Smart Navigation Stick with GPS & GSM Tracking for Visually Impaired Individuals

***Abstract*—This project presents a smart assistive device for visually impaired individuals, enabling them to navigate safely and independently. Traditional white canes provide limited feedback, leaving users vulnerable in unfamiliar environments. The developed smart stick integrates ultrasonic sensors for real-time obstacle detection, a GPS module for continuous location tracking, and a GSM module to send emergency alerts containing a Google Maps link. Powered by two 18650 Li-ion batteries and controlled by an Arduino Nano, the system is designed to be lightweight, affordable, and portable. An emergency button allows the user to trigger an alert when in distress. The ultrasonic sensor detects obstacles up to 2 meters away, triggering a buzzer to warn the user. Real-time GPS coordinates are fetched continuously and on button press, the location is sent to a predefined phone number using the SIM800L GSM module. The prototype was tested under various conditions, showing good performance outdoors and acceptable reliability in network-challenged areas. The total cost of the system was kept low to ensure it is accessible for people in developing countries. This project contributes toward inclusive technology and aims to enhance the autonomy and safety of visually impaired individuals.**

Keywords*—Smart Stick, GPS, GSM, Arduino, Ultrasonic Sensor, Assistive Technology

I. Introduction

The visual impairment is still among the most significant health problems in the world as the number of individuals with visual impairment exceeded 285 million, of which about 39 million have been rendered totally blind [1]. These people face a challenge in their everyday lives, as they cannot freely move around towns and new territories. Existing mobility tools like white canes are of little assistance, as they mostly sense obstacles on the ground but do not offer any form of smart feedback or live situation awareness [2] .This frequently puts the users at the risk of accidents particularly in the busy or complicated environments. Recent years brought new opportunities to assistive devices due to technological improvements in the field of embedded systems and the Internet of Things (IoT). The combination of cheap sensors and microcontrollers with GPS and GSM communication modules have allowed the creation of more intelligent, networked mobility tools [4]. Such innovations have the potential not only to improve obstacle detection but also to offer real-time location tracking and the ability to send emergency alerts, both of which would greatly increase user independence and safety.

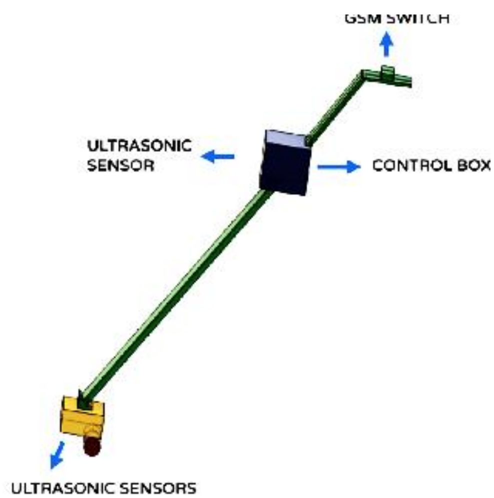

Fig. 1. Smart Blind Stick

The research will develop and fabricate a smart navigation stick which will integrate ultrasonic sensing, location tracking using GPS and emergency communication using GSM into one device which will also be portable. The system relies on Arduino Nano platform, which is low powered and cost effective. The most important goals are detecting obstacles in real-time with the help of ultrasonic sensors, sharing the location with the assistance of GPS and sending the emergency message with the help of GSM. In addition, its design is people friendly and portable, particularly to the rural or developing world user. The paper is a detailed approach of the development of the smart stick which starts with the literature review of the related works, then continued with the description of the system architecture, hardware component and implementation procedure. Though the software simulation, such as Proteus was not applicable because of the hardware module shortcomings, the implementation of the system was carried out in reality and tested under the real operational environment. The findings indicate that the stick is effective in helping visually impaired users to move around safely and with much ease.

II. RELATED WORKS

Several studies [1]–[6] have explored assistive technologies aimed at improving mobility and safety for visually impaired individuals. These research efforts primarily focus on enhancing traditional mobility aids using sensor-based obstacle detection, GPS tracking, and real-time communication technologies.

Khan et al. [1] proposed a smart cane system using ultrasonic sensors to detect nearby obstacles. While effective in obstacle avoidance, the system lacked real-time location tracking and emergency communication features. Roy et al. [2] introduced a GPS and GSM-based blind navigation system, enabling live location sharing via SMS. However, the system suffered from poor indoor GPS performance and lacked close-range obstacle detection. Rahman et al. [3] developed a voice-guided navigation stick, relying on voice commands to provide direction feedback. This system proved less reliable in noisy environments and required significant user input, limiting its usability.

Ahmed et al. [4] enhanced user experience by introducing vibration-based feedback for obstacle alerts. Though effective in silent notification, it failed to integrate emergency communication systems like GSM. Hasan et al. [5] investigated a hybrid solution involving Bluetooth-based obstacle sensing and wearable devices, but the solution was more suited for short-range guidance and required smartphone dependency. Islam et al. [6] incorporated machine learning to predict movement patterns in visually impaired users, though it was limited to simulation and lacked practical hardware implementation.

Despite these contributions, most systems addressed only individual challenges such as obstacle detection or location sharing, but not both. Few offered integrated solutions with low-cost, energy-efficient designs suitable for deployment in rural or underdeveloped regions. Additionally, issues related to power management and reliable GSM communication were largely unaddressed.

In this work, we present an improved and compact smart navigation stick that bridges these gaps by combining ultrasonic-based obstacle detection, GPS-enabled live tracking and GSM-powered emergency alert features in a single embedded system. The device is designed to be low-cost, battery-efficient, and user-friendly, particularly for individuals in developing countries. Unlike earlier systems, our design ensures reliable operation through stable power supply components and hardware-based voltage regulation, making it more suitable for real-world deployment.

III. METHODOLOGY OF THE SYSTEM

This section describes the design, development and implementation phases of the smart navigation stick. The methodology combines multiple hardware modules integrated through an Arduino Nano platform to achieve obstacle detection, real-time location tracking, and emergency alert capabilities. The approach includes hardware selection, circuit design, system workflow, and testing.Authors and Affiliations.

A. System Components

The proposed smart navigation stick integrates several key hardware components to ensure accurate sensing, reliable communication and efficient power management. At the core of the system is the Arduino Nano, a compact and cost-effective microcontroller used to coordinate all sensor inputs and module communications. For obstacle detection, an HC-SR04 ultrasonic sensor is used to detect objects within a 36 centimetres range and triggers a buzzer to alert the user of any obstruction ahead. Location tracking is facilitated by the Neo-6M GPS module, which continuously fetches latitude and longitude coordinates used for real-time monitoring[11].

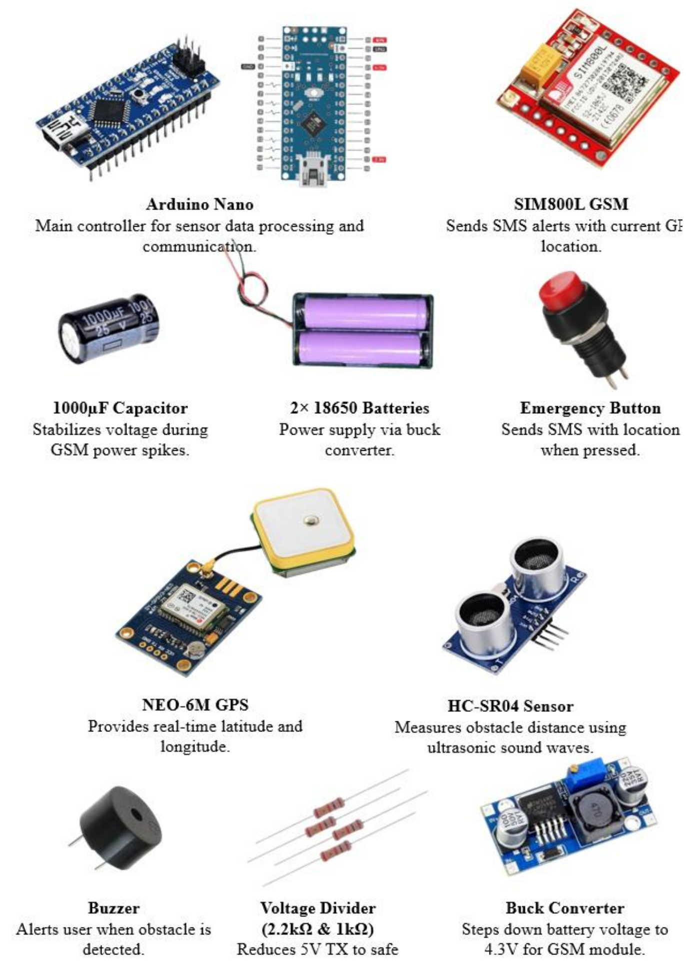

Fig. 2. Hardware Components of the Smart Navigation Stick

To enable emergency communication, the SIM800L GSM module is employed, allowing the system to send SMS alerts containing the user's location. A 1000 µF capacitor is connected across the GSM module to stabilize the current and ensure reliable network connectivity during SMS transmission. To safely interface the Arduino's 5V TX signal with the GSM module's 3.3V RX level, a voltage divider circuit using 2.2 kΩ and 1 kΩ resistors is implemented, protecting the SIM800L from potential damage. Power is supplied by two 18650 lithium-ion batteries connected in parallel, ensuring longer runtime. A buck converter is used to step down the 7.4V battery output to 3.3V for powering the SIM800L, while the Arduino is powered directly from the battery. This combination of components provides a robust, portable, and efficient system tailored for assistive navigation.

B. Circuit Overview

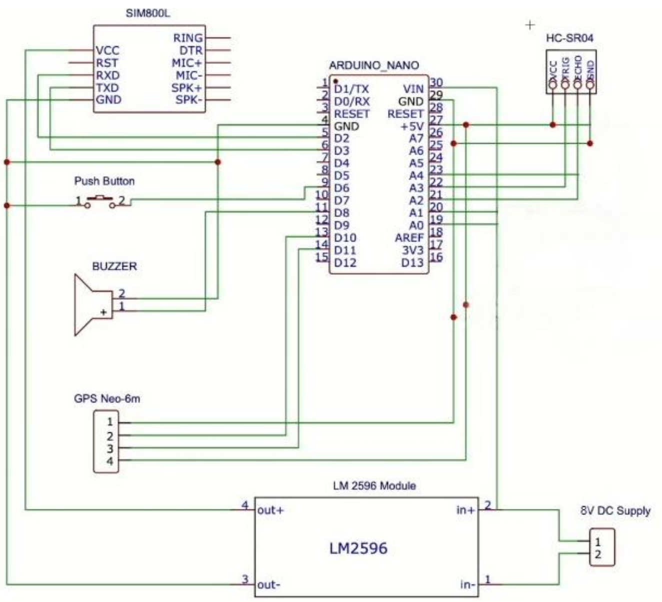

Fig. 3. Circuit Diagram of the System Circuit

The complete circuit architecture of the smart navigation stick is depicted in Fig. 3. The system is powered by two 18650 lithium-ion batteries connected in series, supplying approximately 7.4 V when fully charged. This voltage is fed to the Arduino Uno via the VIN pin, enabling onboard regulation to 5 V. The same 7 V supply is also routed through a buck converter, which steps it down to approximately 4.3 V to power the SIM800L GSM module. The Arduino's regulated 5 V output is further used to supply other low-power peripherals such as the ultrasonic sensor, GPS module, and buzzer. The SIM800L module enables emergency communication by transmitting SMS alerts containing the user's GPS coordinates. To support reliable operation during high current demand, particularly during SMS transmission, a 1000 µF capacitor is placed across the module's power lines to stabilize voltage and prevent brownouts. Additionally, a voltage divider circuit consisting of 2.2 kΩ and 1 kΩ resistors is implemented between the Arduino's TX pin and the GSM module's RX pin to shift the 5 V logic level down to 3.3 V, ensuring safe and reliable signal transmission. For real-time location tracking, a GPS module is interfaced using the SoftwareSerial library, with its TX and RX pins connected to Arduino digital pins D11 and D10, respectively. Obstacle detection is implemented using an ultrasonic sensor, with the Trig and Echo pins connected to analog pins A1 and A0. A passive buzzer connected to digital pin D5 provides auditory feedback when nearby obstacles are detected. A momentary push-button switch on pin D6 acts as an emergency trigger, activating the GSM module to send the user's location via SMS. All components share a common ground, ensuring electrical consistency and reliable system operation.

C. Workflow of the System

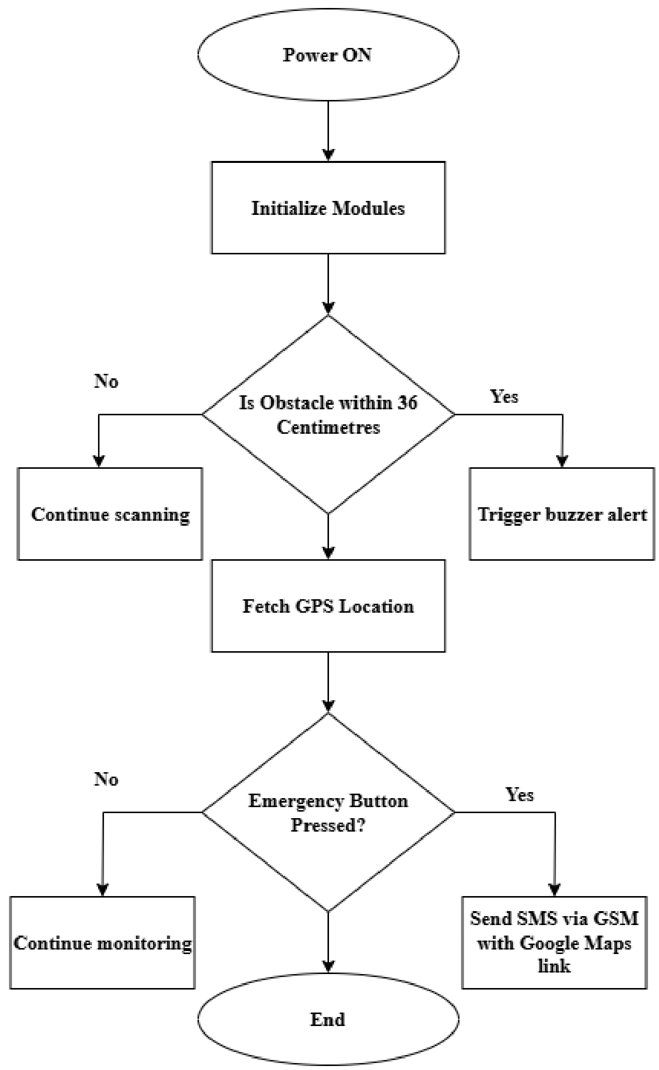

Fig. 4. Workflow of The System

The workflow of the system, shown in Fig. 4, begins with powering on and initializing all sensors and modules. The ultrasonic sensor continuously monitors for obstacles within a

36-centimetres range; if detected, the buzzer alerts the user. Simultaneously, the GPS module obtains the current location. When the emergency button is pressed, the system sends an SMS containing a Google Maps link of the user's location via the GSM module. Power regulation components including the buck converter, capacitor and voltage divider ensure stable operation throughout. This process repeats continuously to provide real-time navigation assistance and emergency communication.

D. *Experimental Setup*

The prototype was implemented on a breadboard and later housed within a PVC stick for portability. Images of the physical prototype, including the wiring, power supply setup, and module placement, were captured and documented.

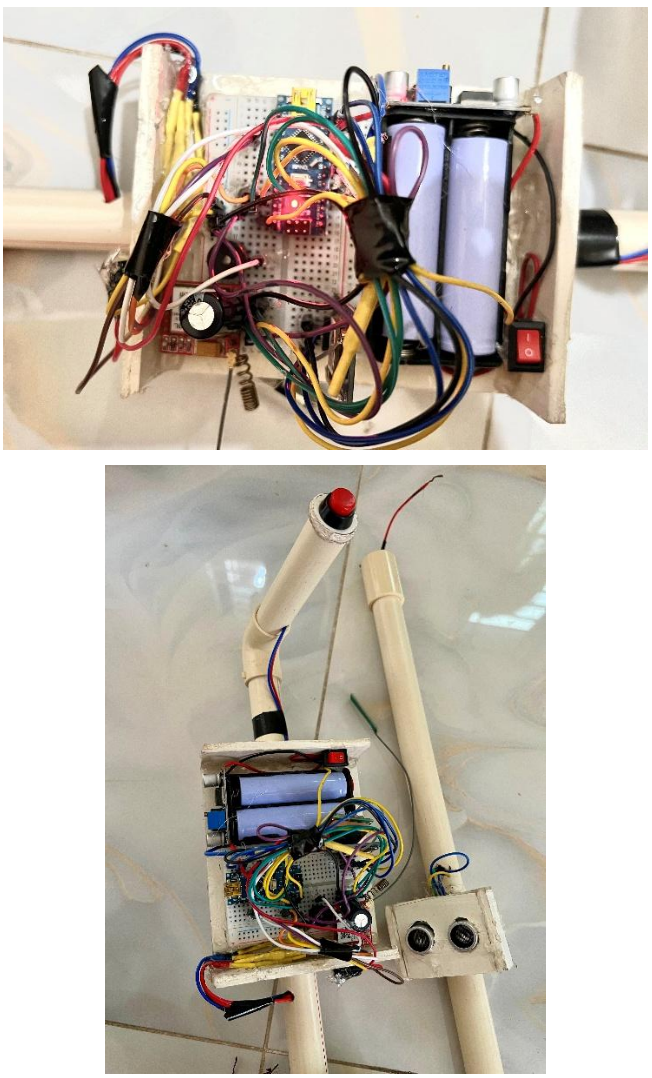

Fig. 5. Prototype of The System

IV. Result and Discussion

The smart navigation stick was tested in outdoor conditions to evaluate the functionality of its emergency alert system. As illustrated in Fig. 6, when the emergency button is pressed, the device successfully retrieves real-time GPS coordinates and sends an SMS containing a Google Maps link to the user's location. A sample message received during testing is:

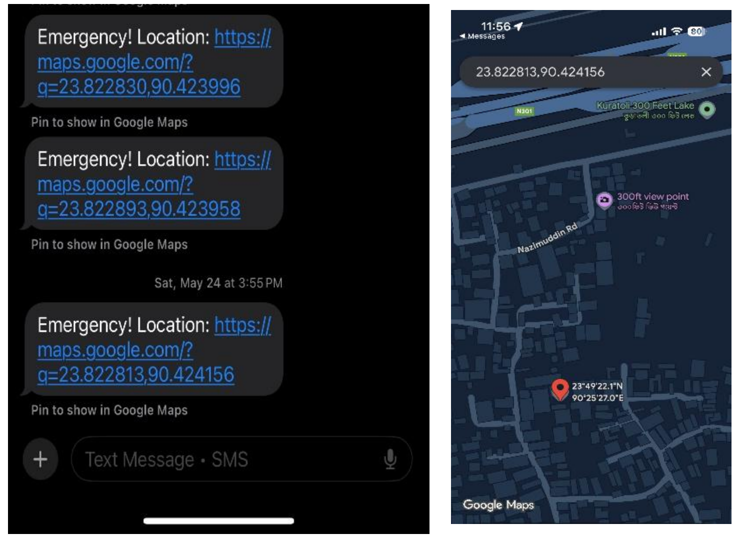

Fig. 6. Emergency SMS with Location

The GPS module accurately acquired the user's location within ±5 meters in open-sky conditions. Location fixes were typically obtained within 30 to 45 seconds after power-up, with faster updates during continuous operation. The temperature sensor provided stable readings, and the values were correctly appended to the SMS in real-time.This integrated alert mechanism ensures that caregivers or emergency responders receive both environmental context and precise location data, enhancing the system's usefulness for supporting visually impaired individuals in real-world scenarios

V. Conclusion and Future Work

This study introduced a smart navigation stick tailored for visually impaired individuals, integrating ultrasonic sensing, GPS tracking and GSM-based communication. The system effectively detects nearby obstacles, provides real-time alerts through a buzzer and enables emergency communication by sending SMS messages that include both temperature data and a Google Maps link to the user's location. Field testing confirmed the system's reliability, with accurate obstacle detection within 36 centimetres and GPS-based location tracking with minimal deviation.

For future work, enhancements may include the integration of voice feedback to guide users more intuitively, support for IoT cloud platforms to enable remote monitoring by caregivers, and the inclusion of additional environmental sensors such as air quality or light intensity. Furthermore, developing a companion mobile application could improve accessibility, customization, and real-time status visualization, making the system more user-friendly and comprehensive.

REFERENCES

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[1] J. H. D. Pham, M. Drieberg, and C. C. Nguyen, "Development of vehicle tracking system using GPS and GSM modem," in 2013 IEEE Conference on Open Systems (ICOS), 2013, pp. 89-94.

[2] A. H. Alquhali, M. B. Roslee, M. Y. B. Alias, and K. S. Mohamed, "IOT Based Real-Time Vehicle Tracking System," in 2019 IEEE Conference on Sustainable Utilization and Development in Engineering and Technologies (CSUDET), 2019, pp. 265-270.

[3] J. A. Afonso, R. A. Sousa, J. C. Ferreira, V. Monteiro, D. Pedrosa, and J. L. Afonso, "IoT system for monitoring and control of vehicles' parameters," in 2017 IEEE International Conference on Internet of Things, Smart Innovation and Usages (IoT-SIU), 2017, pp. 1-6.

[4] A. O. Oke, "Vehicle Monitoring System Based on IoT, Using 4G/LTE," SSRN, 2021. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3902487

[5] S. J. Lee, G. S. Tewolde, and J. Kwon, "Design and implementation of vehicle tracking system using GPS/GSM/GPRS technology and smartphone application," in 2014 IEEE World Forum on Internet of Things (WF-IoT), 2014, pp. 353-358.

[6] M. Alagarsamy, P. Kasinathan, G. Manickam, P. R. Duruvarajan, J. Sakkarai, and K. Suriyan, "IoT based E-vehicle monitoring system using sensors and imaging processing algorithm," Int. J. Reconfigurable Embedded Syst., vol. 11, no. 2, pp. 196-204, Jul. 2022.

[7] T. Thamaraimanalan, M. Mohankumar, S. Dhanasekaran, and H. Anandakumar, "Experimental analysis of intelligent vehicle monitoring system using Internet of Things (IoT)," Int. J. Eng. Adv. Technol., vol. 8, no. 5, pp. 1-6, 2019.

[8] S. K. E. Suresh, K. Srikanth, A. Karthikeya, S. U. Krishna, and G. Rahul, "Smart Blind Stick with GPS Tracking Using GSM," J. New Adv. Online Eng., vol. 15, no. 1, pp. 1–6, Jan.–Jun. 2024.

[9] "Smart Blind Stick with GPS and GSM Module," Int. Res. J. Mod. Eng. Technol. Sci., vol. 6, no. 3, pp. 1–8, Mar. 2024.

[10] K. S. Adithya, N. Sujala, and K. A. Reddy, "GPS and Digital Compass Based Navigation Stick for Blind People," Int. J. Creative Res. Thoughts, vol. 10, no. 5, pp. 774–778, May 2022.

[11] S. A. R. Prasad, M. S. Prasad, and K. M. Reddy, "Development of Sophisticated Smart Blind Stick Using GSM and GPS," in Proc. Int. Conf. Intelligent Computing and Communication, 2021, pp. 1–7.

[12] P. Anand, "Navigation system for blind using GPS & GSM," SlideShare, Jun. 2015. [Online]. Available: https://www.slideshare.net/PrateekAnand4/navigation-system-for-blind-using-gps-gsm

[13] "GSM GPS Based Smart Blind Stick," Projects Factory, 2024. [Online]. Available: https://projectsfactory.in/product/gsm-gps-based-smart-blind-stick/

[14] "IoT-Based Smart Cane with Sensors and GPS as a Modern Medical Solution to Help Safe and Independent Mobility for the Visually Impaired in Daily Life," Tech Briefs Create the Future Design Contest, May 2025. [Online]. Available: https://contest.techbriefs.com/2025/entries/medical/13417

[15] S. S. Raut, R. S. Chavan, and S. S. Patil, "Smart Stick for Blind People with GPS and GSM Module," Int. J. Eng. Res. Technol., vol. 9, no. 5, pp. 1–4, May 2020