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A Comprehensive Review of Smart Wearable Device-Based Emergency Alert System for Women's Safety

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***Abstract*--** **Women's safety has become a significant social and technical issue. This is due to the rising cases of harassment, assault, and emergencies in both public and private spaces. Traditional safety measures like helplines and mobile apps often do not offer quick help during crises. This is mainly because they rely on having a smartphone, a stable internet connection, and the user being active.**

This study thoroughly reviews smart wearable emergency alert systems available for women's safety. The previous literature is systematically analyzed and categorized according to several parameters, including system architecture, wearable hardware components, communication technology (e.g., GPS, GSM, and IoT networks), alert triggering mechanisms, automation level, sensor integration, and power efficiency. Manual and intelligent sensor-based approaches for triggering alerts are examined with respect to their operational principles, benefits, and drawbacks.

The review also identifies significant research gaps in battery performance, localization accuracy, and dependence on networks, false alerts, privacy issues, and the lack of integration for emergency services. Some future research directions that should be considered include: the development of low-power wearable technology; context-aware AI-based detection; multi-contact alert methods; a combination of edge and cloud-based systems for the monitoring of users; and concentrating on user-cantered design of systems. This review will be a comprehensive resource to develop smart wearable solutions that will provide a safe environment for females.

***Keywords*--** **Women Safety, Smart wearable device, Wearable Technology, Emergency Alert System, GPS, GSM, Internet of Things (IoT), Smart Wearable, Personal Safety Devices.**

I. INTRODUCTION

In the last few years, instances of harassment, assault and violence against women have been continuously increasing, making the issue of women's safety a critical challenge at the societal, technological and policy level. There has been considerable advancement in the development of legal frameworks, emergency response systems, and public education programs in relation to women's safety; however, a significant gap still exists between the occurrence of an emergency and the arrival of timely assistance.

In many of these situations, victims are unable to convey distress because they are unable to actively communicate due to either panic or fear, have become physically immobilized, or have lost consciousness from the trauma. These limitations indicate the inadequacies of traditional safety systems and highlight the need for intelligent, fast and non-user- dependent safety mechanisms [18][21][50].

There has been an increase in technology-based solutions aimed at closing this gap. Mobile computing, IoT systems and wearable are some of the areas in which many researchers have been searching for technological solutions to this gap. Out of these solutions, wearable have been the most popular type of technology used for bridging this gap, due to their capacity to stay attached to a user continuously, providing always-on monitoring with real-time responses. Specifically, smart wearable have been a leading example of how advanced wearable platforms that integrate sensing, communicating, and computing functions into one compact form factor, can be used to provide emergency response systems that are useful for women in dangerous situations.

1.1 The Usefulness of Smart Wearable Devices for Women's Safety Applications

Smart Wearable Devices have a number of distinct benefits that make them a good fit for women's safety applications. To begin with, Smart Wearable Devices are always near the user and therefore are easily accessible at the moment of an emergency. Another benefit is that Smart Wearable Devices can be used hands-free; you can activate an alert through various types of physical movements or through some sort of automated detection method. Lastly, Smart Wearable Devices are technologically advanced in their design and usually contain many types of technologies such as GPS (Global Positioning System), GSM (Global System for Mobile Communications), Bluetooth®, accelerometers, and physiological sensors, so they can be used to help to provide manual as well as automated detection of an emergency [17][28].

Wearable Smart Technology (WST) will decrease the amount of thought involved when responding to emergencies by reducing how much you need to interact with the device.

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In addition, WST supports developing systems with flexible architectures so that they can operate separately from or alongside your smartphone and/or into the cloud by using private networks and throughout your home or wherever you use WST. WST continues to face several challenges (e.g., limited battery life, generating false alarms, and privacy) that are the subject of ongoing research [26][32][37].

1.2 Purpose, Goals, and Contributions of this Review

This review aims to give a complete and systematic evaluation of smart wearable devices used in creating emergency alert systems for helping ensure women's safety. The existing studies have been grouped by the various types of wearable architectures, communication technologies, alert mechanisms, levels of automation, sensor integration and energy efficiency used. The key contributions of this review are summarized as follows:

1. a structured taxonomy of women safety systems with a focus on smart wearable device-based solutions,
2. a comparative analysis of the advantages and limitations of the current solutions,,
3. the identification of key research gaps related to the reliability, usability, localization accuracy, and power efficiency of the solutions, and
4. The discussion of future directions for research to develop intelligent, scalable, and cost-effective women safety systems.
5. Discussion of future research directions for developing intelligent, scalable, and cost-effective women safety systems.

II. Review Methodology

An established systematic review methodology is an essential component of a review article to produce comprehensive, unbiased and reproducible results. This study used a structured literature review approach to analyze the current literature on smart wearable devices for implementing emergency alert systems for women's safety. The purpose of this study was to identify relevant articles, to encode the characteristics of the systems analyzed, and to pull out significant insights regarding trends in technologies, limitations of the systems, and gaps in previous research.

2.1 Search strategy for literature

The literature was reviewed from reputable digital libraries and academic databases including IEEE Xplore, ACM Digital Library, ScienceDirect, Microsoft Academic, SpringerLink, and Google Scholar.

Terms/ phrases were used in all combinations possible so as to cover as much of the broad concept areas related to this research problem as possible including women's safety, smart wearable devices, wearable safety devices, and emergency alert systems. Additionally, GPS, GSM, IoT, and personal safety wearables were used in all combinations possible to maximise the coverage of both foundational and current materials across the subject area.Priority was given to peer-reviewed journal articles, conference papers, and survey studies published in reputed venues. To capture recent technological advancements, studies published within the last ten years were emphasized, while earlier foundational works were included where necessary to provide historical and conceptual context [1][3][18].

2.2 Inclusion and Exclusion Criteria

Specific criteria concerning inclusion or exclusion were created before conducting the review to ensure that studies included in the review were both relevant and of high quality. A study was included if it met one or more of the following criteria:

1. Proposed or analyzed wearable technology-enabled safety systems for women or personal safety
2. utilized smart wearable devices, smart bands, or similar wearable platforms,
3. incorporated communication technology like GPS, GSM, or IoT platforms

Safety solutions research studies that focused on safety solutions within mobile application formats but did not include wearable technology were removed as candidates for this review. Studies with technical information that was inadequate or are classified as opinion articles, and were not peer reviewed, were also and additionally excluded from this review. As such, the remainder of safety solutions research studies would be eligible and included as they were deemed to have sound technical application for selection and review [21][22].

2.3 Classification of the Included Studies

The selected studies will be categorized by various parameters to facilitate an organized comparison of the data. The classification parameters are:

System architecture, Type of wearable devices Communication technology, Alert mechanisms, Levels of automation Sensor integration, Energy efficiency

The multi-dimensional classification of review studies is necessary to find the predominant design patterns and technology trends. [16][17]

Systems for generating alerts can be grouped into one of three types based upon how the alert triggering mechanisms work; manual, semi-automatic and automatic.

Manual systems utilize explicit input from an operator (i.e., user) to trigger an alert; while automatic systems trigger an alert based on data from sensors and logic algorithms to identify emergency situations automatically without human action. Semi-automatic systems combine both manual and automated methods of providing alerts to provide greater reliability.

2.4 Evaluation metrics & analysis methods

Review papers differ from experimental research papers in that they are concerned with qualitative (comparative) evaluations rather than quantitative (numerical) metrics relating to performance. An example of the evaluation used for this research involves an analysis of many of the characteristics reported for the systems being evaluated, including response time, reliability, usability, communication success rate, and power consumption.

Of particular interest was how each of the systems met the constraints of a real-world environment including: (1) Network availability, (2) Indoor localization, and (3) Continuous operation [6][7].

2.5 Threats to Validity

Like other Reviews of studies, some limitations can affect the thoroughness of the work completed. Some studies are potentially unavailable because they were not published, or were not able to be published in English. Additionally, as different studies have different methods of evaluating performance, it is difficult to directly compare performance across the various studies evaluated. However, by focusing on architectural attributes and functional capabilities, rather than on absolute performance metrics, this Review minimizes the potential for bias and enhances the generalizability of the Review [5][15].

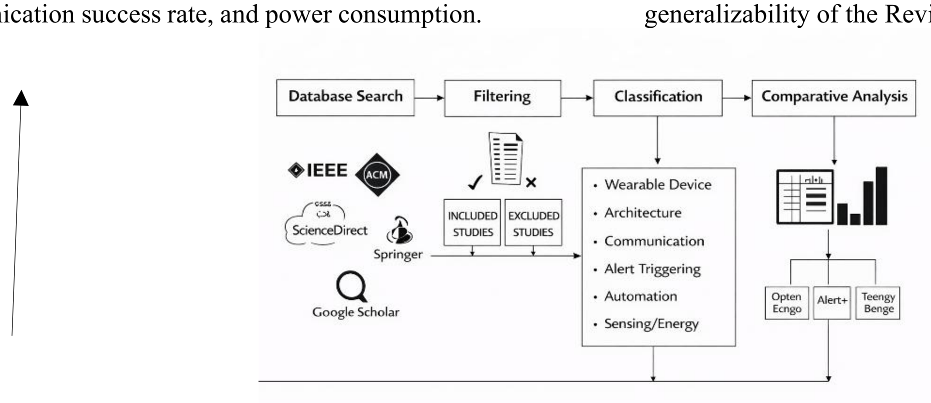

Fig. 1. Systematic workflow adopted for literature selection and classification of smart wearable device–based women safety system

III. Overview Of Women Safety Systems And Technological Evolution

The technology used to enhance women's safety has changed dramatically over the years, thanks mainly to improvements in communications, embedded systems, and wearable. The following section offers a classification of the main types of women's safety technology described in the literature, along with a discussion of each type's progress from old-fashioned (traditional) methods of providing safety assistance to newer (modern-day) systems based on smart wearable devices. Understanding these two major trends in women's safety may help to provide a clearer context for existing research efforts and to identify some common obstacles which remain for wearable safe-guarding technologies.

3.1 Mobile Application–Based Women Safety Systems

The rise of smartphones has made possible many new ways to improve safety for women through apps, including emergency alerts, real-time GPS location sharing, and contact notification through SMS and calling [3][7].

But these apps all depend on having a smartphone, connecting to a network, and taking multiple actions by the user (unlocking the phone and entering the app), which can add significant delays to alert activation in emergency situations [13][14]. This has led researchers to look for alternatives that can provide an alarm quickly and independently of the user.

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3.2 *IoT-Enabled Women Safety Platforms*

IoT-supported platforms for women's safety use sensing devices, communications gear and cloud computing to facilitate continuous transmission of data in real time and central oversight of all activity that takes place within the system through GPS, GSM, and cloud servers to capture the user's location and send alerts [4][15]. These systems enhance the scalability by allowing multiple users (stakeholders) to simultaneously access distress information; nevertheless, many still rely on mobile phones as their intermediary device. Furthermore, data security, private and reliable network, are major concerns in every way[26][32].

3.3 *Wearable Device–Based Safety Systems*

Wearable safety devices that were first developed, such as smart bands, pendants, and clip-on devices with basic GSM and GPS modules, provided direct alerts without requiring interaction from smartphones and thus shortened the time it took for the alert to be transmitted [22], [23]. These systems were limited by their processing power and had a short battery life, which required users to manually activate their S.O.S. button, thus revealing a need for better platforms with advanced features that support smart sensing and improved energy management.

3.4 *Smart wearable device–Based Emergency Alert Systems*

Today's advanced smart wearable technology includes many types of sensors (for example, motion detectors, accelerometers, and heart rate monitors) as well as several communication technologies (for example GPS, GSM, Bluetooth and Wi-Fi), so there is a good chance that emergency situations can be detected either manually or automatically due to having so many sensors in such a small area [16][28]. Current studies are looking at combining both manual SOS methods with context-sensitive sensors to build more reliable systems and to help minimize false alarms [14][19]. These same studies are also providing more support for multi-contact alerts and cloud-based monitoring. There remain several challenges connected with preserving battery life, indoor location accuracy, and user privacy that are driving additional research on the use of these devices for emergency purposes.

IV. Smart Wearable Device–Based Emergency Alert System Architecture

An emergency alert system with smart devices that can be worn offers expected improvements in the capabilities that will allow these systems to provide users with fast, reliable, and personal emergency assistance by integrating the sensing, communication, and processing capabilities of a resource-limited, miniaturized, and worn device. In this chapter, the focus will be on describing the architecture of emergency alert systems based on smart wearable devices, including the components, functionalities, and operation of these systems according to current literature.

The structure of a smart wearable, general women safety system consist of several layers; these layers are: sensing, processing, communicating, and alerting. Each of these components will help permit the delivery of emergency services quickly and efficiently.

4.1 *Overall System Architecture*

The essential components of a smart wearable device for emergency alerts include: the wearable unit, infrastructure for communication and transmitting data, and receiving device (such as supervisor/monitoring server, emergency contact, etc). The device monitors input from the user and data from sensors and transmits location and context information when it detects an emergency situation [16][18]. Wireless connectivity architectures can either be operated independently with GSM technology or coordinated through hybrid solutions combined with an external smartphone and/or cloud platform; both options will have an impact on total system cost and reliability as well as energy efficiency [21][28].

4.2 *Sensing and Input Modules*

The basis of intelligent smart wearable device–based safety systems is represented by sensing modules. Accelerometers, gyroscopes, heart rate monitors and motion sensors are the most common types of sensors included in these modules. The purpose of these sensors is to detect and monitor unusual movements, impacts from shocks, physical stress due to body conditions and inactivity; all of which may be indicators of an emergency.

Another typical category of manual input triggers is SOS buttons and trigger gestures, as they are both simple and reliable means of triggering an alarm. Some researchers advocate a hybrid system consisting of both manual input triggers and sensor-based monitoring to prevent false alarms while also ensuring that the alarm can be triggered in a timely manner. Multiple sensors within a smart device create a level of flexibility and adaptability that can help in any type of emergency situation.

4.3 *Processing and Decision-Making Unit*

Analyzing information received from sensors is the primary role of a processing unit to determine if an emergency situation exists. Basic systems utilize a threshold logic based on pre-defined conditions (e.g., heart rate/pulse, acceleration) while more sophisticated systems use algorithms to increase accuracy [14][28].

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Depending on the system architecture, decision making can take place either on-site at the smart wearable device or be offloaded to either a cellular telephone or cloud server for further processing. Processing on-site produces immediate results; therefore, the need for constant network connectivity is decreased. Conversely, when utilizing cloud services, latency in the response is delayed while an incomplete analysis may consume greater amounts of battery energy [15][26]..

4.4 Communication Technologies

Emergency alerts sent from smart wearers to remote recipients are often transmitted through a variety of different forms of communication (e.g., GPS for location tracking, GSM to send an SMS or call for an alert and Wi-Fi/Bluetooth to connect with a smartphone). Certain systems also include IoT protocols for monitoring and data storage in the cloud ([4], [7]). Researchers have been looking into and developing alternative methods to localise (ie:, non-GPS) and hybrid methods of positioning ([6], [8]).

The accuracy of GPS in indoor environments is still being researched and is therefore one of the main issues concerning GPS manufacturers.

Redundant and reliable communications is a major design issue because of the potential to delay the response time of emergency services to events requiring an emergency response upon failure of the communication network.

4.5 Alert Generation and Dissemination Mechanisms

When an emergency is detected, the alert generation module collects pertinent information including the user's identity, the coordinates of their location, the time that the event happened, and sensor data relevant to the situation. The alerts are transmitted through multiple methods to ensure receipt by pre-defined contacts, emergency services or cloud servers [18][21].

There are many studies that suggest various methods to improve the reliability of multi-contact alerting systems and methods for repetitive notification strategies. These include systems that have an escalation feature, where the alerts will be sent to additional contacts if they have not been acknowledged within an allotted time period. By incorporating such capabilities, systems increase their robustness and reduce the potential of unattended emergencies.

4.6 Energy Management and Power Constraints

A lack of battery capacity makes energy efficiency one of the biggest challenges for smart wearables' safety systems due to their continuous use of sensor technology, GPS, and multiple communication functions that draw on their batteries constantly; as a result, many systems utilize duty cycling event-based sensing, and low power communication techniques to prolong system lifetime. Tradeoffs between system functionality and energy consumption continue to be an important area of research and require that an acceptable battery life is provided for the user to be able to continue using and to help ensure the ongoing viability of safety devices.

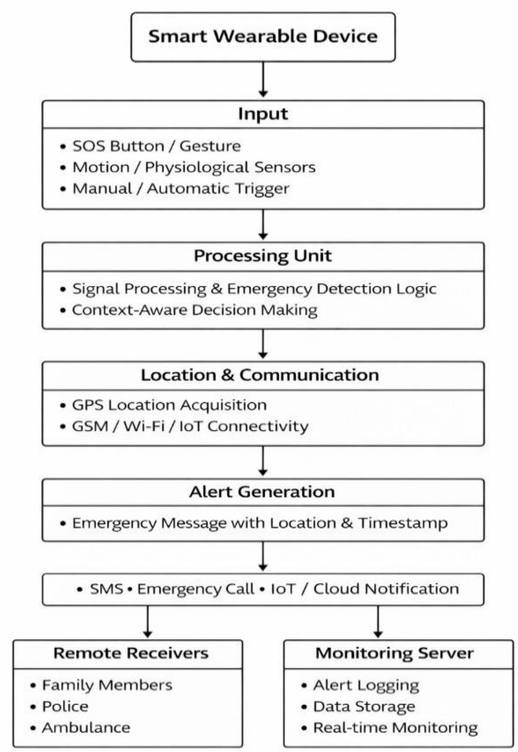

Fig. 2. General architecture of a smart wearable device–based emergency alert system

Fig. 2 depicts a smart wearable device-based emergency alert system in the literature that can be described as a generic emergency alert system.

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The smart wearable device is the main sensor for sending and creating alerts. It contains manual input for generating alerts (i.e., SOS button) and physiological and motion sensing to continuously monitor an individual's health condition [16], [18]. All sensor data and user inputs can be processed locally or sent to a connected device for emergency determination. Once an emergency has been detected, GPS will collect location data while alerts are transmitted via GSM, Wi-Fi, or Bluetooth depending on connection [4], [7]. The alert generation module collects the time and location coordinates of an individual and sends out notifications based on that information. The different types of notifications will differ from SMS, voice calls, and/or IoT-based cloud services and will be sent to family/friends, law enforcement agencies, and EMS [21], [28]. The overall structure of the system is layered, which emphasizes a rapid response to the emergency, redundancy in Communication methods, and the system's end-user design, while also taking into account energy consumption and dependency on the network to work [15], [26].

V. Sensor-Based And Intelligent Women Safety Systems

Recent developments in sensor technology and intelligent data processing have allowed the creation of women's safety solutions that use sensors rather than rely on manual notifications. This report provides an overview of current technologies for facilitating women's safety with smart wearable technologies, including the use of sensors, context-aware algorithms, and intelligent decision-making (IDM), as well as how these technologies can increase the reliability and effectiveness of smart wearables as July 2022.

5.1 Role of Sensors in Emergency Detection

Wearable safety systems are equipped with automatic/ semi-automatic sensors for prompt emergency detection. Wearable systems use several types of sensors, including accelerometers, gyroscopes, heart rate sensors, and motion sensors, which work together to monitor both the activity patterns and physiological changes of the user [14][17][50]. Anything unusual with respect to the normal pattern such as sudden changes in acceleration, abnormal changes in the heartbeat signal, or no activity will indicate possible need for assistance (i.e., fall, assault, or loss of conscience) — by continuously monitoring the above parameters, an emergency situation could be identified via sensor systems without human intervention. This will be especially beneficial in cases where the victim cannot initiate an alert due to emotional response to an emergency (panic) and/or physical limitation.

5.2 Automatic and Semi-Automatic Alert Generation

Based on analysis of sensor data, women's safety systems can be classified as either manual, semi- automatic or fully automated alerts. Semi-automatic systems use sensors to identify emergency situations but require user verification before sending out alarms. Fully automated systems send out an alarm automatically when pre-set conditions are met, which decreases the time taken to respond [19][28][50].

Automatic alert generation improves response times but creates issues with false alarms because everyday activities can create similar patterns as an emergency situation (such as running or making a sudden movement). Therefore, many studies stress the need for a hybrid approach to combine automation with the user's ability to control their own system.

5.3 Intelligent and Context-Aware Detection Techniques

Wearable safety systems have been designed with context-sensitive machine learning, where input from sensors and contextual information (like location, time of the day, or activity) is used to determine whether behavior is typical vs an emergency event [14][28][50]. This type of algorithm is specific to the user and reduces false alarms, while improving the ability to detect an emergency. Unfortunately, these same algorithms have high computational and energy requirements, making them difficult to implement on resource-poor smart wearable devices [15][37][50].

5.4 Challenges in Sensor-Based Safety Systems

While there are many benefits to implementing sensor-based systems for women's safety, there are also some challenges to using these systems. Of these challenges, battery life is one of the most obvious areas that require improvement. Not all sensors will work the same way at all times [37]. Furthermore, the accuracy of a particular sensor differs from one device to another and based upon how each device is used and where it is located in relation to its intended position.

Another major concern is the potential for violation of individual privacy due to the fact that any data collected by sensors could potentially show information about a user's body, as well as other types of physical or behavioral activity of the user. Therefore, in designing intelligent wearable safety systems, both secure data handling and developing and designing a safe and ethical system are also very important [26], [32].

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VI. COMPARATIVE ANALYSIS OF EXISTING WOMEN SAFETY SYSTEMS

To perform a systematic review of existing research on women's safety systems, a comparative analysis is critical to determining which systems are most effective, what common design patterns exist, and what issues remain to be resolved.

This subsection will provide a structured comparison of the various women's safety systems in the literature, with an emphasis on emergency alert systems based on smart wearable. The comparison will occur on several dimensions or criteria: platform type, alert mechanism, communication technology, level of automation, reliability of response, and practical limitations.

6.1 Comparison Based on System Platform

Safety systems for women can be categorized into four categories: mobile app-based solutions, IoT-based solutions, basic wearable devices, and smart wearable device-based solutions. While mobile apps are widely used, they have limitations due to the fact that they require a smartphone and they require the user to take action during an emergency [3][7]. IoT applications have better connectivity via the cloud but still require a smartphone to act as an intermediary [4][15]. Smart wearable are the best type of solution in this category, as they can generate alerts directly, have superior sensing and communication capabilities, and do not require a smartphone [16][18].

6.2 Comparison Based on Alert Triggering Mechanism

Most manual alert systems rely on the user performing some kind of explicit action, such as pressing an SOS button to initiate an emergency response; However, this may not always be feasible when a user is under duress or otherwise unable to perform this action.

Sensor-based alert systems can automatically detectan emergency situation through motion and physiological data [14], and semi-automatic methods use both types of systems combined such that users can still cancel false alarms created by the semi-automatic system. While an automatic alert system provides a user with the fastest emergency response, studies showing the high rate of false alarms associated with automatic systems recommend using some form of hybrid mechanism that balances responsiveness and faithfulness [19], [28]

6.3 Comparison Based on Communication Technologies

GSM-based communication methods are a good option for delivering alerts because they don't need to use the internet. However, if the mobile phone network is congested, delays may occur before alerts are delivered. For instance, smart wearable devices that incorporate several different technologies— GPS for location information in conjunction with GSM or Wi-Fi or Bluetooth to transmit alert communications— create redundancy in order to ensure that alerts get delivered reliably to their intended recipients [4], [21]. However, indoors, the accuracy of GPS can become severely degraded [6], [8]..

6.4 Comparison Based on Automation and Intelligence

While intelligent systems that use sensor fusion and machine learning increase detection accuracy at higher computational and energy costs, manual systems provide user control but have delayed activation [14][28][50]. By combining optional cloud-assisted analysis with lightweight on-device processing, smart wearable device-based systems achieve a balance between acceptable energy efficiency and increased adaptability [15], [37].

6.5 Comparative Summary

The main distinctions between the main categories of women's safety systems covered in this review are outlined in Table I.

Table I. Comparative Analysis of Existing Women Safety Systems

Ref. No.	Year	System Type	Technology Used	Key Features	Limitations
[2]	2017	Embedded device	GPS, GSM	Location-based SMS alerts	Limited processing
[3]	2017	Embedded system	GSM	Automatic SMS alert	No live tracking
[4]	2018	IoT-based Safety Device	GPS, GSM,IOT Cloud	Panic button alert	Power consumption issues
[5]	2018	IoT-based system	GPS, GSM,Clou	Remote monitoring	Internet dependent

[41]	2020	IoT device	Arduino, GPS, Sensors	Multi-sensor, Health monitoring	Battery life, Not portable
[42]	2022	Embedded device	Arduino, GSM	GPS tracking, Emergency button, GSM alerts	Manual activation, Battery not optimized
[43]	2023	IoT wearable	ESP32, Cloud	Auto alerts, Cloud storage	Internet dependent, High power
[44]	2023	Embedded device	Arduino, GPS, GSM	Real-time tracking, Cost-effective	Limited processing, Manual only
[45]	2023	AI–IoT integrated safety system	Wearable IoT sensors, GPS, Mobile App, Cloud, ML	Abnormal activity detection, stress monitoring, intelligent alerts	Internet dependency, system complexity, higher cost for rural deployment
[46]	2025	IoT wearable	ESP32, GPS, GSM, Telegram	Voice activation, Multi-sensor, Cloud evidence	Complex design, Battery drain
[47]	2025	IoT Wearable safety device	ESP32, GPS, GSM, Multi-sensors, Cloud	Voice activation, automatic threat detection, cloud evidence storage	Complex system design, high battery consumption, privacy concerns
[48]	2025	Wearable IoT + ML system	Wearable sensors, GPS, Biometric data, Machine Learning	Real-time crowd panic detection, stress identification, public safety monitoring	False positives, privacy issues, high computational cost
[49]	2025	Wearable IoT	Wearable, SVM ML, GPS, Biometric	ML panic detection, Real-time stress	False positives, Privacy concerns

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VII. Research Gaps And Challenges

Even though there have been tremendous developments in terms of design and implementation of emergency alert systems based on smart wearable devices technology for women safety, there are research gaps and challenges that need to be addressed. This section reflects on the research gaps and challenges as highlighted above based on the comparative analysis.

7.1 Dependence on Manual Alert Activation

A substantial part of the existing women's safety solutions utilizes the manual triggering mechanism. Manual triggering mechanisms include the use of SOS buttons and gesture inputs. Manual triggering mechanisms have the advantage of giving the user the power to control the device. However, the drawback is that the device relies on the consciousness of the victim to send the alert. Manual triggering mechanisms may not work during a panic attack, restraint, and unconsciousness of the victims [18], [21].

Despite the invention of many techniques to overcome the drawback of the manual triggering mechanism, their use is limited due to the problems that may arise from the occurrences of false alarm. There is a significant gap with regard to the design of the system to use the advantages of reliability.

7.2 Localization Accuracy and Indoor Positioning Limitations

Location information is one of the essential parameters that is required to ensure the effectiveness of the emergency response. In the majority of the safety mechanisms that use smart wearable device technology, GPS is used as the primary location tracking technology. However, the effectiveness of GPS is significantly compromised in indoor spaces, underground spaces, and densely populated urban spaces, which may lead to inaccurate location information.

Some alternative location technologies that have been studied for use in indoor spaces include the use of Wi-Fi fingerprinting and sensor fusion. However, the use of these technologies is still a challenge to the resource- constrained smart wearable device-based safety mechanisms.

7.3 False Alarms and Context Awareness

The false alarm problem of automatic emergency detection systems may occur due to normal human activity such as running or even moving around. Such frequent false alarms may cause users not to have faith in the system or may cause alert fatigue in the emergency contact people [14][28][50].

The improvement of context awareness using sensor fusion and adaptive learning is an important research problem in the distinction of real emergencies from normal events. The application of intelligence on resource-constrained devices in the context of a wearable device is a highly challenging task.

VIII. Future Research Directions

Even though the potential for improving the safety of women using smart wearable device-based emergency alert systems has been demonstrated, the existing systems are still limited and require further improvements. Therefore, future work should focus on improving the energy efficiency, intelligence, localization, communication, privacy, and integration of the systems.

8.1 Energy Efficiency

Continuous sensing, GPS usage, and communication are major battery life consumers. Future systems should incorporate energy-efficient hardware, event-driven sensing, duty-cycling, and low-power localization to allow for long battery life without impacting response time.

8.2 Intelligent Detection

Currently, the systems use threshold-based mechanisms that may result in false alarms. Context-aware and machine learning techniques may improve the accuracy of the alarm. However, the techniques should be computationally light to run on the wearable device.

8.3 Improved Localization

This has called for hybrid positioning systems that incorporate inertial measurement units, Wi-Fi, Bluetooth, etc. Low power consumption for indoor positioning systems has become another major challenge in this field.

8.4 Robust Communication

However, the delivery of alerts under poor network conditions necessitates the use of redundant communication approaches. In this case, the use of edge computing and decentralized IoT architectures may improve the reliability and latency of the alerts.

IX. Conclusion

System architectures, sensing mechanisms, communication mechanisms, and smart detection mechanisms. The results reveal that smart wearable devices are a viable solution for emergency alert systems to ensure women’s safety.

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The comparative evaluation of emergency alert systems revealed that smart wearable devices are advantageous in terms of emergency response time, hands-free operation, location awareness, faster response time, and greater accessibility in emergency conditions in comparison to traditional emergency alert systems and mobile application-based emergency alert systems. Smart wearable devices are advantageous in comparison to traditional wearables in terms of greater levels of automation, context awareness, and greater levels of flexibility.

However, issues such as manual alert dependency, battery life limitations, inaccuracy in indoor localization, network dependency, false alarm generation, and unsolved privacy issues are still affecting current systems. Even though intelligent systems and hybrid systems are promising in this regard, it is difficult to implement them on resource-constrained systems. Moreover, there is a lack of standardized benchmarks in current studies, which again emphasizes the importance of a holistic evaluation framework considering factors such as response time, reliability, energy consumption, usability, and privacy simultaneously.

To summarize, to achieve the potential of smart wearable device-based women safety systems, it is important to develop a holistic system considering factors such as intelligence, reliability, energy consumption, and privacy issues. Therefore, it is important to emphasize low- power system development, context-aware detection systems, hybrid localization systems, robust communication systems, and privacy issues in developing a holistic system for researchers and policymakers to develop next-generation wearable safety systems.

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