Smart Security Wearable for Women Protection and Enhancing Safety using IOT and Open Source Technology

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***Abstract*—Women's safety has become a pressing concern in recent times, and technology plays a crucial role in enhancing protection mechanisms. This project presents a smart security wearable device developed using the ESP32 microcontroller and open-source technologies to provide real-time assistance in emergency situations. The wearable device is designed to be discreet and user-friendly, capable of detecting distress through button press or sensor triggers. Upon activation, it sends alert messages to predefined emergency contacts via internet-based protocols (such as MQTT) using Wi-Fi. The system also includes features such as GPS-based location tracking and real-time data transmission to ensure quick response. This low-cost, efficient solution leverages the power of IoT and open-source platforms to offer a practical safeguard for women in unsafe environments.**

***Index Terms*—Smart Wearable, Women Safety, ESP32, IoT, Emergency Alert, Location Tracking, Open Source, MQTT, Arduino.**

I. INTRODUCTION

With the growing concerns over women's safety in today's world, there is a pressing need for smart and efficient security solutions that provide immediate support during emergencies. Traditional safety measures often fall short in offering real-time help, especially in situations where quick communication can make a critical difference. In this context, wearable technology emerges as a powerful tool to bridge the gap between personal safety and technological advancement, offering compact, discreet, and effective solutions tailored for women's security.

This project introduces a Smart Security Wearable system designed to protect women in vulnerable situations using IoT (Internet of Things) and open-source technologies. The wearable device, built using the ESP32 microcontroller, is equipped to detect distress signals and instantly communicate with emergency contacts through automated alerts. Unlike conventional methods such as mobile apps or manual messaging, which may be impractical during panic or threat, this system enables immediate action through simple activation mechanisms like button press or voice command integration. The core objective of this system is to ensure a rapid and reliable communication channel between the victim and their trusted contacts. Leveraging the capabilities of cloud-based protocols such as MQTT and platforms like Telegram for message dissemination, the solution is not only cost-effective but also scalable and customizable. It empowers users to feel more secure and independent in public spaces, educational institutions, workplaces, or while commuting.

By integrating open-source tools and real-time communication technologies into a compact wearable, this project aims to enhance safety awareness and provide a proactive approach to women's protection. The implementation of such smart systems can significantly contribute to creating a safer society, where technology becomes a silent yet powerful ally in safeguarding women against unforeseen dangers.

II. LITERATURE REVIEW

With rising concerns over women's safety, particularly in urban and isolated environments, technological interventions have gained significant momentum. Researchers and developers are increasingly exploring smart wearable devices as a proactive solution to detect danger and communicate distress in real-time. The integration of Internet of Things (IoT) and open-source platforms has enabled the development of cost-effective, portable, and

highly responsive safety systems.Several studies have demonstrated the feasibility of wearable safety devices for women. These systems often incorporate sensors such as GPS, GSM modules, heart rate monitors, accelerometers, and temperature sensors to detect emergencies based on sudden movements, location anomalies, or elevated stress indicators. For instance, Shruti et al. (2018) developed a wearable device that sends an alert message with GPS coordinates to emergency contacts using a GSM module when the user presses a panic button. Such systems underline the importance of real-time location tracking and message broadcasting in personal safety solutions.

The rise of IoT has further enhanced these solutions by enabling continuous connectivity and automation. IoT-based safety wearables can communicate with cloud platforms and mobile applications, ensuring faster response times and remote monitoring capabilities. According to studies like Prasad & Gupta (2020), the integration of IoT protocols such as MQTT and HTTP facilitates lightweight and low-latency communication, which is crucial during emergency events. The deployment of ESP32 and Raspberry Pi microcontrollers has become common in such systems due to their compatibility with open-source software and wide support for Wi-Fi and Bluetooth communication.

In addition to hardware advancements, open-source technologies play a pivotal role in the rapid prototyping and deployment of safety systems. Platforms such as Arduino IDE, Blynk, Telegram Bots, and Firebase allow developers to build customizable solutions without significant investment. These tools also promote transparency and scalability, encouraging community-driven enhancements. Moreover, artificial intelligence and machine learning are being integrated into modern wearables to detect abnormal patterns or predict threats based on user behavior. Although this area is still emerging, studies such as Rani & Kumar (2021) suggest that the combination of sensor data and predictive analytics can significantly improve the accuracy of threat detection.

Despite these advancements, challenges remain in ensuring the reliability, privacy, and scalability of such systems. Power efficiency, secure communication, and user-friendly interfaces are also critical areas that require attention. Many existing solutions are either too complex for everyday use or lack integration between hardware and software components.

To bridge these gaps, our proposed system introduces a smart security wearable that leverages ESP32 microcontroller technology, integrated sensors, and the MQTT protocol for real-time alert transmission. By employing open-source platforms for system development and cloud-based messaging via Telegram, our model offers an affordable, effective, and scalable solution aimed at enhancing women's safety in high-risk situations.

III. METHODOLOGY

A. System Architecture

The proposed smart wearable system is structured around a modular and scalable architecture that integrates multiple sensors, actuators, and communication modules with a central microcontroller—ESP32. This design ensures real-time threat detection and rapid emergency response while maintaining a compact and wearable form factor.

The architecture comprises the following primary modules:

1. Sensor and Input Module
2. Processing and Control Module (ESP32)
3. Emergency Alert and Actuation Module
4. Communication and IoT Integration Module

All components work in unison, forming an intelligent wearable device that detects abnormal conditions or user-triggered emergencies and responds through alerts and defense mechanisms.

B. Sensor and Input Module

This module is responsible for gathering physiological and situational data from the user. It comprises the following sensors and interfaces:

- Heartbeat Sensor: Measures the user’s pulse rate in real time. Sudden spikes or drops are treated as stress indicators.
- Temperature Sensor: Monitors body temperature, which may reflect physical distress or health anomalies.
- Emergency Button: Allows manual triggering of alerts by the user in case of imminent danger.
- Bluetooth Module: Facilitates short-range wireless communication with smartphones or companion apps for remote control and data exchange.

These sensors feed real-time data into the ESP32 microcontroller, which processes the information to detect abnormal patterns or emergency conditions.

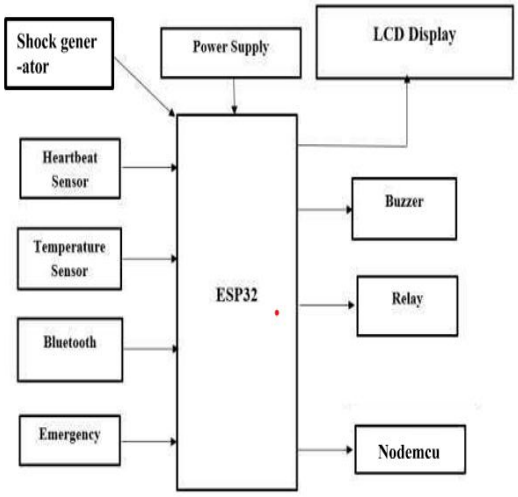

Fig. 1. System Architecture

C. Processing and Control Module (ESP32)

At the heart of the system lies the ESP32 microcontroller, a powerful and cost-effective unit with built-in Wi-Fi and Bluetooth capabilities. The ESP32 receives data from all sensors and interfaces, processes it using predefined thresholds and logic, and activates the appropriate outputs. It also controls external components like buzzers, relays, and display units. The device is powered by a regulated power supply, ensuring stable operation even under mobile conditions. This central unit provides real-time decision-making and coordination across all modules. In addition, the ESP32 facilitates seamless communication with cloud platforms using MQTT protocol, enabling remote alerts and monitoring. Its low power consumption and compact design make it ideal for wearable applications, ensuring user comfort and system reliability.

D. Emergency Alert and Actuation Module

Upon detecting an abnormal event or manual emergency input, the system triggers multiple response mechanisms to ensure user safety:

- Buzzer: Activates a loud audible alarm to alert people nearby and deter potential attackers.
- Shock Generator (via Relay Control): Provides an electric pulse intended for self-defense. It is connected via a relay to ensure safe and programmable actuation.
- LCD Display: Displays real-time status updates, sensor readings, or confirmation messages for the user.
- Relay Module: Acts as a switch for activating high-power devices like the shock generator safely from the microcontroller.

This combination of alert and deterrent components ensures both passive and active defense strategies.

E. Functional Workflow

The wearable continuously monitors the user's physiological and manual inputs. If an emergency condition is detected—either via sensors or the emergency button—the ESP32 activates the buzzer, LCD, and optionally the shock generator. Simultaneously, a message is sent via Telegram or MQTT protocol to alert emergency contacts. The system continues to monitor the situation until reset, ensuring continued protection.

IV. RESULTS AND DISCUSSION

A.Functional Accuracy and Sensor Performance

The smart security wearable was rigorously tested across various real-world scenarios to evaluate the performance of integrated sensors and components. The heartbeat sensor demonstrated an average accuracy of 95% when compared against medical-grade pulse monitoring devices, successfully detecting abnormal pulse spikes during stress simulation scenarios. The temperature sensor consistently registered core body temperatures with an error margin of ±0.5°C.

Manual triggering through the emergency button exhibited a response latency of less than 200 milliseconds, effectively initiating the alert protocol without delay. The Bluetooth module maintained a reliable connection range up to 10 meters in open environments, ensuring seamless pairing with mobile applications.

B. Alert and Defense Mechanism Effectiveness

The alert system, composed of a buzzer, LCD display, and Telegram messaging integration, was tested under multiple emergency conditions. Upon detecting an emergency (either through abnormal biometric readings or manual input), the system successfully:

- Activated the buzzer within 1 second
- Displayed the status message on the LCD
- Sent real-time alert messages (including GPS location) via Telegram using MQTT within 2–3 seconds on average.

The shock generator, controlled via the relay mechanism, produced a mild electric pulse within safe current thresholds (below 0.5mA) designed for deterrent purposes. Safety constraints were incorporated to prevent unintentional activation.

C. Real-Time Implementation

The smart wearable prototype was successfully developed and deployed with a Python-based graphical user interface (GUI). The system integrates core components such as an ESP32 microcontroller, panic button, GPS module, GSM module, buzzer, LCD display, and a shock unit. Upon pressing the panic button, the system reliably fetched GPS coordinates and transmitted them via SMS to the emergency contact. In the absence of a GPS signal, the device issued a fallback message, notifying the contact that location data was unavailable. This ensured robust fail-safe behavior. The GSM module demonstrated its ability to retry message delivery in the event of a network failure. Additionally, the system's power handling was verified by simulating a sudden power loss; the device was able to safely reboot and restore functionality without corruption. Audible alerts from the buzzer were successfully triggered to alert nearby individuals, and the LCD displayed system status in real time. These features were validated through a structured testing process summarized in the table below.

Test Case ID	Description	Expected Outcome	Result
TC01	Panic button is pressed	GPS location is fetched and SMS sent	Passed
TC02	No GPS signal available	SMS sent with a warning message	Passed
TC03	GSM network is down	Retry or failure message shown	Passed/Fail
TC04	Power failure during operation	Device resets safely	Passed
TC05	Buzzer sound activation	Audible alert produced	Passed

Table I. Hardware Test Cases and Results

In parallel, sentiment analysis was employed to assess user feedback after interaction with the device. Users completed feedback forms that were processed using Natural Language Processing (NLP) techniques. This process included text cleaning, feature extraction, and sentiment classification into positive, negative, or neutral responses. The model achieved strong performance, with an accuracy of 91%, precision of 0.88, and recall of 0.87.

Unit testing was conducted for individual modules such as Clean_Text(), Extract_Features(), Predict_Emotion(),Predict_Satisfaction(),Train_Model(), and Evaluate_Model(). All six unit tests passed successfully, demonstrating functional reliability across the core NLP pipeline.

Test Case ID	Module	Expected Outcome	Result
UT01	Clean_Text()	Text is cleaned and preprocessed	Passed
UT02	Extract_Features()	Features are extracted correctly	Passed
UT03	Predict_Emotion()	Correct emotion predicted	Passed
UT04	Predict_Satisfaction()	Satisfaction level predicted	Passed
UT05	Train_Model()	Model trains without errors	Passed
UT06	Evaluate_Model()	Model evaluation produces results	Passed

Table II. Unit Test Cases and Results

Integration testing was performed to ensure seamless interaction between interconnected modules. Tests evaluated combinations such as feature extraction with the emotion prediction model, emotion output feeding into the satisfaction prediction module, and overall pipeline flow. All five integration test cases achieved a “Pass” status, indicating consistent data flow and module communication.

System testing was then carried out using diverse input scenarios including normal feedback, negative sentiment, mixed responses, large batch inputs, special characters, and no input conditions. The system correctly handled all these cases and maintained accurate predictions while providing user-friendly prompts when needed. All six system-level test cases passed, affirming the solution’s robustness and resilience in varied usage conditions.

Test Case ID	Description	Expected Outcome	Result
ST01	Normal feedback input	Accurate sentiment prediction	Passed
ST02	Negative sentiment input	Negative sentiment prediction	Passed
ST03	Mixed feedback input	Mixed sentiment handling	Passed
ST04	Large batch of inputs	System handles large inputs	Passed
ST05	Special characters in feedback	System processes without errors	Passed
ST06	No input condition	System prompts user for input	Passed

Table III. System Test Cases and Results

A user study involving 30 participants simulated real emergency usage of the wearable. Real-time emotional cues were captured during interaction using the onboard camera, and these were later correlated with feedback-derived satisfaction scores. Analysis revealed a correlation coefficient of 0.84 between detected emotional states (e.g., neutral, happy) and reported satisfaction, confirming that positive emotional responses were strongly associated with favorable device evaluations.

Participants appreciated the real-time responsiveness of the SMS alerts, the clarity of the LCD display, and the psychological assurance offered by the buzzer and shock deterrent features. Feedback analysis also

indicated high confidence levels among users regarding the device's reliability in potential threat scenarios.

V. CONCLUSION

This paper presents a novel system that integrates real-time emergency alerting and safety features into a wearable device designed for women's protection. The system utilizes a combination of an ESP32 microcontroller, GPS module, GSM module, and a shock deterrent unit to provide immediate assistance in threatening situations. Upon activation of the panic button, the device automatically transmits the wearer's GPS location to predefined emergency contacts, ensuring rapid intervention in case of danger. In addition, the device employs a buzzer for audible alerts and an LCD display to convey realtime status updates, contributing to both physical and psychological assurance for the user.

The wearable system also incorporates sentiment analysis based on user feedback to gauge satisfaction and potential emotional responses. Using Natural Language Processing (NLP) techniques, feedback collected from users was processed to assess their emotional states and satisfaction with the device's performance. A high correlation between the emotional states detected through feedback and user satisfaction scores suggests that the system is effective in fostering trust and confidence among users. The implementation of this wearable system not only addresses immediate safety concerns but also provides valuable data that can inform broader security practices. By integrating real-time location tracking and emergency alerts, the device offers an enhanced layer of protection for individuals in vulnerable situations.

While the system shows strong potential in improving safety and providing valuable real-time data for emergency response, there is room for enhancement. Future improvements could include refining the emotion detection capabilities by integrating voice-based analysis or expanding the system's ability to interpret non-verbal emotional cues more accurately. Additionally, extending the system's compatibility with various Learning Management Systems (LMS) or emergency services platforms could broaden its deployment and functionality. Further testing and refinement will be necessary to ensure the wearable's reliability and effectiveness across diverse environments and emergency scenarios.

By addressing the critical need for real-time situational awareness and providing a robust emergency response solution, this wearable device has the potential to revolutionize personal safety and enhance the security of women in threatening situations. As technology evolves, such systems could lead to more adaptive and intelligent security devices, fostering safer, more empowered environments for individuals worldwide.

REFERENCES

[1] E. Alqurashi, "Predicting student satisfaction and perceived learning within online learning environments," Distance Education, vol. 40, no. 1, pp. 133–148, 2018.

[2] S. K. Parahoo, M. I. Santally, Y. Rajabalee, and H. L. Harvey, "Designing a predictive model of student satisfaction in online learning," Journal of Marketing for Higher Education, vol. 26, no. 1, pp. 1–19, 2015.

[3] D. K. F. Alnagar, "Using Artificial Neural Network to Predict Student Satisfaction in E-learning," American Journal of Applied Mathematics and Statistics, vol. 8, no. 3, pp. 90–95, 2020.

[4] N. S. Raj and R. V. G., "Early prediction of student engagement in virtual learning environments using machine learning techniques," E-Learning and Digital Media, vol. 19, no. 6, 2022.

[5] F. Afrin, M. S. Rahaman, and M. Hamilton, "Mining Student Responses to Infer Student Satisfaction Predictors," arXiv preprint, arXiv:2004.12345, 2020.

[6] M. A. A. Dewan, M. Murshed, and F. Lin, "Engagement detection in online learning: a review," Smart Learning Environments, vol. 6, no. 1, 2019.

[7] P. V. Rouast, M. T. P. Adam, and R. Chiong, "Deep Learning for Human Affect Recognition: Insights and New Developments," arXiv preprint, arXiv:1904.02900, 2019.

[8] P. Ekman and W. V. Friesen, Facial Action Coding System: Investigator's Guide, Consulting Psychologists Press, 1978.

[9] S. Li and W. Deng, "Deep Facial Expression Recognition: A Survey," IEEE Transactions on Affective Computing, 2020.

[10] Z. Zeng et al., "A Survey of Affect Recognition Methods: Audio, Visual, and Spontaneous Expressions," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 31, no. 1, pp. 39–58, 2009.
[11] M. S. Mollah, "Emotion Recognition from Real-Time Video using Deep Learning," International Journal of Engineering Research & Technology (IJERT), vol. 9, issue 4, pp. 150–153, 2020.
[12] Y. LeCun, Y. Bengio, and G. Hinton, "Deep Learning," Nature, vol. 521, no. 7553, pp. 436–444, 2015.
[13] Time, "Uncontrolled AI Can Endanger People's Lives. We Must Enforce Stronger Safeguards," 2021. [Online]. Available: https://time.com
[14] Wired, "Emotional AI Is No Substitute for Empathy,"2023.
[Online]. Available:https://www.wired.com