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WOMEN'S SAFETY DEVICE: TECHNOLOGICAL ADVANCEMENT WITH ONE TOUCH AUTHENTICATION USING OPTICAL FINGERPRINT SCANNER

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Abstract
The issue of women's safety in our nation has emerged as a significant concern across various dimensions. The incidence of crimes targeting women is escalating at an alarming pace. As a result of these increasing threats, independent women are experiencing heightened feelings of insecurity, which restricts their capacity to lead fulfilling lives. In light of the critical challenges that women encounter in their everyday existence, we propose a rapid response mechanism that functions on a principle of "activation without user interaction." This system is designed to be proactive, operating effectively in situations where the user may be incapacitated, thereby assisting women during unexpected threats. Should a woman find herself in a precarious situation, perceiving that someone with malicious intent is following her (for instance, in cases of potential sexual assault), or if she is uncertain about her route home, this device will safeguard her by notifying her contacts and a control center of her precise location and safety status through an Emergency SMS Alert.
This strategy is consistent with earlier research, such as "TOUCH ME NOT – A Women Safety Device," which underscores the importance of integrating smart sensing and alert systems to support women in crisis. Likewise, IoT-based solutions proposed in recent work highlight the significance of GPS tracking, GSM communication, and wearable safety modules as vital components of contemporary women's safety devices.
This device not only offers assistance from family and law enforcement but also ensures rapid access to all available safety resources.

INTRODUCTION

Contemporary women are making significant contributions across various sectors of society, assuming critical roles in social, corporate, and other domains that often necessitate stepping outside the confines of their homes. While this expansion of their capabilities allows for greater achievements, it simultaneously introduces numerous challenges, particularly concerning their safety and security, which has become increasingly critical due to the rise in violations against women in recent times [14].

To address this pressing issue, especially in an era characterized by advanced technology and smart electronics, there is a need for a straightforward and affordable safety device designed to assist women in

adverse situations. This paper presents a comprehensive overview of the design and implementation of a prototype for an electronic Women Safety Device (MUHAFIZ-E-NISA), which has the potential to function as a wearable safety gadget [14].

This safety detection and messaging system comprises a GPS receiver (Fig. 5), microcontrollers (ESP32 Dev. Kit (Fig. 3) and LILYPAD Arduino (Fig. 4)), a fingerprint scanner, and a GSM modem. The GPS component acquires location data from satellites in terms of longitude and latitude. The microcontroller processes this data, which is then transmitted to emergency contacts via the GSM modem. The Global System for Mobile Communication (GSM) facilitates the sending of an alert SMS to a pre-defined contact number [14].

In situations where a woman feels threatened and requires self-defense, she simply needs to press the designated 'PANIC Button.' Activating this button triggers the entire system into emergency mode. Our model, akin to the methodology outlined in a previous GPS and GSM-based self-defense system for women safety, integrates location tracking with real-time GSM communication to provide prompt assistance and enhance the overall effectiveness of women's security devices [8], [2], [7].

Additionally, inspired by similar models, our system incorporates fingerprint-based user verification to activate the emergency feature, ensuring it is not unintentionally triggered or misused. This secure access method enhances both safety and privacy, while the integration of GPS and GSM technologies ensures rapid and precise location reporting to trusted contacts in critical situations [8], [6], [11].

II. INTRODUCTION

The issue of women's safety is increasingly becoming a significant concern within our society. Given that women constitute nearly half of the population, their lack of safety not only restricts their professional and social development but also impedes national progress as a whole.

In emergencies, the initial step involves contacting emergency services and informing loved ones, which can be complicated by the severity of the incident and the available communication methods. Women frequently fall victim to various crimes, from minor street offenses to severe violent acts. In many instances, they find themselves powerless, either because their communication devices, such as mobile phones, have been confiscated or, in dire circumstances, they are incapacitated and forcibly removed from the scene.

To address this issue, we propose a GPS and GSM-based 'Women's Safety Device' that offers a practical, comprehensive, and cost-effective smart solution. This initiative draws inspiration from earlier research that developed a safety system integrating GPS, GSM, and health monitoring for women, aiming to improve real-time responsiveness and health tracking during emergencies [8], [3]. Additionally, in line with previous methodology, we integrate Arduino-based location tracking to enhance the reliability and adaptability of our emergency alert system in real-world scenarios [4], [10].

Furthermore, recent studies emphasize the effectiveness of IoT and GPS tracking technologies in enhancing women's safety devices [12], [15]. Arduino-based GPS alert systems have also been shown to provide reliable rescue support in emergency situations [16], [17].

The aims of creating this device include:

A. To design and produce a user-friendly, wearable personal safety device utilizing widely accessible LILYPAD Arduino and ESP32 Development Board technology.

B. To establish a wireless connection between the LILYPAD Arduino microcontroller and the ESP32 Development Board through a master-slave Bluetooth configuration.

C. To link the ESP32 Development Board with a Neo7mv2 GPS Module to acquire the user's real-time location.

D. To integrate the ESP32 Development Board with a SIM800A GSM Modem to promptly send an Emergency Alert via SMS, including the user's current location in case of distress.

E. To leverage IoT (Internet of Things) technology as a vital facilitator for improving social welfare by offering an affordable device that ensures timely, economical, automated, and dependable communication when necessary [7], [10].

III. PROPOSED SYSTEM

The suggested system functions as a safety mechanism designed for emergencies, aiming to tackle the underlying issues while offering multiple layers of redundancy should one component fail under specific circumstances, contingent upon the user's perceived risk level. This device is intended not only to serve as a safety tool but also to resolve various concerns. It is designed as a wearable device, akin to a watch, featuring a proactive alert mechanism that operates without user intervention; it activates when it detects a lack of interaction, ensuring it remains operational even if the user is incapacitated. Additionally, the device continuously monitors and transmits the user's location if they are forcibly moved from the incident site. It operates solely on a cellular network for SMS functionality, eliminating the need for internet access or additional hardware such as smartphones or Wi-Fi. This methodology aligns with the framework that advocated for emergency alert systems incorporating real-time location tracking through Arduino-based technologies [4], [17].

The device facilitates rapid assistance from family and emergency services while streamlining the process to be automated, efficient, straightforward, and prompt. As noted in recent 2024 research, the incorporation of fingerprint authentication and proactive emergency triggers, such as electric shocks and image capture, can enhance the security of wearable defense systems for women—concepts that resonate with our current design [8], [17]. The system is designed to ensure safety in public spaces as well as during solo travel on public transportation (e.g., school buses, company vehicles, etc.).

The components of the proposed system include:

- Micro-controller (ESP32 Development Kit)
- Micro-controller (LILYPAD USB)
- GPS Module (Neo7mv2 Module)
- GSM Module (SIM 800A)
- Fingerprint Scanner (GROW R551)
- Trigger Buzzers for alarm
- Bluetooth module (HC-05)
- LCD (for display purposes).

The components of the device can be innovatively integrated in various forms; such as being camouflaged as a makeup case. The two systems engage in wireless communication. The device is designed to ensure that whenever a woman perceives a threat, she simply needs to press and hold the PANIC BUTTON. Once activated, the device mandates the user to re-authenticate through a fingerprint scanner after a predetermined duration. Should authentication fail due to an unfortunate event or unforeseen circumstance, an alarm is triggered to notify individuals in proximity. The wearable component utilizes a LILYPAD Arduino microcontroller, which wirelessly connects to the ESP32 microcontroller located in the woman's purse through a Bluetooth master-slave configuration. Upon receiving a distress signal, the alarm is activated, and the GPS module is engaged to ascertain the woman's real-time location. This information is reformatted by the ESP32 into a Google Maps link and incorporated into a pre-set emergency alert message (for instance, "MY LIFE IS IN DANGER, MY CURRENT LOCATION IS..."). (Fig. 6). This message is dispatched to designated emergency contacts via the GSM Module. The alert mechanism operates continuously, sending a new SMS with updated location coordinates every 10 seconds (or at another specified interval) if the woman is in motion. The emergency loop is only terminated upon successful fingerprint re-authentication, thereby ensuring that only the legitimate user can deactivate the alarm, thus preventing unauthorized interruptions [8], [17].

IV. WORKING OF WOMEN'S SAFETY DEVICE

The proposed initiative is based on two primary elements designed to separate the hardware, enhancing accessibility while supporting the objectives of portability and compactness. The first component features a microcontroller (LILYPAD Arduino USB) that integrates a fingerprint scanner and a Bluetooth module, which is embedded within a women's wearable accessory (such as a watch or jewelry). The second component involves another microcontroller (ESP32) that combines a GPS, GSM, and Bluetooth module, along with an LCD and an alarm buzzer. This system can be discreetly concealed within a woman's purse in various forms (for instance, disguised as a makeup box). Both systems communicate wirelessly. The device ensures that if a

woman feels threatened, she simply needs to press the PANIC BUTTON. Once activated, the device requires her to continuously re-authenticate using the fingerprint scanner after a predetermined duration. Should the device fail to receive authentication within the specified time frame due to an unfortunate event or unexpected incident, an alarm will sound, alerting those nearby. The microcontroller (LILYPAD Arduino) in the wearable device connects wirelessly to the microcontroller (ESP32) in the purse through a Bluetooth master-slave configuration. Upon receiving a signal on the ESP32 indicating that the woman is in danger, the alarm is triggered, and the GPS module activates to obtain her real-time location, which is then sent to the ESP32. The ESP32 reformats this information into a Google Maps link and incorporates it into a 'Pre-Configured Alert Message' (for example, 'MY LIFE IS IN DANGER, MY CURRENT LOCATION IS...') before dispatching it to a list of pre-configured contacts via the GSM Module. This entire process is repeated, sending updated SMS messages with the latest location [8], [17].

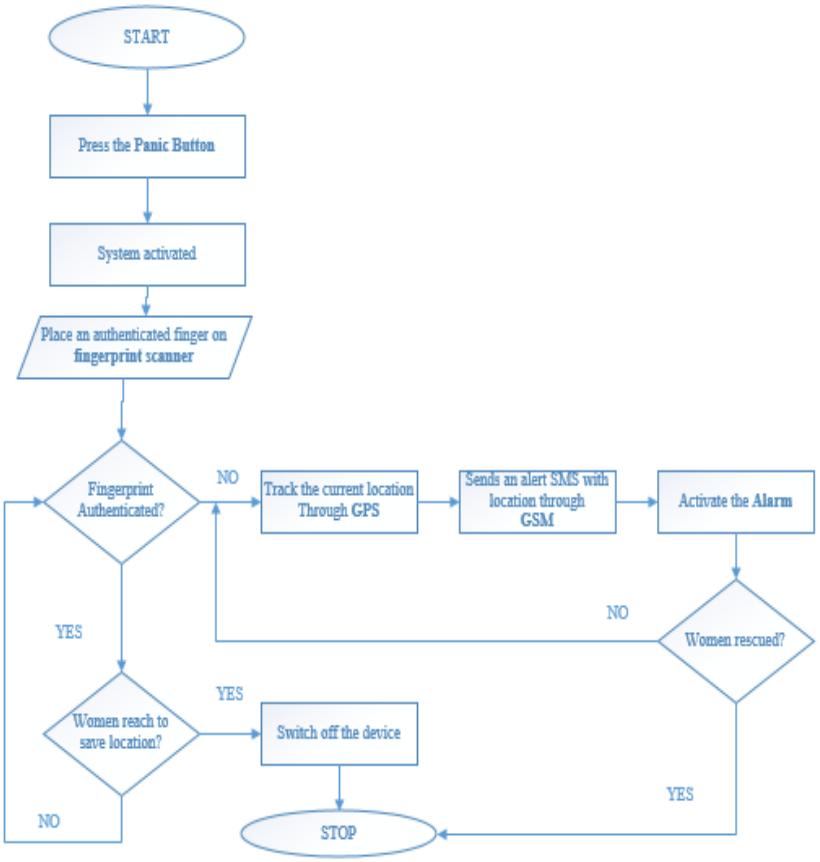

Fig 1: Block diagram of the system

VI. FLOW CHART

The Fig. 2 illustrates the working of the women's safety device, beginning with a panic button press and fingerprint authentication. If verified, the system uses GPS to track location and GSM to send an alert SMS, while also activating an alarm until rescue is confirmed.

BLOCK DIAGRAM

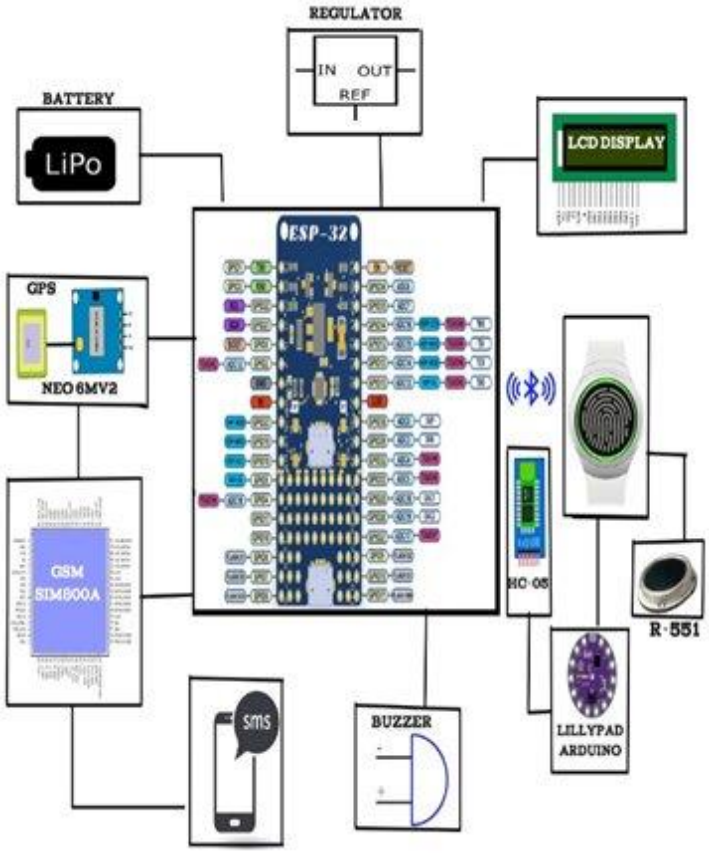

Fig 2: Flow Chart of the system

VII. APPLICATIONS

- Enhances personal safety for women in vulnerable situations.
- Supports child safety through real-time monitoring and alert mechanisms.
- Assists in safeguarding elderly individuals, especially those living alone.
- Provides protection for individuals with physical disabilities.
- Offers immediate assistance for individuals at risk of sudden medical emergencies (e.g., cardiac arrest).
- Serves as legal evidence by capturing precise location data during criminal incidents, aiding in prosecution.

VIII. ADVANTAGES OF THE PROPOSED SYSYTEM

This is a comprehensive system that eliminates the necessity of carrying various devices.
It operates independently of internet access and features wireless connectivity.
Users do not need any technical knowledge or prior experience with gadgets to utilize it.
The installation process is straightforward and quick.
It is cost-effective while delivering high performance, with minimal ongoing expenses limited to battery charging and cellular service fees for SMS.
The system functions continuously and is designed to be environmentally sustainable.

IX. COMPARISON BETWEEN EXISTING SYSTEMS AND PROPOSED SYSTEM

As shown in Table 1, existing systems like PSCA [20], FEMME [19], and Touch Me Not [18], support internet and mobile app integration but lack cost-effectiveness and compactness. The proposed Women's Safety Device, however, is designed to be both cost-effective and compact, though it does not rely on internet or mobile apps.

TABLE 1: Comparison of systems

Parameters	PSCA	FEMME	Touch Me Not	Women's Safety Device
Internet	√	√	√	×
Mobile App	√	√	√	×
Cost Effective	×	×	×	√
Compact in size	×	×	×	√

X. FUTURE SCOPE [9]

1. The proposed system can also be interfaced with smart phones using an android application.
2. It can be incorporated into an integrated safety eco-system with government support by setting up quick response services that may respond to SMS alerts from the device with high priority.
3. It can be integrated with multiple safety and security systems, such as Automated Teller Machine.
4. This module can be turned into primary school children safety by monitoring the child's safety when traveling through school buses.
5. The intrusion detection module can be modified according to the requirement of vehicle safety system module.
6. Reaching out to fashion industry and refine the design further to be more a part of a woman's apparel, thus enhancing user friendliness.
7. Voice recorder and camera can also be added to the system. The camera can give the detailed surveillance of the surroundings thus helping in planning out the possible methods of rescue while voice messages can be sent during need.

XI. PICTURES OF WORKING

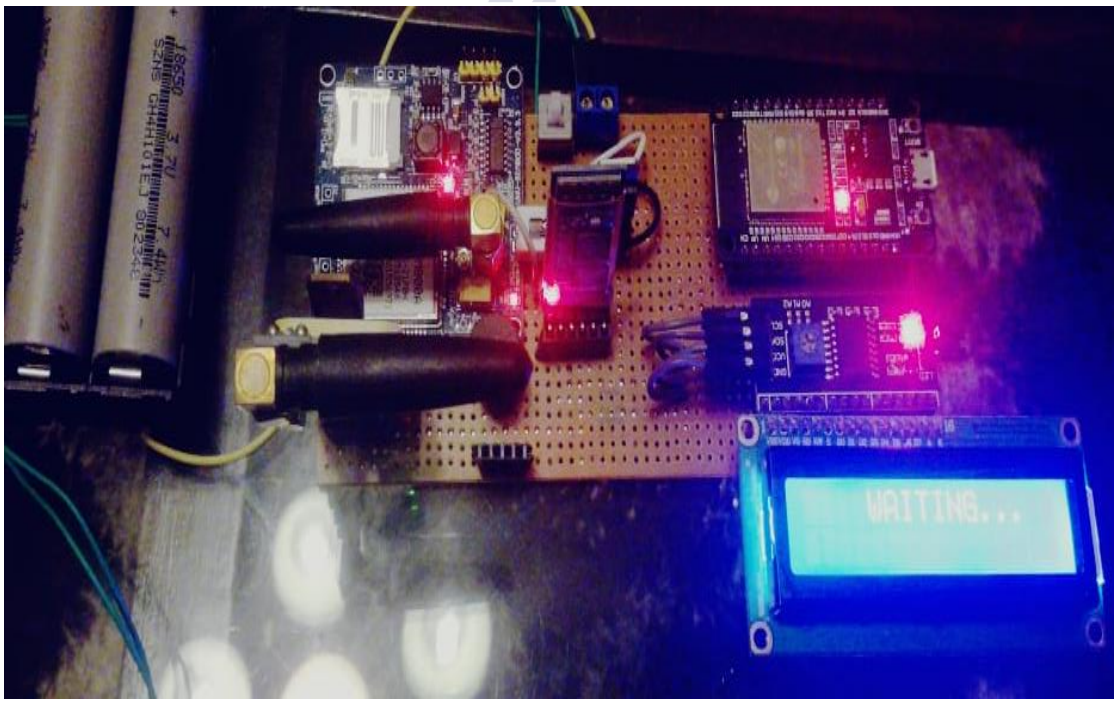

FIG 3: Esp32's System

FIG 4: LILYPAD Arduino's System

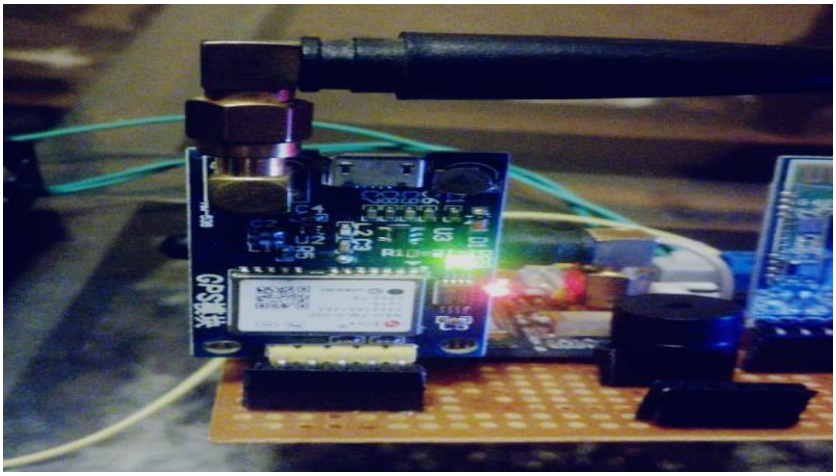

FIG 5: GPS Module Receiver

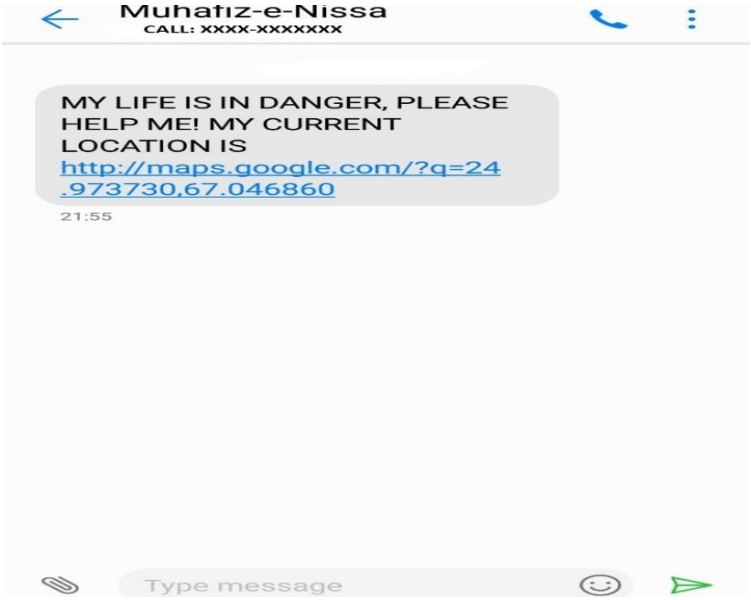

FIG 6: SMS Alert Contains Pre-Defined Text with Google Map Link

CONCLUSION

In conclusion, the safety device known as Muhafiz-e-Nisa offers a practical, compact, and cost-effective solution for safety and security, addressing the shortcomings of existing systems. Unlike conventional methods of seeking assistance, such as mobile phones, which may be impractical in certain scenarios, this device enhances women's empowerment by fostering a secure environment. It serves as a deterrent to potential offenders, thereby contributing to a reduction in crimes against women. This technology not only bolsters women's confidence but also promotes social security and raises awareness by integrating the device into women's apparel. The Women's Safety Device stands out as the most affordable solution to the challenges faced by women in society. The introduction of such technologies and their discussion in mainstream forums can convey a significant message and enhance societal awareness. It is crucial to emphasize that nearly half of the global population is female, and ensuring their safety is not only a social imperative but also vital for national progress, as it enables women to fully realize their potential and contribute to nation-building. Women, as the bearers of future generations, deserve to live in safety

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