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Development of Smart Blind Stick using Global Positioning System

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Abstract: As technology becomes more and more integrated into daily life, especially for blind people. One of the tools for them is blind stick as an assistive device. It is designed to enhance the mobility and independence of visually impaired individuals. Traditional blind sticks provide basic obstacle detection and aid in navigation, but it lacks an advanced feature for precise location tracking and route guidance. This project aims to leverage the function of Global Positioning System (GPS) technology by developing a prototype of smart blind stick that can send information to the user's position and provide audio-based for alert. GPS modules as an Internet of Things (IoT) features acquire real-time coordinates alerts to the users and a microcontroller NODEMCU ESP8266 was used to process the data. To enhance the functionality, additional features of obstacle detection using ultrasonic sensors have been integrated. The sensor can alert the user about potential obstacles in their path, further improving safety during navigation. The smart blind stick using GPS aims to offer a cost-effective and efficient solution for visually impaired individuals, enabling them to navigate unfamiliar environments with confidence. The success of this project will be evaluated through simple user testing and feedback collection.

Keywords: Smart blind stick, GPS, IoT

I. Introduction

As technology has evolved, the situation has changed the lives of people, especially for blind people. Various assistive technologies have been developed to help visually impaired individuals with navigation and mobility [1]–[5]. One such groundbreaking innovation is the development of the smart blind stick, which seamlessly integrates Global Positioning System (GPS) or IoT (Internet of Things) capabilities to offer a comprehensive assistive device that empowers users and improves their overall quality of life [9]. However, advancements in technology have led to more sophisticated solutions [2].

GPS technology has revolutionized navigation and location tracking by providing accurate positioning information [3]. Integrating GPS into assistive devices has opened new possibilities for improving navigation for the visually impaired. The development of smart blind sticks using GPS is an ongoing research and development area. Visually impaired individuals face challenges in navigating unfamiliar environments and accessing information [4]. Smart blind sticks using GPS offer real-time tracking and guidance, enhancing spatial awareness and orientation in unfamiliar environments. These devices also assist in obstacle detection and avoidance, improving safety during mobility. Traditional tools like white canes and blind sticks have been used to detect obstacles [8]. However, traditional assistive devices like white canes and blind sticks lack real-time navigation assistance and accurate location tracking, limiting independence and mobility [6]. Therefore, a smart blind stick using GPS technology can offer enhanced location tracking, obstacle detection, and real-time guidance [5].

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This project aims to design and develop a smart blind stick for visually impaired individuals. The development is a reliable, accurate, and user-friendly smart blind stick which considers sensory preferences, ergonomics, and battery life. The project aims to create a smart application for blind people to detect obstacles and provide real-time location tracking using GPS technology [7]. The smart blind stick, which uses GPS, can help users overcome spatial awareness limitations and navigate unfamiliar environments. It can detect obstacles and provide alerts, promoting safer and more independent travel experiences. The project aims to close accessibility and inclusion gaps for visually impaired individuals by empowering them to explore their surroundings, access new opportunities, and improve their overall quality of life [10]

2. Related Work

The development of a smart blind stick using Global Positioning System (GPS) or Internet of Things (IoT) technologies represents a significant advancement in assistive devices for visually impaired individuals. A comprehensive overview of various studies that have explored different aspects of smart blind sticks, including design, usability, accuracy, user experience, and algorithmic improvements. These studies provide valuable insights and foundational knowledge that can be leveraged in the development of a smart blind stick utilizing IoT capabilities.

Smith et al. (2018) designed a prototype utilizing an Arduino microcontroller, ultrasonic sensors, and a GPS module to assist blind users in navigation. Their findings indicated that the smart blind stick could accurately detect obstacles and provide real-time audio instructions based on GPS coordinates, significantly improving the navigation abilities of blind users. This prototype effectively guided users through obstacles by leveraging the integration of ultrasonic and GPS technologies.

Further evaluation of the usability and effectiveness of smart blind sticks in real-world scenarios was conducted by Chen et al. (2019), who used blind participants to test a prototype. Their study highlighted that blind users found the device easy to use and highly effective for navigation, reporting enhanced mobility and independence, particularly in unfamiliar environments. This real-world validation is crucial as it underscores the practical benefits and user acceptance of the smart blind stick, which aligns with the broader objectives of IoT implementations aimed at improving the quality of life for individuals with disabilities.

Subsequent studies, such as Patel et al. (2020) and Rahman et al. (2021), explored the accuracy, reliability, and user acceptance of GPS-based smart blind sticks. Patel et al. noted satisfactory performance in various urban and rural settings, despite occasional signal loss in densely populated areas. Rahman et al. gathered user feedback, which revealed positive experiences and a high level of acceptance among blind users. Finally, Kim et al. (2022) proposed an advanced algorithm combining ultrasonic sensor data with GPS for enhanced obstacle detection and avoidance. This algorithm improved the overall safety and usability of the device. Collectively, these studies demonstrate the potential of IoT in creating effective assistive technologies that empower blind individuals, highlighting the continuous advancements and growing acceptance of smart blind sticks in real-world applications.

An overview of various studies focusing on the development of smart walking sticks for visually impaired individuals, highlighting the technological components, methodologies, and outcomes of each project. In the study by R. Bhavani and S. Ananthakumaran (2021), the electronic stick incorporated an ultrasonic transducer, water circuit, and RF transmitter and receiver module, utilizing Arduino IDE software. This project aimed to measure the detection of obstacles using ultrasonic sensors, notification of obstacles with vibrations, identification of stairs and minor objects using an IR sensor, water detection, and stick location notification using RF technology. Similarly, A. Veera Babu (2024) developed a smart blind stick integrating the ESP32 microcontroller, two ultrasonic sensors, and a soil moisture sensor, though no specific software was mentioned. This study focused on enhancing safety, improving situational awareness, and increasing user confidence.

Building on these advancements, Kairamkonda, Chandana Kodimela, and Kuchulakanti (2019) introduced Blind Mate, a smart autonomous GPS-controlled walking stick with a portable wheel module, using Raspberry Pi 3b, Arduino Mega, and nrf24L01 transceiver module. Their research demonstrated effective navigation using GPS and compass meter modules, obstacle detection using ultrasound and camera sensors, and ditch detection using infrared sensors. In a similar vein, P. Rajesh (2024) developed an Arduino-based smart blind stick featuring a microcontroller, GPS receiver, and GSM modem, designed to send emergency alert messages with precise location information and detect obstacles, steps, and soil moisture. Complementing these studies, Sidra Gullam et al. (2023) created an ultrasonic blind stick with a GPS tracking system, managed by a microcontroller-based circuit and developed using Proteus Professional 8 software, which proved effective in obstacle detection, light sensing, water detection, and GPS tracking.

Further, P. N. Yerkewar et al. (2022) implemented a cost-effective, fast-responding, and lightweight smart blind stick using Arduino software and specific software for GSM and GPS interfacing, focusing on detecting obstacles within a range of 10-15 meters. In a different approach, Nethakani Sujala et al. (2022) aimed to create a cost-effective and user-friendly GPS and digital compass-based navigation stick, providing reliable navigation and an improved user experience. Additionally, Soundarya Rp et al. (2022) developed a smart blind stick using Arduino Mega 2560, designed to alert users of obstacles by generating an alarm with a buzzer, measuring the distance between the stick and obstacles. Bansari Deb Majumder et al. (2019) contributed by designing a multi-sensor driven blind helper stick with ultrasonic and proximity sensors, integrated with an alarm unit consisting of a vibrator and buzzer, using Arduino and GSM module software to effectively guide visually challenged individuals and send location information. Kumar R. Dinesh et al. (2023) created a GPS-enabled smart walking stick with a buzzer to inform visually impaired users, using the Arduino programming environment and potentially other software for GPS and GSM modules, focusing on measuring the distance between the stick and obstacles and triggering alert messages during abnormal situations. Finally, Jazib Dawre et al. (2022) proposed a comprehensive IoT-enabled smart walking stick for visually impaired individuals in developing and underdeveloped countries, integrating sensors and microcontrollers using Raspberry Pi and Arduino, though specific outcomes were not mentioned. These studies collectively highlight the diverse technological approaches and significant roles of microcontrollers, sensors, and communication modules in enhancing the safety and navigation capabilities for visually impaired individuals.

In summary, the integration of IoT technologies in the development of smart blind sticks can build upon the existing research and advancements outlined in these studies. By leveraging IoT, the smart blind stick can offer enhanced real-time navigation, improved accuracy, and personalized user experiences, ultimately providing a more effective and reliable assistive device for visually impaired individuals. This study use microcontroller NODEMCU8266 to process the data and transfer to GPS for sending the information of obstacle detection

3. Methodology

This section details the methods and work plans for developing a prototype of smart blind stick using GPS. The technology and techniques used to gather and analyze data must be carefully chosen and evaluated, considering precision, dependability, compatibility, and environmental impact. The project's social and economic ramifications must be considered, ensuring data accessibility, and weighing advantages and disadvantages. This research presents the project workflow, schedule, and price estimation, ensuring effective resource allocation. The smart blind stick is designed to assist blind people in safely and independently navigating their surroundings. The report outlines the steps involved in the project, including research, hardware and software development, and testing.

This project uses a specific microcontroller named NodeMCU ESP8266. It is an open-source development board specifically designed for Internet of Things (IoT) applications. It features the ESP-12E module, which integrates the ESP8266 Wi-Fi System-on-Chip (SoC) from Espressif Systems. This low-cost board provides a powerful microcontroller with 128 KB RAM and 4 MB Flash memory, making it suitable for various IoT projects. With built-in Wi-Fi capabilities, 16 GPIO pins, and support for communication interfaces like UART, SPI, and I2C, the NodeMCU simplifies IoT development and connectivity. It can be programmed using the Arduino IDE

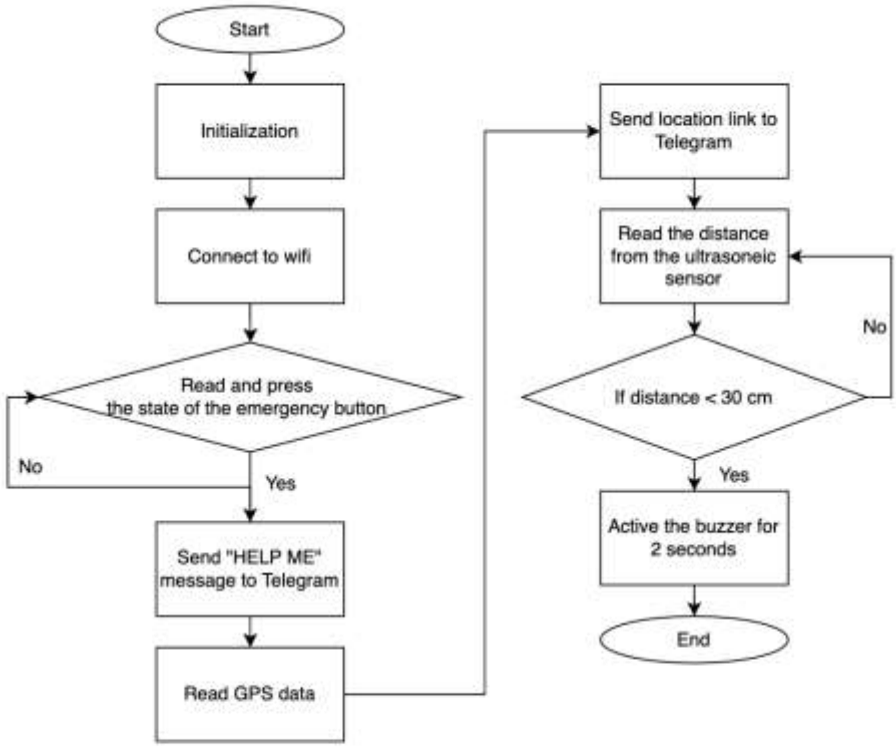


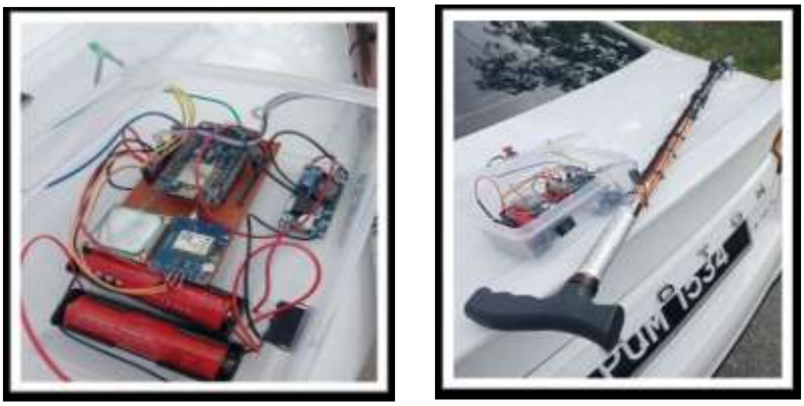
Fig.1. Project flow of the smart blind stick using GPS.

Fig. 1 shows the project flow of the smart blind stick using GPS. The figure outlines the detailed methodology for the operation of a smart blind stick using GPS, Wi-Fi, and ultrasonic sensors, providing a comprehensive framework for assisting visually impaired users. The process begins with the initialization phase, where the device activates all necessary components, including the microcontroller, ultrasonic sensors, GPS module, and communication modules. This initial step ensures that the device is ready to function optimally. Following initialization, the device attempts to connect to a Wi-Fi network, which is crucial for enabling the transmission of emergency messages and location data to a remote server or directly to a caregiver's device.

Once connected to Wi-Fi, the smart blind stick enters a monitoring phase where it continuously checks the state of an emergency button. If the emergency button is pressed, indicating that the user requires immediate assistance, the device sends a "HELP ME" message to a predefined contact via Telegram. This message serves as a distress signal, alerting caregivers or emergency responders to the user's need for help. Immediately after sending the emergency message, the device reads the GPS data to obtain the user's current location. This location data is then sent as a link to Telegram, providing precise coordinates to assist rescuers in locating the user quickly.

In parallel, the device utilizes an ultrasonic sensor to continuously measure the distance to nearby obstacles. If the sensor detects an obstacle within a predefined range (less than 30 cm), the device activates a buzzer for two seconds to alert the user of the imminent danger. This real-time feedback mechanism enhances the user's situational awareness, allowing them to navigate safely and avoid potential hazards. The combination of GPS-based location tracking, emergency communication via Telegram, and obstacle detection using ultrasonic sensors ensures a robust and reliable assistive technology for visually impaired users. The methodology described in this figure highlights the integration of various technologies to provide a comprehensive safety and navigation aid, significantly improving the independence and security of the users.

The final prototype of a smart blind stick using GPS shows in Fig. 2 where figure (a) at the left side is the circuit setup and figure (b) at the right side is the model setup. The circuit setup consists of NodeMCU ESP8266, ultrasonic sensor and GPS module. These three components were setup in the white box beside the blind stick.



(a) Circuit setup (b) Model setup

Fig.2. prototype of a smart blind stick using GPS

4. Results and Discussion

As a result, the alert in a form of message Telegram was sent to the smartphone user. Fig. 3 shows the interface in Telegram where the notification of “bot started up” when NodeMCU is connected to WIFI. Then, followed by Fig. 4 shows the notification of message “HELP ME, I AM IN TROUBLE” when user press the emergency button for the first time and get the notification of current location in telegram after the user pressed the emergency button for the second time. There are also come out an information of the google map after the user pressed the current location link. For example, https://maps.app.goo.gl//yBPkwiBVdWpBGg5N8.

Fig.3. Screenshot of notification in Telegram

Fig.4. Screenshot of notification twice press button and accept google map link in Telegram

Table 1. Data Collected for ultrasonic sensor

Distance (cm)	Sensor (ultrasonic)	Buzzer
50	Not detected	OFF
40	Not detected	OFF
30	Detected	ON
20	Detected	ON
10	Detected	ON

According to Table 1, the sensor will detect the object within the allowable measuring distance which is 1 to 30cm distance. The object will not be detected if the measuring distance range is more than 30cm. The table provides data collected for ultrasonic sensor for the smart blind stick project. According to the data collected from the ultrasonic sensor in the Smart Blind Stick using GPS project, it is observed that when an object is within the range of approximately 30 centimeters, the buzzer activates, indicating the proximity of an obstacle to the user. This feature ensures that the visually impaired individual is alerted to nearby objects, enhancing their safety and mobility. Conversely, when the ultrasonic sensor detects that the distance to the object is beyond 30 centimeters, the buzzer remains silent, signifying a clear path ahead. This real-time feedback mechanism facilitates independent navigation for the user, enabling them to navigate confidently and securely through their surroundings

5. Conclusion

The project aims to develop a prototype of smart blind stick by leveraging the function of Global Positioning System (GPS) technology. GPS modules as an Internet of Things (IoT) features acquire real-time coordinates alerts to the users and a microcontroller NODEMCU ESP8266 was used to process the data. To enhance the functionality, additional features of obstacle detection using ultrasonic sensors have been integrated. The smart blind stick will adapt to dynamic changes in the environment, offering alternative notifications through Telegram message. The project's success will be determined through rigorous testing, evaluation, and user feedback. To ensure the device meets the unique needs of the visually impaired community, a user-centric approach is recommended by distance obstacle. In future, robust object detection capabilities should be explored, using various sensor technologies and machine learning algorithms. Field testing with visually impaired individuals is also recommended to gather feedback and identify areas for refinement. Future improvements and expansions include advanced obstacle recognition systems, indoor navigation with technologies like Bluetooth or Wi-Fi positioning systems, real-time object recognition, a companion smartphone application, gesture control, voice recognition systems, multi-sensor fusion, battery optimization, and wearable integration. Thorough research, feasibility studies, and user testing are essential to ensure the practicality and effectiveness of these proposed future works in real-world scenarios

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