

Vision Care Glasses for Blind Person

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Abstract - VisionCare Spectacles is an IoT-based assistive system developed to make everyday movement a little safer and more manageable for visually impaired individuals. The project combines simple but reliable technologies — mainly the ESP32 microcontroller, ultrasonic sensors, and the ESP-NOW communication protocol — to create a wearable device capable of detecting nearby obstacles in real time and alerting the user instantly. Alongside obstacle detection, the system also includes GPS and GSM modules for emergency communication and location tracking, which can be genuinely useful in situations where a user needs immediate assistance outdoors or in crowded areas.

Rather than trying to replace existing mobility aids, the idea here is to provide an additional layer of support through a lightweight and connected device. The paper explains the overall system architecture, hardware setup, and working methodology in detail, while also discussing practical challenges, limitations, and possible future improvements. Although the prototype is still dependent on sensor accuracy and network availability in some cases, it demonstrates how affordable IoT technologies can be adapted into meaningful assistive solutions for day-to-day use.

Keywords — Internet of Things (IoT), Smart Blind Glasses, Assistive Technology, ESP32, Ultrasonic Sensor, ESP-NOW, GPS/GSM Module, Obstacle Detection, Emergency Communication, Wearable Device.

I. INTRODUCTION

Visual impairment continues to affect millions of people worldwide, and for many, even ordinary daily activities can become difficult without assistance. Something as simple as crossing a busy road, walking through a crowded market, or identifying obstacles in an unfamiliar place often requires constant caution. Traditional mobility aids like white canes and

guide dogs have supported visually impaired individuals for decades, and they still remain important. However, they are not without limitations. A white cane, for instance, can only detect objects within a short range and depends heavily on physical contact. Guide dogs, on the other hand, require extensive training, regular care, and considerable expense, which may not be practical for everyone. More importantly, neither approach really offers real-time communication or emergency connectivity in critical situations [1], [2].

Because of this, researchers and developers have increasingly turned toward IoT-based assistive technologies. The idea is fairly straightforward: connect sensors, microcontrollers, and wireless communication systems in a way that allows the device to continuously “understand” the surroundings and respond quickly when needed. In practical terms, if a user approaches a wall, staircase, or unexpected obstacle, the system can immediately generate an alert. Some setups can even share the user’s live location with caregivers during emergencies, which adds an extra layer of safety that conventional aids generally cannot provide [3], [4].

Over the years, several smart assistive systems have been proposed using ultrasonic sensors, GPS modules, and wireless communication technologies. Many of them improve obstacle detection and remote monitoring quite effectively [5], [6]. Still, a noticeable gap remains between experimental prototypes and devices that people would actually feel comfortable wearing every day. Some systems are bulky, overly complicated, or focused on only one feature while neglecting usability and portability [7], [8].

The VisionCare Spectacles project was developed with these concerns in mind. Instead of designing a purely theoretical model, the focus here is on creating a compact and wearable assistive system that combines obstacle detection, wireless connectivity, and emergency communication into a single platform. The

proposed device uses affordable components such as the ESP32 microcontroller, ultrasonic sensors, GPS/GSM modules, and the ESP-NOW communication protocol to build a practical solution rather than an overly complex one. Admittedly, the system still depends on sensor accuracy and stable network connectivity in certain conditions. Even so, it demonstrates how low-cost IoT technology can be adapted into a more reliable and user-friendly mobility aid for visually impaired individuals.

II. SYSTEM OVERVIEW

The VisionCare Spectacles system is designed as an IoT-based assistive solution intended to improve mobility and personal safety for visually impaired individuals. The overall idea is fairly practical: create a lightweight wearable device that can detect obstacles, communicate wirelessly, and provide emergency support when required. Instead of relying on a single function, the system combines sensing, communication, and alert mechanisms into one integrated setup, making it more useful in real-world situations.

At the core of the system, two ESP32 microcontrollers are used to handle data processing and wireless communication efficiently. A dual-controller arrangement was chosen mainly to reduce processing load and improve response speed between sensing and alert operations. The sensing section uses an HC-SR04 ultrasonic sensor, which continuously scans the nearby surroundings for obstacles. Whenever an object is detected within a certain distance, the information is transmitted wirelessly from one ESP32 module to another through the ESP-NOW communication protocol. This protocol was selected because of its low latency and its ability to work without requiring an active internet connection, which makes the system more reliable in outdoor or low-network areas [1].

Once the receiver ESP32 obtains the sensor data, it immediately processes the information and activates a buzzer alert if the obstacle is too close. The response is intentionally simple and quick. After all, in situations like walking

through a crowded hallway or approaching a staircase, even a small delay could create difficulty for the user. The alert mechanism therefore focuses more on fast awareness rather than complicated feedback systems.

Navigation, however, is only one part of the design. The system also integrates a Neo6M GPS module and a SIM800L GSM module to support emergency communication and remote location tracking. If the user presses the panic button — or if a location request is triggered remotely — the device sends the user's real-time location through SMS to a predefined contact. In practical situations, such as getting lost in an unfamiliar area or needing immediate assistance, this feature can make the device considerably more useful than a standalone obstacle detector [2], [3].

Even though the prototype is compact and functional, certain limitations still exist. Sensor accuracy can vary slightly depending on environmental conditions, and GSM communication depends on network availability. Even so, the system demonstrates how low-cost IoT hardware can be integrated into a wearable assistive device that is both practical and reasonably efficient for everyday use.

III. BLOCK DIAGRAM DESCRIPTION

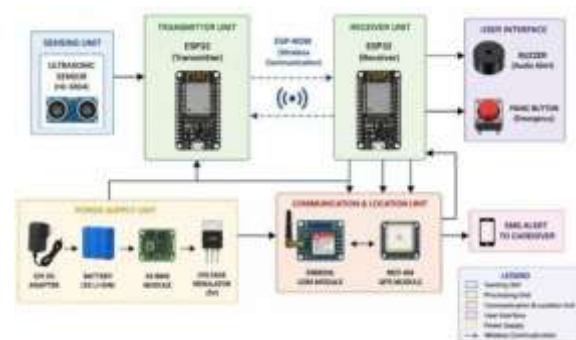


Fig 3.1 : Block Diagram of Smart Blind Glasses System

The VisionCare Spectacles system is built using several interconnected functional units that work together to assist visually impaired users in navigation and emergency situations. Rather than depending on a single sensor or controller, the

system combines sensing, processing, communication, alert generation, and power management into one wearable setup. The complete design is based on a dual ESP32 microcontroller architecture, mainly to improve communication speed and make the overall operation more stable and responsive.

1. Input Unit (Ultrasonic Sensor & Panic Button)

The input section includes an HC-SR04 ultrasonic sensor and a panic button. Mounted on the spectacles, the ultrasonic sensor continuously scans the surrounding environment by transmitting ultrasonic waves and measuring the returning echo time. Using this information, the system estimates the distance between the user and nearby obstacles. In simple situations — for example, approaching a wall, staircase, or parked vehicle — the sensor helps the device identify potential collisions before they happen. Along with obstacle detection, a panic button is also included as a manual emergency trigger. If the user feels unsafe, gets lost, or requires immediate assistance, pressing this button activates the emergency communication system. In many ways, this small feature adds a sense of reassurance because the user does not need to depend entirely on automatic detection. The input unit therefore acts as the primary source of both environmental and user-generated information.

2. Processing Unit (ESP32 - Transmitter & Receiver)

The processing section forms the core of the entire system and uses two ESP32 microcontrollers working together. The transmitter ESP32 is mainly responsible for collecting distance data from the ultrasonic sensor and forwarding it wirelessly. The receiver ESP32 acts as the central controller, processing the received information, comparing the detected distance with a predefined threshold of about 50 cm, and then controlling the alert and communication mechanisms accordingly.

A dual-controller arrangement may seem slightly excessive for a small wearable prototype at first glance. However, separating sensing and response tasks reduces processing load and allows faster

operation, especially during continuous monitoring. The ESP32 was selected because it offers low power consumption, dual-core processing capability, built-in wireless features, and support for the ESP-NOW protocol, all of which are useful for compact battery-powered devices.

3. Output Unit

The output unit mainly consists of a buzzer and the SIM800L GSM module. Since the user may not be able to rely on visual indicators, the buzzer provides audio feedback in different patterns depending on the situation. For instance, one alert pattern may indicate a nearby obstacle, while another may confirm successful message transmission or signal a GPS-related issue. Keeping the feedback simple but distinguishable was considered more practical than using overly complicated sound patterns.

The GSM module works as the system's communication interface with the outside world. During emergencies, it sends an SMS containing the user's real-time location, usually in the form of a Google Maps link, along with battery status information to predefined contacts or caregivers. This feature becomes especially valuable in unfamiliar or crowded environments where immediate support may be required.

4. Communication & Location Unit

Wireless communication and location tracking are handled through the ESP-NOW protocol and the Neo-6M GPS module. ESP-NOW enables direct peer-to-peer communication between the two ESP32 controllers without requiring a Wi-Fi router or internet connection. This reduces communication delay and makes the system more reliable in areas with weak connectivity.

Meanwhile, the GPS module continuously acquires real-time geographic coordinates. These coordinates are later used by the GSM module whenever an emergency message needs to be transmitted. Admittedly, GPS accuracy can vary depending on environmental conditions such as tall buildings or poor satellite visibility. Even so, it remains sufficiently accurate for emergency tracking in most practical situations.

5. Power Supply Unit

The entire device is powered through a rechargeable battery supported by a Battery Management System (BMS) and a voltage regulation circuit. This section ensures that stable voltage is supplied to all components, particularly the SIM800L module, which can behave unpredictably during voltage fluctuations. Since the system is intended to be wearable, energy efficiency becomes extremely important. A bulky or frequently discharged device would reduce practicality, regardless of how advanced the features are.

Overall, the operation of the VisionCare Spectacles system depends on close coordination between all these functional units. The transmitter ESP32 continuously monitors obstacle data and sends it to the receiver. Whenever an obstacle is detected within the threshold range, the receiver immediately activates the buzzer alert. In emergency situations, pressing the panic button triggers the GPS and GSM modules to obtain the user's location and send an SMS alert. Together, these units create a connected assistive system focused on improving mobility, awareness, and user safety in day-to-day environments.

IV. SYSTEM FLOW AND OPERATION

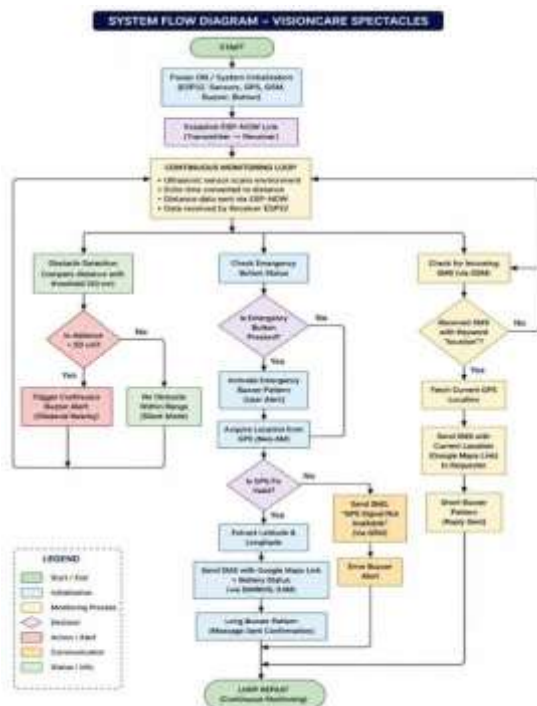


Figure 4.1: System Flow Diagram

The VisionCare Spectacles system operates through a continuous sequence of sensing, communication, processing, and response actions. In simple terms, the device is always observing the surroundings, making quick decisions, and reacting whenever necessary. The process begins at the transmitter side, where the HC-SR04 ultrasonic sensor continuously scans the nearby environment for obstacles. As soon as an object comes within detectable range, the sensor calculates the distance by measuring the time taken for the ultrasonic echo to return. This distance data is then forwarded wirelessly to the receiver ESP32 using the ESP-NOW protocol, which was selected mainly because it provides fast communication without depending on internet connectivity [1].

Once the receiver ESP32 obtains the sensor data, it starts the decision-making process. The controller compares the received distance value with a predefined safety threshold of approximately 50 cm. If the detected object falls within this unsafe range, the system immediately activates the buzzer to generate an audio warning for the user. The alert continues until the obstacle moves away or the user changes direction. In practical situations — such as approaching a staircase edge, a wall, or even a parked bike on a footpath — this quick response can help reduce accidental collisions. On the other hand, if no nearby obstacle is detected, the system stays silent and continues monitoring normally, which keeps the device from becoming unnecessarily distracting during regular movement [2], [3].

Along with obstacle detection, the system simultaneously keeps track of the panic button status. If the user presses the emergency button, the device immediately switches into emergency response mode. A separate buzzer pattern is generated first, mainly to confirm that the emergency request has been successfully registered. After that, the receiver ESP32 communicates with the Neo-6M GPS module to obtain the user's real-time geographic coordinates. The raw GPS data is processed to extract valid latitude and longitude values, and once a stable location is available, the SIM800L GSM module sends an SMS alert to a predefined contact number. The message includes a Google Maps location link along with the current battery

status of the device. To avoid uncertainty, another distinct buzzer indication confirms successful message transmission [4].

The system also supports a remote location tracking feature, which adds another layer of safety. The GSM module continuously listens for incoming SMS commands. If an authorized user sends a keyword such as “location,” the system automatically retrieves the current GPS coordinates and replies with the location details. This allows caregivers or family members to check the user’s position when necessary, especially during travel or emergencies. Of course, location tracking still depends on GPS signal availability, and in crowded urban areas or indoor spaces, accuracy may fluctuate slightly. To handle such situations, a fallback mechanism has been included. If valid GPS data cannot be obtained, the system sends an alternative message indicating GPS failure, while separate buzzer alerts notify the user about the issue [5].

Overall, the entire operation runs continuously in a loop. After completing any obstacle alert or emergency communication process, the system automatically resets itself and resumes monitoring the environment, panic button activity, and incoming GSM requests. This uninterrupted and event-driven operation helps the device respond quickly to multiple situations without requiring manual restarting or user intervention. Although the prototype still has practical limitations related to sensor accuracy and network dependency, it demonstrates how coordinated IoT modules can work together to provide a compact and responsive assistive system for visually impaired individuals [6].

V. HARDWARE AND SOFTWARE IMPLEMENTATION

A. HARDWARE IMPLEMENTATION



Figure 5.1: Hardware Implementation of Smart Blind Glasses System

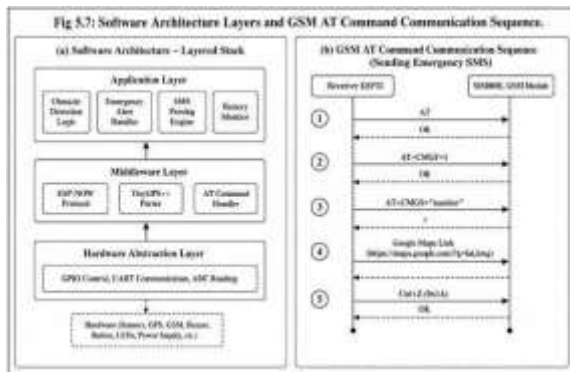


Figure 5.2: Wearable Smart Blind Glasses Prototype

The VisionCare Spectacles hardware is designed using compact and low-power components integrated into a wearable glasses structure. The system includes two ESP32 microcontrollers, an HC-SR04 ultrasonic sensor, a Neo-6M GPS module, a SIM800L GSM module, a buzzer, a panic button, and a regulated power supply unit. The transmitter ESP32 collects obstacle distance data from the ultrasonic sensor and sends it wirelessly to the receiver ESP32 using the ESP-NOW protocol. The receiver ESP32 acts as the main controller, processing the received data and activating the buzzer whenever an obstacle is detected within the predefined safety range. It also controls the GPS and GSM modules for emergency communication and location tracking. A panic button is connected to the receiver unit to allow the user to manually trigger emergency mode. When activated, the system obtains GPS coordinates and sends the user’s location through SMS to predefined contacts. All components are powered through a regulated battery supply to ensure stable operation, especially for the GSM module.

The complete circuit is assembled on a PCB and integrated into a wearable spectacles prototype, with the ultrasonic sensor mounted at the front for effective obstacle detection. Although compact and functional, the prototype can still be improved further in terms of size, comfort, and battery efficiency for long-term daily use.

B. SOFTWARE IMPLEMENTATION



The software implementation of the VisionCare Spectacles is developed using the Arduino IDE and programmed in Embedded C/C++. The software controls all major system functions, including obstacle detection, wireless communication, GPS tracking, GSM messaging, and buzzer alerts.

The two ESP32 microcontrollers communicate using the ESP-NOW protocol after pairing through registered MAC addresses. The transmitter ESP32 continuously reads distance data from the ultrasonic sensor and sends it wirelessly to the receiver ESP32. The receiver processes this data and compares it with the predefined 50 cm safety threshold. If an obstacle is detected within this range, the buzzer is activated to alert the user; otherwise, the system remains in monitoring mode.

For emergency communication, the software controls the SIM800L GSM module using AT commands. When the panic button is pressed or a "location" SMS request is received, the receiver ESP32 fetches real-time coordinates from the Neo-6M GPS module using the TinyGPS++ library. The obtained location is converted into a Google Maps link and sent through SMS to predefined contacts.

Different buzzer patterns are programmed to indicate obstacle alerts, emergency confirmation, successful message transmission, and GPS errors. The software operates continuously in a loop to ensure real-time monitoring and fast system response. Efficient programming and state management techniques are used to improve reliability, reduce delay, and support smooth multitasking operation.

VI. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

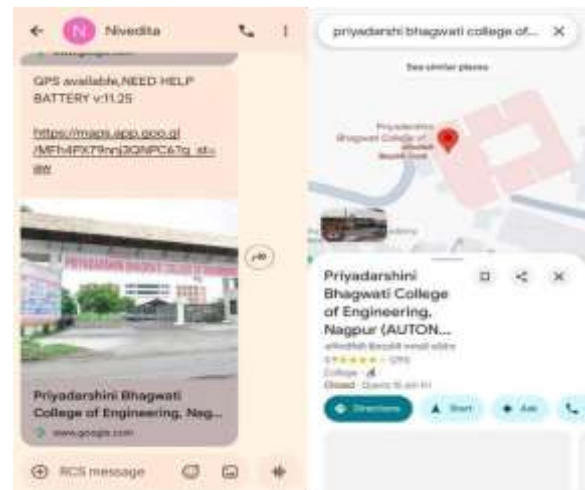


Figure 6.1: Live Location SMS Alert Generated by the System

The VisionCare Spectacles system was tested under different real-time conditions to evaluate how effectively it performs in practical situations. Multiple obstacle scenarios, emergency events, and communication tests were carried out to examine parameters such as detection accuracy, response speed, communication reliability, system stability, and power efficiency. The testing also helped identify a few practical limitations that could be improved in future versions of the device [1]–[3].

Detection Accuracy:

During testing, the HC-SR04 ultrasonic sensor detected obstacles accurately within the configured range of approximately 2 cm to 50 cm. Whenever an object entered the threshold distance, the buzzer alert was activated correctly, while no alert was generated when the path was clear. In practical use, the system was able to detect nearby walls, furniture, and stationary

objects quite reliably. However, like most ultrasonic sensors, performance varied slightly with soft or sound-absorbing surfaces [1].

Response-Time:

The system response time was measured from obstacle detection to buzzer activation. The delay was almost unnoticeable during operation, making the alerts feel nearly instantaneous. This fast response was mainly achieved because of the low-latency ESP-NOW communication and the efficient processing capability of the ESP32 microcontrollers [2]. In real walking conditions, quick response is essential since even small delays could reduce user confidence while navigating.

Communication Reliability:

Wireless communication between the two ESP32 modules remained stable throughout the tests, with negligible packet loss observed during normal operation. The SIM800L GSM module also performed reliably, successfully sending emergency SMS alerts within roughly 5 to 10 seconds after panic button activation. Each message included a working Google Maps location link along with battery status information, which made the emergency feature more practical and informative [3].

Emergency & Tracking Performance:

The Neo-6M GPS module provided location accuracy of nearly ± 5 meters under open-sky conditions. The panic button feature operated consistently, and the system correctly responded to remote SMS requests containing the “location” keyword. A fallback safety mechanism was also tested. If GPS coordinates could not be obtained due to weak satellite signals, the system automatically sent a default emergency help message instead of failing completely. This added a layer of reliability during unexpected situations [4].

System Stability:

Long-duration testing showed that the dual-ESP32 architecture remained stable during continuous operation. The receiver ESP32 successfully handled multiple tasks simultaneously, including sensor monitoring, GPS reading, and GSM message processing,

without freezing or noticeable slowdown. This multitasking capability improved the overall reliability of the system during prolonged use [5].

User Interface Performance:

The buzzer-based feedback system proved simple but effective. Different sound patterns were used for different situations, such as continuous tones for obstacle alerts, pulsed tones for panic button confirmation, long beeps for successful SMS transmission, and separate patterns for GPS failure notifications. Since the system is intended for visually impaired users, these distinct non-visual alerts made interaction easier and more intuitive [6].

Power Efficiency:

The system consumed relatively low power because of the energy-efficient ESP32 controllers and the selective activation of the GSM module only during communication events. This helped improve battery life and made the prototype more suitable for portable wearable use. Even so, long-term battery optimization could still be improved in future versions.

Limitations:

A few practical limitations were observed during testing. GPS performance depended heavily on signal availability and was less reliable indoors or in densely built-up areas. The SIM800L GSM module also required a stable high-current power supply for proper operation. Additionally, the ultrasonic sensor occasionally showed reduced accuracy with soft or irregularly shaped objects that absorb sound waves instead of reflecting them effectively.

Overall Performance:

Overall, the VisionCare Spectacles system demonstrated reliable and efficient performance in obstacle detection, emergency communication, and real-time monitoring. The integration of IoT-based sensing, wireless communication, and immediate audio feedback created a practical assistive solution that can improve mobility and user safety. Although certain hardware limitations still exist, the prototype shows strong potential as an

affordable and wearable smart assistive device for visually impaired individuals.

VII. APPLICATIONS



The VisionCare Spectacles system can be used in several practical situations beyond basic obstacle detection. Its combination of navigation assistance, emergency communication, and wearable design makes it useful in different assistive and safety-related applications.

Assistive Mobility

The primary application of the system is to assist visually impaired individuals in navigating safely through indoor and outdoor environments. By detecting nearby obstacles and providing immediate audio alerts, the device helps reduce the risk of collisions during daily movement.

Elderly Care

The system can also be adapted for elderly individuals who may require additional safety monitoring. Features such as emergency alerts and live location sharing can help caregivers quickly respond if the user faces difficulty or becomes disoriented.

Personal Safety Device

Apart from assistive navigation, the device can function as a personal emergency system. When the panic button is pressed, the system immediately sends an SOS message along with the user's live location, which may be useful during accidents or unsafe situations.

Navigation in Unfamiliar Environments

The system may also assist users while moving through unfamiliar or low-visibility environments where visual awareness is limited. In such situations, real-time obstacle alerts can provide an additional layer of safety and confidence.

VIII. FUTURE SCOPE

Although the current VisionCare Spectacles prototype performs effectively for obstacle detection and emergency communication, several improvements can still be explored to make the system smarter, more accurate, and more user-friendly in the future.

AI-Based Object Recognition

Future versions could integrate a camera module with artificial intelligence and deep learning algorithms to identify specific objects instead of simply detecting obstacles. For example, the system could recognize stairs, doors, vehicles, or pedestrians and provide more meaningful guidance to the user.

Voice Assistant Integration

The buzzer-based feedback system could be replaced or supplemented with voice guidance through earphones or bone-conduction audio systems. This would allow the device to provide spoken navigation instructions and confirmation messages in a more interactive manner.

Haptic Feedback System

Another possible improvement is the use of vibration motors instead of audio alerts. Haptic feedback could provide silent and less distracting notifications, especially in crowded or noisy environments where buzzer sounds may be difficult to hear clearly.

Improved Positioning Accuracy

Location tracking performance could be enhanced by upgrading to advanced multi-constellation GNSS modules or by implementing dead-reckoning techniques. This would help improve positioning accuracy in indoor areas or densely populated urban environments where GPS signals are weaker.

Mobile Application Integration

A dedicated mobile application could be developed for caregivers and family members. The application may include features such as live location tracking, alert history, device status monitoring, and remote configuration settings for easier system management.

Advanced Power Management

Future designs may include solar-assisted charging or intelligent power-saving modes to improve battery life. Better power optimization would make the wearable device more practical for long-term outdoor use.

Multi-Sensor Fusion

The system can also be enhanced by integrating additional sensing technologies such as LiDAR or Time-of-Flight sensors. Combining data from multiple sensors would improve obstacle detection accuracy, widen the field of view, and enable more detailed 3D environmental mapping.

XI. CONCLUSION

The VisionCare Spectacles system demonstrates how IoT and embedded technologies can be combined to create a practical and wearable assistive solution for visually impaired individuals. By integrating ultrasonic obstacle detection, wireless ESP-NOW communication, GPS tracking, and GSM-based emergency alerts into a single compact device, the system provides much more than basic navigation support. Unlike traditional mobility aids that mainly depend on physical contact with obstacles, the proposed system offers real-time awareness and emergency connectivity, which can improve both user confidence and personal safety during daily movement.

The use of a dual ESP32 architecture helped achieve fast and reliable communication with minimal delay, while the GPS and GSM modules enabled effective emergency response through live location sharing. During testing, the system showed accurate obstacle detection, stable wireless communication, and near-instant alert generation under different operating conditions. The distinct buzzer feedback patterns also made the interaction simple and understandable without relying on visual indicators.

Another advantage of the system is its affordability and practical implementation. Most of the hardware components used are low-cost and easily available, which makes the device more accessible for small-scale deployment and future development. Of course, certain limitations still exist, particularly regarding GPS signal dependency and sensor accuracy in some environments. Even so, the prototype successfully demonstrates that low-cost IoT hardware can be adapted into a reliable assistive technology solution.

Overall, the VisionCare Spectacles project offers a meaningful step toward smarter and more connected mobility assistance systems. With future improvements such as AI-based object recognition,

voice guidance, mobile application integration, and advanced sensing technologies, the system can evolve into a more intelligent and user-friendly wearable platform capable of addressing complex real-world navigation and safety challenges for visually impaired individuals.

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