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EmpowHer : Wearable Tech for Women's Security

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Abstract : In recent years, the need for innovative safety solutions for women has gained significant attention due to rising safety concerns in public and private spaces. This paper presents AlertX, a wearable device integrated with IoT and mobile technologies designed to address real-time emergencies. The system utilizes a Raspberry Pi 3B+, camera module, and tactile button to instantly capture surroundings and send live location and visual data to preconfigured emergency contacts. The emergency data is transmitted via SMS using the Twilio API and email using SMTP protocols. An Android application, developed in Java, allows users to manage contacts and assess zone-based safety levels across states using Firebase as the backend. The results confirm a reliable, fault-tolerant, and user-friendly system capable of functioning across different geographical conditions. This solution bridges the gap between reactive safety applications and proactive response systems, with scope for future enhancements such as voice-command activation, AI-based image filtering, and cloud integration for large-scale deployment.

IndexTerms **- Women's Safety, IoT, Raspberry Pi, Android Application, Emergency Alert System, Real-Time Location Tracking, Cloud Computing, Smart Wearable Devices.**

I. INTRODUCTION

With increasing concerns about personal security, especially for women, the demand for a reliable, automated, and intelligent safety system has risen. Traditional safety measures, including mobile applications and wearable panic buttons, have limitations due to their dependency on user intervention and potential network connectivity issues. Physiological monitoring-based solutions, such as those relying on heart rate or body temperature variations, often generate false alarms due to stress or physical activity. These challenges highlight the need for a robust and autonomous safety device capable of delivering real-time alerts without requiring manual smartphone operation.

This paper presents a wearable women's safety device that integrates hardware and software components for real-time distress alerts. The device consists of a push button, a camera module, and a GPS module controlled by Raspberry Pi 3b+, ensuring immediate capture of the surrounding environment and accurate location tracking. The Android application linked to the system facilitates contact configuration and crime-zone classification, allowing users to assess the safety of their surroundings. The emergency alert mechanism is powered by Google Firebase, Twilio API, and SMTP Protocol, ensuring seamless data transmission and cloud storage. This study aims to develop an efficient, automated, and user-friendly system that enhances personal security by providing real-time monitoring and emergency alert transmission. The subsequent sections discuss related research, system architecture, methodology, experimental results, and potential future enhancements.

II. LITERATURE SURVEY

Before Women's safety has been a significant research focus in recent years, with several technological advancements aimed at providing efficient and reliable emergency response systems. The increasing cases of harassment, violence, and crimes against women necessitate the development of intelligent, real-time safety mechanisms that can alert authorities and trusted contacts in case of danger. Several systems have been proposed, including wearable devices, smartphone applications, IoT-based security systems, and AI-driven surveillance models. However, most of these systems have various limitations in terms of accuracy, reliability, and real-time response.

2.1 Wearable Safety Devices

Wearable safety devices have gained attention due to their portability and ease of use. Various research works have attempted to incorporate IoT-enabled smart wearable technology for personal security.

One of the earliest solutions was Suraksha, a safety device that utilizes GPS and GSM modules to send distress alerts to pre-configured contacts. While effective in transmitting location data, this system lacks real-time image capture and multi-channel communication, reducing its ability to provide complete situational awareness.

Another approach, SHE (Society Harnessing Equipment), introduced a wearable electric shock system designed to deter attackers. This system, while useful in self-defense, does not provide a means of alerting law enforcement or emergency contacts, making it a reactive rather than a proactive safety mechanism.

A more advanced solution, AESHS (Advanced Electronics System for Human Safety), integrates GPS tracking and GSM-based alert transmission. However, its reliance on manual intervention and lack of cloud storage for real-time monitoring limits its effectiveness.

Several commercial wearable safety devices, such as Safelet and Revolar, provide Bluetooth-enabled panic buttons that send alerts via connected smartphones. However, these solutions depend on the availability of a smartphone, which may not always be accessible in high-risk situations.

The primary limitation of wearable safety devices is that most require manual activation, making them less effective in sudden emergency situations where the victim might not be able to trigger the alert. Additionally, most of these solutions do not capture and transmit real-time visual evidence, reducing their usability in legal proceedings or law enforcement interventions.

2.2 Mobile-Based Safety Applications

Mobile applications have been developed as an alternative to wearable safety devices, offering GPS-based tracking and emergency alert features. The VithU app sends emergency location updates to pre-configured contacts upon pressing the power button twice. However, it is highly dependent on smartphone availability and network connectivity, which can be a challenge in remote areas.

Other mobile-based solutions, such as Safe and My SafeLink, offer features like real-time tracking, emergency alerts, and incident reporting. While these apps provide crime mapping and predictive analytics, they still require manual operation and do not include automated distress triggers or real-time image capturing.

AI-driven mobile safety applications, such as Guardians AI, use machine learning models to predict risky situations based on user movement and location history. These systems are promising but still lack an autonomous distress alert mechanism, requiring users to trigger alerts manually.

The major drawback of mobile-based safety applications is their reliance on smartphones. In high-risk scenarios, the victim may not have enough time to unlock their phone, open the app, and send an alert. Additionally, these applications often face network dependency issues, making them ineffective in areas with poor connectivity.

2.3 IoT-Based Smart Security Systems

The integration of Internet of Things (IoT) technology has introduced new possibilities for smart security systems. Several research works have proposed IoT-enabled women’s safety solutions using cloud computing and AI-driven analytics.

A study by Sharma et al. introduced an IoT-enabled smart bracelet that continuously monitors the user’s physiological parameters, such as heart rate and body temperature, to detect stress conditions. While this approach aims to provide automated distress detection, it often results in false positives, as physical activity, anxiety, or environmental factors can alter vital signs.

An IoT-based RFID and ZigBee module system was introduced by Kumar et al., allowing users to transmit emergency signals without internet access. While effective in low-connectivity environments, this system lacks image capturing and does not integrate real-time location tracking.

A cloud-integrated IoT security framework proposed by Gupta et al. offers AI-based risk detection through live surveillance. While AI-driven monitoring has shown potential in urban crime prevention, such systems require a dedicated infrastructure, making them impractical for personal safety applications.

The major limitations of IoT-based security systems include high implementation costs, false positives in physiological monitoring, and limited real-time alert transmission methods.

2.4. AI and Smart Surveillance-Based Safety Solutions

Artificial intelligence has been explored for enhancing safety through real-time facial recognition, behavior analysis, and predictive analytics. AI-driven surveillance systems, such as those implemented in smart cities, use computer vision and deep learning algorithms to detect potential threats. A study by Wang et al. introduced an AI-powered predictive model that analyzes user movement patterns to detect anomalies in real time. While this system shows promise for public safety, it requires constant internet connectivity and high computational power, making it unsuitable for wearable safety devices.

Another AI-driven approach was proposed by Verma et al., who developed a voice-activated emergency response system using natural language processing (NLP) to detect distress signals in real time. While NLP-based systems have demonstrated high accuracy in controlled environments, their effectiveness in real-world situations with background noise and multiple speakers remains a challenge.

The primary limitation of AI-based safety solutions is that they rely on complex algorithms and cloud-based processing, which may introduce latency in real-time emergency responses.

2.5. Identified Gaps in Existing Solutions

After analyzing existing solutions, the following limitations were identified:

1. Manual dependency – Most wearable and mobile-based safety systems require manual activation, making them ineffective in sudden emergencies.
2. Lack of real-time evidence capture – Few solutions provide automated image capturing, which is crucial for law enforcement intervention.

3. False positives in physiological monitoring – Systems relying on heart rate or temperature tracking may trigger alerts due to stress or exercise, leading to unnecessary panic.
4. Network dependency – Many mobile applications and cloud-based solutions rely on internet connectivity, making them unreliable in remote locations.
5. Lack of multi-channel communication – Existing systems often use either SMS or app-based alerts, limiting their effectiveness if one channel fails.

2.6. Proposed Solution

To address these gaps, the proposed system integrates:

1. Automated push-button activation that triggers distress alerts instantly.
2. Real-time GPS tracking and image capturing to provide accurate evidence.
3. Multi-channel communication using SMS, email, and cloud storage for enhanced reliability.
4. Zone-based crime classification to improve situational awareness.
5. Minimal smartphone dependency, allowing the system to operate even if the user is unable to access their phone.

By combining Raspberry Pi, IoT, cloud computing, and real-time communication, the proposed system provides an efficient, automated, and multi-functional women's safety device, addressing the key limitations observed in previous research.

III. SYSTEM ARCHITECTURE

The proposed system consists of hardware and software components designed to ensure a real-time, automated, and efficient emergency response. The system architecture is structured to facilitate immediate distress alerts, real-time location tracking, image capturing, and multi-channel communication through SMS, email, and cloud-based logging. The integration of Raspberry Pi as the processing unit, along with multiple communication protocols, ensures reliability and ease of operation.

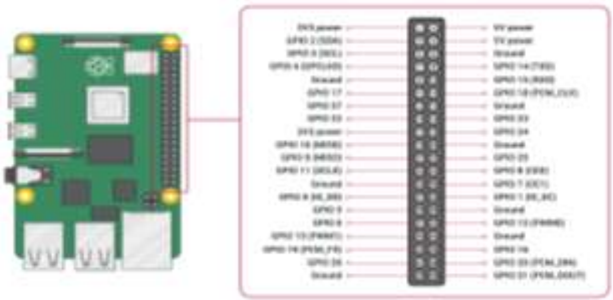

Fig 1: Structure of Raspberry Pi

3.1. Hardware Implementation

The hardware implementation includes multiple electronic components that collectively form an integrated and functional emergency response system. The core processing unit is Raspberry Pi 3b+, which is responsible for handling data acquisition, processing emergency alerts, and interfacing with various sensors and communication modules.

The system includes a push button that serves as the primary activation mechanism. This button is directly connected to the Raspberry Pi's General-Purpose Input/Output (GPIO) pins, allowing the microcontroller to detect the press event and initiate the emergency alert sequence. Unlike mobile-based applications that require unlocking a device or navigating through menus, this push-button mechanism enables instant distress signal transmission without any additional user intervention.

A camera module is integrated into the system to capture real-time images of the surroundings at the moment the emergency button is pressed. The camera is interfaced with Raspberry Pi through the Camera Serial Interface (CSI) port, allowing high-resolution image processing. This feature enhances the credibility of emergency alerts by providing visual evidence, which can assist law enforcement authorities in identifying potential threats or suspects.

A GPS module is included in the system for accurate location tracking. The GPS receiver retrieves real-time latitude and longitude coordinates from satellite signals, which are then transmitted along with the distress alert. The GPS module communicates with Raspberry Pi using a Universal Asynchronous Receiver-Transmitter (UART) interface, ensuring minimal latency in data retrieval. The system ensures continuous tracking of the user's location until the emergency situation is resolved.

The device is powered through a micro-USB adapter, ensuring a continuous power supply for all components. Unlike battery-powered devices that may fail due to low charge, the use of a direct power adapter ensures uninterrupted operation. The hardware design is optimized for low power consumption while maintaining high performance.

3.2. Software Implementation

The software component consists of multiple modules that manage data processing, alert transmission, user interface interactions, and cloud storage. The Raspberry Pi runs a Linux-based operating system that supports Python scripting for device control, data transmission, and external API integration.

An Android application is developed to provide an interactive interface for configuring emergency contacts, receiving safety zone classifications, and monitoring emergency logs. The application is built using Java and XML in Android Studio, ensuring a user-friendly experience. The application retrieves real-time data from Firebase, allowing users to access historical alerts and event logs.

Google Firebase is used as the backend for cloud storage and real-time event logging. Firebase provides a secure database for storing emergency contacts and distress alerts, ensuring high availability and reliability. The integration with Firebase allows emergency responders or family members to track distress alerts remotely.

The system utilizes the Twilio API for sending SMS alerts to pre-configured contacts. Twilio allows the transmission of text messages containing emergency details, including real-time GPS coordinates. Since SMS-based alerts do not require internet access, the Twilio API ensures that distress signals are delivered even in low-connectivity environments.

For email communication, the system implements the Simple Mail Transfer Protocol (SMTP). When an emergency alert is triggered, the Raspberry Pi captures an image and attaches it to an email along with the location details. The email is sent to emergency contacts, providing visual evidence of the situation.

To enhance the reliability of distress alerts, the system implements a multi-channel communication approach. In case one communication method fails, such as an SMS delivery delay, the email and Firebase storage act as alternative channels, ensuring that emergency alerts reach the intended recipients.

3.3. Data Flow and Communication

The system follows a structured data flow model to ensure a seamless transition from emergency activation to alert transmission and response logging.

1. When the push button is pressed, the Raspberry Pi detects the activation signal and immediately initiates the emergency response sequence.
2. The camera module captures an image of the surroundings, which is stored in the Raspberry Pi's memory for processing.
3. The GPS module retrieves the user's real-time location data and formats it for transmission.
4. The emergency alert is generated, containing the timestamp, location coordinates, and captured image.
5. The Twilio API transmits an SMS alert to the emergency contacts with the location details.
6. The SMTP module sends an email to the emergency contacts with an image attachment and GPS coordinates.
7. Firebase logs the emergency event, allowing remote tracking by authorized users.
8. The Android application retrieves Firebase data, enabling users to monitor the emergency situation in real time.

Fig 2. Architecture Design

3.4. System Reliability and Fault Tolerance

The proposed system incorporates fault tolerance mechanisms to ensure high reliability in emergency situations. The system is designed to function in both internet-connected and offline environments. If internet access is unavailable, the SMS transmission through Twilio ensures that emergency alerts are still delivered.

To prevent accidental activations, the push button mechanism includes a debounce logic, ensuring that only intentional presses trigger the alert. Additionally, a reset mechanism is included, allowing users to cancel a false alarm within a specified time window.

Security measures are implemented to protect user data. Firebase authentication is used to ensure that only authorized individuals can access emergency logs. All data transmissions are encrypted, preventing unauthorized interception of distress alerts.

IV. METHODOLOGY

The proposed women's safety device follows a structured methodology to ensure real-time emergency response, automated alert transmission, and reliable multi-channel communication. The methodology is divided into **hardware-based emergency activation, data acquisition, processing, transmission, and cloud storage for event logging**.

4.1 Emergency Activation and Data Collection

The device is designed to be activated instantly when the user presses the emergency button. The push button is connected to the Raspberry Pi's GPIO pins, which detect the signal and initiate the emergency response sequence.When activated, the Raspberry Pi triggers the **camera module** to capture real-time images of the surrounding environment. The captured images are stored temporarily in the device's local memory before being transmitted to emergency contacts. Simultaneously, the **GPS module** fetches the user's **latitude and longitude coordinates**, ensuring precise location tracking.Unlike mobile-based applications that require unlocking a device and manually navigating through an interface, this **push-button activation ensures a rapid response time**, reducing delays in emergency situations. The use of a **dedicated hardware-based activation mechanism** makes the system more reliable compared to traditional smartphone-based distress alert applications.

4.2 Data Processing and Multi-Channel Transmission

Once the emergency alert is triggered, the system processes and structures the collected data for transmission. The captured image, GPS coordinates, and timestamp are formatted into a structured alert message.The emergency alert is then transmitted to pre-configured emergency contacts using **three independent communication channels**:

1. **SMS Transmission:** The Twilio API is used to send an SMS alert containing the user's real-time GPS coordinates. This method ensures that distress alerts are delivered even in low-network areas, where mobile data or internet access may be unavailable.
2. **Email Transmission:** The SMTP protocol is used to send an email containing the emergency message along with the captured image as an attachment. This feature provides additional situational awareness to emergency responders by offering **visual evidence** of the surroundings.
3. **Cloud Storage and Event Logging:** The emergency alert is logged in **Google Firebase**, ensuring that the distress call is recorded for future reference. The Android application retrieves the stored data, allowing trusted contacts to access real-time emergency reports remotely.

4.3 Crime-Zone Classification

A unique feature of the system is **crime-zone classification**, implemented through the Android application. The system classifies locations into three safety zones based on historical crime data:

1. **Green Zone** – Areas with a low crime rate, considered safe.
2. **Pink Zone** – Moderate-risk areas with reported incidents.
3. **Red Zone** – High-risk areas with frequent criminal activities.

The classification data is obtained from publicly available crime reports and law enforcement records, ensuring accuracy in assessing the **safety level of a given area**. The user is notified about their current location category, allowing them to take preventive measures if they are in a **high-risk zone**.

4.4. Cloud-Based Emergency Monitoring

All distress alerts are **logged in real-time** into the Firebase cloud database, allowing trusted contacts or authorities to **remotely access emergency reports**. The stored data includes. The **cloud-based monitoring feature ensures traceability**, enabling law enforcement or family members to track past incidents and analyze emergency patterns.

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V. RESULTS AND DISCUSSION

The AlertX system was tested under various real-life scenarios to evaluate its performance in terms of response time, accuracy, and reliability. The primary goal was to ensure the system could consistently capture and transmit critical data (location and image) during an emergency with minimal latency.

5.1. Response Time Analysis

Tests were conducted over 15 trials across different environments — indoor, outdoor, and low-signal areas. The time taken from pressing the emergency button to successful data transmission (SMS and email) was recorded. The outdoor tests showed the fastest and most accurate results due to stronger GPS signals and stable connectivity. Even in low-signal environments, the device was able to complete all actions within a tolerable time frame.

Environment	Average Response Time (seconds)	Location Accuracy (meters)
Indoor	Yes (Button + Image)	Partial (App only)
Outdoor	GPS-enabled SMS	Limited Accuracy
Low-signal	Pi Camera Integration	Not Available

5.2. Image Capture Reliability

The Raspberry Pi camera module consistently captured and sent images in all test cases. The image size and resolution were optimized to ensure successful email delivery without lag.

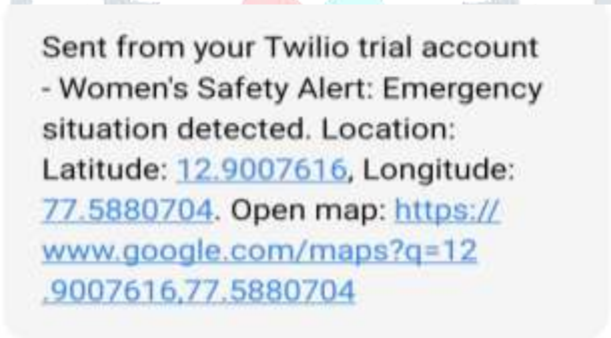

Fig 3: SMS Alert

Fig 4: Tracked location

5.3. Android App Functionality

The companion Android application allowed seamless addition and management of emergency contacts. The zone-based safety classification feature (Green, Pink, Red) was manually tested using different state settings, and the app reflected real-time updates accurately. These results demonstrate that AlertX offers a reliable and practical solution for personal safety, especially for women in distress. Future improvements could focus on reducing dependency on internet bandwidth and integrating alternative communication modules like GSM or LoRa for even broader coverage

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