan[2], Datu Ahmed Zadar L. Bahjin[3], Jhon Kylle C. Clarang[4] Gajil J. Santos[5]

Western Mindanao State University, Zamboanga City, Philippines

***Corresponding Author**: Jullie Marie R. Ordaniza; Gajil J. Santos

DOI: *https://doi.org/10.5281/zenodo.19875560*

Article History
Original Research Article
Received: 09-03-2026
Accepted: 14-04-2026
Published: 29-04-2026

Citation: Jullie Marie R. Ordaniza, Fatimah Sherfa M. Arjan, Datu Ahmed Zadar L. Bahjin, Jhon Kylle C. Clarang & Gajil J. Santos (2026). A smart cane with integrated alert and GPS navigation system for enhanced mobility of visually impaired individuals. *UKR Journal of Multidisciplinary Studies (UKRJMS)*, 2(4), 180-183.

Abstract

Visual impairment has a profound impact on the freedom and mobility of billions of people globally, posing both safety risks and economic challenges. Traditional white canes, while useful for tactile input, are ineffective for detecting high risks or communicating in an emergency. This study outlines the creation of an Arduino-powered smart cane equipped with ultrasonic sensors for obstacle detection and an HC-05 Bluetooth module for emergency notifications. The process included calibrating three HC-SR04 sensors to achieve a 140 cm detection range and integrating an MPU-6050 sensor for fall detection. System testing results show that the cane successfully provides aural and tactile feedback when obstacles are within 75 cm and broadcasts real-time GPS coordinates via a linked smartphone application in the case of a fall. This low-cost approach overcomes the constraints of standard mobility aids by providing a proactive safety net for visually impaired individuals and their caregivers.

Keywords: *Arduino, Assistive technology, Fall detection, Obstacle detection, Smart cane.*

1.0 Introduction

Visual impairment is a widespread health condition that has a substantial influence on an individual's independence, mobility, and general quality of life. According to the World Health Organization (2023), at least 2.2 billion individuals worldwide suffer from near or distant vision impairment, with roughly 1 billion instances that may have been avoided or handled sooner. Beyond personal health, untreated visual impairment has serious economic ramifications, including an estimated $410.7 billion in yearly productivity loss. These data highlight the critical global need for improved mobility solutions to assist visually impaired people.

Despite its practical advantages, the conventional cane has significant limits; its usefulness is limited to detecting obstructions within its physical length, and it does not account for high risks, unexpected fall, or items outside its immediate reach. Furthermore, ordinary canes lack key functions like as real-time communication and position tracking, which are essential for safety and emergency response. While modern innovations have introduced smart canes with ultrasonic sensors and GPS, as demonstrated by the WeWALK Smart Cane 2 (2022) and Ahmed and Raj's (2021) studies, there is still a need for a dependable, low-cost tracking and alarm system that addresses dangerous situations like falls.

The goal of this project is to overcome these limitations by creating an Arduino-powered Smart Cane with an integrated alarm and GPS navigation system. This work is notable because it provides a proactive safety net for visually impaired people and their caregivers by improving mobility, security, and independence using scalable and cost-effective assistive technology.

2.0 Methodology

This section details the procedures used to develop the Smart Cane with Integrated Alert and GPS Navigation. The study follows an experimental research design, emphasizing a low-cost, reliable, and portable solution for visually impaired individuals.

2.1 Research Design

The present study uses an experimental research design to construct and calibrate an Arduino-powered prototype. This design was chosen to enable iterative sensor testing and calibration, ensuring that the device efficiently addresses the limitations of traditional tactile-only canes, such as the inability to identify elevated risks or offer emergency communication.

2.3 Research Instrument

The system acts as a researcher-made technological instrument. It is controlled by an Arduino Nano microcontroller. The integrated components include:

- Ultrasonic Sensors (HC-SR04): Three units used to detect obstacles by measuring distance via sound waves.
- MPU-6050 (Accelerometer + Gyroscope): A 6-axis motion sensor used to detect sudden impacts or falls.
- HC-05 Bluetooth Module: Facilitates wireless communication between the cane and a paired Android smartphone.
- NEO-6M GPS Module: Provides real-time location data (latitude and longitude) for emergency tracking.
- Piezo Buzzer and Vibration Motor: Provide auditory and haptic feedback to the user.
- Power Source: A rechargeable 18650 lithium-ion battery with a TP4056 charging module.

2.4 Data Gathering Procedure

Data was collected through controlled system testing and calibration of the prototype's sensors.

Obstacle Calibration: Sensors were initially adjusted to establish an effective detection range of 140 cm.

Proximity Thresholds: Iterative testing established a 75 cm threshold for high-intensity alerts to prevent user desensitization while maximizing response time.

Emergency Alert Testing: Fall detection was validated by simulating cane drops to trigger the "fall" message transmission from the MPU-6050 through the HC-05 module to a smartphone running MacroDroid.

GPS Accuracy: Accuracy was gathered by comparing the smartphone-reported coordinates against the actual location, with a 5-meter variance defined as the reliability target.

2.5 Data Analysis Procedure

Quantitative data was analyzed to determine the accuracy and responsiveness of the system.

- Accuracy Analysis: Measured across various distances (30 cm to 150 cm) to ensure consistent sensor response.
- Latency Measurement: Latency was measured between a simulated fall event and the reception of the SMS alert on a caregiver's device to ensure rapid emergency response.
- Energy Consumption: A total current draw analysis was performed to predict the continuous operating life of the battery.

2.6 Ethical Considerations

The system prioritizes participant safety and data security by guaranteeing that real-time location data and emergency warnings are only sent to pre-registered contact numbers via the user's own smartphone. This establishes a secure proactive safety net for the user and their caretakers, preventing unwanted location exposure.

3.0 Results and Discussion

This chapter presents the quantitative results from the testing of the Arduino-Based Smart Cane prototype. The evaluation focuses on system accuracy across varying distances, the functionality of the fall detection and emergency alert system, and overall power consumption.

3.1 System Response and Accuracy

The system identifies obstacles and categorizes them into three distinct proximity levels based on ultrasonic sensor feedback. Table 1 outlines the binary response of the system at specified distances.

Table 1. *Distance Variations and Smart Cane Alert Response*

Distance	System response
150	No Alert
120	Alert Activated (Farthest Range)
100	Alert Activated (Medium Range)
80	Alert Activated (Closest Range)
50	Alert Activated (Closest Range)
30	Alert Activated (Closest Range)

The study revealed that the cane uses progressive notifications to prevent user desensitization while maintaining safety. The buzzer and vibration motor are activated at maximum intensity when obstacles are within the closest range (≤ 80 cm) to warn of impending danger. Objects between 81 cm and 110 cm cause a moderate warning, whereas those at the furthest range (111 cm to 140 cm) produce a mild alert. Beyond 140 cm, the system remains inactive since the items are beyond range.

3.2 Fall Detection and Emergency Alert Mechanism

The MPU-6050 sensor's performance was assessed by simulating falls that triggered the emergency procedure. When the microcontroller detects an abrupt impact or tilt, it sends a "fall" string to the HC-05 Bluetooth module and a linked smartphone. The smartphone software (MacroDroid) then sends an SMS and email with real-time GPS coordinates to a registered caregiver.

This capability fills a crucial research gap found in the existing literature, as typical canes lack real-time communication capabilities. The system's integration of automatic notifications greatly decreases emergency response times, offering a proactive safety net that extends beyond simple navigation help.

3.3 Energy Consumption and Reliability

The prototype's operational life was evaluated by analyzing the overall current draw of its active components, which included the Arduino Nano, sensors, and communication modules. The technology, which uses an 18650 lithium-ion battery, was developed to offer continuous operation for day-long mobility support. Reliability measurements centered on GPS accuracy, with a goal deviation of 5 meters from the real position to guarantee caregivers can exactly find the user during a fall occurrence.

4.0 Conclusion

The study successfully created and verified a low-cost, Arduino-powered smart cane that combines proactive obstacle detection with an automatic emergency response system. The fundamental contribution of this study is to bridge the gap between simple tactile feedback and high-cost assistive devices. The work creates a comprehensive safety net by integrating three-directional ultrasonic sensors with a fall detection method that uses current smartphone infrastructure.

This study has important implications for practice since it provides a scalable option for visually impaired persons in low-resource situations where commercial smart canes are typically prohibitively expensive. In terms of policy and research, these findings call for the incorporation of low-cost embedded technologies into national health and accessibility frameworks. Furthermore, the utilization of open-source components such as Arduino in this study serves as an instructional model for future engineering students seeking to build human-centric breakthroughs.

Future research should focus on increasing the device's longevity with 3D-printed weather-resistant shells and incorporating machine learning algorithms to discriminate between accidental drops and true human falls. Furthermore, including haptic feedback via bone-conduction audio may improve the user experience by keeping the user's ears attentive to ambient environmental stimuli.

References

1. Ahmed, S., & Raj, A. (2021). GPS navigation and communication modules for smart canes. International Journal of Assistive Technology, 15(2), 112–125. https://tinyurl.com/AhmedRaj2021
2. Al-Samaraie, H., & Ali, N. Z. (2024). Usability and design guidelines for smart canes. Journal of Engineering Research, 22(1), 45–58. https://doi.org/10.1016/j.jer.2024.01.005
3. Kaur, M., & Kaur, P. (2021). Smart walking stick for the visually impaired using ultrasonic sensors and Arduino. International Journal of Engineering Research & Technology, 10(3), 45–50. https://doi.org/10.17577/IJERTCONV10IS03012
4. Lions Clubs International. (2021). The history and significance of the white cane. Retrieved from https://tinyurl.com/LionsWhiteCane
5. Nandhini, S., Premkumar, M., & Rajesh, K. (2024). Limitations of traditional mobility aids for the blind: A comprehensive survey. Journal of Disability Studies, 9(2), 201–215. https://doi.org/10.1007/s40123-024-00891-x
6. Phoenix Medical Systems. (2022). Smart canes for the blind. Retrieved from https://tinyurl.com/PhoenixSmartCane
7. Piculo dos Santos, R., Garcez, A., & Silva, J. (2020). Integrated GPS and alert systems for the visually impaired. Research on Biomedical Engineering, 36(4), 415–422. https://doi.org/10.1007/s42600-020-00088-3
8. Robocraze. (2024). Understanding the HC-05 Bluetooth Module. Retrieved from https://tinyurl.com/RobocrazeHC05
9. Roentgen, U. R., Gelderblom, G. J., Soede, M., & de Witte, L. P. (2018). Reliability and validity of the traditional white cane. Journal of Visual Impairment & Blindness, 112(4), 357–369. https://doi.org/10.1177/0145482X1811200403
10. Sahoo, B., Mohapatra, P., & Mishra, S. (2021). Smart walking stick for the visually impaired using ultrasonic sensors. International Journal of Engineering Research & Technology, 10(3), 45–50. https://doi.org/10.17577/IJERTCONV10IS03044
11. TechLink. (n.d.). Smart cane with sensor technology enhances safety and independence. Retrieved from https://tinyurl.com/TechLinkSmartCane
12. Verma, Y., Parul, Joshi, S., Verma, I., & Singh, P. K. (2025). Enhancing mobility for the visually impaired: A review of smart blind stick technologies. International Journal of Engineering Research & Technology, 13(6). https://doi.org/10.17577/IJERTCONV13IS06035
13. WeWALK. (2022). WeWALK Smart Cane 2 product overview. Retrieved from https://tinyurl.com/WeWALKSmart2

14. World Health Organization. (2021). World report on vision. Retrieved from https://tinyurl.com/WHOWorldVision

15. World Health Organization. (2023). Vision impairment and blindness. Retrieved from https://tinyurl.com/WHOVision2023

16. WHO & UNICEF. (2022). Global report on assistive technology. Retrieved from https://tinyurl.com/WHOAssistTech2022