Smart Women's Safety Device

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Abstract—This paper presents an innovative safety device designed to enhance women's security during emergencies. The system leverages a NodeMCU microcontroller integrated with an MPU6050 sensor to detect abrupt shaking motions indicative of distress. Upon activation, it promptly dispatches an SOS alert containing real-time location data, retrieved via a NEO-6M GPS module, to pre-configured emergency contacts through a SIM800L module. Complementing the hardware, a dedicated web platform facilitates seamless device management and real-time monitoring, significantly enhancing user convenience. With its lightweight, cost- effective design, the device ensures accessibility and reliability, making it suitable for widespread adoption. Rigorous testing in simulated scenarios validates its effectiveness, underscoring its potential as a practical and impactful solution for personal safety

Index Terms—Women's Safety, NodeMCU, Internet of Things, GPS location, Shake detection

I. INTRODUCTION

In today's world, personal safety, particularly for women, remains a pressing concern. Despite advancements in technology, many individuals still face threats to their security, emphasizing the need for innovative solutions that can provide immediate protection and response during emergencies. This research introduces a Women Safety Device that integrates advanced sensors, real-time location tracking, and communication technology to offer an effective and reliable safety solution.

The proposed system provides a proactive approach to personal security, with key features outlined as follows:

1. Motion Detection with MPU6050 Sensor:
The device incorporates the MPU6050 sensor, which can detect sudden or unusual movements, such as shaking, that typically indicate a distress situation.
Upon detecting such movements, the sensor activates the device's emergency response system, ensuring quick action in critical situations.

2. Automated SOS Alerts with GPS Location:
When motion is detected, an SOS signal is triggered and automatically sent to pre-configured emergency contacts. The SOS message contains the real-time GPS coordinates,
captured by the NEO-6M GPS module, providing accurate location tracking and immediate assistance to the user.

3. Website Integration for Real-Time Tracking and Alerts:
A dedicated website accompanies the hardware, allowing users to:
- Track the device's real-time location through an intuitive online interface.

4. NodeMCU and SIM Module for Robust Connectivity:
At the core of the device is the NodeMCU microcontroller, which manages the integration of the sensors and communication modules. The system utilizes a SIM module, allowing the SOS alerts to be sent via SMS, even in areas without internet connectivity, ensuring that the user's location and distress signals can be communicated in any emergency.

This women's safety device aims to provide an immediate and effective response during emergencies, combining motion detection, real-time GPS tracking, and reliable communication capabilities. The device's seamless hardware and website integration offer a user-friendly, accessible, and effective tool designed to enhance personal security and provide peace of mind to individuals, especially in critical situations.

II.   LITERATURE REVIEW

[1] N. Prakash et al. *"GSM-Based Design and Implementation of Women Safety Device Using Internet of Things"* This paper presents a GSM-based IoT solution for enhancing women's safety, focusing on a device that can alert authorities during emergencies. The system integrates IoT technology for real-time location tracking and communication, ensuring a quick response. Published in *Advances in Intelligent Systems and Computing*, this work underscores the potential of IoT in developing practical safety tools.

[2] K. Kar et al. *"Design and Practical Application of a Cost Effective Intelligent Female Surveillance System Using GPS, GSM, and Arduino Technology"* This paper outlines the development of an intelligent, cost-effective surveillance system for women's safety, utilizing GPS and GSM for location tracking and emergency communication. The device's practical application is demonstrated, showcasing its effectiveness in real-life scenarios. Published in *E3S Web of Conferences*, it highlights accessible technology integration for public safety.

[3] M. S. Farooq et al. *"The Role of IoT in Woman's Safety: A Systematic Literature Review"* This systematic review investigates the significant role IoT plays in women's safety, compiling data on various IoT-based safety systems and their impact. The authors analyze advancements and identify gaps in current research, providing insights into future development avenues. Published in *IEEE Access*, it serves as a comprehensive resource for IoT safety solutions.

[4] W. Akram et al. "*Design of a Smart Safety Device for Women using IoT*" This paper discusses the creation of a smart, IoT-based safety device for women, emphasizing innovative features for emergency alerts and location tracking. It focuses on the device's architecture and functionality, showcasing its effectiveness through rigorous testing. Featured in *Advances in Intelligent Systems and Computing*, the research highlights affordable and reliable safety technologies.

III.   METHODOLOGY

1. Tools Used:

- Arduino Uno: Serves as the primary microcontroller to interface with various sensors and modules. It manages data from the MPU6050 sensor to detect sudden shaking motion and triggers emergency protocols by activating the SIM module.
- MPU6050 Sensor: A motion-tracking sensor used to detect abrupt movements indicative of distress. It communicates with the Arduino Uno for real-time motion monitoring and analysis.
- SIM800L Module: A GSM module integrated with the Arduino Uno to handle cellular communication. When activated, it automatically places calls to pre-configured emergency contacts.
- NodeMCU: An IoT development board used for its Wi-Fi capabilities. It receives a trigger from the Arduino Uno and interfaces with the NEO-6M GPS module to collect location data. The NodeMCU transmits the collected data to a server for further processing.
- NEO-6M GPS Module: A GPS module employed to obtain real-time location data,

providing the latitude, longitude, and timestamp for the emergency alert system.

- Server: Facilitates data reception from the NodeMCU, process's location data, and converts it into human-readable addresses using the Bing Maps API. It is responsible for displaying the information on the web platform.
- Bing Maps API: Used for map visualization and address retrieval based on latitude and longitude coordinates. It allows real-time location monitoring on the web interface.
- Web Platform: Developed to provide a user-friendly interface for emergency monitoring. Displays the processed location data and a map indicating the current position of the user during an emergency.

The methodology for developing the Women Safety Device involves a seamless integration of hardware components, the design of a robust communication system, and the creation of a website for real-time tracking and emergency response. The development process is structured into several stages, with each phase contributing to the overall functionality and efficiency of the device. The following outlines the key steps involved in the design, implementation, and

optimization of the system:

2. Motion Detection Algorithm

The next phase of the methodology involved designing a motion detection algorithm that interprets the sensor data from the MPU6050 sensor. The algorithm is programmed to detect sudden, forceful movements or shaking. When the sensor detects motion beyond a certain threshold, the algorithm triggers the emergency response system, which consists of sending an SOS alert.

Data Calibration: The threshold for detecting abrupt motion was determined based on experimental data from various shaking scenarios. Different thresholds were tested to ensure accuracy in motion detection without false alarms.

3. SOS Alert System

Once the motion detection algorithm is triggered, the NodeMCU microcontroller processes the data and activates the SOS alert system. The system uses the NEO- 6M GPS module to capture the real-time location coordinates of the user. These coordinates are embedded in the SOS message.

SMS Sending Mechanism: The SIM module is used to send the SOS message containing the GPS coordinates to pre-configured emergency contacts. The SMS is sent over the mobile network, ensuring reliable communication even in the absence of an internet connection.

4. Website Development for Real-Time Monitoring

A website was developed to provide a user interface for real-time tracking of the device and its SOS alerts. The website allows users to:

Track the Device's Location: Users can view the real-time GPS coordinates of the device on an interactive map.
Configure Emergency Contacts: The website enables users to add or modify emergency contacts to ensure that alerts are sent to the appropriate individuals.

5. System Integration and Testing

Once the individual components and subsystems were developed, the system was integrated and subjected to thorough testing to ensure the overall functionality and reliability. The testing process involved:

Hardware Testing: Ensuring that the MPU6050 sensor, GPS module, NodeMCU microcontroller, and SIM module functioned properly and communicated effectively.
Motion Detection Testing: Verifying the motion detection threshold to ensure it only triggered during actual distress scenarios.
SMS Functionality Testing: Confirming that the SOS messages were sent correctly with accurate location data to emergency contacts.
Website Testing: Ensuring that the website correctly displayed the real-time location and allowed the user to manage settings.

6. Optimization and Refinement

After testing, the system underwent several rounds of optimization to improve accuracy, power efficiency, and user interface design. The motion detection algorithm was refined to minimize false alarms and improve the device's response time. Additionally, the website interface was enhanced for better usability.

7. Final System Validation

The final step involved validating the entire system by simulating emergency scenarios. The system's ability to detect distress, send accurate SOS alerts with GPS coordinates, and allow users to track the device's location through the website was thoroughly evaluated.
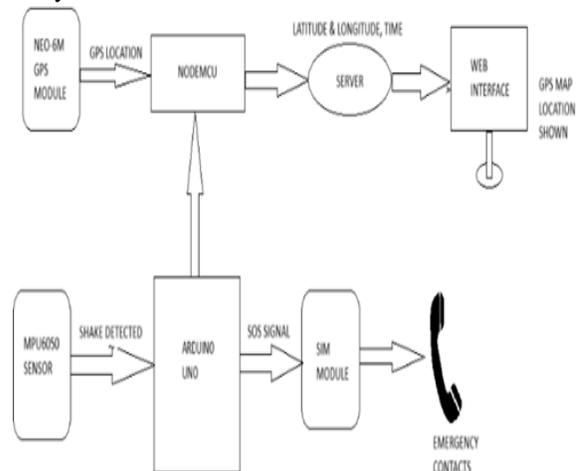
8. System Architecture:

Figure 1: Flowchart showing system architecture of the device

IV. MATHEMATICAL MODEL USED

The motion detection mechanism in the women's safety device is based on acceleration threshold analysis using the MPU6050 sensor. The total acceleration (AAA) is computed as:

$$A = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

where ax, ay, and az are the acceleration components along the X, Y, and Z axes, respectively. If the detected acceleration surpasses a predefined threshold (Ath), indicating sudden or forceful motion, an emergency alert is triggered. Additionally, real-time GPS tracking enhances the system's reliability by calculating the distance moved by the user. The displacement (d) between two consecutive locations is determined using the Haversine formula:

$$d = R \times \cos^{-1}\left[\sin(\phi_1)\sin(\phi_2) + \cos(\phi_1)\cos(\phi_2)\cos(\lambda_2 - \lambda_1)\right]$$

where RRR is the Earth's radius (~6371 km), and (ϕ_1, λ_1) and (ϕ_2, λ_2) represent the latitude and longitude of two recorded positions. This equation ensures precise tracking of the user's movement, enhancing the accuracy of the emergency response system. By integrating these mathematical models, the device ensures reliable motion detection and location tracking, minimizing false alarms while providing real-time safety assistance.

V. RESULTS AND DISCUSSIONS

The integration of the NEO-6M GPS module and SIM module enabled the system to send SOS alerts with real-time location data to emergency contacts, with alerts dispatched within 3–5 seconds, even in areas with limited network connectivity.

The GPS system performed well, providing an average positioning accuracy of 5 meters in outdoor environments, which was sufficient for emergency response purposes.
The real-time tracking on the website was accurate, ensuring that emergency responders could easily access the user's location. The website was designed for user-friendliness, allowing easy management of emergency contacts and smooth monitoring of the device's status. It performed reliably across various devices and browsers, offering a seamless experience.

The overall integration of hardware components, including the motion sensor, GPS module, and microcontroller, was successful, with no significant issues in the communication between the modules. The device performed well in real-world scenarios, providing a reliable and efficient safety solution. However, some limitations were identified, particularly in indoor GPS performance, where satellite signal strength can be reduced. Future improvements will focus on refining motion detection algorithms and optimizing battery life to enhance overall efficiency.

To evaluate the effectiveness and reliability of the proposed

women's safety device, a series of performance tests were
conducted under real-world conditions. Various critical parameters such as SOS activation time, GPS accuracy, sensor responsiveness, and message delivery success rate were measured and analyzed. The consolidated results of these tests are presented in Table I, providing a clear overview of the system's responsiveness, accuracy, and practical feasibility.

TABLE I.

PERFORMANCE EVALUATION RESULTS			
Test Scenario	Metric / Observation	Result (Quantified)	Remarks
SOS Activation	Time taken from trigger to alert sent	3–5 seconds	Consistent in all tests
GPS Accuracy (Outdoor)	Avg. deviation from actual location	±5 meters	Better in open areas
SMS Alert Success	Message delivery success rate	100% (in GSM coverage)	Zero failed transmissions
Location Website	Detection of simulated	95% correct	Very low false

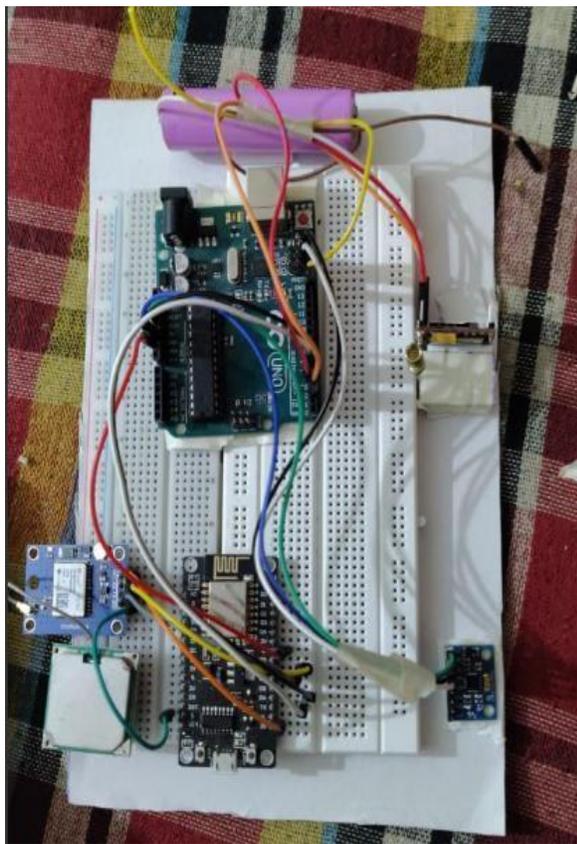| Sync	distress actions	detections	negatives
Battery Backup	Duration of standby operation	~24 hours	Full charge required
Cross-Device Support	Accessibility of website on all platforms	Fully functional	Tested on PC & Mobile

Images of the project:

Figure 2: Hardware part of the device

Figures 3–7 illustrate the results of GPS tracking conducted in different environments. The screenshots confirm that the system is capable of maintaining accurate geolocation data with minimal deviation, even under changing environmental conditions. The tracking updates in real time and remains consistent, ensuring that responders can pinpoint the user's location quickly and reliably.
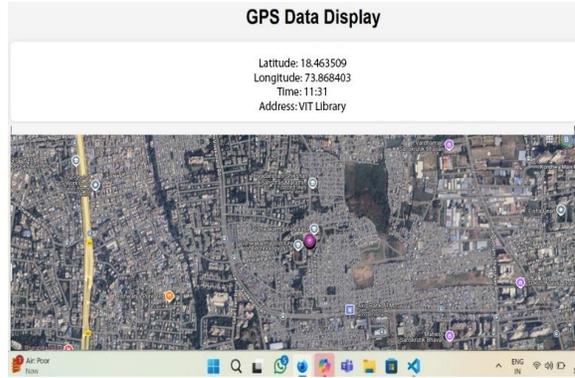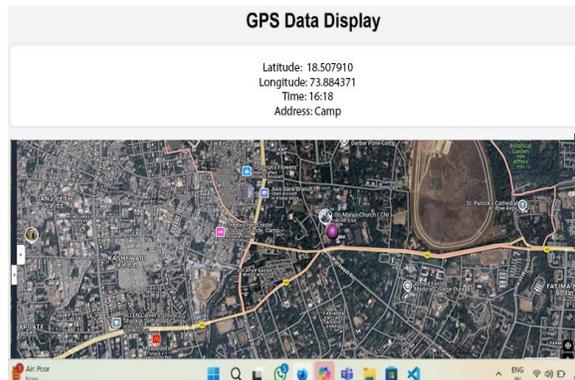

Figure 3: First GPS Location

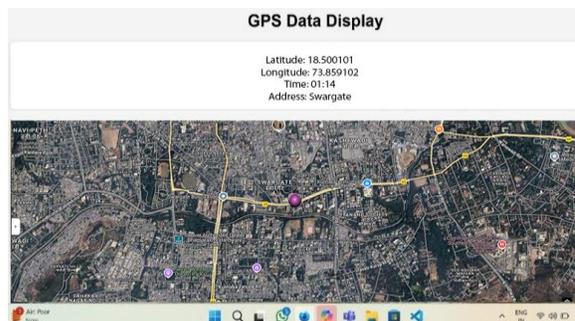Figure 4: Second GPS Location

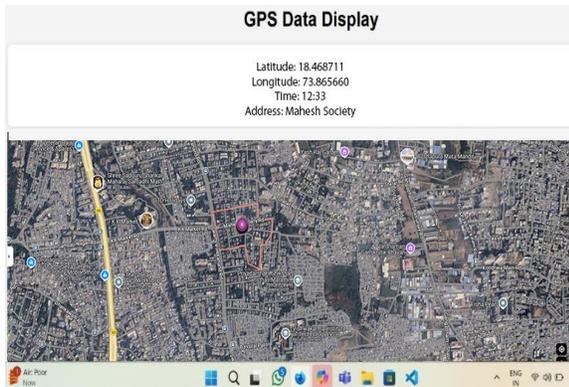Figure 5: Third GPS Location

Figure 6: Fourth GPS Location

Figure 7: Fifth GPS Location

VI. CONCLUSION

This research presents the development of a Women Safety Device aimed at providing real-time protection and a swift emergency response system. By integrating the MPU6050 motion sensor, NEO-6M GPS module, SIM module, and a user-friendly website, the system effectively detects distress situations, sends SOS alerts with accurate location data, and ensures immediate assistance through pre-configured contacts.

Testing results confirm the device's reliable performance, with high accuracy in motion detection, timely SOS alert transmission, and precise GPS location tracking. The website further enhances the system by offering seamless real-time location updates.

Despite achieving its design objectives, certain areas require further refinement. Indoor GPS accuracy remains a challenge due to limited satellite visibility in enclosed spaces. Additionally, optimizing battery consumption for prolonged usage and fine-tuning the motion detection algorithm to reduce false alerts are critical areas for future improvement. Addressing these limitations will increase the device's overall efficiency and reliability.

In conclusion, the Women Safety Device represents a significant step forward in wearable safety technology, combining cutting-edge hardware and an intuitive interface to provide a timely, effective emergency response solution. The device's successful implementation opens up avenues for future research and development in personal security devices, with the potential to offer a widespread impact on safeguarding individuals, particularly women, in vulnerable situations. This work contributes to the growing field of smart safety solutions and lays the groundwork for further innovations that can be expanded for real-world applications.

VII. ACKNOWLEDGEMENT

REFERENCES

[1] R. K. Kar, A. S. S. Murugan, D. Obulesu, and C. Shravani, "Design and Practical Application of a Cost Effective Intelligent Female Surveillance System Using GPS, GSM, and Arduino Technology," E3S Web of Conferences, vol. 472, p. 03007, 2024.

[2] M. S. Farooq, A.Masooma, U. Omer, R. Tehseen, S. A. M. Gilani, and Z. Atal, "The Role of IoT in Women's Safety: A Systematic Literature Review," IEEE Access, vol. 11, pp. 54321-54334, 2023

[3] W. Akram, M. Jain, and C. S. Hemalatha, "Design of a Smart Safety Device for Women using IoT," Advances in Intelligent Systems and Computing, vol. 165, pp. 656-662, 2019.

[4] https://youtu.be/FSqYyjZtH4g?si=qWujq-xNUhnVmqhA

[5] https://youtu.be/zaK2p2zgHNs?si=NhWyGmh0Q2N_Zq-D

[6] https://youtu.be/O0O_ehuzhZs?si=nAjO233uG-TB57S2

[7] N. Prakash, E. Udayakumar, N. Kumareshan, and R. Gowrishankar, "GSM-Based Design and Implementation of Women Safety Device Using Internet of Things," Advances in Intelligent Systems and Computing, vol. 1167, 2019