

Smart Belt Obstacle Detection with Voice Output for Blind Person

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Abstract: *The field of healthcare is experiencing remarkable advancements through the integration of technological innovations. Information technology, when applied to the realm of medicine, has showcased its potential to create innovative solutions for individuals with disabilities. Navigating through the world independently poses a significant challenge for visually impaired individuals. To address this, the Smart Belt for Obstacle Detection with Voice Output integrates cutting-edge technology to provide real-time assistance. This project utilizes ESP32 microcontroller, GSM/GPS modules, and ultrasonic sensors to create a comprehensive assistive device. The Smart Belt detects obstacles in the user's path and communicates vital information through voice output, enhancing safety and autonomy. By continuously tracking the user's location, it ensures timely assistance and peace of mind for both the user and caregivers. This abstract explores the Smart Belt's functionality, highlighting its transformative potential for the visually impaired community*

Keywords: Ultrasonic sensor, ESP32, GSM/GPS Module, Object Detection, Smart Belt

I. INTRODUCTION

1.1 Overview

The prevalence of visual impairment globally underscores the urgent need for innovative solutions to enhance the quality of life for affected individuals. With over 2.2 billion people experiencing near or distance vision impairments, of which nearly half could have been prevented or addressed, the challenges of navigating the world safely are substantial. Traditional mobility aids offer limited assistance, leaving many visually impaired individuals reliant on others or vulnerable to obstacles. Recognizing these challenges, the Smart Belt for Visually Impaired emerges as a groundbreaking solution. By integrating ultrasonic sensors, a buzzer, voice module, ESP32 Microcontroller, and GSM/GPS module, this intelligent system acts as an artificial vision and alarm unit. It detects obstacles in real-time, providing audio cues through a voice module to guide users away from potential dangers. This revolutionary technology aims to empower visually impaired individuals to navigate their surroundings more independently and safely.

Recent advancements in technology have paved the way for tailored solutions to address the specific needs of visually impaired individuals. The Smart Belt for Obstacle Detection with Voice Output exemplifies this progress, offering continuous scanning of the environment to identify obstacles and hazards. Through intuitive interfaces, it provides personalized audio cues and haptic feedback, enabling users to make informed decisions and avoid obstacles in real-time. Its sleek and adjustable design prioritizes user comfort, ensuring that individuals can wear it comfortably throughout the day. Lightweight and discreet, the Smart Belt seamlessly integrates into daily life, empowering visually impaired individuals to navigate their surroundings with confidence and independence.

In conclusion, the Smart Belt for Visually Impaired represents a significant advancement in assistive technology, redefining accessibility for those with visual impairments. By leveraging cutting-edge sensors, intelligent algorithms, and user-friendly design, this remarkable invention addresses the unique challenges faced by visually impaired individuals, enhancing their independence, confidence, and safety in navigating the world. As technology continues to evolve, the Smart Belt serves as a beacon of hope, demonstrating the transformative power of innovation in improving the lives of millions globally.

1.2 Motivation

The motivation behind the development of the Smart Belt for Visually Impaired stems from a deeply ingrained commitment to enhancing the quality of life for individuals with visual impairments. With billions worldwide facing challenges in navigating their surroundings safely and independently, there exists a pressing need for innovative solutions that empower rather than limit. By leveraging cutting-edge technology, the Smart Belt aims to bridge this gap, offering real-time obstacle detection and personalized guidance to users. Motivated by the desire to promote independence, confidence, and safety, this pioneering assistive device represents a beacon of hope, signaling a brighter, more inclusive future for visually impaired individuals worldwide.

1.3 Problem Definition and Objectives

The Smart Belt for Visually Impaired is an innovative assistive device designed to enhance the mobility and independence of visually impaired individuals. Equipped with advanced obstacle detection capabilities and voice output functionality, it detects obstacles from all directions and provides real-time guidance through a voice module. Additionally, it can detect obstacles directly in front of the user's face and alerts them through vibrations. This device aims to empower visually impaired individuals to navigate their surroundings safely and independently, offering a cost-effective, flexible, and user-friendly solution to improve their quality of life. To develop a Smart Belt equipped with obstacle detection capabilities and voice output functionality to assist visually impaired individuals in navigating their surroundings safely and independently.

- To enable visually impaired people to detect obstacles coming from any direction and guide them using voice module.
- To detect obstacle coming on face.
- To alert the user of obstacles using a vibrator.
- To provide visually impaired people with an independent, economical, flexible, and user-friendly Smart Belt solution.

1.4. Project Scope and Limitations

The project aims to develop a Smart Belt for visually impaired individuals equipped with obstacle detection capabilities and voice output functionality, facilitating safe and independent navigation. It encompasses the design, development, testing, and implementation of the Smart Belt, ensuring its effectiveness in assisting users in various environments and scenarios.

Limitations As follows:

- Environmental Constraints: The effectiveness of obstacle detection may be influenced by environmental factors such as extreme weather conditions, crowded spaces, or complex terrain.
- Technology Limitations: The Smart Belt's performance may be limited by the capabilities of its sensors, voice output module, and other integrated components, affecting its accuracy and reliability in detecting obstacles.
- User Adaptability: The success of the Smart Belt relies on users' ability to adapt to and effectively utilize the device. Factors such as user familiarity with technology, comfort level with voice-guided instructions, and physical limitations may impact its usability and effectiveness in real-world scenarios.

II. LITERATURE REVIEW

[1] Sathyaet. al., had proposed a smart walking stick for blind person. The system identified obstacle images indoors and outdoors through a camera, while the stick gauged the distance from objects using an ultrasonic sensor. Image processing was integrated to offer users a form of vision. The setup included a camera-equipped walking stick, USB camera, RF module, rain sensor, ultrasonic sensor, Raspberry Pi, and attached headphones. The Raspberry Pi served as the central controller. Images captured by the camera were matched against a dataset through image processing, employing morphology segmentation for analysis.

[2] Jayakumaret. al., this project designed a smart walking stick for the visually impaired, integrating various sensors such as ultrasonic, humidity, temperature, and light sensors. Additionally, a speaker with volume control was employed to convey status information to the users. The inclusion of GPS enabled path tracking, and in case of emergencies, a GSM neighbors. The implementation utilized DSPIC30F2010 and ARM Processor, alongside DISPIC30F 2010 controller

[3] Dada Emmanuel et. al., this project study introduced a smart walking stick for the visually impaired, integrating ultrasonic sensors and Arduino. The research utilizing ultrasonic sensors and Arduino programming in C language. The accuracy was verified and tested by visually impaired individuals. The device effectively detects obstacles within a 2m range. Core components include ultrasonic sensors, Arduino ATmega328 microcontroller, mobility aid, and an alarm system.

[4] D.Sekar, S.Sivakumar, P.Thiyagarajan, R.Premkumar, and Vivekkumar this study proposed an ultrasonic and voice-based smart stick, integrating GPS technology for route guidance. Pre-programmed locations aid in selecting routes. The system involves ultrasonic, temperature, and humidity sensors, GPS receiver, vibrator, voice synthesizer, speaker/headphone, PIC controller, and battery.

[5]M Narendran, SarmisthaPadhi, and AashitaTiwari this study introduced a wearable system named "Third Eye" for the blind, utilizing Arduino and ultrasonic sensor technology. An Arduino Pro Mini 328 board was designed as a wearable device equipped with ultrasonic sensors. This system enables visually impaired individuals to detect nearby objects, aiding their mobility. Notifications are conveyed through beeps, vibrations, or a Voice Module when objects are detected. Core components encompass Arduino, wearable band, buzzer, ultrasonic technology, and the visually impaired community

III. REQUIREMENT AND ANALYSIS

ESP32 Microcontroller: The ESP32 is a versatile System on Chip (SoC) microcontroller developed by Espressif Systems, featuring single or dual-core 32-bit LX6 microprocessors with clock frequencies up to 240 MHz. It boasts integrated Wi-Fi and Bluetooth functionalities, making it ideal for IoT applications. With extensive memory resources, programmable GPIOs, and support for various serial communication protocols, the ESP32 is well-suited for a wide range of projects. Additionally, it offers features like ADC, DAC, PWM, and cryptographic hardware acceleration, further enhancing its capabilities for diverse applications.

Ultrasonic Sensor: The ultrasonic sensor, often exemplified by the HC-SR04 module, is widely used for distance measurement in electronic projects. It operates by emitting ultrasonic waves and measuring the time it takes for the waves to bounce back after hitting an object. Based on this time measurement, the sensor calculates the distance to the object. The HC-SR04 module is easy to use and offers a wide detection range from 2 cm to 400 cm, making it suitable for various applications requiring precise distance sensing.

Buzzer: A buzzer is a compact component commonly used to add auditory feedback to electronic projects. It generates sound when powered, emitting a continuous beep in the case of the buzzer described. With its simple 2-pin structure, it can be easily integrated into breadboards, perfboards, or PCBs. The buzzer operates within a specified voltage range and consumes minimal current, making it suitable for battery-powered applications. Its small size and versatility make it a popular choice for projects requiring sound alerts or notifications.

A9G GSM/GPS Module: The A9G GSM/GPS module is a comprehensive communication module based on the RDA8955 chip. It supports quad-band GSM/GPRS communication and features an integrated GPS module for accurate location tracking. With support for voice calls, SMS, and GPRS data transmission, the A9G module is suitable for various IoT applications, vehicle-mounted equipment, and remote localization systems. It operates within a wide temperature range and consumes low power, making it suitable for battery-powered devices. Additionally, its GPIOs and AT command compatibility provide flexibility for customization and integration into different projects.

Arduino IDE: The Arduino Integrated Development Environment (IDE) serves as a comprehensive platform for writing, compiling, and uploading code to Arduino-compatible microcontrollers, including the ESP32. It offers a user-friendly interface with features such as text editing, message display, console interaction, and toolbar functionalities, simplifying the development process for embedded systems.

Proteus: Proteus Design Suite is a powerful software tool used for electronic design automation. It enables engineers and technicians to create schematics, design electronic prints, and simulate circuits, including microcontroller-based systems like the Smart Belt. Proteus facilitates the development and testing of electronic designs before fabrication, helping ensure functionality and reliability.

Blynk Application: The Blynk application provides a user-friendly platform for creating IoT projects and applications. It allows developers to easily connect hardware, such as the ESP32 or Arduino, to the Blynk cloud service, enabling remote control and monitoring via smartphones or tablets. Blynk simplifies the development of IoT solutions, offering customizable widgets, data visualization, and integration with various hardware modules.

IV. SYSTEM DESIGN

4.1 System Architecture

The below figure specified the system architecture of our project.

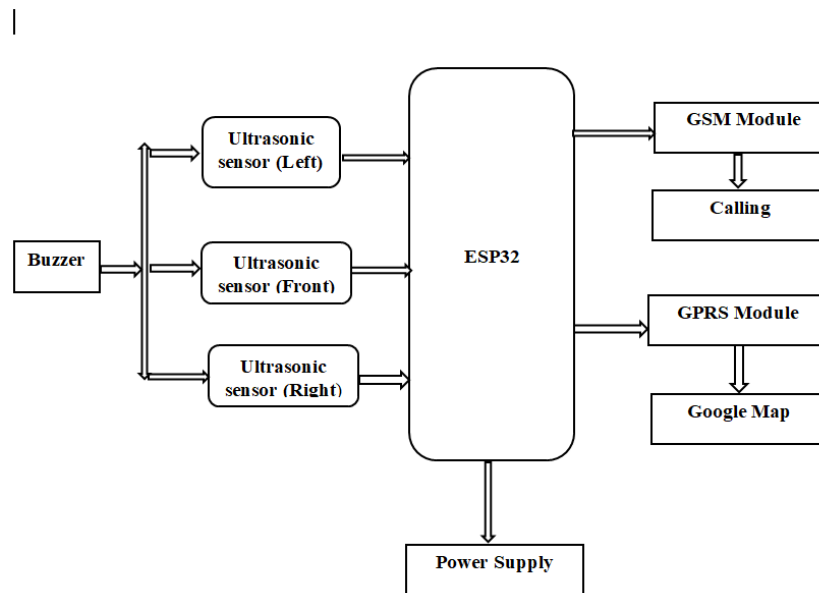


Figure 4.1: System Architecture Diagram

4.2 Working of the Proposed System

The Smart Belt system for visually impaired individuals integrates various components to facilitate safe and independent navigation. Upon activation, the ultrasonic sensor module initiates distance measurements between obstacles and the user. This process begins automatically when the device is powered on, providing real-time distance information for obstacles located on the left, right, and in front of the user. The measurements collected by the ultrasonic sensor are then transmitted to the ESP32 Microcontroller, which processes the data to determine the appropriate instructions for the user. Through the voice module, users receive audible commands guiding them away from obstacles and ensuring safe navigation. Additionally, a buzzer supplements this guidance by alerting users to obstacles from their left and right sides. The system operates on a 12-volt power supply, providing power to all integrated units. Furthermore, the inclusion of a GSM/GPS module enhances functionality by enabling real-time location tracking and communication. Leveraging GPS technology, the module accurately determines the user's position and communicates with GSM networks to send location updates and alerts, further enhancing the safety and effectiveness of the Smart Belt system for visually impaired individuals.

4.3 Circuit Diagram

The below figure specified the circuit diagram of our project.

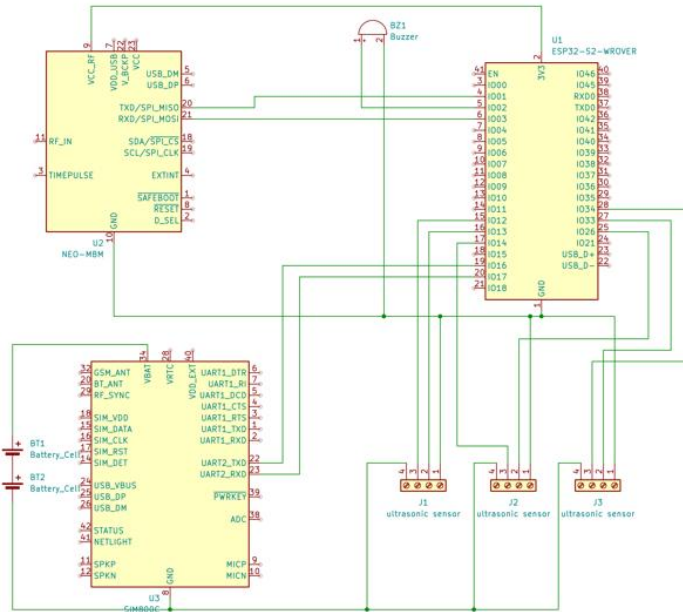


Figure 4.2: Circuit Diagram

V. RESULT

The Smart Belt for Visually Impaired is designed to address the specific needs of individuals with visual impairments by incorporating key features to enhance safety, independence, and convenience. Firstly, the belt integrates ultrasonic sensors to accurately detect obstacles in the user's path, issuing prompt warnings when objects are detected within a predefined range. This real-time obstacle detection capability ensures users can navigate their surroundings safely and confidently. Additionally, leveraging GPS data, the belt provides navigation assistance by guiding users along predefined routes or towards specific destinations, enhancing their mobility and autonomy. The inclusion of a voice output module converts alerts, warnings, and navigation instructions into spoken words, allowing users to receive information audibly and enhancing their situational awareness. Furthermore, the belt features communication functionality, enabling users to send SOS messages or make emergency calls to predefined contacts in urgent situations, providing users with a crucial lifeline when needed. The user-friendly interface is intuitive and easy to operate, catering to the needs of visually impaired individuals with possible enhancements such as tactile feedback or simple button controls. Lastly, prioritizing comfort and convenience, the belt is lightweight, comfortable to wear, and equipped with a sufficient battery life for extended use, ensuring users can wear it comfortably throughout the day without hindrance.

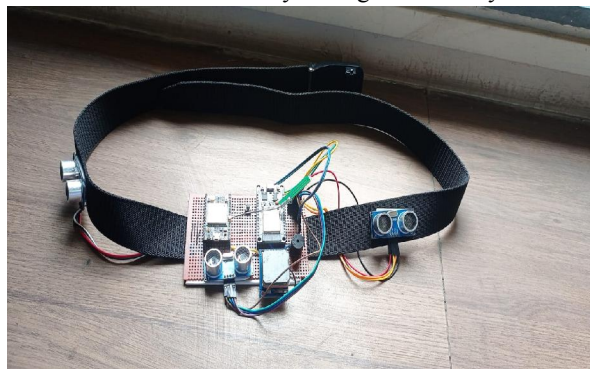


Figure 5.1: Output of System

VI. CONCLUSION

Conclusion

In conclusion, the Smart Belt for Visually Impaired represents a significant advancement in assistive technology, offering a comprehensive solution to enhance the mobility, safety, and independence of individuals with visual impairments. By integrating features such as obstacle detection, navigation assistance, voice output, communication functionality, user-friendly interface, and portability, the Smart Belt addresses the specific challenges faced by visually impaired individuals in navigating their surroundings. With its intuitive design and functionality, the Smart Belt empowers users to navigate safely, communicate effectively in emergencies, and experience greater autonomy in their daily lives, thereby improving their overall quality of life.

Future Work

- **VLSI Technology:** Use of VLSI Technology will improve the design unit of PCB unit.
- **Artificial Intelligence:** It can be enhanced by including Image processing and adding camera to the existing system.
- **Integration of AI:** Incorporating artificial intelligence algorithms for advanced obstacle recognition, allowing the Smart Belt to identify complex obstacles and provide more detailed guidance to users.
- **Wearable Integration:** Exploring integration with wearable devices such as smart glasses or haptic feedback systems to provide more discreet and intuitive navigation assistance.
- **Cloud Connectivity:** Adding cloud connectivity to enable data storage, analysis, and remote configuration, enhancing the Smart Belt's functionality and scalability.
- **Community Engagement:** Engaging with the visually impaired community for feedback and co-designing features to ensure the Smart Belt meets their evolving needs and preferences effectively.

BIBLIOGRAPHY

- [1]. AbdulhameedAlsanie, Abdulwahed Abbas, and Mohammed Alreshoodi, "A Smart Belt with Ultrasonic Sensors for Obstacle Detection and Mobility Assistance for Visually Impaired People," International Journal of Advanced Computer Science and Applications, 2021.
- [2]. Akash Gupta, Pankaj Singh, and Sandeep Joshi, "Design and Implementation of a Smart Belt for the Visually Impaired," International Journal of Computer Applications, 2018.
- [3]. Amirudin Bin Sanusi, Muhammad Hafiz Abdul Aziz, and MohdAzriMohd Noor, "Development of Obstacle Detection Device for the Blind Using Ultrasonic Sensor," International Journal of Electrical and Computer Engineering, 2015.
- [4]. Arvind Kumar, N. Arun Kumar, and R. Vidhya, "Smart Belt for Visually Impaired with Obstacle Detection and Location Indication," International Journal of Engineering and Advanced Technology, 2019.
- [5]. Asit Kumar Jena, Anup Kumar Das, and Ramesh Kumar Jena, "Smart Obstacle Detection and Navigation System for Visually Impaired People Using Ultrasonic Sensor and Arduino," International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 2019.
- [6]. ChetnaNandwani, DikshaDhiman, and Anoop Singh, "Assistive Device for Visually Impaired People Using Arduino," International Journal of Computer Science Trends and Technology, 2015.
- [7]. D. S. Choudhari, S. R. Nalbalwar, and S. G. Adlak, "Smart Obstacle Detection System for Blind People," International Journal of Science, Engineering and Technology Research, 2016.
- [8]. Deepali S. Chaudhari, Vinayak S. Biradar, and Sagar G. Adlak, "Smart Stick for Blind People with Ultrasonic Sensor," International Journal of Engineering Science and Computing, 2017.
- [9]. Dilip Kumar Jena, Saumendra K. Mohapatra, and Sudhansu K. Jena, "A Review on Smart Stick for Blind Person," International Journal of Scientific Research and Management, 2019.
- [10]. Manju Thomas, G. S. Sharath Kumar, and M. K. Shaila, "Development of Obstacle Detection System for Visually Impaired People Using Ultrasonic Sensor," International Journal of Advanced Research in Computer Science and Software Engineering, 2016.

- [11]. Mohamed Ashraf M. Abdelkader, "Smart Cane for Visually Impaired People," International Journal of Electronics and Communication Engineering and Technology, 2017.
- [12]. Mukesh G. Kurund, Mangesh D. Pokharkar, and Shrikant S. Sawai, "Obstacle Detection and Navigation System for Blind," International Journal of Engineering Research and Technology, 2015.
- [13]. R. G. Khadse, S. A. Kulkarni, and P. P. Bansod, "Smart Stick for Blind," International Journal of Engineering Development and Research, 2016.
- [14]. Renuka Jain, S. Swathi, and K. Swetha, "Smart Stick for Blind Person Using Arduino," International Journal of Innovative Research in Science, Engineering and Technology, 2015.
- [15]. S. SaiManikanta, S. Harika, and M. Mounika, "Smart Stick for Visually Impaired Using Arduino," International Journal of Advanced Research in Computer and Communication Engineering, 2017.
- [16]. SangeetaTanwar, AmandeepKaur, and AnjuBala, "Smart Walking Stick for Blind," International Journal of Advanced Research in Computer Science and Software Engineering, 2015.
- [17]. Shaila S. Patil, Jitendra M. Mohite, and Mithun S. Harnal, "A Smart Stick for Blind Person," International Journal of Science, Engineering and Technology Research, 2017