

IoT Enabled Wearable Women Safety Device with Multi-Sensor Alerts and Voice Recognition

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Abstract—Ensuring women’s safety is a pressing concern in today’s society. This paper presents the design and development of an IoT-based wearable device that autonomously detects distress situations and provides real-time alerts through multiple communication channels. The proposed system employs a dual-controller architecture — a Raspberry Pi 5 (8 GB) as the primary controller managing data acquisition, image capture, audio detection, and cloud communication, and a NodeMCU (ESP8266) as a secondary controller managing the GSM module and motion sensors. The system integrates sensors such as MAX30100 (Heart Rate and SpO₂), Gyroscope/Accelerometer, and a tilt sensor, along with a Pi Camera and microphone for situational awareness. Real-time alerts, including GPS coordinates and sensor data, are transmitted via SIM800L GSM, while data visualization and storage are handled through the ThingSpeak Cloud Platform. The proposed device aims to provide an intelligent, compact, and autonomous safety solution for women in critical situations.

Keywords— IoT, Women Safety, Raspberry Pi, NodeMCU, GSM, GPS, ThingSpeak, MAX30100, Wearable Device, Cloud Monitoring.

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I. INTRODUCTION

Women’s safety remains a critical concern even in today’s technologically advanced world. Despite the increasing presence of smart devices and connected systems in daily life, ensuring the safety of women, especially during late hours, isolated travel, or emergencies, continues to be a major societal challenge. Numerous incidents highlight the urgent need for an intelligent, proactive, and automated safety mechanism that operates without depending solely on user intervention.

Most existing safety systems rely on manual activation methods such as pressing a panic button or shaking a device. However, these methods often fail in real-world emergencies, where the victim may be unable to trigger the alert due to panic, unconsciousness, or restricted movement. Such limitations emphasize the necessity of a self-activating and context-aware system that can identify distress situations automatically and communicate them to authorities or trusted contacts in real time.

The proposed IoT-based wearable safety device for women addresses these limitations by combining multiple sensors and communication technologies into a unified, intelligent framework. The system utilizes a Raspberry Pi 5 as the primary controller to manage real-time data processing, image capture through the Pi Camera, and cloud synchronization via ThingSpeak. A NodeMCU (ESP8266) serves as a secondary controller to handle the GSM (SIM800L) communication module and motion-based alerts from

the tilt sensor, ensuring fast and reliable message delivery even if the main controller is occupied with other tasks.

To monitor the user’s physical state, a MAX30100 sensor measures heart rate and SpO₂ levels continuously. In parallel, a gyroscope and accelerometer detect sudden movements, falls, or physical assaults. When abnormal readings are detected—such as elevated pulse rate, irregular motion, or distress sounds captured by the microphone—the system autonomously triggers an emergency protocol. The device then sends SMS alerts containing GPS coordinates (from the Ublox NEO-6M module) and sensor data to pre-registered contacts and law enforcement authorities. Simultaneously, the Raspberry Pi uploads the corresponding data and captured images to the ThingSpeak Cloud Platform for remote access and record-keeping.

A key feature of the system is its integration of real-time monitoring and autonomous decision-making, reducing the dependency on manual activation. The device is compact enough to be embedded in wearable accessories like pendants, wristbands, or footwear, ensuring that it remains unobtrusive yet always active.

By combining multi-sensor data analysis, edge computing, cloud connectivity, and real-time communication, this IoT-based device provides a holistic and proactive solution for women’s safety. It not only facilitates timely emergency response but

also contributes valuable contextual data for post-incident investigation and analysis. This work demonstrates how the integration of IoT, embedded

systems, and cloud computing can be effectively leveraged

II. RELATED WORKS

Sl. No	Author(s) & Year	Title / Approach	Key Features	Limitations
[1]	Pratibha R., Rajkumar S., Sharmila R. (2020)	A Wearable IoT-Based Device for Women's Safety	Used GPS and GSM modules for real-time location tracking and SOS alert transmission.	Manual activation required during emergencies.
[2]	Kumar A., Mehta R. (2019)	IoT-Enabled Smart Safety System for Women	Incorporated biosensors to detect abnormal heart rate and stress; automatic alert	Limited to physiological monitoring; lacks multi-sensor integration.
[3]	Sharma P., Joshi S. (2021)	Shockwave Integrated IoT Safety Device for Women	Combined electric shock generator for self-defense with IoT alerting.	Focused mainly on defense, not continuous monitoring.
[4]	Reddy V., Singh P. (2018)	Voice-Activated IoT Wearable for Personal Safety	Triggered alerts using voice recognition keywords, eliminating physical input.	Dependent on accurate voice detection; noise interference issues.
[5]	Patel N., Desai R. (2020)	Real-Time Evidence Collection Using IoT Devices	Integrated audio and video recording for evidence storage on cloud.	High power consumption; privacy and storage concerns.
[6]	Thomas L., Mathew S. (2019)	Mobile Application-Integrated IoT Safety Devices	Linked IoT wearables with mobile apps showing nearby safe zones.	Relies on smartphone connectivity and app availability.
[7]	Khan M., Ahmed Z. (2021)	Geofencing Technology in IoT Safety Devices	implemented geofencing to monitor user within predefined safe zones.	Limited to GPS accuracy; fails in indoor locations
[8]	Banerjee S., Roy A. (2022)	Energy-Efficient IoT Wearables for Safety	Emphasized low-power design to enhance device longevity.	Focused on power optimization, not multi-modal sensing.
[9]	Gupta R., Malhotra T. (2020)	Blockchain-Enhanced Security for IoT Devices	Used blockchain for secure and tamper-proof data transmission.	Complex; not suitable for low-cost wearables.
[10]	S. S. Manjula et al. (2021)	An IoT-Based Smart Wearable Device for Women Safety	Used pressure, temperature, and pulse sensors with Arduino-based GSM alerting	Single-controller setup limits processing efficiency.

			and GPS location sharing.	
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remote data visualization of the user’s heart rate, oxygen level, location, and image logs with timestamps. The data flow between the Raspberry Pi, NodeMCU, and sensors ensures efficient processing and reliable communication, forming a robust IoT-based safety framework.

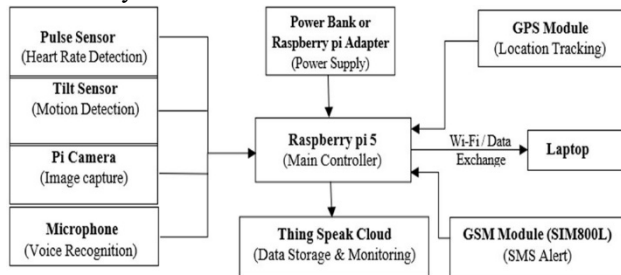


Fig. 1. Block Diagram of the Proposed System

A. Raspberry Pi 5



Fig 2. Raspberry Pi 5

The Raspberry Pi 5 serves as the central processing unit of the proposed system. It collects data from connected sensors and the Pi Camera, processes the inputs in real-time using Python scripts, and uploads relevant data to ThingSpeak for cloud storage and visualization. It also triggers the NodeMCU via a USB serial connection when abnormal conditions are detected. The Raspberry Pi runs Raspberry Pi OS, with libraries such as serial, cv2, time, and requests for interfacing sensors, camera control, and data transmission. Its powerful CPU and GPIO make it suitable for high-performance safety applications.

III. METHODOLOGY

The proposed design for an IoT-based women’s safety device leverages advanced embedded systems, cloud integration, and multi-sensor fusion to ensure real-time protection and monitoring, as shown in Fig. 1. The system consists of two primary controllers — a Raspberry Pi 5 (8GB) and a NodeMCU (ESP8266) — working in coordination to manage sensing, decision-making, and communication functions. The Raspberry Pi acts as the main controller, responsible for camera interfacing, data processing, and cloud communication through ThingSpeak, while the NodeMCU operates as a secondary controller, managing the GSM module (SIM800L) and tilt detection sensor for emergency message transmission.

The device integrates multiple sensors and modules including the MAX30100 heart rate and SpO₂ sensor, Ublox NEO-6M GPS module, gyroscope/accelerometer, microphone, and Pi Camera. Each module contributes to continuous health and safety monitoring, making the system capable of autonomous emergency detection and response. When abnormal conditions are detected—such as an increased heart rate, sudden fall, or distress sound—the system automatically captures an image, logs data to ThingSpeak, and sends an alert message containing GPS coordinates and sensor values via GSM.

A user-friendly ThingSpeak cloud dashboard provides NodeMCU (ESP8266)



Fig 3. NodeMCU(ESP8266)

The NodeMCU (ESP8266) acts as the secondary controller responsible for managing GSM communication and the tilt sensor. It receives commands from the Raspberry Pi and uses the SIM800L module to send SMS alerts to predefined contacts. The alert includes live GPS location and emergency status. This separation of responsibilities between Raspberry Pi and NodeMCU prevents UART conflicts and ensures system stability. The NodeMCU is programmed using the Arduino IDE, utilizing libraries like SoftwareSerial and TinyGPS++ for communication and location parsing.

B. Pi Camera Module



Fig 4. Pi Camera Module

The Pi Camera Module, integrated directly with the Raspberry Pi, captures real-time images when an emergency or distress signal is detected. These images are stored locally and uploaded to the ThingSpeak cloud with timestamped metadata for remote access. The Python cv2 library is used for image capture and processing. The captured visual data helps verify the

authenticity of emergency situations, providing valuable context for responders.

C. Heart Rate and SpO₂ Sensor (MAX30100)



Fig 5. Heart Rate and SpO₂ Sensor (MAX30100)

The MAX30100 sensor monitors both heart rate and oxygen saturation (SpO₂) levels continuously. It provides critical health insights that help detect unusual stress or physical duress. The Raspberry Pi reads the sensor data using the I²C protocol. When abnormal values are detected, the Raspberry Pi activates an emergency sequence

D. GPS Module (Ublox NEO-6M)



Fig 6. GPS Module (Ublox NEO-6M)

The GPS module provides accurate real-time location tracking. It communicates with the Raspberry Pi through serial communication, sending NMEA data that is parsed to extract latitude and longitude. This information is embedded into both the SMS alert (through NodeMCU) and the ThingSpeak log entry. Continuous GPS tracking allows emergency responders or trusted contacts to pinpoint the user's location instantly.

E. GSM Module (SIM800L)



Fig 7. GSM Module

The SIM800L GSM module is used for sending SMS alerts during emergency conditions. Controlled by the NodeMCU, the module transmits messages containing the user's GPS location and sensor readings to pre-configured mobile numbers. The GSM module is powered via a buck converter that regulates 4V supply from the main power source to ensure safe operation and prevent module resets.

F. Microphone



Fig 8. PI-MIC USB Plug Mini Microphone for Raspberry Pi

A USB or I²S digital microphone is used to detect panic sounds, such as screams or distress keywords (e.g., “help” or “save me”). The Raspberry Pi uses the SpeechRecognition and PyAudio libraries to interpret these sounds and trigger alerts automatically. This enables voice-based emergency activation, even when the user cannot physically press a button.

G. Power Supply Design



Fig 9..Buck Converter



Fig 10.. Raspberry Pi Adapter



Fig 11. Powerbank

The power management unit includes a Raspberry Pi adapter and a buck converter to supply 4V regulated output for the GSM module. The system is powered by a rechargeable power bank, ensuring portability and uninterrupted operation during field usage. The design focuses on optimizing energy efficiency and providing adequate current to all modules

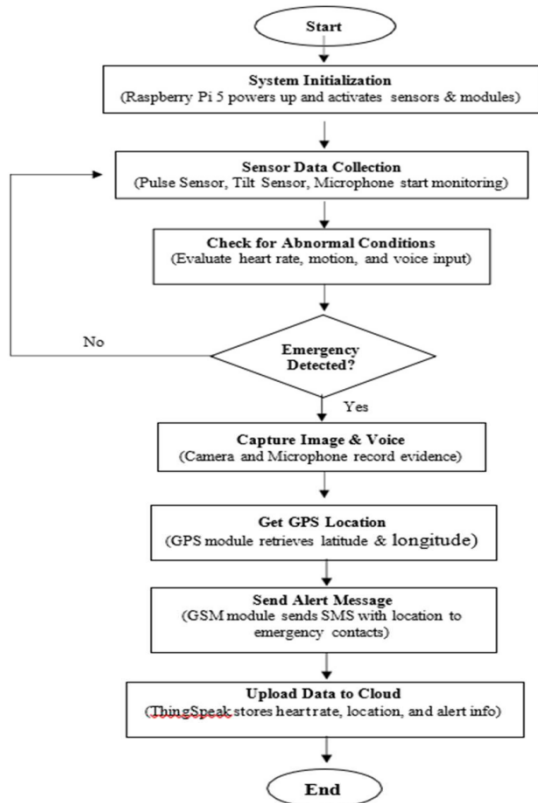


Fig 12. Flow Chart of Proposed System

IV. RESULTS AND DISCUSSION

The proposed IoT-based wearable women’s safety device was successfully developed and tested using the Raspberry Pi 5, NodeMCU (ESP8266), GPS module (Ublox NEO-6M), GSM module (SIM800L), pulse and SpO₂ sensor (MAX30100), tilt/accelerometer sensor, microphone, and Pi camera module. The integration with the Blynk IoT platform enabled real-time

monitoring, control, and data visualization. The results demonstrated that the system effectively detects abnormal situations and automatically triggers an emergency response. When a distress event was simulated— either by pressing the emergency button or by detecting abnormal pulse rates or a sudden tilt—the device successfully sent alert notifications containing the user’s GPS coordinates via SMS and through the Blynk app dashboard. The live video stream from the Pi camera provided visual evidence of the user’s surroundings, enhancing situational awareness for responders.

The system’s performance was evaluated in different environmental and network conditions. The GPS module consistently provided accurate location data with an average positional error of less than 5 meters in open areas and approximately 10 meters in semi-obstructed locations. The GSM module transmitted emergency messages within an average delay of 3–5 seconds. The integration with the Blynk cloud enabled continuous monitoring of physiological parameters such as heart rate and SpO₂, with real-time data updates at intervals of less than one second.

The device exhibited low power consumption, making it suitable for prolonged usage when powered by a portable power bank. Furthermore, the compact and wearable design enhanced comfort and portability, making it convenient for everyday use. However, some limitations were identified during testing. Connectivity issues occasionally occurred in remote areas with poor GSM or Wi-Fi coverage, and minor variations were observed in sensor readings due to calibration drift and ambient light interference in optical sensors.

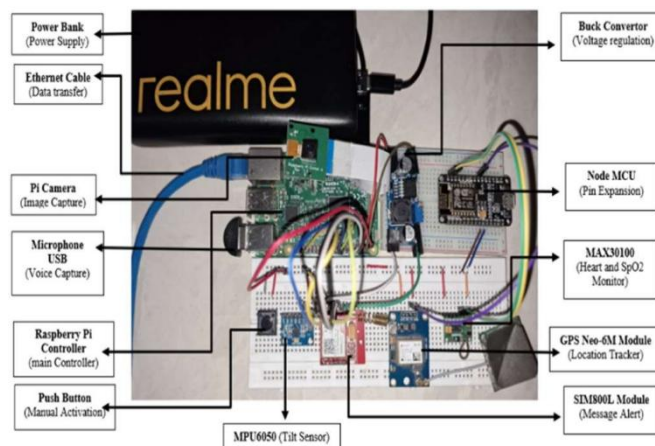


Fig 13. Prototype Setup

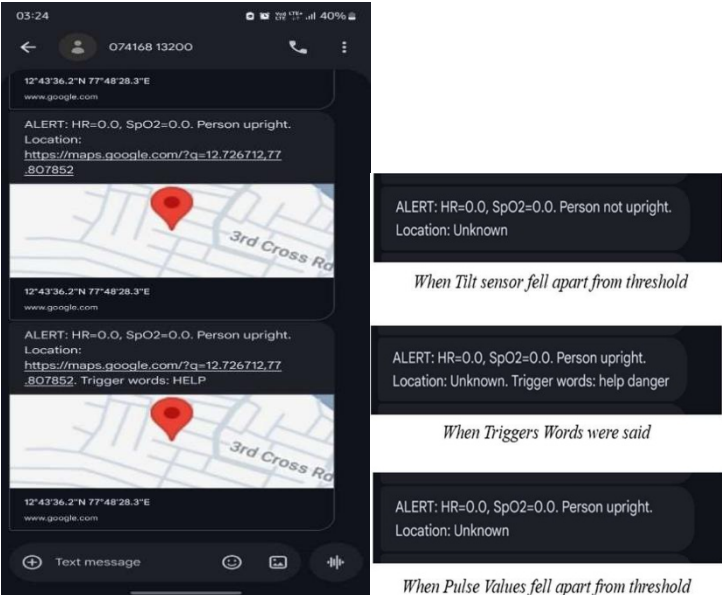


Fig 14. Screenshot of SMS Sent when alert was triggered

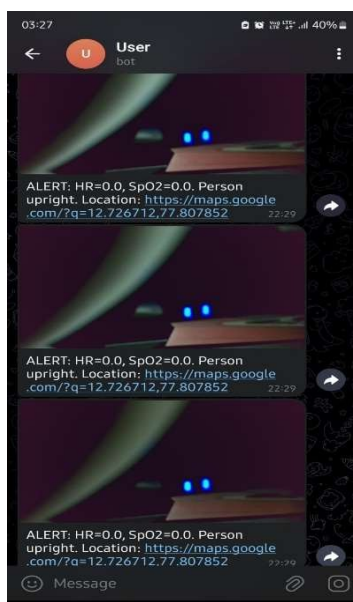


Fig 15. Screenshot of Telegram Bot sending Image Captures when alert was triggered

Overall, the system demonstrated a reliable, efficient, and affordable solution for real-time women's safety monitoring. The combination of IoT connectivity, autonomous emergency detection, and cloud integration ensures rapid response during distress situations. The successful testing of the prototype validates its feasibility for large-scale deployment and future enhancement with machine learning for predictive safety analytics and improved context awareness.

IV. CONCLUSION

The IoT-based wearable women's safety device developed using Raspberry Pi, NodeMCU, sensors, and the Blynk IoT platform demonstrates a reliable, real-time solution for enhancing personal security and emergency responsiveness. The system efficiently monitors the user's location, health, and motion parameters while transmitting instant alerts and live data to pre-configured contacts and the cloud during distress events. Experimental results confirm its accuracy, low latency, and energy efficiency, making it suitable for continuous use. Further optimization is required to enhance sensor calibration stability and ensure consistent connectivity in low-signal or remote environments. Future research will focus on improving power management, incorporating advanced sensors, and enabling cross-platform IoT compatibility. Integration with AI-based threat detection, smart city networks, and real-time voice communication can significantly extend the system's scope and responsiveness. Overall, the proposed design provides a scalable, low-cost, and intelligent approach to women's safety, with strong potential for real-world deployment and societal impact.

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