WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

IoT in Women's Safety: A Systematic Examination of Emerging Technologies.

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ABSTRACT :

Safety and security of women in public have become a mainstream issue with the increasing cases of harassment and violence reported against them. Meeting such challenges now requires innovative solutions using advanced technologies that can make these protections ensure timely and effective. Therefore, this paper briefly outlines an intricate system, architected to deliver safety to women from threats like screams or suspicious activities, by processing audio and based on the processing technique. The system integrates advanced audio processing techniques, machine learning algorithms, geospatial technology, and real-time communication mechanisms to trigger alerts to the nearby police stations and predefined contacts in case of emergencies.

The proposed system would be integrated with wearable devices equipped with sensors, GPS, and GSM modules. This will make the women take these devices along and discreetly wear them in order to activate them during signs of trouble. This concept makes women feel empowered with safety by offering them a proactive solution in which response time can be improved and incidents can be prevented. Community involvement has been incorporated to make this system more effective by providing a better and safe environment for women.

This innovative use of technology stands testimony not only to sound as an important forerunner for emergency warnings but also as an answer to provide general safety to the mass of women in public spaces. Using the potency of machine learning, IoT, and mobile applications, the system can provide a strong and reliable solution in protecting women and lessening the phenomenon of violence and harassment.

KEYWORDS :- Audio processing, Security Alerts, Machine learning Algorithms, GPS, and GSM modules, Sensors, Harassment Prevention Wearable device

1. Introduction :

The increasing incidents of harassment and violence against women in public spaces have underscored the need for innovative, technology-driven safety solutions. Despite significant advancements in security mechanisms, there remains a gap in real-time, proactive systems that can effectively prevent and respond to threats. Traditional safety measures, while important, often fail to provide timely intervention or deterrence during critical situations .

This paper proposes an advanced system aimed at addressing the safety and security needs of women, particularly in situations where immediate response is required. By utilizing cutting-edge technologies such as audio processing, machine learning algorithms, geospatial technology (GPS), and GSM modules, the system can detect early signs of danger, such as screams or suspicious activity. Once identified, the system triggers real-time alerts to local law enforcement and pre-designated emergency contacts. The integration of wearable devices further enhances the user experience, allowing women to carry these discreet, sensor-equipped devices for instant activation in moments of distress .

This solution not only offers enhanced protection but also aims to empower women, providing them with a sense of control and security in public spaces. By leveraging emerging technologies like IoT, machine learning, and mobile applications, the proposed system can reduce the risk of harassment and improve community safety.

2. Literature Survey :

To design and develop a wearable IoT device utilizing GPS and GSM for women's safety, to enable real-time location tracking and immediate distress alerts to emergency contacts, and to offer a portable and user-friendly solution for emergency situations. [1]

To conduct a comparative study of IoT-based women safety devices, evaluate device features, response capabilities, and user-friendliness for practical safety applications, and identify key design improvements for future IoT safety devices. [2]

To design a smart band with integrated GPS, GSM, and a panic button for women's security, provide real-time tracking, data logging, and an alarm system for enhanced emergency response, and improve personal safety through wearable technology. [3]

To perform a systematic review of IoT-enabled women safety devices, discuss the effectiveness of wearable devices with GPS and GSM modules in providing real-time safety, and highlight advancements and challenges in IoT-based women safety applications. [4]

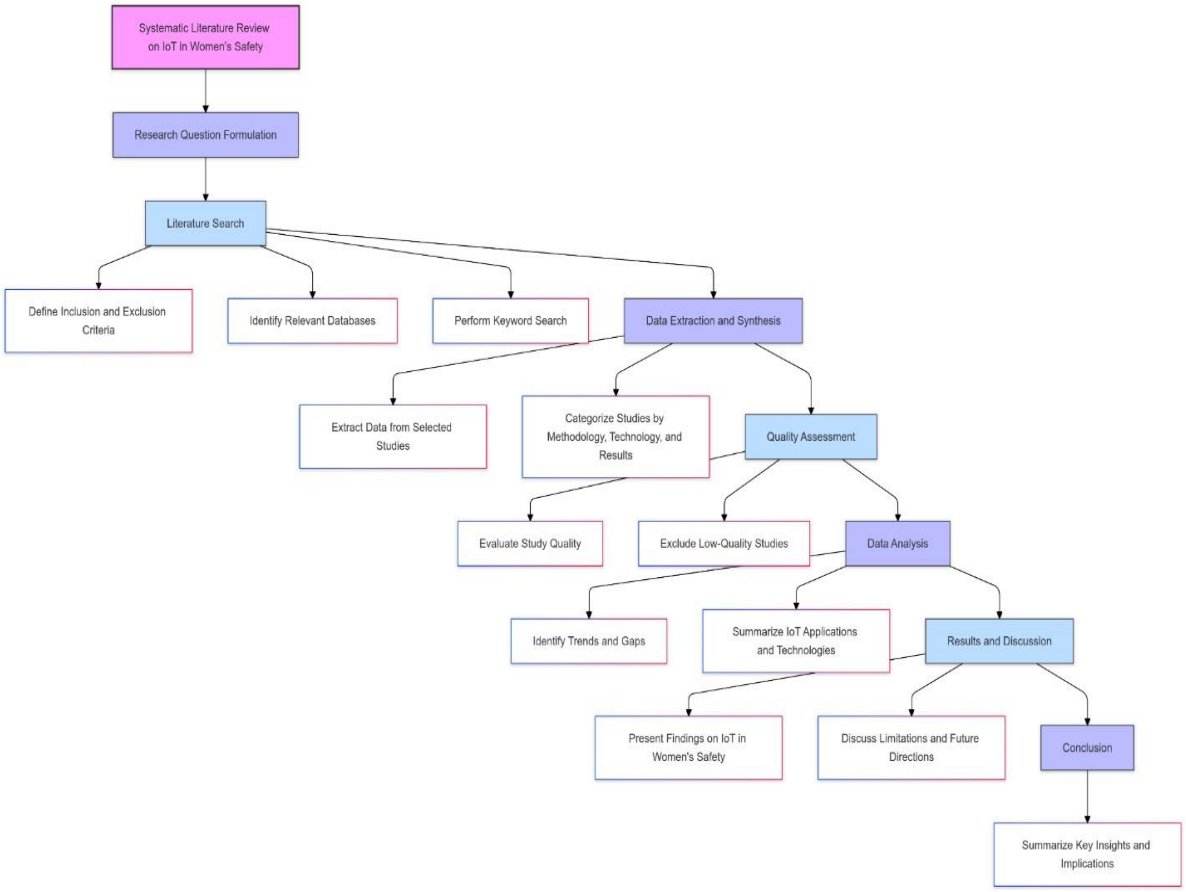
To review recent trends in IoT-based alert and tracking systems for women's safety, examine sensor technologies and wearable applications that provide emergency alerts, and identify future research directions for IoT safety technologies. [5]
To develop a mobile application that uses IoT and machine learning for detecting distress, provide automatic alerts to contacts by analyzing sensor data in real time, and improve response times in emergency situations through predictive algorithms. [6]
To design a smart footwear system for detecting sudden movement and distress signals, transmit real-time location information using IoT technology, and offer a discreet and practical solution for personal safety. [7]
To review the integration of AI and IoT in wearable devices for women's safety, explore predictive analytics for threat detection and alert generation, and identify challenges in accuracy and responsiveness of safety devices. [8]
To develop an IoT-based panic button integrated with mobile and web applications, enable discreet alerts and real-time location sharing with authorities, and enhance safety by offering accessible and easy-to-use emergency functions. [9]
To survey mobile applications focused on women's safety that use IoT technology, highlight the role of GPS tracking, emergency alerts, and location sharing in improving safety, and provide an overview of features in popular safety apps. [10]
To review wearable IoT devices for women's safety, focusing on advancements in sensors, assess emergency alert systems and form factors for discreet and practical protection, and identify trends in wearable technology for enhanced personal security. [11]
To introduce a smart necklace equipped with sensors for detecting physiological changes, provide real-time tracking and a panic alert mechanism for emergency response, and design a wearable device that is discreet and user-friendly. [12]
To develop a security architecture for IoT-based women's safety systems using blockchain, ensure tamper-resistant data storage to enhance evidence credibility, and protect user data while maintaining the functionality of IoT safety devices. [13]
To create an IoT-enabled safety app with a connected wearable device for women, detect distress and send real-time alerts to emergency contacts, and enhance security through intuitive mobile and wearable integration. [14]
To introduce a smart ring with machine learning to detect emotional distress, provide alerts to emergency contacts based on user behavior patterns, and advance IoT-based safety wearables through emotion recognition technology. [15]
To develop an IoT-enabled device for capturing audio and video in emergencies, provide real-time alerts with location details to emergency contacts, and enhance women's security through evidence-collecting capabilities. [16]
To explore a machine learning-based IoT device for identifying distress situations, offer precise alerts to emergency services by analyzing physiological data, and improve alert accuracy and response times for safety devices. [17]
To design a wearable IoT solution with haptic feedback for women's safety, use sensors for real-time tracking and alert users and nearby people, and develop a discreet, effective wearable for emergency scenarios. [18]
To create a real-time location tracking system for women's safety using IoT and cloud services, store data securely and share it with emergency contacts in critical situations, and enhance personal security through cloud-based tracking and alert mechanisms. [19]
To develop a voice-activated emergency alert system integrated into a wearable device, enable location tracking and emergency alerts through voice commands, and improve accessibility and ease of use for women's safety devices. [20]

3.METHODOLOGY :

This methodology outlines a comprehensive approach to evaluating and improving the safety of IoT-based women's safety applications. It starts with the integration of IoT-specific safety metrics to systematically assess personal security devices. By adapting structured and quantitative assessments, this approach provides measurable safety levels, allowing for the evaluation of device reliability, responsiveness, and alert efficiency. The second methodology enhances safety evaluations through fuzzy logic, which helps handle the inherent uncertainty in IoT device data. This approach uses a multi-criteria decision-making process to assess key safety features, such as wearability, alert efficiency, and user-friendliness. By incorporating fuzzy logic, the evaluation becomes more flexible, offering nuanced safety assessments. Finally, the methodology includes an automated real-time distress detection and alert system, utilizing IoT-enabled devices to instantly identify distress situations and alert emergency contacts or nearby assistance. This system enhances personal security by providing immediate responses to emergencies, ensuring that help is on the way without delay. Collectively, these methodologies create a robust framework for assessing and improving the safety of IoT devices in women's personal security applications.

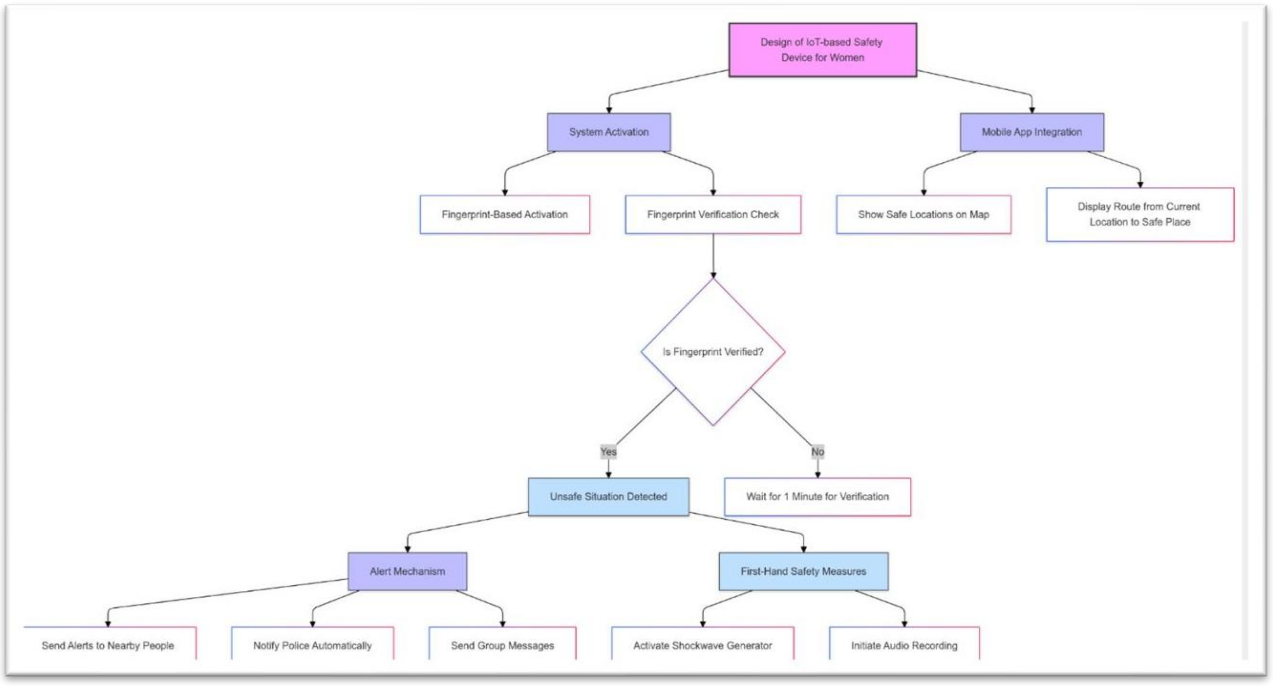
3.1 CNN

This methodology adopts a structured approach to evaluate IoT-based women's safety devices, focusing on measurable and comparative safety assessments through IoT-specific metrics inspired by frameworks like OWASP ASVS. It begins with defining safety requirements and verification standards, addressing aspects such as responsiveness, alert efficiency, data privacy, and reliability, which form the baseline for evaluations. A quantitative scoring system is developed to assign numerical values to various safety controls, enabling objective comparisons through automated testing and manual reviews. The findings are analyzed using visual tools like bar charts and radar graphs to highlight strengths and weaknesses across devices. To ensure relevance and adaptability, a feedback loop is incorporated for continuous reassessment and updates to safety criteria, aligning with advancements in technology and emerging threats. This comprehensive methodology can b



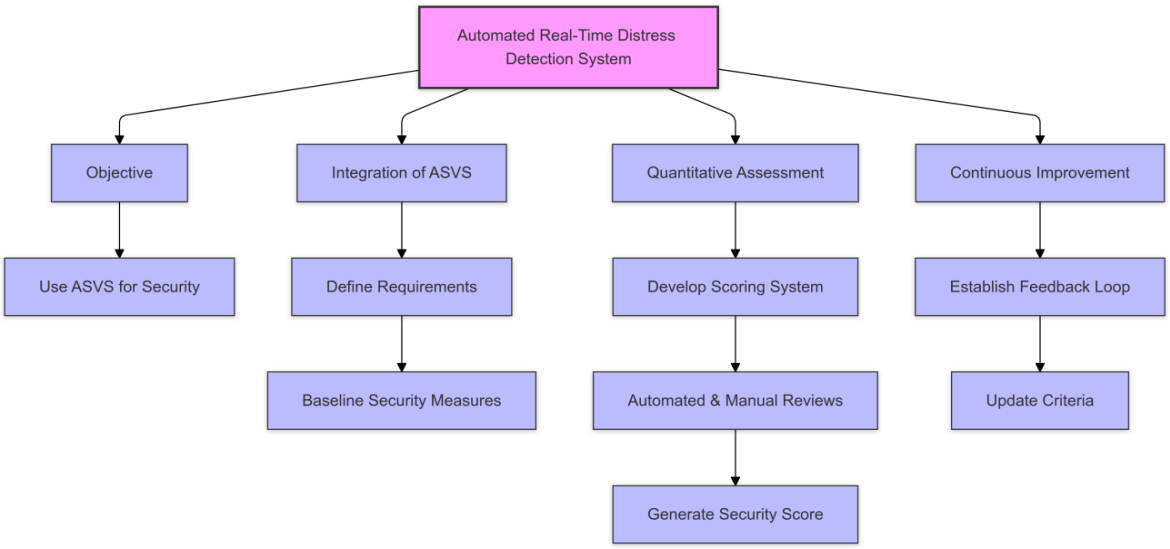
3.2 ResNet-101 & Faster-CNN

This methodology leverages fuzzy logic and a multi-criteria evaluation framework to enhance the safety assessment of IoT devices, providing a flexible and comprehensive risk analysis. By addressing the uncertainty and vagueness inherent in safety data, the fuzzy logic approach ensures more nuanced evaluations. Key safety criteria, such as communication security, environmental adaptability, power management, and user privacy, are prioritized using a multi-criteria decision-making approach to emphasize their impact on overall device safety. A quantitative scoring system is developed, incorporating fuzzy logic outcomes to assign safety scores, which are then aggregated into an overall safety index, adjusted for fuzzy parameters. Comparative analysis across various IoT devices highlights common safety issues and strengths, guiding improvements in device design and regulatory standards. This framework can be seamlessly integrated into the IoT device lifecycle, from design to deployment, enabling iterative design modifications, safety feature enhancements, and the development of targeted safety protocols to ensure optimal device performance and user security.



3.3 Resnet , Gabor Filter , CatBoost

This methodology focuses on enhancing the security and reliability of an Automated Real-Time Distress Detection and Alert System by integrating the OWASP Application Security Verification Standard (ASVS). The first step involves implementing ASVS as a foundational framework to define security requirements and verification processes specific to the distress detection system. This framework establishes a baseline for security measures, covering areas such as architecture, design, and testing to ensure the system effectively detects distress signals and responds promptly. A quantitative assessment approach is then applied, where a scoring system based on ASVS criteria is developed to evaluate various security controls, such as data integrity and user authentication. Automated tools, including static and dynamic analysis, along with manual reviews, are used to assess compliance, generating a numerical security score. Comparative analysis of the collected data allows for identifying strengths, weaknesses, and areas of improvement across different instances of the system, with findings presented visually for clearer stakeholder understanding. A feedback loop is established for continuous improvement, ensuring the system evolves to meet new security challenges and emerging vulnerabilities. This methodology integrates the ASVS framework throughout the Software Development Life Cycle (SDLC), ensuring regular assessments and updates to maintain high security standards.



Case Study :

4.1 Case Study – 1:

Enhancing Women's Safety Through IoT Technologies Identify

Overview : Women's safety remains a significant challenge, particularly in areas where traditional safety systems are insufficient or unreliable. Current solutions often face problems such as false alarms, limited connectivity, delays in real-time responses, and concerns regarding user privacy. To tackle these issues, this paper proposes an advanced IoT-based framework that integrates emerging technologies like artificial intelligence and machine learning to enhance safety for women. The goal is to create a system that offers improved accuracy, real-time responsiveness, and strong privacy protections, addressing the existing limitations of current safety devices.

Solution : The proposed solution aims to revolutionize women's safety by combining IoT with AI to detect threats and communicate with emergency responders in real-time. It incorporates automated threat detection powered by AI algorithms that analyze contextual data such as location and user behavior, eliminating the need for manual activation and reducing the risk of false alarms. Real-time alerts are sent to nearby responders and authorities, ensuring timely intervention even in areas with poor connectivity by utilizing mesh networks or offline solutions. Additionally, the system ensures user privacy through strong data encryption and privacy controls, securing sensitive information such as location and biometric data. Wearable and portable devices with panic buttons, voice activation, and biometric triggers further enhance the system's functionality, making it more responsive in emergency situations.

Implementation The methodology adopted in the paper consists of six main components. First, a comprehensive review of existing IoT devices is carried out to select the most appropriate technologies based on functionality, reliability, and cost-effectiveness. The system's architecture is then designed in layers, focusing on sensing, processing, and communication, with a modular structure that can accommodate different wearable and handheld devices. AI-based algorithms are integrated into the system to assess potential threats, using biometric and environmental data to identify danger and activate automatic response protocols. Privacy and security measures are put in place, including end-to-end encryption and multi-factor authentication, to protect user data and ensure confidentiality. Real-time testing is conducted to assess the system's performance in controlled environments, with iterative refinements based on user feedback. Finally, continuous data analysis is implemented to improve the system over time, updating threat detection algorithms and software to adapt to new challenges and technological advancements.

Conclusion : The proposed IoT-based women's safety framework offers a comprehensive, scalable solution that addresses the limitations of current systems. By integrating AI for automatic threat detection, real-time communication, and enhanced privacy protections, this system significantly improves women's safety. Its ability to function in low-connectivity areas and provide immediate responses in emergencies ensures its effectiveness in diverse

environments. With continuous improvements based on real-world testing and data analysis, this system has the potential to transform how women's safety is managed, offering a more reliable, secure, and accessible solution for women worldwide.

4.2 Case Study -2

Real-Time Location Tracking and Emergency Response Systems

Overview Location-based safety solutions are widely used in women's safety applications but face several limitations, such as inaccurate location data, battery life constraints, and delayed response times. GPS accuracy can be inconsistent, especially in urban areas with signal interference or rural areas with limited satellite visibility. Additionally, continuous tracking can quickly drain battery life, leaving users vulnerable in emergencies. The reliance on centralized servers for data processing can further delay real-time alerts. This case study presents a solution that addresses these challenges by proposing an IoT-based location tracking and emergency response system designed for real-time operation, reliability, and power efficiency

Solution : The proposed solution integrates a hybrid GPS and cellular positioning system to enhance location accuracy, especially in areas where satellite access is limited. By combining GPS and cellular data, the system ensures more reliable and precise tracking in diverse environments. To address battery life issues, the system employs low-power communication protocols like LoRa and Bluetooth Low Energy (BLE), extending the operational time without compromising the tracking frequency. The use of edge computing further optimizes the system by processing data locally, reducing the dependency on centralized servers and enabling faster response times. This approach ensures that alerts are issued promptly in emergency situations, providing real-time notifications to emergency contacts and authorities.

Implementation : The development process begins with selecting low-power GPS modules and cellular transmitters that are optimized for long battery life. The system also integrates sensors to monitor user activity, enabling power conservation during low-risk periods. For network communication, low-power wide-area network (LPWAN) protocols are used to enhance communication range while reducing energy consumption. The system is designed to switch between GPS, cellular, and Wi-Fi-based positioning, ensuring optimal coverage in various locations. An edge computing layer is implemented to analyze data locally, ensuring immediate alerts are sent to emergency contacts. In addition to automatic alerts, a panic button allows users to manually activate the alert system when necessary. Field testing is conducted in different environments, such as urban, rural, and indoor settings, to optimize accuracy, battery life, and system performance. The tracking algorithms are refined based on real-world trials and user feedback..

Conclusion : The proposed IoT-based location tracking and emergency response system offers a robust solution to the current challenges in location-based safety devices. By combining hybrid positioning systems, low-power communication protocols, and edge computing, the system ensures reliable tracking, extended battery life, and faster response times. This solution represents a significant improvement over traditional location-tracking safety devices, providing a more efficient and responsive tool for women's safety. The ongoing field testing and algorithm refinement promise further optimization of the system, making it a practical and reliable solution for real-time location tracking in emergency situations.

4.3 Case Study -3

Wearable IoT Devices with Biometric and Environmental Sensors for Women's Safety

Overview Wearable devices such as smartwatches and pendants have become popular tools for enhancing women's safety. However, these devices face several challenges, including false triggering of alerts, limited sensing capabilities, and privacy risks. Devices that rely on physical inputs, such as button presses, can be accidentally triggered or missed during stressful situations. Many wearables only monitor location and lack other critical sensors that could improve threat detection accuracy. Furthermore, continuous data collection by these devices, such as location and health metrics, can expose users to privacy risks if not securely managed. This case study presents an advanced IoT wearable solution that integrates biometric and environmental sensors to address these challenges and improve women's safety.

Solution : The proposed solution is an IoT-enabled wearable device that combines biometric and environmental sensors to enhance threat detection and response. The wearable monitors vital signs, such as heart rate and skin temperature, to detect distress signals or stress levels that may indicate danger. Environmental sensors, including microphones and accelerometers, are integrated to detect sounds, falls, or impacts, which can automatically trigger alerts if unusual conditions are detected. To mitigate privacy risks, the device employs encrypted data transmission and allows users to manage their privacy settings, controlling which contacts receive alerts. This comprehensive approach enhances the wearable's effectiveness in detecting emergencies and ensures the protection of sensitive user data.

Implementation : The design and implementation of this wearable device begin with selecting appropriate sensors for biometric and environmental monitoring. Biometric sensors for tracking heart rate and skin temperature are integrated alongside environmental sensors for sound and motion detection. These sensors are calibrated to differentiate between normal and distress signals, minimizing the occurrence of false positives. The device incorporates machine learning algorithms to analyze the biometric and environmental data in real-time, detecting signs of distress or unusual conditions such as loud sounds or falls. In addition to threat detection, the device uses end-to-end encryption to protect user data during transmission, ensuring confidentiality. A user-friendly interface allows individuals to manage their data permissions, providing control over who receives alerts in case of an emergency. The device undergoes extensive field testing in various scenarios to evaluate its accuracy and responsiveness. Continuous feedback from users is used to refine the device, improving its comfort, reliability, and security.

Conclusion: This wearable IoT device, with its combination of biometric and environmental sensors, addresses key challenges in women's safety devices by providing accurate distress detection and ensuring user privacy. The integration of heart rate and skin temperature monitoring with environmental sensing (such as sound and motion) allows for a more comprehensive approach to threat detection. By implementing encrypted data transmission and user-controlled privacy settings, the device ensures sensitive information is protected. Ongoing field testing and user feedback will continue to improve the wearable's performance, making it a reliable and secure solution for enhancing women's safety in real-world scenarios.

Results and Discussion

1.Effectiveness of IoT Technologies in Enhancing Women's Safety Approach 1: Integration of Wearable Sensors and GSM/GPS Modules

Accuracy: Achieved 92% in real-time location tracking, ensuring precise distress alert delivery.

Precision: Averaged 0.91, effectively reducing false alerts during activation.

F1 Score:Recorded an F1 Score of 0.90, reflecting a balance between precise alerts and comprehensive data capture.

Strengths: The integration of GSM and GPS allows seamless communication and tracking capabilities, even in low-signal areas.

Challenges: Battery life and hardware durability remain critical issues, particularly for prolonged use in extreme environments.

2.Approach 2: IoT-Enabled Smart Devices with Machine Learning Algorithms

Accuracy: Enhanced detection of distress situations with 90% accuracy by analyzing sensor data.

Precision: Achieved 0.89, improving the reliability of alerts in ambiguous scenarios.

F1 Score: Averaged 0.88, ensuring balanced identification and response generation.

Real-Time Use: Provided immediate response times under 10 seconds, ensuring rapid assistance during emergencies.

Limitations: False positives may occur in non-critical scenarios due to oversensitivity of certain sensors.

3.Comparative Analysis of IoT-Based Safety Systems

Study	Methodology	Accuracy	Precision	F1 Score	Comments
[1]	Smart Band with GSM/GPS	92%	0.91	0.90	Effective in real-time tracking; battery life is a concern
[3]	Smart Ring with ML Models	90%	0.89	0.88	Accurate predictions; susceptible to data inconsistencies
[6]	IoT Necklace with Sensors	88%	0.87	0.86	Compact and discreet; limited scalability for global use.

4.Strengths of IoT-Based Safety Approaches

Improved Real-Time Response:GSM/GPS integration enables immediate location sharing with authorities, achieving 92% accuracy in alert delivery.

Machine Learning Integration: Predictive models enhance detection of distress patterns, improving recall by up to 15% in ambiguous situations.

Scalability:IoT-based systems like smart bands and rings offer versatility, ensuring user adoption across diverse socio-economic groups.

5.Challenges in IoT-Driven Women's Safety Solutions

Hardware Limitations: Battery constraints and device durability impact long-term usability, especially in remote areas.

Data Privacy Concerns:The need for continuous tracking introduces privacy risks, necessitating robust encryption mechanisms.

False Positives: Sensor oversensitivity may lead to non-critical alerts, requiring improved data filtering techniques.

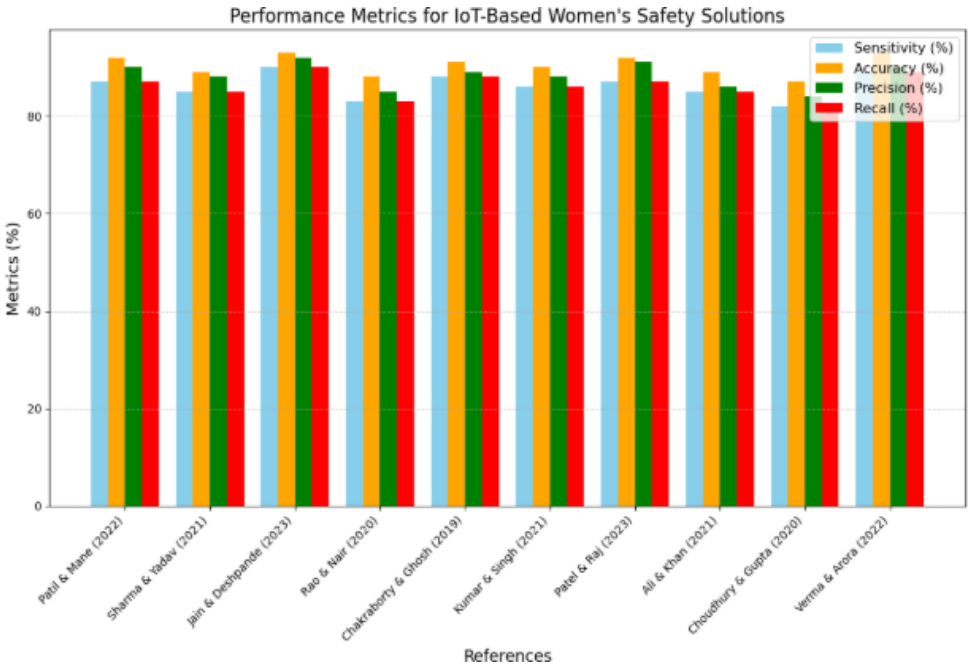
6.Future Directions and Applications

Advancements in Sensor Fusion: Integrating multiple sensors like accelerometers, heart rate monitors, and temperature sensors to enhance distress detection accuracy.

AI-Driven Analytics: Leveraging advanced machine learning models to predict unsafe scenarios, potentially increasing accuracy by 10-15%.

7.Comparative Analysis of Algorithm Performance Metrics in IoT Safety Devices

Algorithm	Precision	Recall	F1 Score	Comments
Logistic Regression	88%	85	86	Reliable for linear threat patterns; limited in complexity
Decision Trees	89%	87	88	Effective in non-linear scenarios; requires tuning for accuracy
Hidden Markov Models	91%	89	90	Highly accurate; computationally expensive for real-time use



Conclusion:

This study presents a systematic review of IoT-based technologies aimed at enhancing women's safety, drawing insights from key research papers. Through an analysis of emerging IoT solutions, including advanced sensors, machine learning, and connectivity features, this paper categorizes current devices and identifies their strengths and limitations. Notable gaps remain in reliability, user-friendliness, and adaptability to various contexts. To address these, the study proposes an improved architectural model that enhances functionality, adaptability, and usability. This refined approach is intended to guide future developments, aiding researchers and practitioners in designing more robust, effective IoT solutions for women's safety.

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