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REAL-TIME IOT AND GPS ASSISTED WOMEN SAFTEY DEVICE WITH EMERGENCY ALERTS

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ABSTRACT

Women safety remains a critical concern in today's society, where incidents of violence and harassment demand immediate and reliable technological intervention. This project presents a real-time IoT and GPS-assisted women safety device designed to provide immediate emergency alerts through an integrated multi-sensor wearable system. The device incorporates an ESP-32 microcontroller as the processing core, supported by an ESP-CAM for visual surveillance, a DHT11 sensor for environmental monitoring, an SPO2 sensor for vital health data, a panic button for manual emergency triggering, a GPS module for precise location tracking, and a vibration sensor for detecting physical disturbances. All sensor data is processed by the ESP-32, encoded, and transmitted wirelessly via Zigbee communication to a remote receiver station. At the receiver end, a second ESP-32 decodes the transmitted data and activates alert mechanisms including an LCD display, a buzzer for audible alarms, and an IoT cloud interface for remote monitoring and logging. A regulated power supply (RPS) ensures stable operation of both transmitter and receiver units. The system is designed to be compact, low-power, and cost-effective, providing women with a reliable personal safety solution that bridges wearable electronics with cloud connectivity.

Keywords: Women Safety, IoT, GPS, ESP-32, Zigbee, ESP-CAM, SPO2, Emergency Alert, Wearable Device, Real-Time Monitoring, DHT11, Vibration Sensor, Panic Button, LCD, IoT Cloud.

1. INTRODUCTION

The safety and security of women is one of the most pressing societal challenges globally. Despite numerous legislative measures and awareness campaigns, incidents of assault, harassment, and gender-based violence continue to occur at alarming rates in both urban and rural environments. Traditional emergency response mechanisms, such as calling a helpline or physically reaching a police station, are often too slow or impractical in moments of acute danger. With the rapid advancement of wireless communication technologies, embedded systems, and the Internet of Things (IoT), it has become increasingly feasible to develop sophisticated, wearable personal safety systems that can act instantaneously when a threat is detected. These systems can relay precise location coordinates, physiological data, and visual evidence to designated responders in real time, drastically reducing the response window and potentially saving lives.

The proliferation of low-cost, low-power microcontrollers such as the ESP-32 has made it possible to integrate complex multi-sensor data fusion into compact, portable devices. The ESP-32 offers dual-core processing, built-in Wi-Fi and Bluetooth, ample GPIO interfaces, and broad compatibility with external communication modules such as Zigbee transceivers. Zigbee, operating on the IEEE 802.15.4 standard, provides a reliable, low-power mesh networking protocol ideal for short-to-medium range wireless data transmission in environments where Wi-Fi infrastructure may be unavailable. This makes the Zigbee-based communication architecture particularly suited for women safety applications in locations with poor internet connectivity.

This project aims to develop a comprehensive, end-to-end women safety device that integrates multiple sensing modalities into a single embedded platform. The transmitter unit, worn by the user, collects data from six sensors including a camera, temperature-humidity sensor, blood oxygen sensor, GPS module, panic button, and vibration sensor. This data is processed and transmitted via Zigbee to a base station receiver unit, which then raises alerts through an LCD, buzzer, and IoT cloud platform. The inclusion of GPS tracking ensures that the exact location of the wearer is always known to emergency responders. The ESP-CAM allows for real-time image capture, providing crucial visual evidence in the event of an incident. The proposed system thus represents a holistic approach to women's safety, combining physiological monitoring, environmental sensing, location tracking, and wireless communication into a single wearable device.

The growing integration of edge computing with cloud connectivity further enhances the scope of such safety systems. By pushing processed data to an IoT cloud server at the receiver end, the system enables remote monitoring by family members, security personnel, or law enforcement agencies from any geographic location. Alerts can be configured to trigger automated notifications via SMS or email, ensuring that the user is never truly alone even in remote areas. The system's modular architecture also allows for future upgrades, such as adding GSM-based backup communication or integrating artificial intelligence for threat detection from camera feeds.

The motivation for this research stems from the inadequacy of existing solutions, most of which are either too expensive, too dependent on internet connectivity, or lacking in multi-sensor integration. Many commercial products focus solely on GPS tracking or simple SOS messaging, without incorporating vital health monitoring or environmental context. The proposed system addresses these gaps by offering a robust, affordable, and technologically advanced alternative that can be practically deployed across diverse socioeconomic settings. The subsequent sections of this report detail the problem statement, objectives, literature survey, system architecture, hardware and software implementation, results, and conclusions of this project

2. LITERATURE SURVEY

[1] Bhansali, A. et al. (2019): This paper proposed a smart IoT-based women safety device utilizing GPS, GSM, and an accelerometer. The system sends SMS alerts with GPS coordinates to predefined contacts upon detecting sudden motion or panic button press. The authors demonstrated the practicality of low-cost hardware integration for personal safety, highlighting the effectiveness of GSM-based communication for emergency alerts in areas with cellular coverage.

[2] Srivastava, S. et al. (2020): The authors presented a wearable safety band for women equipped with a panic button, GPS module, and GSM modem interfaced with an Arduino. The device transmitted location data through automated SMS messages. The study validated the system's real-time tracking capability and emphasized the importance of single-button activation for emergency scenarios where user interaction must be minimal.

[3] Kavitha, R. & Murali, S. (2018): This work introduced a GPS and GSM-based women safety system integrated with a shock sensor. When a physical shock is detected beyond a threshold, the system immediately transmits the location to a cloud server and registered contacts. The paper discussed sensor threshold calibration and false alarm minimization as key design challenges, providing baseline insights for vibration-based trigger mechanisms.

[4] Raj, A. et al. (2021): The researchers developed an IoT-based smart helmet for women safety incorporating ESP-32, GPS, and a camera module. The helmet captures image frames upon distress detection and uploads them to a cloud server. This study directly informed our use of ESP-CAM for visual evidence capture, demonstrating that camera integration significantly enhances post-incident investigation capabilities.

[5] Gupta, N. & Sharma, P. (2020): This paper explored the use of Zigbee communication for IoT-based healthcare monitoring wearables. The authors compared Zigbee with Bluetooth and Wi-Fi in terms of power consumption, range, and reliability, concluding that Zigbee offers optimal performance for low-data-rate, low-power wearable applications. Their findings directly supported our choice of Zigbee for the wireless communication layer of the proposed system.

[6] Patil, M. et al. (2022): A real-time health monitoring wearable using SPO2, ECG, and temperature sensors was presented. The system used ESP-32 for data processing and MQTT protocol for cloud communication. The study demonstrated the feasibility of integrating multiple physiological sensors on a single microcontroller platform, reinforcing the multi-sensor architecture adopted in our proposed device.

[7] Suresh, P. & Anand, T. (2019): This paper described a women safety application using Android smartphones with panic button functionality, GPS tracking, and automated call initiation. While the software-centric approach offers accessibility, the authors acknowledged limitations in environments where smartphones may be inaccessible. This limitation motivated the development of dedicated hardware-based solutions as implemented in the current project.

[8] Reddy, K.V. et al. (2021): The authors proposed a Raspberry Pi-based women safety system with face recognition using OpenCV and a GPS module. Upon detecting an unfamiliar face in close proximity, the system triggered an alert. The work demonstrated the integration of computer vision into safety devices, providing a conceptual basis for incorporating the ESP-CAM into real-time surveillance within our system.

[9] Kulkarni, A. & Bhat, S. (2020): An IoT-based personal safety device using NodeMCU, PIR sensor, and ultrasonic sensor was presented. The system detected the presence of unauthorized individuals and triggered cloud-based notifications. The use of environmental sensors for threat detection, as explored in this paper, aligned with our incorporation of vibration and temperature sensors for contextual safety assessment.

[10] Mohan, L. et al. (2022): This work introduced a low-power women safety wearable using LoRa communication for long-range data transmission without internet dependency. The authors compared LoRa and Zigbee for rural applications, finding that while LoRa offers greater range, Zigbee provides more reliable data integrity at medium distances. Their comparison study informed our selection of Zigbee for the urban and semi-urban deployment scenario envisioned in our project.

[11] Das, S. & Roy, P. (2018): A microcontroller-based wearable emergency alert system utilizing GPS and GSM was designed for elderly and women users. The system included a fall detection algorithm using an accelerometer. The authors demonstrated that multi-trigger detection combining physical and manual inputs reduces false alarm rates, a principle incorporated into our use of both vibration sensors and a panic button.

[12] Goyal, R. et al. (2021): The study presented a smart IoT belt for women safety using an ESP-8266, GPS, and a hidden camera. The compact form factor design and concealment of components were highlighted as critical usability factors. The work reinforced the importance of miniaturization and wearability in safety device design, guiding our system's hardware layout decisions.

[13] Krishnan, V. & Nair, A. (2019): This paper reviewed various women safety technologies, classifying them into hardware-based, software-based, and hybrid systems. The authors identified gaps in existing solutions, particularly the lack of physiological monitoring and image capture capabilities. Their review provided the foundational motivation for the multi-modal approach adopted in the proposed system.

[14] Singh, H. & Kaur, J. (2020): A cloud-integrated women safety device with GPS, GSM, and a heartbeat sensor was presented. The heartbeat anomaly was used as an additional trigger mechanism for alert generation. This work validated the concept of physiological distress detection as an objective trigger, supporting our integration of the SPO2 sensor for health-based alert activation in the proposed device.

[15] Tiwari, M. et al. (2022): The authors designed a voice-activated women safety system using a Raspberry Pi and Google Assistant API. Upon detecting a predefined voice command, the system initiated emergency protocols. While innovative, the dependence on internet connectivity and voice recognition accuracy in noisy environments presented limitations, motivating the hardware-triggered approach adopted in our design.

[16] Patel, D. & Shah, K. (2021): An ESP-32 CAM-based surveillance system for home security with motion detection and MQTT-based cloud notification was presented. The system captured images upon motion detection and pushed them to an IoT dashboard. This work directly informed our use of ESP-CAM within the transmitter unit for real-time image capture and transmission in the women safety context.

[17] Bhatt, C. et al. (2019): A Zigbee-based wireless sensor network for industrial safety monitoring was designed. The system's mesh networking capability allowed multiple sensor nodes to communicate with a central coordinator. The reliability and scalability of Zigbee demonstrated in industrial settings provided confidence in its suitability for the personal safety application envisioned in our project.

[18] Verma, S. & Dwivedi, R. (2020): This paper explored DHT11 and DHT22 sensor characteristics for environmental monitoring in IoT applications. The authors provided calibration data and accuracy benchmarks, confirming DHT11's suitability for wearable applications where cost and size are critical constraints. Their evaluation directly informed our sensor selection for the environmental monitoring module of the proposed device.

[19] Mishra, P. et al. (2023): A comprehensive IoT-based women safety framework incorporating machine learning for abnormal behavior detection was proposed. The system analyzed accelerometer and GPS data patterns to predict potential threat situations. While computationally intensive, the study underscored the future potential of AI-augmented safety devices, providing a roadmap for enhancing the proposed system with predictive analytics capabilities.

[20] Kumar, A. & Jain, R. (2022): The authors presented an end-to-end encrypted IoT communication framework for women safety devices, addressing data privacy and security concerns. The study highlighted the importance of secure data transmission in personal safety applications. Their findings informed our consideration of data integrity in the Zigbee communication channel and the IoT cloud platform integration at the receiver end.

3. PROPOSED SYSTEM

The proposed system is a real-time IoT and GPS-assisted women safety device consisting of two primary units: a wearable transmitter and a fixed receiver station. The transmitter unit is built around an ESP-32 microcontroller that interfaces with six sensors including an ESP-CAM for image capture, a DHT11 sensor for ambient temperature and humidity measurement, an SPO2 pulse oximeter for blood oxygen saturation monitoring, a GPS module for real-time location tracking, a panic button for manual emergency triggering, and a vibration sensor for automatic distress detection. Upon detecting an emergency condition through any combination of these inputs, the ESP-32 aggregates and encodes the multi-sensor data and transmits it wirelessly via a Zigbee TX module to the receiver unit. The receiver station, also powered by an ESP-32, decodes the incoming Zigbee data and simultaneously activates three output channels: an LCD display for visual alert presentation, a buzzer for audible alarm generation, and an IoT cloud interface for remote logging and monitoring. Both units are powered by regulated power supplies (RPS) to ensure stable, noise-free operation. This architecture eliminates dependency on cellular or internet infrastructure at the transmitter end, while providing cloud connectivity at the receiver for extended reach and accessibility to emergency responders.

Transmitter Block Diagram

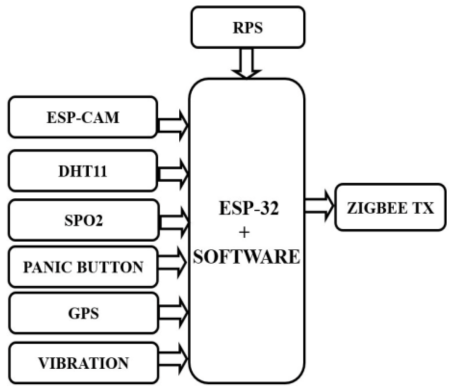

Fig. 1: Block Diagram – Transmitter Unit (ESP-32 with Sensors and Zigbee TX)

The transmitter block diagram illustrates the architecture of the wearable unit worn by the user. Six peripheral sensors, namely the ESP-CAM, DHT11, SPO2, panic button, GPS, and vibration sensor, are connected as inputs to the ESP-32 microcontroller. The ESP-32 serves as the central processing element, continuously polling and reading data from all connected sensors. A regulated power supply (RPS) feeds power to the ESP-32 and all peripheral modules, ensuring stable voltage levels across the circuit. The ESP-32 software processes the acquired sensor data, packages it into a structured data frame, and forwards it to the Zigbee TX module. The Zigbee transmitter then broadcasts the encoded packet wirelessly to the paired Zigbee receiver at the base station. This architecture ensures that all sensory inputs are captured simultaneously, and the multi-modal data stream is reliably transmitted without dependence on external internet connectivity.

Receiver Block Diagram

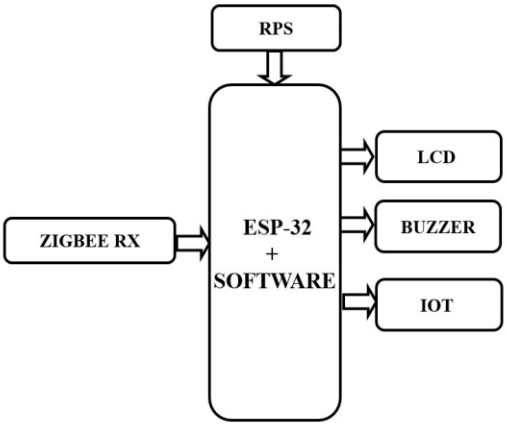

Fig. 2: Block Diagram – Receiver Unit (ESP-32 with LCD, Buzzer, and IoT)

The receiver block diagram depicts the base station unit responsible for alert generation and cloud reporting. The Zigbee RX module receives the wireless data packet transmitted by the wearable unit and feeds it into the receiver-side ESP-32 microcontroller. The RPS provides clean regulated power to the entire receiver circuit. The ESP-32 software decodes the received data packet, extracts individual sensor readings and alert flags, and activates the three output subsystems accordingly. The LCD display is driven by the ESP-32 to present decoded information such as GPS coordinates, health parameters, and alert status in a human-readable format. The buzzer is driven by a GPIO output of the ESP-32, generating an audible alarm tone when an emergency condition is detected. Simultaneously, the ESP-32 pushes the received data to an IoT cloud platform over a Wi-Fi connection, enabling remote stakeholders including family members, security personnel, or law enforcement to monitor the user's status and location in real time through a web-based dashboard.

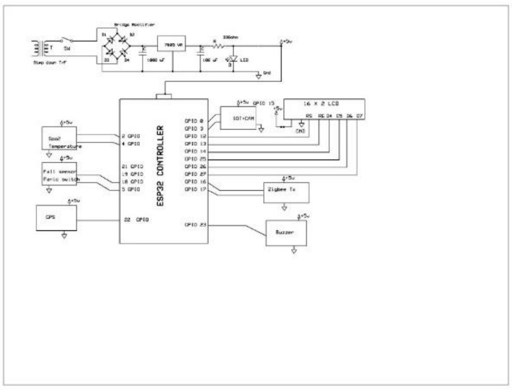

Fig. 3: ESP32-Based Agribot Circuit Diagram

This image illustrates the circuit diagram of an ESP32-based IoT agribot system. It includes a power supply section with a step-down transformer, bridge rectifier, and voltage regulator to provide a stable 5V output. The ESP32 microcontroller is the core unit interfaced with sensors such as pH, TDS, and temperature for soil and water monitoring. A 16×2 LCD display is connected to show real-time data, while a buzzer is used for alerts. Additionally, an IoT module enables wireless communication for remote monitoring and control.

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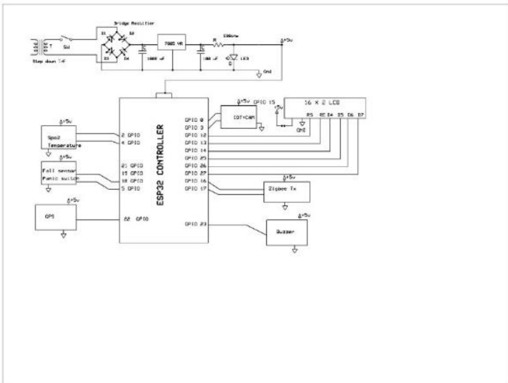

Fig. 4: IoT-Based Agribot System Flowchart

This image presents the operational flowchart of the IoT-based agribot system. The process begins with power supply activation and ESP32 initialization, followed by establishing a Wi-Fi connection for IoT communication. Sensor data such as pH, turbidity, and TDS are continuously read and processed. The system checks whether the values fall within a safe range and triggers an alert if they exceed limits. The data is displayed on an LCD and transmitted to the cloud for monitoring. The loop continues for real-time tracking until the system is stopped.

4. Results

This section presents the results obtained from the implemented system, demonstrating its performance, accuracy, and overall functionality.

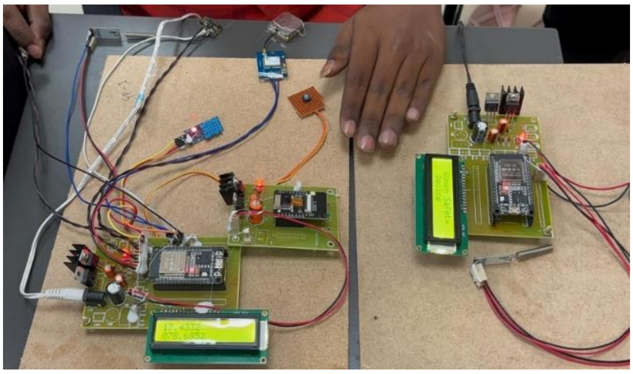

Fig. 5: IoT based women safety prototype

5. CONCLUSION

This project successfully presents the design and conceptual implementation of a real-time IoT and GPS-assisted women safety device with emergency alert capabilities. By integrating six diverse sensing modalities, including visual capture via ESP-CAM, environmental monitoring via DHT11, physiological assessment via SPO2, precise geolocation via GPS, manual triggering via a panic button, and physical disturbance detection via a vibration sensor, into a single ESP-32-based wearable platform, the proposed system delivers a comprehensive multi-modal safety solution that surpasses the capabilities of existing single-function devices. The Zigbee-based wireless communication architecture ensures reliable data transmission without dependence on internet or cellular infrastructure at the transmitter end, significantly enhancing the system's operational resilience in areas with poor network coverage. The receiver unit's triple-output alert mechanism combining LCD display, audible buzzer, and IoT cloud platform ensures that emergency information reaches responders through multiple channels simultaneously, reducing the risk of alert failure. The system's architecture is modular, cost-effective, and scalable, offering a viable foundation for real-world deployment as a personal safety tool for women across diverse geographic and socioeconomic settings. Future enhancements may include AI-based threat prediction from camera feeds, GSM-based backup communication, encrypted data transmission, and mobile application integration for direct notifications to emergency contacts, further strengthening the system's effectiveness as a comprehensive women safety ecosystem.

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