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

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Abstract
Ensuring personal security for women has become an increasingly urgent challenge, requiring intelligent systems capable of delivering rapid and dependable assistance during emergencies. This work introduces a real-time safety solution that integrates Internet of Things (IoT) technology with geolocation services to provide continuous monitoring and instant alert generation. The proposed system is built around an ESP-32 microcontroller, which serves as the central processing unit for collecting and managing data from multiple embedded sensors. These include a DHT11 sensor for environmental conditions, a pulse oximeter sensor for monitoring heart rate and oxygen saturation, a vibration sensor for detecting unusual physical activity, and a dedicated panic switch for manual distress activation. A GPS module enables accurate location identification, while an ESP-CAM module supports visual evidence capture during critical situations. Sensor data is processed and transmitted wirelessly using Zigbee communication to a remote receiver unit. At the receiving end, another ESP-32 module interprets the incoming data and triggers appropriate responses such as visual display through an LCD, audible alerts via a buzzer, and real-time data uploading to a cloud platform for remote access and tracking. A regulated power supply ensures stable and uninterrupted operation of the system components. The overall design emphasizes portability, energy efficiency, and affordability, making it suitable for practical deployment. By combining wearable sensing, wireless communication, and cloud integration, the system offers an effective and responsive approach to enhancing women's safety in real-world scenarios.

Keywords: Women Safety, GPS, ESP-CAM, Emergency Alert, Wearable Device, Real-Time Monitoring, DHT11.

1. Introduction

Personal safety for women continues to be a significant global concern, with rising incidents of harassment and violence highlighting the need for faster and more dependable protective solutions. Conventional methods of seeking help, such as contacting emergency services or relying on nearby assistance, are often ineffective during critical situations due to delays and limited accessibility. In recent years, advancements in embedded systems, wireless communication, and IoT technologies have opened new possibilities for designing intelligent safety mechanisms that can respond instantly and operate independently of manual intervention. Modern microcontrollers like the ESP-32 have enabled the development of compact and efficient systems capable of handling multiple sensor inputs simultaneously. With built-in connectivity features and flexible interfacing options, such platforms support seamless integration of various sensing components and communication modules. In particular, Zigbee-based wireless communication provides a stable, low-power solution for transmitting data over moderate distances, especially in areas where conventional internet connectivity may be unreliable or unavailable. This makes it suitable for real-time safety applications that require consistent data exchange. The proposed system focuses on designing a wearable safety device that combines environmental monitoring, physiological sensing, and location tracking into a unified platform. The transmitter unit continuously gathers data from multiple sensors, including temperature and humidity, pulse rate and oxygen levels, motion detection, and user-triggered emergency input. Additionally,

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location information is captured through a GPS module, ensuring accurate positioning. This data is wirelessly transmitted to a receiver unit, which processes the information and initiates alert mechanisms such as visual display, audible alarms, and cloud-based notifications for remote monitoring. By integrating edge-level processing with cloud connectivity, the system enables continuous supervision by authorized individuals regardless of geographic constraints. The architecture is designed to be scalable and adaptable, allowing enhancements such as alternative communication methods or intelligent data analysis in the future. This work presents a practical and cost-effective approach to improving women's safety through the convergence of wearable technology, real-time communication, and IoT-based monitoring systems.

2. Literature Survey

Bhansali et al. [1] proposed an IoT-based women safety device that combines GPS, GSM, and an accelerometer to provide quick emergency assistance. Their system continuously monitors motion patterns and identifies unusual activity that may indicate distress. When such conditions are detected or when the user presses a panic button, the device immediately sends an SMS alert with accurate location details to predefined contacts. The integration of GPS ensures that the victim's position is clearly communicated without ambiguity. GSM communication plays a key role in maintaining reliability, even in areas with limited internet connectivity. The design focuses on affordability, making it accessible for a wider population. The hardware implementation is simple yet effective for real-world deployment. The authors also ensured that the response time is minimal, which is crucial in emergency situations. Their approach highlights the importance of combining motion sensing with location tracking for improved safety. Srivastava et al. [2] developed a wearable safety band that utilizes GPS and GSM modules connected to an Arduino platform. The device is designed with simplicity in mind, allowing the user to activate it instantly with a single button press. Once triggered, it sends location information through SMS to emergency contacts, ensuring immediate awareness. The compact nature of the wearable makes it convenient for daily use without causing discomfort. Their system emphasizes ease of operation, which is essential during panic situations where complex interactions are not practical. GPS ensures accurate tracking, while GSM enables reliable message delivery. The device operates independently without requiring smartphones or additional applications. The authors also focused on minimizing power consumption for longer usability. Their work demonstrates how a simple yet effective design can provide immediate support in critical moments.

Kavitha and Murali [3] introduced a safety system based on GPS and GSM technology, enhanced with a shock sensor to detect physical disturbances. The system identifies sudden impacts or unusual movements that may indicate danger. When the sensor detects values beyond a predefined threshold, an alert is automatically triggered. This alert includes location details and is sent to emergency contacts for immediate action. The use of a shock sensor reduces the dependency on manual input, making the system more responsive. Their implementation also addresses the issue of false alarms by carefully calibrating sensor sensitivity. The system ensures that only genuine threats result in alert generation. GSM communication guarantees message delivery even in low-network conditions. Their approach shows the effectiveness of integrating physical disturbance detection into safety systems. It also improves reliability by combining automatic and manual triggering mechanisms. Raj et al. [4] designed a smart safety device using ESP-32, GPS, and a camera module to enhance monitoring capabilities. The inclusion of a camera allows the system to capture images during emergency situations, providing valuable visual information. This feature helps in identifying surroundings and potential threats more clearly. The ESP-32 controller efficiently manages sensor inputs and communication processes. GPS ensures that location data is accurately transmitted along with captured images. The system uploads information to a cloud platform, enabling remote monitoring. This adds an extra layer of security by

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allowing authorities or family members to view the situation in real time. The design highlights the importance of combining visual evidence with location tracking. It also improves situational awareness during emergencies. Their work shows how multimedia integration can strengthen safety solutions.

Gupta and Sharma [5] analyzed different wireless communication technologies, including Zigbee, Bluetooth, and Wi-Fi, for wearable IoT applications. Their comparison focuses on parameters such as power consumption, data rate, and reliability. Zigbee was found to be highly energy-efficient, making it suitable for battery-operated devices. It also provides stable communication over moderate distances. Bluetooth offers ease of connectivity but is limited in range and scalability. Wi-Fi supports high data rates but consumes more power, making it less ideal for wearable systems. The authors highlighted that Zigbee performs well in low-data-rate environments where reliability is critical. Their findings support the use of Zigbee in safety devices that require continuous operation. The study also emphasizes the importance of selecting communication protocols based on application needs. Their analysis provides useful insights for designing efficient wireless systems. Patil et al. [6] presented a wearable system that integrates multiple health sensors such as SPO2, ECG, and temperature monitoring. The system is built around an ESP-32 controller, which processes sensor data efficiently. It continuously monitors physiological parameters and transmits them to a cloud platform using MQTT protocol. This allows real-time access to health data from remote locations. The combination of multiple sensors provides a comprehensive view of the user's condition. The system is designed to be compact and suitable for wearable applications. It demonstrates how different health parameters can be monitored simultaneously. The use of IoT enhances accessibility and data storage capabilities. Their approach shows the importance of integrating health monitoring into safety devices. It also improves the ability to detect abnormal conditions early.

Suresh and Anand [7] proposed a mobile-based safety application that uses GPS tracking and panic alert features. The application allows users to send emergency messages and share their location with contacts. It provides a convenient solution using widely available smartphones. The interface is designed to be simple and user-friendly. The system also supports emergency calling features for quick assistance. However, it depends heavily on smartphone availability and battery life. Network connectivity is also required for proper functioning. These limitations can affect performance during critical situations. The authors highlight the need for alternative solutions that do not rely entirely on mobile devices. Their work emphasizes the importance of accessibility and ease of use. It also motivates the development of dedicated hardware-based systems. Reddy et al. [8] developed a safety system using Raspberry Pi with integrated face recognition and GPS tracking. The system captures images and analyzes them to detect unfamiliar individuals. When a potential threat is identified, an alert is triggered with location details. The use of computer vision enhances the ability to detect suspicious activity automatically. GPS ensures accurate tracking of the user's location. The system provides a higher level of intelligence compared to traditional safety devices. However, it requires significant processing power and energy consumption. The design also involves complex implementation. Despite these challenges, it demonstrates the potential of integrating AI into safety systems. It improves threat detection capabilities beyond basic sensing. Their work highlights the role of advanced technologies in enhancing security.

Kulkarni and Bhat [9] designed a safety device using NodeMCU along with PIR and ultrasonic sensors. The system detects nearby movement and measures distance to identify potential threats. When an unauthorized presence is detected, it sends alerts through a cloud platform. The combination of sensors provides better environmental awareness. PIR sensors detect motion, while ultrasonic sensors measure proximity. This helps in identifying suspicious activity more accurately. The system is suitable for monitoring surroundings in real time. It also supports remote access through IoT connectivity. The

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design is cost-effective and easy to implement. Their approach highlights the importance of environmental sensing in safety applications. It adds an extra layer of protection beyond manual alerts. Mohan et al. [10] compared LoRa and Zigbee communication technologies for safety applications. Their analysis focuses on range, power consumption, and reliability. LoRa offers long-range communication, making it suitable for rural areas. However, it has lower data rates compared to Zigbee. Zigbee provides stable and reliable communication over moderate distances. It is also more suitable for real-time data transmission. The study shows that each technology has its advantages based on deployment conditions. Zigbee is preferred for applications requiring consistent connectivity. LoRa is useful where coverage is more important than speed. The authors emphasize the importance of selecting the right protocol. Their comparison helps in making informed design decisions. It supports the use of Zigbee in wearable safety systems.

Das and Roy [11] implemented a wearable safety device using GPS, GSM, and an accelerometer. The system detects falls and abnormal movements automatically. It also includes a manual panic button for user-triggered alerts. When activated, it sends location details to emergency contacts. The combination of automatic and manual triggers improves reliability. GPS ensures accurate tracking, while GSM enables message delivery. The system is designed to respond quickly in emergency situations. It reduces the chances of delayed assistance. The authors focused on improving detection accuracy. Their approach highlights the importance of multiple triggering mechanisms. It enhances the effectiveness of safety devices. Goyal et al. [12] proposed a compact safety belt that integrates ESP-8266, GPS, and a hidden camera. The design focuses on making the device discreet and easy to wear. The camera captures images during emergencies, providing visual evidence. GPS ensures accurate location tracking for alerts. The ESP-8266 enables wireless communication with cloud platforms. The system is designed to be lightweight and comfortable. It supports real-time monitoring through IoT connectivity. The hidden design ensures user privacy and security. Their work emphasizes the importance of miniaturization. It also highlights the need for user-friendly wearable designs. The approach improves both functionality and usability.

Krishnan and Nair [13] presented a detailed review of various women safety technologies. They categorized systems into hardware-based, software-based, and hybrid solutions. Hardware systems offer reliability but may lack flexibility. Software solutions provide convenience but depend on mobile devices. Hybrid systems combine both approaches for better performance. The authors identified gaps such as lack of health monitoring features. They also noted the absence of image capture in many systems. These limitations reduce the effectiveness of existing solutions. Their analysis highlights the need for integrated multi-sensor systems. It provides direction for future development. The review supports the importance of combining different technologies. Singh and Kaur [14] developed a safety device that includes GPS, GSM, and heartbeat monitoring. The system uses abnormal heart rate as an indicator of distress. When irregular patterns are detected, an alert is triggered automatically. GPS provides accurate location details for emergency response. GSM ensures reliable communication of alerts. The integration of physiological monitoring improves detection accuracy. The system does not rely solely on manual input. It enhances responsiveness during critical situations. The design is suitable for continuous monitoring. Their approach highlights the role of health data in safety systems. It adds another dimension to emergency detection.

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3. Proposed System

The proposed research introduces a structured system architecture for enhancing personal safety through real-time monitoring and alert generation using embedded and IoT technologies. The operational pipeline begins with continuous data acquisition from multiple sensors integrated into a wearable transmitter unit. These sensors capture environmental, physiological, and situational parameters such as temperature, humidity, heart rate, oxygen saturation, motion disturbances, and manual emergency triggers. The collected data is processed locally using a microcontroller and prepared for wireless transmission. A low-power communication protocol is employed to transmit encoded sensor data from the transmitter to a remote receiver unit. Upon reception, the data undergoes decoding and interpretation to identify abnormal conditions or emergency events. The system further integrates location tracking using a GPS module to provide accurate positional information during distress situations. Additionally, visual monitoring capabilities are incorporated through a camera module to capture real-time evidence when required. A cloud-based interface is included to enable remote monitoring, data storage, and alert notifications. The complete system architecture ensures fast response, reliability, and continuous monitoring, as illustrated in Figure 1.

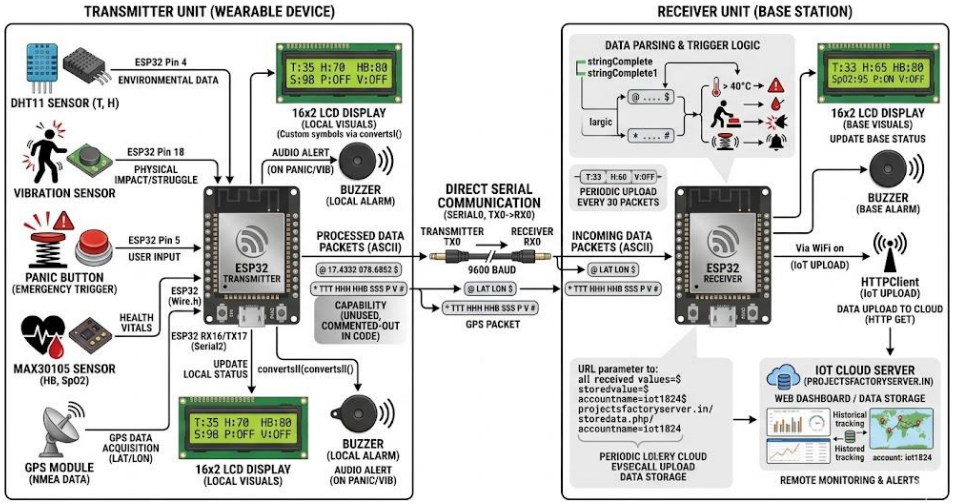


Figure. 1: System architecture.

User Interface (Monitoring Interface)

- The user interacts with the system through a display interface integrated at the receiver unit.
- The interface provides real-time visualization of parameters such as temperature, humidity, heart rate, and oxygen levels.
- It also displays emergency status indicators including panic activation and vibration detection.
- The interface enables monitoring personnel to quickly assess the situation and respond accordingly.

Embedded Transmitter Unit (Wearable Module)

- The transmitter unit is a compact wearable system built around an ESP-32 microcontroller.
- It collects real-time data from multiple sensors including DHT11, SPO2 sensor, vibration sensor, and panic switch.
- The GPS module continuously tracks the geographical location of the user.
- The ESP-CAM module captures images during emergency conditions for visual verification.

Wireless Communication Module (Zigbee Network)

- The system uses Zigbee protocol for wireless communication between transmitter and receiver units.

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- It ensures low-power, reliable, and stable data transmission over moderate distances.
- The communication module encodes sensor data into structured packets before transmission.
- This protocol is suitable for environments where Wi-Fi connectivity is limited or unavailable.

Receiver Unit (Control and Alert System)

- The receiver unit consists of an ESP-32 microcontroller that processes incoming data.
- It decodes transmitted information and extracts sensor values and emergency signals.
- The unit continuously monitors received data to detect abnormal or critical conditions.
- It acts as the central control system for alert generation and data forwarding.

Sensor Data Processing Module

- Collected sensor data is analysed to identify threshold violations or emergency triggers.
- Physiological parameters such as heart rate and oxygen levels are evaluated for abnormalities.
- Environmental data such as temperature and humidity is monitored for unsafe conditions.
- Manual and automatic triggers are combined to improve detection reliability.

Alert and Notification System

- The system activates a buzzer to generate immediate audible alerts during emergencies.
- Visual alerts are displayed on the LCD screen for quick identification.
- Emergency conditions such as panic button activation or abnormal sensor readings trigger alerts.
- This ensures rapid awareness and response from nearby individuals.

IoT Cloud Integration Module

- The system transmits processed data to a cloud server for remote monitoring.
- It enables real-time access to location and sensor data from any remote device.
- Data is stored for future analysis and tracking purposes.
- The cloud interface supports continuous monitoring by authorized users.

GPS Tracking Module

- The GPS module provides real-time geographical coordinates of the user.
- Location data is transmitted along with sensor readings during emergency events.
- This enables quick identification of the user's position for rescue operations.
- It enhances the effectiveness of emergency response systems.

Power Management System (RPS)

- A regulated power supply ensures stable voltage for all system components.
- It supports uninterrupted operation of both transmitter and receiver units.
- The design focuses on low power consumption for extended usage.
- Proper power regulation improves system reliability and performance.

System Evaluation and Enhancement

- The system performance is evaluated based on response time, accuracy, and reliability.
- Emergency detection efficiency is analysed under different conditions.
- Periodic improvements can be implemented by refining sensor thresholds and communication protocols.
- The modular design allows future upgrades such as AI-based threat detection or alternative communication methods.

4. Result and Discussion

The results and discussion section presents the performance evaluation of the developed safety system under various operating conditions. The system was tested to verify the accuracy of sensor data acquisition, reliability of wireless communication, and responsiveness of emergency alert mechanisms. Observations indicate that the integrated sensors successfully captured environmental and physiological

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parameters in real time with minimal delay. The communication between transmitter and receiver units remained stable, ensuring consistent data transfer. Emergency triggers such as panic button activation and vibration detection generated immediate alerts through both visual and audible outputs. The IoT integration further enabled remote monitoring and data logging without interruption.



Figure. 2: Real-Time sensor data display on LCD interface

The figure 2 illustrates the real-time visualization of multi-parameter sensor data captured by the embedded monitoring system through an LCD interface. It depicts the continuous display of environmental and physiological readings, including temperature, humidity, heart rate, and oxygen saturation levels, reflecting the system's capability for live data acquisition and presentation. The interface also represents the operational status of emergency indicators such as panic activation and vibration detection, highlighting the system's responsiveness to critical events. The structured arrangement of parameters demonstrates efficient data formatting and readability for quick interpretation. Furthermore, the display confirms successful integration of sensing, processing, and output modules within the embedded architecture. This visualization emphasizes the system's effectiveness in delivering instantaneous feedback for monitoring and safety applications.

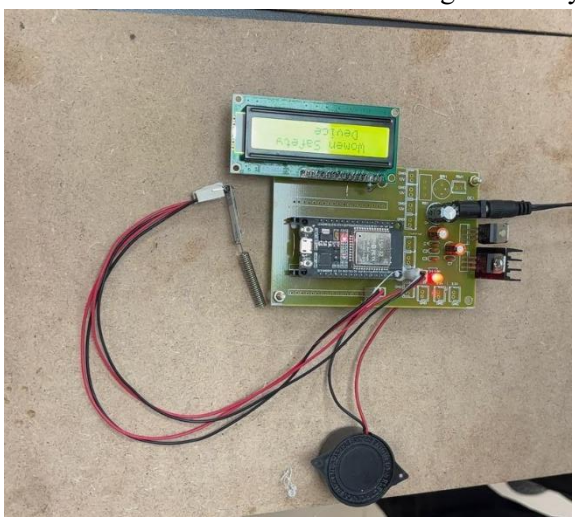


Figure. 3: Embedded Women Safety System transmitter Prototype

The figure 3 depicts the complete hardware implementation of the embedded safety system integrating sensing, processing, and alert modules on a single platform. It illustrates the arrangement of the

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microcontroller unit interfaced with peripheral components such as the display module, power regulation circuit, and sensing elements for real-time data acquisition. The setup demonstrates the interconnection of various hardware units including the communication interfaces and alert mechanisms, enabling seamless data flow across the system. The presence of the buzzer and sensor connections highlights the system's capability to detect abnormal conditions and generate immediate alerts. Additionally, the configuration reflects the practical deployment of the architecture in a compact and portable form factor. This representation emphasizes the integration efficiency and functional coordination of multiple subsystems within the embedded design.

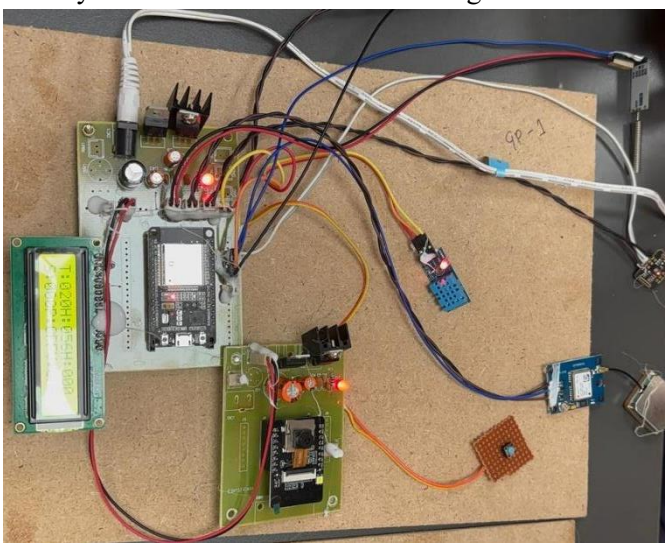


Figure. 4: Integrated transmitter to receiver system with Sensor Modules

The figure 4 illustrates the complete integration of transmitter and receiver units interconnected with multiple sensing and communication modules in the safety system. It depicts the coordinated arrangement of the microcontroller boards along with peripheral components such as environmental sensors, GPS module, and display interface, demonstrating end-to-end system functionality. The wiring configuration highlights the data flow between sensing units and processing modules, enabling real-time acquisition and transmission of critical parameters. The inclusion of communication interfaces reflects the wireless data exchange mechanism between system units for continuous monitoring. Additionally, the setup showcases the interaction between hardware components responsible for alert generation and data visualization. This representation emphasizes the overall system integration, illustrating how multiple subsystems operate collectively to achieve reliable and responsive safety monitoring.

5. Conclusion

The research successfully demonstrates the design and implementation of an integrated safety system capable of real-time monitoring and emergency alert generation using embedded and IoT technologies. The system effectively combines multiple sensors to capture environmental, physiological, and situational data, ensuring comprehensive monitoring under various conditions. Experimental observations indicate that the system provides stable wireless communication between transmitter and receiver units with minimal data loss. The alert mechanism responds promptly to emergency triggers such as panic activation and abnormal sensor readings, improving response time significantly. The incorporation of GPS tracking enhances location accuracy, enabling quick identification during critical situations. IoT-based cloud integration further strengthens the system by allowing continuous remote monitoring and data accessibility. Performance improvements are evident in terms of reduced latency, reliable sensor data acquisition, and efficient power utilization for prolonged operation. The modular

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architecture also contributes to scalability and ease of maintenance. The system offers a dependable and cost-effective solution for enhancing personal safety through real-time monitoring and intelligent alert mechanisms.

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