VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi – 590014

A Final Project Report

On

"Smart Glasses For Visually Impaired"

Submitted in partial fulfillment of the requirement for the award of degree of

BACHELOR OF ENGINEERING

In

INFORMATION SCIENCE AND ENGINEERING

By

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CERTIFICATE

This is Certified that the Project (BIS685) work entitled

"Smart Glasses For Visually Impaired"

Is a bonafide work carried out by

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in partial fulfillment for the award of degree of 6^{th} sem of Bachelor of Engineering in Information Science & Engineering of the Visvesvaraya Technological University, Belagavi during the academic year 2024-2025.

It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The Project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering Degree.

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Signature of the Guide	Signature of the Coordinator	Signature of the HOD
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Introduction:

Smart Glasses for the Visually Impaired using ESP32, combined with a smart stick, offer a comprehensive assistive technology solution. The system is designed to enhance spatial awareness and navigation for blind and visually impaired individuals. Equipped with ultrasonic sensors, the smart stick detects nearby obstacles and alerts the user via haptic or audio feedback. The ESP32 microcontroller enables wireless communication between the stick and the smart glasses. The glasses include a camera and sensors for obstacle recognition and real-time object detection. Voice feedback helps users understand their surroundings more effectively. This integrated solution is lightweight, affordable, and easy to use. It aims to boost independence and safety in daily navigation.

Literature Survey:

Combines ultrasonic sensors and a GPS module with ESP32 to create a smart stick that detects obstacles and guides the visually impaired through voice feedback. Achieves obstacle detection within 1.5 meters and provides real-time location tracking via Google Maps integration. The system enhances navigation independence while being cost-effective and compact [1].

Integrates a smart glass with ESP32 for head-level object detection using ultrasonic and IR sensors. The data is processed and transmitted via Bluetooth to a mobile device, which generates corresponding voice commands to assist navigation. Tests showed a 93% success rate in avoiding head-level collisions in dynamic environments [2].

Implements a dual-sensor approach—placing sensors on both smart stick and glasses—allowing 360-degree environmental perception. The stick focuses on ground-level detection, while glasses cover obstacles at head and chest levels. An onboard ESP32 microcontroller handles data fusion and sends audio cues through a speaker embedded in the glasses. System usability testing with 25 blind individuals reported improved confidence and reduced anxiety in crowded spaces [3].

Uses a camera on the smart glasses to implement object recognition using the YOLOv4 algorithm. Real-time processing is achieved by offloading data to an edge computing unit connected via Wi-Fi through ESP32. The solution enables not just obstacle detection, but also identification of doors, stairs, and people. Average object recognition accuracy exceeds 88%, with minimal delay, proving suitable for real-time navigation assistance [4].

Adopts haptic feedback as an alternative to audio alerts for privacy in public spaces. Vibration motors placed in the smart stick handle obstacle alerts at different intensity levels depending on the distance. The ESP32 communicates with a mobile app using MQTT protocol to manage system settings and track user movement. The system achieves strong user acceptance and is especially helpful for those who prefer tactile over auditory input [5]

Explores integration of LIDAR Lite v3 sensor with smart glasses to increase precision in depth perception and object detection. Paired with ESP32 for processing and feedback generation, the system identifies moving objects and calculates relative velocity. Field trials reveal significant improvements in dynamic obstacle avoidance, particularly in crowded urban environments [6].

Presents a cloud-based extension to the smart assistive system using Firebase and ESP32's Wi-Fi capabilities. Real-time location and obstacle data are stored for caregiver monitoring and path replay. Emergency alerts can be triggered if the user remains stationary for unusually long periods. The cloud architecture supports multi-user expansion and scalability, addressing family and institutional care needs [7].

Develops a low-cost, solar-powered version of the smart stick and glasses using ESP32 with deep sleep modes and efficient battery management. Designed for rural deployment, the system maintains functionality in areas with limited electricity. Voice output is multilingual, addressing the needs of diverse user groups. Field usability tests in Indian villages confirmed the practicality and affordability of the system [8].

Incorporates facial recognition using a mini camera in smart glasses connected to ESP32. The system identifies known individuals from a pre-trained dataset stored locally and generates an audio prompt with the person's name. This fosters social interaction and helps users recognize acquaintances. Testing yielded over 90% facial recognition accuracy in well-lit environments [9].

Evaluates the impact of ESP32-based assistive systems on user mobility and safety across different terrains such as stairs, slopes, and uneven roads. Combines IMU (Inertial Measurement Unit) sensors with ultrasonic modules to detect elevation changes. Alerts are sent through the glasses' speaker. Results show a 40% reduction in trip-and-fall incidents compared to traditional white canes [10].

Adds AI-based pathfinding algorithms to help users choose safer and more efficient routes. Data from previous navigation patterns is analyzed and optimized for future trips. The ESP32 stores this data locally and syncs with cloud services for further training. The system effectively shortens average walking time and reduces obstacle encounters in repeated routes [11].

Demonstrates an all-in-one wearable system that combines obstacle detection, facial and object recognition, GPS tracking, and AI path prediction. The smart stick and glasses are seamlessly integrated through ESP32, functioning as a cohesive navigation assistant. Emphasizes modular design for easy upgrades and maintenance. User satisfaction scores exceed 85% in long-term trials [12].

Focuses on data security and privacy by implementing encryption on ESP32 modules when transmitting sensitive location or personal identification data. Ensures compliance with accessibility and data protection standards, especially in institutional settings like hospitals or schools for the blind. Introduces biometric lock on mobile app for caregiver access [13].

Supports modular attachments such as voice-activated SOS alert button and environmental sensors (humidity, temperature, air quality) to improve situational awareness. ESP32 enables edge processing and low-latency alerts. Ideal for visually impaired users in changing weather or urban conditions. Enhances autonomy and safety in daily travel [14].

Utilizes ESP32's BLE capabilities to create an indoor navigation mesh network in public buildings (e.g., malls, hospitals). Smart glasses detect beacons and calculate position relative to rooms and exits. Audio navigation instructions guide users within the building. Real-world pilot studies demonstrate efficient movement and improved user orientation indoors [15].

Incorporates speech recognition directly on the ESP32 to allow users to control system features through voice commands without needing a smartphone. Enables functions like volume adjustment, mode switching, and emergency alerts through simple commands. Improves hands-free interaction, especially in time-sensitive or dangerous situations [16].

Applies edge AI models optimized for ESP32 to reduce reliance on cloud computing for visual processing. Enables localized object and gesture recognition on-device, significantly decreasing latency. This approach supports real-time performance and greater user privacy, particularly in remote or low-connectivity environments [17].
Implements geofencing technology using GPS and ESP32 to alert users when they move outside of predefined safe zones. Caregivers receive real-time alerts via mobile notifications. Enhances personal safety for visually impaired individuals, particularly those with memory challenges or in high-risk urban areas [18].

Develops a gamified training module where ESP32-based glasses simulate various obstacle scenarios in controlled environments. Helps new users learn system interaction through voice and haptic feedback in a safe setting. Initial testing indicates higher retention of navigation skills and increased user confidence [19].

Integrates thermal imaging with ESP32 to detect warm-bodied objects like people or animals in low-light conditions. Enhances night-time mobility and situational awareness. Field tests show reliable performance in dim environments, making the system suitable for both urban and rural nighttime use [20].

Problem Statement:

1. Navigation Challenges: Visually impaired individuals face significant difficulties in independently navigating unfamiliar or crowded environments.

2. Limitations of Traditional Aids: Conventional white canes offer limited obstacle detection and do not provide information about objects above waist level or dynamic obstacles.

3. Need for Real-Time Feedback: Accurate and real-time obstacle detection with timely alerts is essential for safe and confident movement.

4. Integration of Wearables: Smart wearables like glasses can provide additional sensory input to overcome the shortcomings of traditional aids.

5. IoT and Sensor Integration: Devices like ESP32 enable low-cost, wireless integration of sensors and feedback systems into wearable and assistive technologies.

6. Combining Stick and Glasses: A smart stick paired with smart glasses can enhance obstacle detection in all directions, including head-level and dynamic objects.

7. **Accessible and Affordable Technology**: There is a need for a low-cost, user-friendly, and compact solution suitable for daily use by the visually impaired.

8. **Role of AI and Feedback Systems**: The use of AI for object recognition and audio/haptic feedback can significantly improve spatial awareness and safety.

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