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RASPBERRY PI-BASED WOMEN SAFETY SYSTEM USING GPS AND GSM FOR REAL-TIME EMERGENCY ALERT AND LOCATION TRACKING

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ABSTRACT
Women's safety remains an important societal concern, particularly during emergency situations in which immediate communication and location sharing are essential. Conventional safety mechanisms based on smartphones and mobile applications may become ineffective when the user cannot access the phone, operate an application, or obtain reliable Internet connectivity. This paper presents a Raspberry Pi-based women safety system that provides a dedicated emergency alert mechanism using GPS and GSM technologies. The proposed system integrates a Raspberry Pi 4 controller, NEO-6M GPS module, SIM800L GSM module, emergency push button, LED indicator, buzzer, and portable power supply. During an emergency, activation of the dedicated push button initiates the emergency sequence. The Raspberry Pi acquires the user's geographical coordinates from the GPS module and generates an emergency message containing the latitude, longitude, and map-accessible location. The message is subsequently transmitted through the GSM module to a pre-registered emergency contact using SMS. Simultaneously, the LED and buzzer provide local visual and audible confirmation. The prototype was functionally evaluated through emergency-button activation, GPS location acquisition, SMS transmission, LED/buzzer operation, indoor and outdoor testing, and reliability assessment. The documented experiments demonstrated successful emergency triggering, location acquisition, SMS-based alerting, and local feedback. The principal limitations observed are reduced GPS performance in indoor environments and dependence on cellular network availability. The proposed system provides a compact, low-cost, and relatively independent emergency communication platform that can serve as a foundation for future wearable miniaturization, intelligent threat detection, cloud-based monitoring, and mobile application integration.

Keywords: Women safety, Raspberry Pi, GPS, GSM, emergency alert, location tracking, embedded system, SMS, personal safety, IoT.

I. INTRODUCTION

Personal safety has become an important application area for embedded systems and Internet of Things technologies. In emergency situations involving harassment, assault, abduction, accidents, or other threats, the ability to communicate an emergency message and the user's location rapidly can significantly improve the possibility of timely assistance. Conventional safety approaches such as telephone calls, mobile applications, and Internet-based emergency platforms provide useful services, but they can require the user to access and operate a smartphone during a stressful situation. Such requirements may introduce additional delays or may become impractical when the smartphone is inaccessible, discharged, damaged, or disconnected from the Internet. GPS and GSM technologies provide complementary functionality for this application. GPS enables geographical position acquisition, primarily in terms of latitude and longitude, while GSM enables the transmission of emergency information through the cellular network. Consequently, the proposed system does not depend entirely on Wi-Fi or Internet connectivity for emergency notification. This characteristic is particularly useful for a portable safety device intended for operation outside the home or workplace.

Previous studies have investigated GPS- and GSM-based women safety systems, IoT-enabled security solutions, wearable safety devices, and smartphone applications. Sriranjini presented a GPS and GSM-based self-defense system for women, demonstrating the usefulness of combining location acquisition with cellular emergency communication [1]. Harikiran *et al.* investigated an IoT-based smart security solution for women, illustrating the potential of connected embedded devices for personal safety

[2]. Wearable approaches have also been explored for women and girl-child safety, with portability being one of their principal advantages [3]. Other systems have investigated dedicated emergency devices and GPS-GSM tracking architectures [4]–[9].

Although these approaches demonstrate the feasibility of technology-assisted personal safety, practical challenges remain. Smartphone dependency, Internet requirements, battery limitations, manual interaction, GPS performance in indoor environments, and cellular network availability can affect real-world deployment [1]–[9]. These challenges motivate the development of an emergency device that provides simple hardware-based activation, automatic location acquisition, and SMS-based communication through a compact embedded platform.

The main contribution of this work is therefore not the introduction of a new GPS or GSM algorithm, but the development and functional integration of an independent emergency communication architecture. The proposed system combines emergency triggering, GPS-based location identification, GSM-based SMS communication, and local visual/audible feedback within a Raspberry Pi platform. The architecture can subsequently be miniaturized into wearable or keychain configurations and extended with additional sensing and intelligent decision-making capabilities.

The remainder of this paper is organized as follows. Section II discusses related research. Section III presents the proposed architecture. Section IV describes the methodology and implementation. Section V presents the experimental setup and functional results. Section VI discusses the system's advantages and limitations. Section VII presents potential applications and future enhancements. Section VIII concludes the paper.

II. RELATED WORK

GPS-GSM integration is one of the commonly investigated approaches for location-based emergency communication. Sriranjini [1] developed a GPS and GSM-based self-defense system for women in which location information could be communicated to predefined contacts during an emergency. The work demonstrated that GPS and cellular communication can be combined to provide location-aware emergency notification. However, GPS reception can become less reliable in indoor environments and other locations with obstructed satellite visibility.

Ansari *et al.* [5] investigated a women security system based on GSM and GPS. Their approach demonstrated the applicability of GPS for determining user location and GSM for transmitting emergency information. Similarly, Shimpi [6] investigated GPS-GSM-based tracking and security for women, emphasizing emergency communication and location tracking. These studies establish GPS and GSM as practical technologies for emergency notification but also highlight the importance of communication reliability and positioning performance.

The proposed system adopts the same fundamental communication principle while introducing Raspberry Pi as a programmable central controller. A dedicated push button is used as the emergency trigger, reducing the number of user actions required before transmission.

IoT technologies have enabled safety systems to combine sensing, processing, communication, and notification functions. Harikiran *et al.* [2] proposed an IoT-based smart security solution for women. Such systems can provide enhanced connectivity and monitoring functionality; however, many IoT architectures may depend on Internet connectivity or smartphone-based interfaces.

IoT-based safety systems are attractive because they can integrate multiple sensors and communication technologies. Nevertheless, an emergency device should ideally continue to provide a basic notification mechanism when Internet connectivity is unavailable. The present work therefore uses GSM-based SMS as the principal remote communication mechanism rather than depending exclusively on Internet services.

Wearable technology provides an important direction for personal safety because the device can remain physically attached to the user. Pramod *et al.* [3] investigated an IoT wearable device for women and girl-child safety. Helen *et al.* [8] investigated an IoT-based smartwatch for women security. Such approaches demonstrate the potential of integrating emergency functionality into compact wearable platforms.

Dedicated hardware-based safety systems have also been proposed. Chougula [4] presented a Smart Girls Security System, while Bhardwaj and Aggarwal [9] developed the Suraksha women safety device. These approaches demonstrate the value of dedicated emergency mechanisms that reduce dependence on smartphone applications.

The present system extends this concept by combining a Raspberry Pi controller with GPS and GSM modules and a dedicated emergency push button. The programmable nature of Raspberry Pi also provides an opportunity for future integration of additional sensors, cloud services, and intelligent threat-detection techniques.

Smartphone applications provide convenient interfaces for emergency communication and tracking. Yarrabothu and Thota [10] proposed Abhaya, an Android application for women safety that incorporates alerting and tracking functionality. Smartphone applications can provide sophisticated user interfaces and access to several services. However, their operation depends on the availability, power, accessibility, and usability of the smartphone.

During an emergency, requiring the user to unlock a device, open an application, select an emergency option, and establish communication may not always be practical. A dedicated push-button system provides a simpler alternative in which the emergency sequence can be initiated through a single physical action.

The principal distinction of the proposed system is therefore its integrated and relatively independent emergency communication architecture, rather than a new communication protocol or location-detection algorithm. The source project identifies portability, affordability, reduced smartphone dependency, GSM-based communication, and simple emergency activation as important design objectives.

III. PROPOSED SYSTEM

The proposed women safety system is designed as a portable emergency alert platform. The complete operational sequence is:

Emergency Button → Raspberry Pi → GPS Location Acquisition → GSM SMS Transmission → Guardian Notification

The LED and buzzer operate as local feedback indicators.

The Raspberry Pi serves as the central controller. It continuously monitors the emergency push button. Under normal conditions, the system remains in standby mode. When the button is activated, the Raspberry Pi initiates the emergency procedure, obtains valid GPS coordinates, constructs the emergency message, and sends the information through the GSM module.

The architecture is intentionally simple so that the core emergency operation can be executed with minimal user interaction. The documented methodology specifies Raspberry Pi, GPS, GSM, emergency button, LED, buzzer, and portable power as the principal components.

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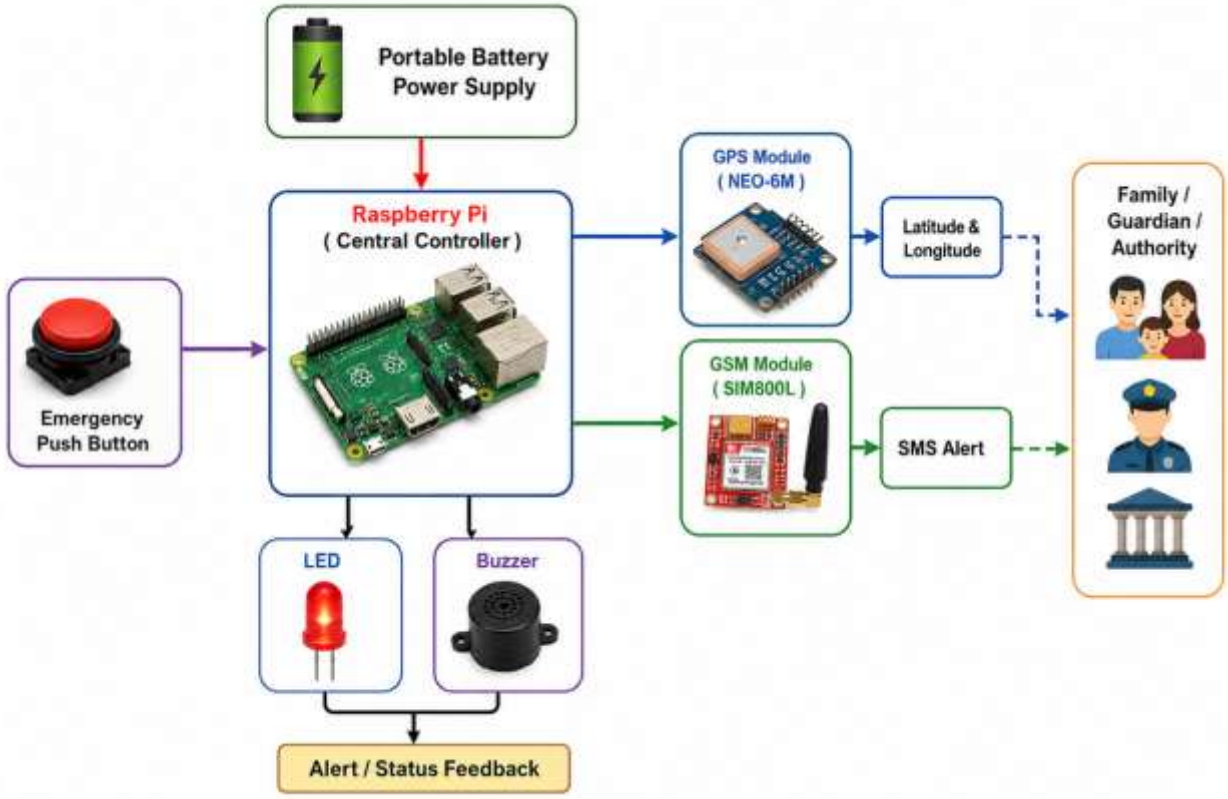


Figure 1 The overall architecture of the proposed system.

B. Hardware Architecture

1) Raspberry Pi 4

Raspberry Pi 4 functions as the central controller. It monitors the emergency input, communicates with the GPS and GSM modules, processes the received location information, constructs the SMS, and controls the LED and buzzer.

The programmable nature of Raspberry Pi makes the platform suitable for future expansion with additional sensors, communication interfaces, and intelligent processing.

2) NEO-6M GPS Module

The NEO-6M GPS module is used to acquire the geographical location of the user. The receiver communicates with the Raspberry Pi through a serial interface and provides navigation information from which latitude and longitude are obtained.

The implementation reads GPS sentences and identifies valid location information before continuing with the emergency notification procedure.

3) SIM800L GSM Module

The SIM800L GSM module provides cellular communication. Once valid location information is available, the Raspberry Pi communicates with the module using AT commands and configures it for SMS transmission.

The emergency message contains the emergency notification together with the obtained geographical coordinates and a map-accessible location.

4) Emergency Push Button

The emergency push button is the primary user interface. It is connected to a Raspberry Pi GPIO input. The controller continuously monitors the input and enters emergency mode when the button is activated.
The use of a dedicated physical button eliminates the need for the user to interact with a smartphone application during an emergency.

5) LED Indicator

The LED provides visual feedback regarding system operation. It can indicate activation of the emergency mechanism and provide confirmation that the system has entered the alert sequence.

6) Buzzer

The buzzer provides audible confirmation after emergency activation. The combination of LED and buzzer gives immediate local feedback to the user.

7) Battery Power Supply

A portable battery supply enables the system to operate away from fixed power sources. This feature supports the intended portable implementation and provides a basis for future wearable miniaturization.

IV. METHODOLOGY AND IMPLEMENTATION

A. System Initialization

When the system is powered on, the Raspberry Pi initializes the GPIO pins associated with the emergency button, LED, and buzzer. Serial communication is then established with the GPS and GSM modules.
The implementation uses Python together with GPIO and serial communication libraries. The documented implementation specifically uses RPi.GPIO, PySerial, pynmea2, and standard timing functions.

B. Emergency Detection

The system continuously monitors the emergency button.
During normal operation, the device remains in standby mode. When the button is pressed, the Raspberry Pi detects the corresponding GPIO state and invokes the emergency-alert routine.
This event-driven mechanism reduces the amount of user interaction required to initiate an alert.

C. GPS Location Acquisition

After emergency activation, the Raspberry Pi reads data from the GPS module through the serial interface. The implementation waits for valid GPS information and processes appropriate NMEA sentences.
The source implementation specifically monitors GPGGA and GNGGA sentences and verifies that the latitude and longitude values are non-zero before accepting the location.
If valid coordinates are obtained, they are incorporated into the emergency message. A map-accessible query is also generated from the coordinates.
If a valid GPS position cannot be acquired, the implementation still sends an emergency SMS indicating that the GPS location is unavailable. This is an important fail-safe feature because the emergency communication mechanism does not completely terminate when positioning information is unavailable.

D. Emergency Message Generation

After location acquisition, the Raspberry Pi constructs the emergency message.
The documented implementation generates a message containing:

- Emergency notification
- Immediate assistance requirement
- Latitude
- Longitude
- Map-accessible location

This allows the receiving guardian to obtain both the numerical coordinates and a convenient map reference.

E. GSM-Based SMS Transmission

The Raspberry Pi communicates with the SIM800L module through serial communication. The GSM module is initialized and configured for text-message operation.
The implementation performs the principal SMS operations by:

1. Checking communication with the GSM module.

2. Selecting text-message mode.
3. Specifying the predefined destination number.
4. Transmitting the emergency message.
5. Submitting the message through the GSM network.

The system consequently provides a direct communication path from the emergency button to a registered guardian.

F. Local Alert Feedback

After the emergency sequence is initiated, the Raspberry Pi activates the LED and buzzer. The indicators remain active for a short predefined period and are subsequently switched off.

This provides confirmation to the user that the emergency operation has been initiated.

G. Standby Recovery

After completion of the emergency sequence, the system waits for the emergency button to be released and then returns to standby mode.

This prevents a continuously pressed button from repeatedly initiating the emergency routine. A short delay is also used between operations to reduce unintended repeated activation.

H. Complete Operating Algorithm

The complete algorithm is summarized as follows:

1. Start the Raspberry Pi.
2. Initialize GPIO interfaces.
3. Initialize GPS serial communication.
4. Initialize GSM serial communication.
5. Enter standby mode.
6. Continuously monitor the emergency push button.
7. If the button is not pressed, continue monitoring.
8. If the button is pressed, enter emergency mode.
9. Acquire GPS data.
10. Verify the availability of valid coordinates.
11. Generate the emergency message.
12. Add latitude and longitude when available.
13. Generate a map-accessible location.
14. Configure the GSM module for SMS transmission.
15. Send the emergency message to the predefined contact.
16. Activate the LED and buzzer.
17. Wait for button release.
18. Return to standby mode.
19. Continue monitoring.

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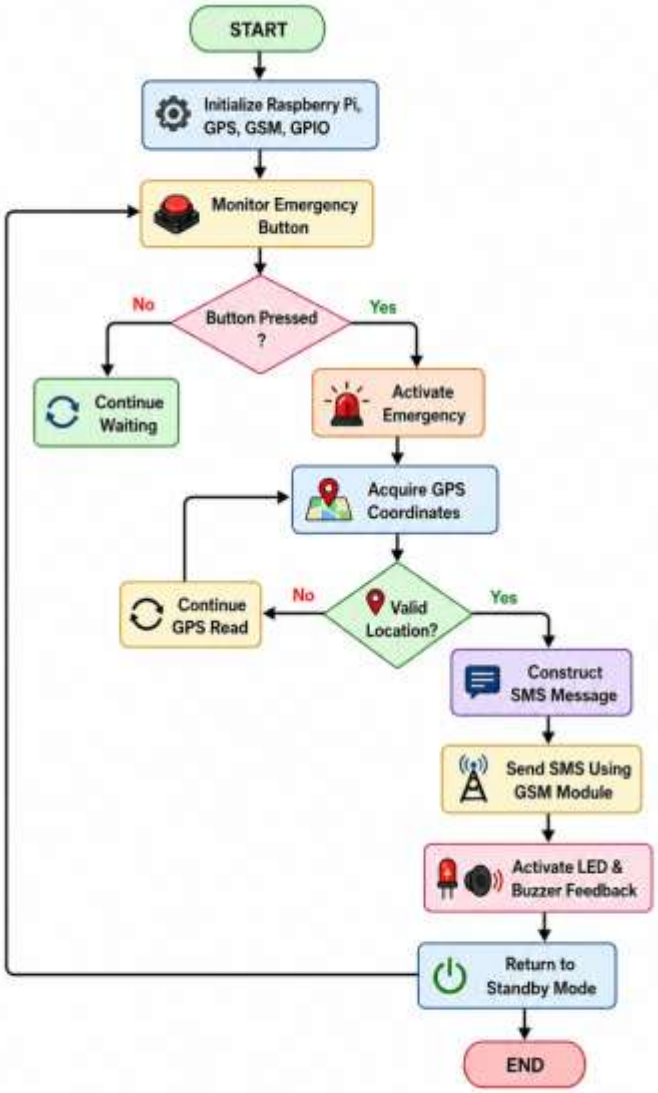


Figure 2 The complete methodology flow chart

V. EXPERIMENTAL SETUP AND RESULTS

The prototype consists of Raspberry Pi 4, NEO-6M GPS module, SIM800L GSM module, emergency push button, LED, buzzer, battery/power supply, and connecting wires. The Raspberry Pi performs the control and processing functions, while GPS and GSM modules are connected through serial communication. The software environment consists of Raspberry Pi OS and Python. The implementation uses GPIO and serial communication libraries to operate the hardware components.

B. Experimental Procedure

The prototype was evaluated through a sequence of functional tests:

1. System initialization.
2. Emergency-button activation.
3. GPS coordinate acquisition.
4. Emergency-message generation.

5. GSM SMS transmission.
6. LED operation.
7. Buzzer operation.
8. Indoor and outdoor operation.
9. Repeated operation and recovery.
10. Portable-power considerations.

C. Emergency Button Evaluation

The emergency button was tested to determine whether the Raspberry Pi correctly distinguishes between standby and emergency states.

When the button remained inactive, the system stayed in standby mode. When the button was activated, the emergency routine was initiated. The subsequent GPS acquisition and GSM communication stages were successfully invoked.

The documented functional test confirms the expected behavior of the emergency input and the transition from standby to emergency operation.

D. GPS Location Evaluation

GPS testing was performed by verifying whether the received latitude and longitude represented the user's location.

The system successfully acquired GPS coordinates during the documented tests, and these coordinates were subsequently incorporated into the emergency message.

The source documentation also identifies indoor GPS performance as a limitation because satellite visibility can be reduced inside buildings.

Therefore, although GPS provides a practical location mechanism for the proposed system, its performance is environment-dependent.

E. SMS Alert Evaluation

The GSM module was tested by transmitting an emergency message containing the location information to the pre-registered contact.

The documented results indicate that SMS transmission was successfully performed during testing. The emergency communication chain was therefore demonstrated as:

Emergency Button → Raspberry Pi → GPS → Emergency Message → GSM → Cellular Network → Guardian

The source document reports consistent alert delivery during testing, but it does not provide a numerical SMS success percentage. Consequently, a specific delivery rate is not reported in this paper.

F. LED and Buzzer Evaluation

The LED and buzzer were tested during emergency activation.

The LED successfully provided visual indication, while the buzzer generated audible feedback. Their simultaneous operation provided confirmation that the emergency routine had been activated.

This local feedback mechanism is useful because it allows the user to immediately recognize that the system has responded to the emergency button.

G. Indoor and Outdoor Evaluation

The system was considered under both indoor and outdoor conditions.

Outdoor operation generally provides more favorable conditions for GPS signal acquisition because the receiver has improved access to satellite signals. Indoor environments can result in weaker or obstructed GPS reception.

The experimental observations therefore support the use of GPS for outdoor location acquisition while identifying indoor positioning as an area requiring additional technology.

H. Reliability Evaluation

Repeated emergency-button operation, GPS acquisition, GSM communication, SMS reception, indicator activation, and recovery to standby were considered as part of the reliability assessment.

The proposed system demonstrates that a relatively simple embedded architecture can provide an independent emergency communication mechanism. The combination of a physical emergency button, Raspberry Pi controller, GPS receiver, and GSM transmitter creates a direct emergency-response pathway

without requiring the user to interact with a smartphone application. One important advantage is the reduction in user interaction. During an emergency, a dedicated physical button can be easier to operate than a smartphone application requiring multiple steps. The Raspberry Pi automatically handles subsequent location acquisition and SMS generation. The second important feature is location-aware communication. Instead of sending only a generic emergency notification, the proposed system incorporates the user's geographical coordinates into the message. This provides the recipient with information that can assist in locating the user. Another advantage is the reduced dependence on Internet connectivity. GSM SMS communication is used as the primary remote communication mechanism, allowing the system to operate without relying entirely on Wi-Fi or mobile Internet services.

XI. CONCLUSION

This paper presented a Raspberry Pi-based women safety system for real-time emergency alert and location tracking. The proposed architecture integrates a Raspberry Pi controller, NEO-6M GPS receiver, SIM800L GSM module, emergency push button, LED, buzzer, and portable power supply.

The system is designed to minimize user interaction during an emergency. Activation of the dedicated emergency button initiates the emergency sequence, after which Raspberry Pi obtains the user's GPS coordinates and generates an SMS containing the emergency notification and location information. The GSM module transmits the message to a pre-registered contact, while the LED and buzzer provide local feedback.

Functional experimentation demonstrated successful emergency-button detection, GPS location acquisition, SMS alert transmission, local feedback, and recovery to standby. The results demonstrate the feasibility of integrating GPS and GSM technologies with Raspberry Pi to create a portable emergency communication device.

The principal limitations are indoor GPS performance, dependence on cellular network coverage, battery constraints, and the absence of automatic threat detection. Future development can therefore focus on wearable miniaturization, multi-contact notification, cloud integration, improved indoor positioning, battery optimization, and intelligent sensing. Overall, the proposed system provides a practical foundation for an independent and low-cost personal emergency communication platform.

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