HerGuard: Fusion of Artificial Intelligence and IOT for Women Safety Monitoring

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Abstract - In the present-day society, the security of women is an important issue, especially with the rise of harassment and unsafe traveling conditions. To overcome this problem, the Women Security System is introduced using Raspberry Pi Pico with the integration of GSM and GPS technologies. The system includes a push button as an emergency trigger. When pressed, the Raspberry Pi Pico sends GPS location coordinates as an alert SMS to registered mobile numbers through the GSM module with a Google Map URL. Additionally, the system incorporates a MAX pulse sensor (MAX30102/MAX30100) and motion sensor (PIR/MPU6050) for automatic emergency detection using artificial intelligence. The system operates without Internet connectivity.

Keywords--- *Women Safety System, Raspberry Pi Pico, GSM Module, GPS Tracking, Emergency Alert System, Embedded Systems, Pulse Sensor, Motion Sensor.*

I. INTRODUCTION

The problem of personal safety is a major concern in the present times, especially for ladies who are prone to traveling alone or working late. Despite technical achievements and public awareness, prompt emergency response is delayed due to lack of fast communication and position exchange. This loophole necessitates a high-quality, convenient, and cost-effective safety device.

The Raspberry Pi Pico Women Security System fulfills this requirement by providing immediate assistance in distress situations. The device is triggered either by pressing a push button or by detecting abnormal body conditions such as unusual heart rate and abnormal movements. Once triggered, an alert message along with the live location is sent to pre-registered contacts via compact hardware using GSM, GPS, and AI technologies.

II. LITERATURE SURVEY

Women's safety has garnered significant research focus over the last decade, leading to the development of numerous IoT-based wearable and embedded devices. These devices have evolved from simple manual trigger-based alert systems to increasingly autonomous AI-enabled platforms.

Priya et al. [1] designed an early IoT-based device using Raspberry Pi Pico incorporating temperature, pulse rate, and pressure sensors to automatically detect physiological anomalies, sending GPS coordinates via GSM to family members and nearby police stations.

Vineeth Reddy et al. [2] addressed the practical problem of smartphone seizure by attackers, creating a standalone wearable system that sends SMS alerts, GPS coordinates, and photographs captured by an ESP-32 camera module via a Telegram bot.

Sogi et al. [3] developed SMARISA, a compact smart ring on Raspberry Pi Zero that captures attacker images via camera and sends image links alongside GPS location through an Android application, activating a high-frequency buzzer for nearby attention.

Ghosh et al. [4] introduced passive activation using a flex sensor embedded in a garment to detect unwanted pressure, eliminating the requirement for deliberate victim action—a critical improvement for high-stress assault scenarios.

Tejonidhi et al. [5] proposed a wristband combining Raspberry Pi Zero with pulse, motion, GPS, and GSM sensors, supporting both manual and automatic triggering with real-time IoT monitoring via the Ubidots platform.

Clement et al. [6] advanced detection by replacing threshold logic with a Logistic Regression machine learning classifier, achieving 95% accuracy and substantially reducing false positives compared to rule-based approaches.

Singh et al. [7] added biometric security with fingerprint-based authentication, addressing situations where the victim loses consciousness post-activation through a passive time-out mechanism. Savla et al. [8] presented ResQ, combining heart rate spike detection with MEMS-based fall detection using an algorithm running on a Django server, remaining operational even if the physical band is damaged.

Sen et al. [9] developed ProTecht, a three-way safety device combining a nerve stimulator, video camera, GSM-GPS, and voice-activated alerts via Google speech-to-text API, representing one of the most comprehensive integrated safety platforms reviewed.

Taken together, these works reveal a clear progression: from simple button-activated SMS systems toward autonomous, AI-enabled, multi-sensor wearables capable of acting without conscious user input.

III. HARDWARE COMPONENTS

The following table presents the hardware components used in the Women Security System along with their specifications and descriptions.

TABLE I. Hardware Components and Specifications

No.	Component	Spec.	Description
1	Raspberry Pi Pico	RP2040	Dual-core ARM Cortex-M0+, GPIO, I2C/SPI/UART. Central control unit.
2	GSM Module	SIM800L/SIM900A	Cellular comms for SMS alerts; serial interface to MCU.
3	GPS Module	NEO-6M	Real-time satellite location; provides lat/long data.
4	Push Button	Tactile Switch	Manual emergency trigger to activate alerts.
5	Buzzer	5V Active	Audible emergency alert and system status indicator.
6	LED Indicator	Red/Green LED	Visual system state indicator (power, normal, emergency).
7	Resistors	1kΩ, 10kΩ	Current limiting and voltage division for protection.
8	Power Supply	Battery/Power Bank	Portable rechargeable power for all components.
9	Breadboard/PCB	Mini Board/PCB	Prototyping and permanent component interconnection.
10	Motion Sensor	PIR/MPU6050	Detects sudden movements for automatic triggering.
11	Pulse Sensor	MAX30102/MAX30100	Heart rate & SpO2 monitoring for auto-trigger.

IV. IMPLEMENTATION

The block diagram illustrates the functional layout of the proposed women's security system with the Raspberry Pi Pico as the controller. It incorporates a push button for manual operation, a GPS device for continuous location tracking, and motion and pulse sensors to monitor unusual body movements and heart rate patterns.

During a detected emergency, the Raspberry Pi Pico processes all sensor inputs and triggers multiple alert mechanisms: an SMS with live Google Maps location via the GSM module, and simultaneous activation of the LED indicator and buzzer as warning signals.

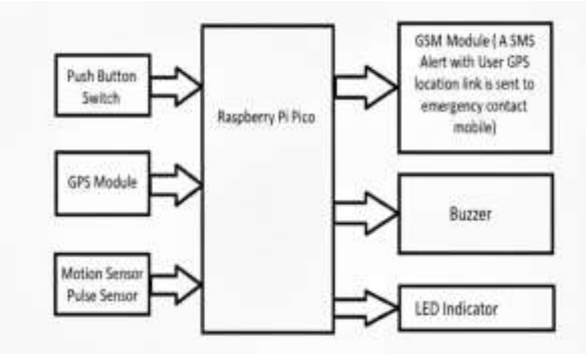

Fig. 1. Block diagram of the HerGuard women security system.

<u>Flow Chart</u>

The process flow diagram shows the working of the proposed women security system. The Raspberry Pi Pico continuously monitors all sensors for both manual and automatic emergency conditions. When a trigger is detected (button press or abnormal sensor reading), the system enters the emergency action phase: the GPS module retrieves current coordinates, the buzzer and LED activate for audible and visual signalling, and an alert SMS containing a Google Maps link is forwarded to all pre-registered emergency contacts.

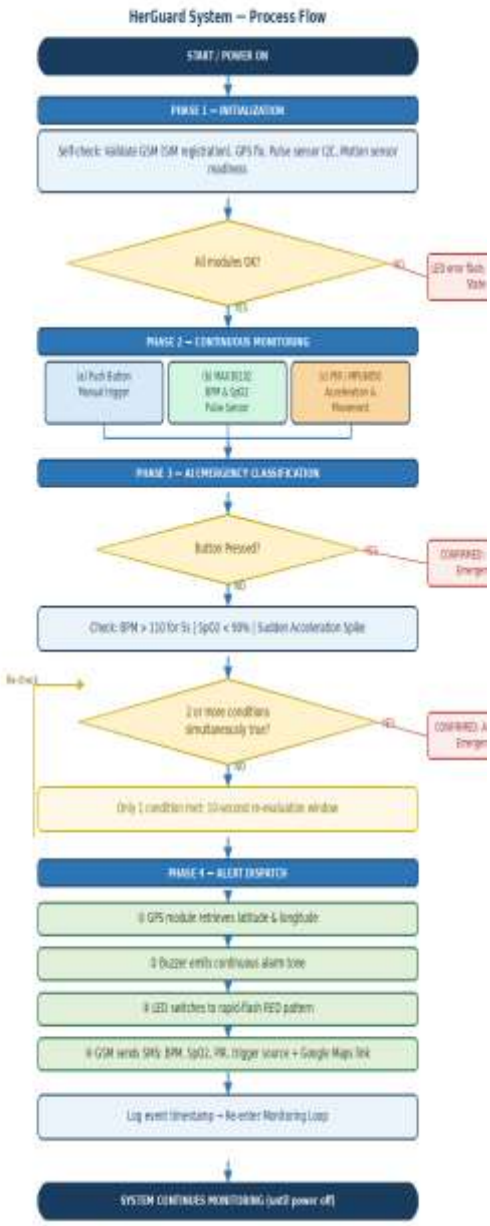

Fig. 2. Flowchart of HerGuard system operation.

V. RESULTS AND DISCUSSION

Software Implementation

The system powers up automatically. The GPS module quickly starts tracking the exact position of the user so that accurate coordinates are always available. When the push button is pressed, or autonomously based on data from motion and heartbeat sensors with AI assistance, the system instantly obtains current GPS coordinates and transmits them through the GSM module as an SMS to pre-loaded emergency contacts.

Hardware Implementation

The hardware setup is the heart of the total system, with the Raspberry Pi Pico as the main controller coordinating all elements. Key modules include the GPS module, GSM module, panic button, pulse sensor, and motion sensor, all connected for synchronized operation.

The hardware implementation delivers fast response, robust communication, and high reliability in real-time emergencies.

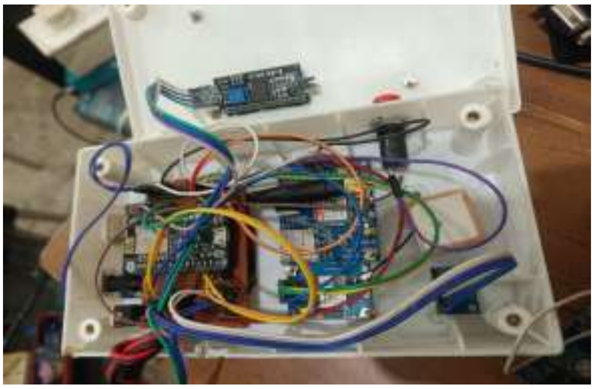

Fig. 3. Hardware prototype of the HerGuard women security system.

SMS Alert Validation

The end-to-end alert mechanism was tested under simulated emergency conditions. When activated (PIR motion sensor detection with recorded heart rate of 65 BPM), the system successfully relayed an SMS alert to the emergency contact within seconds. The SMS contained real-time BPM, average BPM, PIR sensor status, push button state, and a hyperlink to Google Maps with GPS positioning.

Fig. 4. Sample SMS alert message received by the emergency contact, showing real-time sensor data and Google Maps location link.

GPS Location Accuracy

The GPS module demonstrated accurate real-time location tracking. The emergency SMS location of 17.747029°N, 83.257653°E was confirmed using Google Maps and matched coordinates of 17°44'49.3"N, 83°15'27.6"E at Visakhapatnam, Andhra Pradesh. The Plus Code (P7W5+R36) confirmed sub-street level location resolution, validating the GPS module's efficacy in real-world conditions.

Fig. 5. GPS location verification on Google Maps, confirming sub-street level accuracy at the test site in Visakhapatnam.

VI. FUTURE ENHANCEMENTS

HerGuard is a functional, validated prototype and serves as a starting point for further development across several dimensions.

A. Wearable Form Factor Integration

The most pressing requirement is converting the circuit board assembly into a wearable personal device such as a smart bangle, wristband, or pendant necklace using compact SoC modules like the ESP32-S3 or nRF9160.

B. Edge AI and On-Device Machine Learning

Moving from threshold-based detection to a TensorFlow Lite Micro-based machine learning model trained on labeled physiological data will enable the system to distinguish between exercise, stress, and genuine emergency without cloud dependency.

C. Audio and Video Evidence Capture

Future versions could incorporate a small camera and MEMS microphone to record timestamped, encrypted video and audio upon emergency detection, uploaded to a secure cloud location accessible by law enforcement.

D. Direct Integration with Police and Emergency Services

Integration with the ERSS Dial 112 Emergency Response System for India would enable automatic transmission of GPS coordinates and sensor data directly to the nearest police control room without human intervention.

E. Companion Mobile Application

A mobile application could facilitate emergency contact management, alert history, real-time location sharing, and push notifications to complement SMS alerts, along with a wellness indicator for prolonged inactivity detection.

F. Solar Energy Harvesting and Extended Battery Life

Incorporating thin-film solar cells and deep-sleep firmware modes for the Raspberry Pi Pico could extend battery life to several days, eliminating battery anxiety as a barrier to consistent device usage.

VII. CONCLUSION

The proposed women security system guarantees instantaneous assistance in emergency cases, increasing the safety and confidence of women through continuous monitoring via Raspberry Pi Pico. The system combines manual and automatic triggering through push button, pulse, and motion sensors with AI algorithm integration. Upon emergency detection, the system retrieves GPS coordinates, activates audible and visual warnings, and sends an emergency message with Google Maps link to pre-registered contacts.

The system is reliable, user-friendly, and cost-effective, with the significant benefit of operating without real-time user intervention in distress situations. Future improvements may include audio and video evidence recording and transformation into wearables such as smart bracelets or smartwatches for enhanced convenience and accessibility.

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