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SecureHER: A Tech-Driven Approach to Women's Safety

Mansi Kakeshwarkar[1], Prof. Sweta Kale[2], Shravani Kaleshwarkar[3], Dhruti Kamat[4], Rupali Patra[5]
Department of Information Technology[1,2,3,4,5]
RMD Sinhgad Technical Institutes Campus, Pune

Abstract: *In an era where personal security, especially for women, remains a critical concern, the integration of modern technology into safety systems presents a promising solution. This project introduces an IoT-based Women Safety Device designed to provide real-time emergency response, location tracking, and audio-video evidence collection during distress situations. The system is built around the Raspberry Pi microcontroller and integrates essential components such as a panic button, GPS module, USB camera, microphone, and Twilio SMS service to offer a comprehensive safety mechanism. Once the panic button has been engaged the device initiates a multi-stage response: audio and video recording; fetching the GPS co-ordinates; and sending an alert message to one or more pre-configured emergency contacts. The software architecture for the device was designed to be modular, easily integrated into new devices, with reliable performance and low latency. The device will be a wearable, sleek and discreet accessory prioritizing privacy, data security, and seamless integration with personal accessories. Future improvements will include development of a mobile application, auto-detect and alert for threats, and biometric access to avoid false alarms*

Keywords: Women Safety, IoT, Raspberry Pi, Emergency Alert System, GPS Tracking, Audio-Video Recording

I. INTRODUCTION

Over the past few years, concerns around women's safety have become a key focal point internationally, drawing interest from policymakers, legislators, activists, technologists, and the general public. Both the increased reporting of harassment, sexual assault, and gender based violence has exposed just how precarious women's safety is on a day-to-day in any context, in every context, at any socio-economic level. Whether in fast-paced cities, or local small towns, the possibility for danger to women remains when it comes to their personal safety. Whether it is an actual physical danger that puts women's physical safety in jeopardy, or the potential for women to be restrained, the underlying issue is that women's movements are impeded and their personal freedom and autonomy are restricted. Despite governments' passing laws or working through government policies, safety and solutions to mitigate harm and sexual based violence can be delayed or too late and many times safety measures do not come when it matters most.

Women's safety mechanisms, whether it is mobile applications, emergency helplines, or community awareness campaigns, are useful but they are reactive, rather than proactive. Most mobile applications, helplines or apps require cumbersome processes while in a physically restricting situation or high stress situation, oftentimes requiring the user to unlock their phone or navigate through an app, and often also requiring an data access. Helplines can either take too long to respond to the request for help, or are simply not able to accurately locate the individual at the time of distress.

In response to this demand, the present paper proposes the construction of an IoT-based wearable safety device designed specifically for women. This is a small, inconspicuous device that allows the user to receive help and gather evidence in their moment of vulnerability. At the heart of this system is the Raspberry Pi microcontroller—a powerful yet inexpensive computer that can be easily adapted and connected to a multitude of sensors and communication modules. This device consolidates multiple safety capabilities into a single device that includes real-time GPS tracking to check location, emergency SMS text messages to alert trusted friends and family, and simultaneous audio-video recording in the event that evidence is needed to support charges in court.

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The functionality of this device offers a simple and seamless execution: a single press of a panic button activates the whole safety device. When the panic button is triggered, the GPS module locates the user's coordinates, while the camera and microphone record what is taking place around them. During this time, an emergency message is sent to pre-configured emergency contacts through the Twilio SMS API, which includes the user's live location along with a request for help.

This project aims to combine the advantages of IoT and edge computing technology to overcome many of the shortcomings of traditional safety solutions and provide a proactive barrier against gender-based threats. Our seamless integration of capabilities into a easy-to-use device brings together real-time tracking, multimedia evidence capturing, and automated communication into a single device. This approach is important not just for its technological innovation, but more importantly, for its social purpose that reflects a holistic approach to safety. We hope that our research will not only be beneficial to wearable smart devices, but also be a catalyst for future developments in technology for personal security for vulnerable groups.

II. LITERATURE SURVEY

The internet of things (IoT) has seen rapid development in personal safety systems over the last decade, particularly due to the increasing concern for women's safety in both public and private spaces. There have been many academic and basic industrial effort to innovate new ways to create an on-spot alerting systems by integrating multiple hardware components, such as GPS modules for location tracking, GSM modules for sending emergency messages, and cameras/microphones for taking real-time evidence. Most of these IoT safety systems were made for micro-controllers such as Arduino, ESP8266, or Raspberry Pi depending on their power consumption, processing power, and quickly accessorizing sensors. Despite the development of the aforementioned technologies, a critical assessment of the approaches taken to develop personal safety IoT devices reveals typical shortcomings: for example, many devices addressed only one or two features of safety, lacked emergency robustness in execution, or relied too heavily on non-technical users making quick decisions in a distressed state.(*Tejesh et al.*, 2020 [1]; *Humaira et al.*, 2021 [4]; *Raganna et al.*, 2021 [3]).

Even though many mobile-app-based safety systems are widely recognized, they all suffer the same limitations: reliance on internet connectivity and manual user activation. Some app-based solutions, for instance, require the user to wake their smartphone, to find that app, and then push it into a few keystrokes, gestures, or voice commands before any alerts are actually made. When a time-critical emergency occurs and the victim is dazed or restrained, this means to activate is rendered desertly impractical, even obsolete. With that said, mobile devices are also subject to battery depletion, not always carried, and even lost, not all scenarios are reliable and dependable enough to lean on mobile devices alone. An app-only system does provide no hardware redundancy and without the possibility of collecting any live evidence, their forensic and litigation value as systems of record are limited. (*Nikam et al.*, 2022 [5]; *Patil et al.*, 2022 [7]; *Masud et al.*, 2022 [9]).

The other major concern, recently noted by research studies, is the lack of discreet OR wearable/ergonomically designed personal safety devices. Overly-large, obvious, and some difficult to discreetly activate, safety devices can create more risk than the original situation entailed when in jeopardy or distress. Some prototypes claiming personal safety have utilized wristbands, or 'smart' jewelry, yet have not executed other key attributes like recording live video/audio, and if the capabilities do exist, the design is so expensive in terms of custom-built and proprietary hardware and software applications. (*Humaira et al.*, 2021 [4]; *Cardoso & Landers*, 2019 [11]; *Das et al.*, 2021 [12]).

Furthermore, short battery life, limited storage space, and cloud-computer/processing Ubuntu outcomes create another obstacle to true real-time, independent use. These gaps demonstrate a critical need for a small, inexpensive, and versatile solution that can fit within their lives, and acts as an instantaneous (with little user interaction) solution.

Against these challenges, the proposed project will be distinctive by producing a Raspberry Pi-based wearable that fits within the use-case in a single device, where it includes GPS location tracking, GSM/SMS communication with the Twilio API, and live (real-time) audio-video recording. The Raspberry Pi's computer processing capability can complete different tasks simultaneously; for example, it can encode the video and transmit the location information,

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providing a higher level of capabilities over the simpler microcontrollers in a more complex application. (*Tunggadewi et al.*, 2021 [2]; *Suganya*, 2022 [8]).

Additionally, the one-touch panic button would not even require the user to confirm their actions, which would avoid digressions from their goal. In addition, the use of compact camera modules and MEMS microphone would allow users to create evidence without adding unnecessary bulk to their life. Finally, rechargeable battery modules like power banks and local storage like micro SD cards can give longer and safer data to manage. Moreover, the system can support programming to make edge level decisions, like retry sending the SMS, or saving data locally, when the programmer decides the network is unreliable.-- and practicing reliability and autonomy.

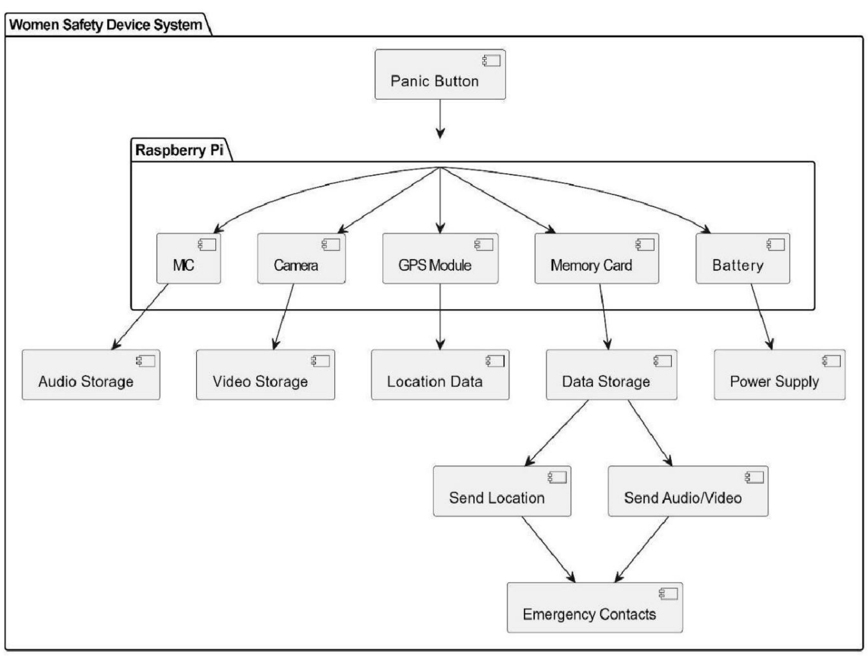
By taking this holistic design approach, this device overcomes the technological problems encountered previously while simultaneously being user-friendly, easy to access, and covertly worn that may open possibilities for women's safety in a way that can be implemented, not only as a prototype, but as a device that exists in real life, provide a physical complement to app-based systems and provide law enforcement or emergency responders with able to assess variables in their current context to intervene sooner. Thus, the knowledge from the literature review provides a strong basis to proceed on this project with developing new prototypes, testing them, and ultimately deploying them in structured environments. (*Manikumar*, 2021 [10]; *Tejesh et al.*, 2020 [1]).

III. PROBLEM STATEMENT

Women remain at risk because the current security solutions are limited in function and react only when a situation has occurred. The underlying issue is the need for a system that can autonomously manage alerts, provide real-time tracking, and collect evidence in moments of panic. This project will address the issue by developing a small, trusted and easy-to-use wearable that can help to fill this gap.

IV. SYSTEM ARCHITECTURE

The proposed architecture integrates the Raspberry Pi as the central unit with peripherals such as a panic button, camera, microphone, GPS module, and power supply. Once activated, the device records audio and video, captures GPS data, and sends an SMS alert via Twilio. All components work in synergy to ensure rapid, secure, and efficient response.



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V. SOFTWARE REQUIREMENTS

The software stack is built on Raspbian OS and Python. Libraries include RPi.GPIO, OpenCV, PyAudio, and Twilio API.

Key functionalities:

- Panic button detection
- Real-time audio-video recording
- GPS location fetching
- SMS alerting Secure data storage

Functional Requirements:

- Press once: Start recording
- Press twice: Send SMS alert with location
- Press thrice: Stop and send "I am Safe" message

VI. SYSTEM IMPLEMENTATION

6.1.1 SYSTEM DESIGN

The system design for the IoT-based women safety device focuses on how data flows through the system, how modules interact, and how information is structured and stored. One of the most effective ways to represent this design is through diagrams such as Data Flow Diagrams (DFDs), Unified Modeling Language (UML) diagrams, and Entity-Relationship (ER) diagrams. Each of these plays a specific role in defining and visualizing different aspects of the system.

The Data Flow Diagrams (DFDs) help break down the system's processes into levels. Level 0 DFD provides a bird's eye view of the entire system as a single unit — showing how input from the user (like pressing the panic button) flows through to generate SMS alerts, record media, and store data. DFD Level 1 and Level 2 further expand this by showing how subcomponents like the GPS tracker, audio/video recorder, and Twilio SMS module interact with each other and exchange information.

UML diagrams help visualize system behavior and structure. The Use Case diagram outlines how the user interacts with the system — such as activating an alert or stopping the recording. The Class Diagram shows the internal data structure — what objects (like User, GPS module, SMS module) exist, their attributes (like phone number, location), and what functions they perform. The Sequence Diagram explains the step-by-step interaction: when the button is pressed, the system begins recording, fetches the GPS location, and sends an alert. The ER diagram represents how information (like contacts, audio/video data, and location) is stored and related inside the system's database.

6.1.2 HIGH LEVEL DESIGN

High-level design refers to how the entire system is organized in terms of both hardware and software. It shows how each component works together as a whole system to fulfill its objective of ensuring women's safety. This kind of design is often shown using a block diagram to indicate the relationship between components. Raspberry Pi acts as the core controller that manages all operations. It is connected to a panic button that the user presses in an emergency.When this button is pressed, the Raspberry Pi communicates with a number of modules – the GPS module (location), the USB camera and microphone (recording evidence), and the Twilio API module (sending emergency SMS). The whole system is powered by a small battery unit, allowing portability.

This architecture is modular so you can update or swap out an individual component with no changes to the remaining modules; and allows for the device to be packaged into wearable formats like pendants, belts, or bags. The focus in designing these systems is low power consumption, intuitive operation, real-time and effective evidence collection. By prototyping the system at this abstract level, the team has provided a framework that is scalable, flexible, and practical to use in the world.

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6.1.3 IMPLEMENTATION AND MODULES

The system is built by combining several critical modules, each responsible for one specific function. These modules are programmed using Python and make use of libraries like RPi.GPIO, OpenCV, and Twilio.

Panic Button Detection: This is the core activation module. It constantly checks if the button is pressed and determines the number of presses. A single press triggers recording; a double press sends an emergency SMS; a triple press sends an "I'm safe" message. The system uses Raspberry Pi's GPIO pins to monitor the button. The logic is optimized for responsiveness, ensuring it works instantly in panic situations.

Audio/Video Recording: When activated, the USB camera and microphone immediately start recording. The video is captured using OpenCV and the audio with PyAudio. These files are saved locally in timestamped formats. The goal is to preserve high-quality evidence, even in low light or noisy environments.

GPS Tracking: This module interacts with a GPS sensor that continuously fetches the latitude and longitude of the user. This data is passed to the SMS module so that emergency contacts know the exact location of the individual in danger. The system also handles GPS errors and ensures accuracy through multiple readings.

SMS Alert System: This is the communication module. It uses the Twilio API to send a pre-written SMS containing the user's location to predefined contacts. The integration with Twilio ensures global reach and reliability. It is designed to send alerts even if the internet connection is weak or unstable.

Each module is self-contained but also works in synchronization with others. The system is built to remain operational even if one module (like GPS) temporarily fails, ensuring redundancy and reliability.

6.1.4 TESTING AND VALIDATION

Testing is a crucial part of the development process. It guarantees that each module is functioning properly independently and in conjunction with the complete system. Several tests would be performed to investigate the function of the safety device under different scenarios.

Panic Button Activation Test: This test provides verification of the button's responsiveness and the differentiation of a single, a double, or a triple button press. Testing the panic button includes a variety of lighting conditions and movement to mimic a real-world situation. Using the information gained from testing the panic button, an effort to ensure that the system activates and de-activates consistently will occur.

GPS Accuracy Test: The test involves testing the GPS module to see how rapidly and accurately it can lock to the user position. Testing occurs in open ground, a building, and low signal environment to validate performance.

SMS Delivery Test: Investigating the ability of Twilio to send the SMS to the emergency contacts after the panic button is pressed. Any time that it took to deliver the message, did it not deliver, did it deliver the wrong case, is monitored and debugged. This testing is embraced on various networks and approaches (like APN) including multiple internet and signal speeds as well as formats for the user's contacts.

Audio / Video File verification: Testing the device to verify that it was capturing audio and video that was continuous, clear, and correct. The tests range in performance environment including situations with background noise, low lighting, and movement. Finally, the files captured are scrutinized for clarity, size and accessibility

System Cancelation Test: When an emergency is over, the user shall quit the system and report their safety. The test ensures that hitting the button three times will stop any recording and send an "I am safe" SMS, while ensuring that there are not any object remaining running unintentionally in the background.

These tests, collectively, confirm that the device is responsive, robust, and will fulfill its intended purposed during real emergency situations. The system was also tested for battery life, portability, and durability which made the device usable for the long term

VII. CONCLUSION

The Women Safety Device (IoT-based), is a more holistic safety technique that covers significant gap areas left void in existing solutions. The device is user friendly, network-independent, and can securely collect evidence, while notifying emergency contacts in real-time. This device illustrates the powerful capabilities of embedded systems and IoT, particularly its impact on safety in the world.

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