Sri Lanka Institute of Information Technology

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Smart Assistance Device for the Visually Challenged: Integrating GPS Technology and Emergency Support Features with RTOS

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1. Declaration and Group Details

We declare that this is our own work, and this assignment does not incorporate without acknowledgment any material previously submitted by anyone else in SLIIT or any other institution. Each member contributed equally to the completion of this assignment.

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2. Abstract

The visually impaired face numerous challenges with mobility and emergency situations, making it essential to develop assistive technologies to improve their independence and safety. This paper focuses on a smart assistance device that integrates GPS technology, emergency support systems, and object detection, powered by an ESP32 microcontroller and FreeRTOS. This innovative device enhances user autonomy, navigation, and emergency response capabilities.

3. Introduction

The increasing global population of visually impaired individuals, estimated at over 37 million, highlights the urgent need for advanced technologies that can enhance their independence, mobility, and safety. Traditional mobility aids, such as blind sticks, provide only basic obstacle detection and are limited in scope, offering minimal assistance in complex environments. These conventional tools also lack critical features like real-time location tracking and emergency alert systems, which are essential in situations of disorientation or danger, such as theft or human trafficking.

Recent technological advancements have opened new possibilities for addressing these limitations. In response to these challenges, a research paper by Kruthika Y., Anju Das, and Parvathy Thampi M. S. introduces an innovative smart assistance device for the visually impaired. This device incorporates GPS technology, a GSM-based emergency alert system, and a Real-Time Operating System (RTOS) to provide enhanced navigation, safety, and multitasking capabilities. Utilizing modern components such as the ESP32 microcontroller and ultrasonic sensors, this comprehensive and low-cost solution aims to significantly improve the quality of life for visually impaired individuals by offering real-time navigation support and emergency communication in a user-friendly format.

The proposed device addresses key challenges, including navigating unfamiliar environments and ensuring immediate assistance during emergencies, ultimately aiming to empower visually impaired individuals with greater autonomy and peace of mind.

4. Methodology

The smart assistance device is built around an Arduino-based system, with the ESP32 microcontroller handling data processing and communication. Ultrasonic sensors detect obstacles, and the ESP32 processes the data to determine proximity. If an obstacle is within range, a buzzer is activated to alert the user. In emergencies, the user presses a button that triggers the ESP32 to retrieve GPS coordinates and sends an emergency message to a designated guardian via the GSM module, prioritizing immediate communication for swift assistance.

System Flow and Task Allocation

The system workflow begins with ultrasonic sensors detecting obstacles and sending signals to the ESP32, which activates the buzzer to warn the user. For emergencies, the GPS module retrieves the user's location, and the GSM module sends an alert message. FreeRTOS manages the system's tasks, assigning the highest priority to GPS data acquisition for accurate location tracking. Other tasks, like obstacle detection, communication, and emergency handling, are efficiently managed to ensure reliable performance.

Testing in both controlled and real-world environments confirmed the system's reliability, with minimal delays in sending emergency messages and effective obstacle detection, making it a valuable tool for visually impaired users.

5. Problem Being Addressed

The primary problem addressed in the paper is the limitation of existing mobility aids for visually impaired individuals. Traditional blind sticks, while helpful in detecting nearby obstacles, lack features that address the broader needs of visually impaired users, particularly in terms of safety, navigation, and communication. Specifically, the paper focuses on providing a solution that integrates GPS tracking for real-time location data, emergency support through GSM communication, and object detection using ultrasonic sensors. This combination aims to enhance both mobility and security for users, allowing them to navigate more confidently and receive help when needed.

The paper emphasizes the importance of these features, particularly for users in unfamiliar or dangerous environments where traditional blind sticks fall short. The integration of these technologies into a single device addresses the dual concerns of navigation and emergency response, providing a more comprehensive solution for visually impaired individuals.

6. Proposed Solution

The authors propose a smart assistance device that incorporates GPS technology, a GSM module, ultrasonic sensors, and the ESP32 microcontroller running FreeRTOS. The system is designed to provide real-time assistance to visually impaired individuals by detecting obstacles, sending emergency alerts with GPS coordinates, and offering navigation support.

The main components of the system include:

- **GPS and GSM Modules**: These modules are used for tracking the user's location and sending emergency alerts to a pre-defined guardian via SMS. The GPS module provides real-time location data, while the GSM module is responsible for communication.
- **Ultrasonic Sensors**: These sensors detect objects within a range of 400 cm, ensuring that the user is alerted to nearby obstacles. The system processes the sensor data and triggers a buzzer to inform the user of potential hazards.
- **ESP32 Microcontroller**: The ESP32 serves as the core of the system, managing input from the sensors, GPS, and GSM modules. It runs FreeRTOS, which enables efficient multitasking and ensures that the system responds quickly to user input and sensor data.
- **FreeRTOS**: The Real-Time Operating System (RTOS) is responsible for managing the various tasks of the system, such as GPS data acquisition, user interface management, and emergency response. FreeRTOS ensures that these tasks are handled concurrently and efficiently, improving the overall responsiveness of the device.

This solution is both affordable and scalable, making it accessible to a wide range of users. The integration of FreeRTOS allows for better task management, ensuring that the system remains responsive even under multiple concurrent processes.

7. Results and Implications

The smart assistance device successfully achieved its design objectives, demonstrating effective obstacle detection, reliable GPS tracking, and rapid emergency communication. Testing in both urban and rural environments showed that the ultrasonic sensors accurately detected obstacles within the specified range of 400 cm, and the buzzer provided a clear, timely alert to the user. The system consistently sent GPS data within 10 seconds of pressing the emergency button, ensuring prompt support in critical situations.

Additionally, the integration of FreeRTOS optimized task management, allowing the system to handle multiple tasks simultaneously without performance degradation. The low-cost design, using affordable components like the ESP32 and GSM modules, makes the device accessible to a wide range of users, including those in low-income communities. This affordability, combined with the system's efficiency, positions the device as a scalable and practical solution for visually impaired individuals.

The study also suggests opportunities for future enhancements, such as integrating voice feedback and expanding navigation capabilities, which could further improve user independence and safety. These findings highlight the device's potential for widespread adoption and its ability to significantly enhance the quality of life for visually impaired individuals.

8. Critical Evaluation

While the proposed solution is highly effective and addresses the key challenges faced by visually impaired individuals, there are several areas where the system could be improved. One potential weakness is the reliance on the GSM network for emergency communication. In areas with poor network coverage, the system may fail to send emergency messages, potentially putting users at risk. Future versions of the device could explore alternative communication methods, such as integrating a satellite-based communication system to ensure coverage in remote areas.

Another area for improvement is the user interface. Currently, the system relies on a push button to trigger emergency communication, which may not be intuitive for all users. Incorporating voice commands or haptic feedback could make the device more user-friendly, especially for individuals with additional disabilities.

Overall, the paper presents a well-designed solution that effectively combines multiple technologies to address the needs of visually impaired individuals. However, further research is needed to refine the system and expand its capabilities.

9. Broader Concepts in Operating Systems

The research paper on the smart assistance device for the visually impaired significantly contributes to the understanding of real-time operating systems (RTOS) and multitasking in embedded systems. By using FreeRTOS, the paper demonstrates the importance of managing concurrent tasks, such as GPS data acquisition, object detection, and emergency messaging, ensuring timely execution of each task. This concept is essential in operating systems, where resource allocation and task prioritization are key to optimizing performance.

The relevance of the paper to modern operating systems lies in its use of real-time processing, which is increasingly crucial in IoT (Internet of Things) and smart devices. The device's ability to handle multiple inputs, respond to sensor data, and send emergency notifications in real-time is directly applicable to the needs of current operating systems that manage complex, concurrent processes. Furthermore, FreeRTOS's task scheduling and low-latency processing are integral to modern systems that require efficient multitasking.

The ideas from this paper could be extended in future operating systems by incorporating machine learning for adaptive obstacle detection and cloud integration for real-time data analytics and tracking. As operating systems evolve towards supporting more IoT and edge devices, the principles demonstrated in this research, such as efficient task management, real-time responsiveness, and embedded system optimization, will play a larger role in enhancing the performance and functionality of future OS designs.

10. Conclusion

The research paper presents a significant advancement in assistive technology by introducing a smart assistance device designed for visually impaired individuals. This device integrates GPS technology, emergency communication, and object detection into a single, user-friendly tool, enhancing both mobility and security for its users. The implementation of FreeRTOS facilitates efficient task management, ensuring the system is both responsive and reliable. While there are opportunities for further improvement—such as incorporating voice feedback and extending battery life—the current design represents a noteworthy step forward in assistive technology and has the potential for widespread adoption.

11. Contribution

- **IT 23293830**: Introduction, Proposed solution.
- **IT 23289802**: Methodology, Broader concepts in Operating Systems.
- **IT 23292918**: Critical evolution, Conclusion.
- **IT 23298408**: Problem being addressed, Results and implications.