iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IV Month of publication: April 2026

DOI: https://doi.org/10.22214/ijraset.2026.80389

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Machine Learning & IOT Based Smart System for Women Safety and Emergency Response

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Abstract: Women's safety remains a significant global concern due to the increasing number of harassment and assault incidents, particularly in public and isolated areas. Traditional safety systems, such as mobile applications and emergency services, often suffer from delayed response times, network dependency, and frequent false alerts, limiting their effectiveness. To overcome these challenges, this project proposes a Machine Learning and IoT-based Smart System for Women Safety and Emergency Response that provides a reliable, real-time protection mechanism. The system integrates a wearable IoT device with an Android application, enabling one-click emergency alerts that automatically share the user's GPS location, capture audio evidence, and send notifications to emergency contacts and nearby authorities. It operates efficiently even in low-network areas and features a low-power design for extended usability. Furthermore, by using Machine Learning algorithms, the system generates heatmaps that identify unsafe zones and predict potential risks based on historical and user-reported data. This intelligent and user-friendly approach ensures proactive safety awareness, faster emergency response, and enhanced personal security. Overall, the proposed system aims to empower women through technology, offering a practical, scalable, and independent safety solution that ensures real- time monitoring, rapid assistance, and greater confidence in daily mobility.
Key words: IoT, Machine Learning, Women Safety, GPS, Emergency Alert, Heatmaps, Android Application

I. INTRODUCTION

Women's safety remains a pressing concern worldwide, requiring solutions that go beyond traditional reactive approaches and move toward proactive, technology-driven protection systems. The proposed Machine Learning and IoT-based Smart System enhances safety by combining real-time sensing, intelligent data processing, and seamless communication into a unified platform. The wearable IoT device is designed to be discreet, lightweight, and easy to use, equipped with sensors such as GPS, microphone, and possibly accelerometers to detect unusual movements or distress patterns. In emergency situations, the system can be triggered manually or automatically,instantly transmitting location coordinates, live audio, and alert messages through multiple communication channels such as SMS, internet, or low-bandwidth networks to ensure reliability even in poor connectivity conditions. The Android application complements the device by providing features like live tracking, emergency contact management, and visualization dashboards. On the analytical side, Machine Learning models process historical incident data and user-reported inputs to identify high-risk areas, generating dynamic heatmaps and predictive alerts that can warn users before entering potentially unsafe zones. The system may also incorporate cloud storage for secure data handling, encryption techniques for privacy, and integration with local law enforcement systems for faster response. By reducing dependency on continuous smartphone interaction and minimizing false alarms through intelligent filtering, this solution significantly improves response time and accuracy. Overall, it represents a scalable, cost-effective, and robust framework that not only responds to emergencies but also helps in prevention, awareness, and long-term safety planning, thereby empowering women with greater confidence and autonomy in their daily lives.

II. LITERATURE REVIEW

The paper "Design and Development of Women Safety System Using IoT Technology" [1] explains that IoT-based safety systems can provide real-time protection by combining sensors, GPS, and communication modules into one framework. The proposed system includes a wearable device with a panic switch that sends emergency alerts and the user's location to registered contacts. The authors show that the system speeds up response times in critical situations. However, the study lacks a secure way to transmit data and heavily relies on network connectivity, which reduces its effectiveness in remote areas.

The paper “IoT Based Women Safety Device with GPS Tracking and Emergency Alert System” [2] states that combining Internet of Things (IoT) technology with wearable devices can greatly improve personal safety by allowing real-time monitoring and emergency response.

The proposed system uses a panic button, GPS module, and GSM communication to send the user’s location to predefined contacts during emergencies. It also includes sensors that detect unusual conditions and trigger alerts automatically. Experimental results show that the system reliably tracks location and sends immediate notifications. However, the study points out limitations like reliance on network availability and insufficient secure data transmission, leaving the system open to unauthorized access.

The paper “Smart Mobile Application for Women Safety Using Android Platform” [3] suggests a mobile-based solution that lets users send emergency alerts by simply shaking their phone or pressing a button. The application has features like live location sharing, audio recording, and emergency contact notification. The authors show that the system makes it easier to access and use, making it suitable for real-time situations. However, the research finds issues like accidental activation of alerts and privacy concerns related to centralized data storage, which could expose sensitive user information.

The paper “GPS and GSM Based Tracking System for Personal Security” [4] introduces a tracking mechanism that uses GPS for location detection and GSM for communication. The system constantly monitors the user’s position and sends updates via SMS to guardians or authorities. The study highlights the reliability of GSM communication in areas with poor internet connectivity. Even though it works well, the system lacks smart decision-making abilities and does not have secure data handling methods, which limits its growth in modern applications.

The paper “Wearable Smart Device for Women Safety Using Sensor Integration” [5] describes a wearable solution with sensors like heart rate monitors, temperature sensors, and motion detectors to identify abnormal conditions. The system automatically sends alerts when it detects unusual patterns, reducing the need for manual intervention. Experimental evaluation shows it responds better in emergencies. However, the study identifies problems like high power usage, limited battery life, and challenges in real-world deployment due to hardware issues.

The paper “Artificial Intelligence Based Safety System for Threat Detection” [6] looks at using machine learning methods to improve safety systems by evaluating behavior patterns and environmental data. The proposed model detects anomalies and predicts potential threats using trained datasets. Results show better accuracy in recognizing risky situations compared to traditional methods. Nonetheless, the research points out challenges such as the need for large datasets, complex calculations, and lack of clear explanations, which affect reliability in critical situations.

The paper “Blockchain-Based Secure Emergency Response System” [7] suggests a decentralized framework for managing emergency data through blockchain technology. The system ensures secure storage and sharing of user information by applying cryptographic techniques and distributed ledgers. The authors show that blockchain improves data integrity and stops unauthorized changes. Despite these benefits, the study notes issues like higher computational demands, delays, and complexity in execution, which might hinder real-time performance.

The paper “Integrated IoT and Mobile Application for Personal Safety” [8] presents a hybrid system that combines IoT devices with a mobile application to offer various safety features. The system enables smooth communication between hardware and software components, allowing for real-time alerts and monitoring. Experimental results indicate better coordination and quicker response times. However, the study lacks a strong security framework and does not tackle data privacy issues, which are vital in safety applications.

The paper “Secure Women Safety System Using IoT and Blockchain Technology” [9] describes an advanced approach that links IoT devices with blockchain to ensure both functionality and security. The system offers real-time tracking, emergency alerts, and secure data storage. The authors demonstrate that this combination improves reliability and trust. However, the research highlights challenges like system complexity, increased resource needs, and difficulties in scaling the implementation.

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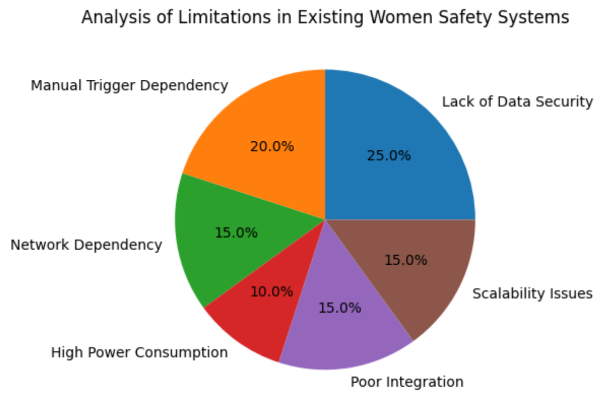

Fig. 2.1: Analysis of Limitations in Existing Women Safety Systems

Fig. 2.1 shows the major limitations found in current women safety systems based on the literature survey. The lack of data security represents the largest issue, meaning most existing solutions do not protect sensitive user information because they rely on centralized systems. Another major limitation is the dependency on manual activation, as users may not be able to trigger alerts during emergency situations. Network dependency impacts the reliability of these systems, especially in remote or low-connectivity areas. Furthermore, problems like poor integration between IoT devices and mobile applications, challenges with scalability, and high power consumption further weaken these systems. These insights emphasize the need for a more secure, automated, and integrated approach. The proposed system addresses these issues by using IoT and blockchain technology.

III. METHODOLOGY

A. *IoT-Based Emergency Detection System*

The IoT-based module acts as an independent safety unit that operates without depending on the mobile application. It focuses on quickly detecting emergencies and generating alerts.

1) *Continuous Monitoring:*

The IoT device constantly monitors the user’s activity with embedded sensors. It spots unusual conditions like sudden movements or extended inactivity that could signal danger.

2) *Emergency Activation:*

The system enables manual activation with a panic button and can also trigger automatically based on abnormal sensor readings. This ensures it works reliably even if the user cannot respond.

3) *Location Tracking:*

When an emergency occurs, the GPS module records the user's real-time location. This data is essential for pinpointing their exact position during critical moments.

4) *Direct Alert Transmission:*

The IoT device sends alerts directly to selected contacts using communication modules such as GSM. This guarantees that emergency notifications go through even without the mobile application.

B. *Mobile Application-Based Safety System*

This mobile app works as its own safety tool, giving you more ways to stay safe and get help when things go wrong.

1) *User Registration and Setup:*

The app lets you sign up and save important contact info for emergencies. We use these contacts to send out alerts when you're in trouble.

2) *Manual SOS Trigger:*

You can just tap an SOS button right in the app to send an emergency alert. This gives you another option to send out an alert.

3) Location Sharing:

Once it's on, the app shares your exact location with your emergency contacts, so they can find you fast.

4) Live Tracking Feature:

The app can keep tracking your location, letting your contacts see where you're going if there's an emergency.

5) Alert Notification System:

The app sends out notifications using the internet, making sure messages get through quickly and smoothly**.**

C. Communication Mechanism

This part explains how both systems send out alerts on their own, each using a different way to communicate. For example, the smart device uses mobile networks (like what your phone uses) to text alerts directly to your emergency contacts. The phone app, on the other hand, sends alerts and notifications over the internet, through its own built-in services. Both systems are made to work completely independently. This means if one system stops working, the other can still reliably get the message through. Having these two different ways to communicate significantly increases the chances that alerts will be delivered, even if the network conditions aren't ideal.

D. System Working

The whole system works by having two separate parts, each operating on its own. The IoT device keeps an eye on the user constantly, looking for any emergency situations. If it senses trouble, it immediately sends out alerts to the designated emergency contacts, including all the location details.On a different note, the mobile app gives users the option to manually send out an alert whenever they need to, using an SOS feature.This application also shares the user's location in real-time and allows for live tracking. Both of these systems function independently, which helps make sure everything is as reliable and safe as it canbe.

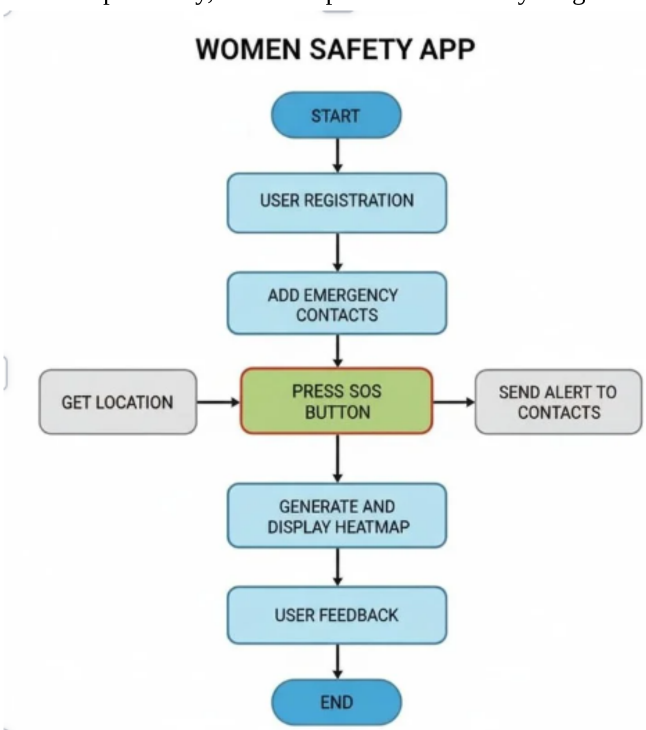

Fig. 3.1: Proposed System Architecture

The system we're suggesting has two main parts that work on their own: a wearable device that uses IoT tech, and a mobile app. The wearable device can send emergency alerts directly through its own mobile signal. Meanwhile, the app can also create its own alerts and show where someone is in real-time, all by using the internet. Both of these parts are meant to offer good, dependable safety support, and they don't rely on each other to do it.

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IV. SYSTEM DESIGN

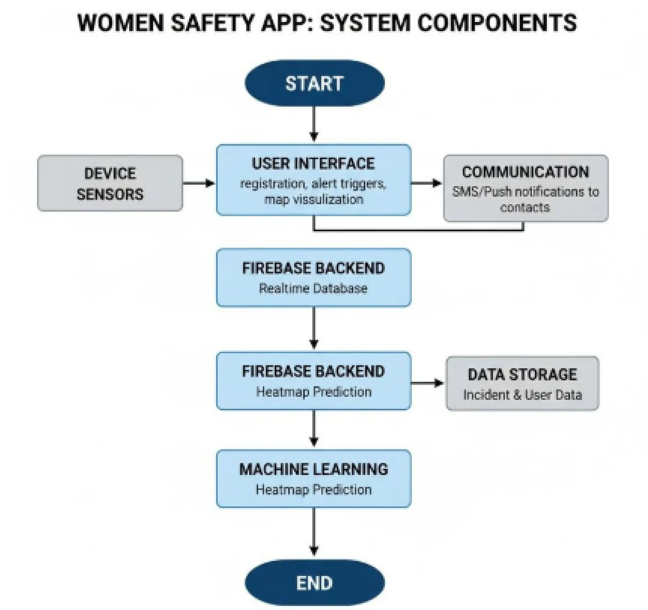

Fig. 4.1 :System Components

A. System Architecture

We've put together a system that combines a small, wearable device, a phone app, and cloud services that use machine learning. This setup lets us keep an eye on things live, respond quickly in emergencies, and even predict potential safety issues.

The system has three main parts, or 'layers': the device itself, the app, and then the cloud where all the smart stuff happens. This layered approach helps us build it in pieces, so it can grow easily and be managed well.

B. System Components

Our system is made up of four key parts: the wearable device, the Android app, the cloud 'brain' (backend), and the machine learning part.

The wearable device is what instantly spots trouble and sends out an alert. We built it with an ESP32 chip, a GPS for finding where you are, and a GSM module to send messages. It has a button you can push in an emergency and a buzzer to make noise. When you use it, the device grabs your location and sends a warning message to people you've listed, all while making a sound right there.

The Android app is basically how you interact with the system and control it. It lets you log in, manage your emergency contacts, manually trigger an SOS, and see your location live. Plus, you can use the app to report problems or see potentially dangerous areas on a map.

We use Firebase for the backend, which helps us store data in real-time, handle logins, and send notifications. It's in charge of managing all the user information, keeping track of incidents, and making sure all the different parts of the system stay in sync.

The machine learning part looks at old data and what users report to find patterns. Then, it creates 'safety heatmaps' that show how risky different areas are. This helps people be more aware of potential dangers before something happens.

C. Data Flow Architecture

The system handles information in a very organized way: it gathers data, sends it, processes it, and then shows it to you.

We collect data from several places. This includes GPS coordinates from both the wearable device and the app, plus incidents users report and things triggered by sensors. The wearable device sends out emergency alerts using regular phone signals (GSM), while the app talks to the backend over the internet.

Everything gets stored and handled in Firebase's Realtime Database. The machine learning part then looks through all this data to spot patterns and guess where risks might be. Finally, this processed info is shown to users through alerts, notifications, and those heatmap pictures.

D. Functional Workflow

The system mainly works in two ways: handling emergencies and constantly keeping an eye on things.

If there's an emergency, you can trigger the system either with the wearable device or the app. Once it's on, it finds your location right away and sends alerts to your saved contacts. These alerts can be text messages or notifications through the app. The system can also record audio, which can be useful later.

When it's just monitoring, the system keeps gathering and updating user data all the time. The machine learning part then uses this data to update the risky areas, showing them as heatmaps in the app. This helps users see where potential dangers are so they can avoid them.

E. Communication Architecture

The system uses a mix of communication methods, so it stays reliable even when network signals are spotty.

The wearable device talks using regular mobile phone signals (GSM). This means it still works even if there's no internet, making sure emergency alerts can always be sent as text messages.

The app, on the other hand, needs the internet to connect through Firebase. This allows for live updates, notifications, and data crunching. Having both ways to communicate makes the whole system much stronger and more reliable.

F. Design Considerations

When we designed this system, we really focused on making it dependable, efficient, and easy to use. It can still work even with weak network signals, thanks to its GSM connection. The wearable device is also made to use very little power, so it lasts longer. And because we use cloud services, the system can grow easily and handle data well.

The app's interface is built for quick and easy use, especially when you need to trigger an emergency. We've also thought about security, adding login features and making sure your data is stored safely. Since it's built in separate parts, each piece can work on its own, but they all fit together seamlessly.

G. Advantages of the Proposed Design

Our design means you get help right away in an emergency, and it works whether you're online or not. It lets us track locations live and even collect evidence, which makes it much more reliable when things get serious. By using machine learning, we can predict unsafe areas, helping users be more aware. On top of that, the system can expand easily and doesn't cost a fortune, so it's a good fit for using in more places.

V. IMPLEMENTATION

We built this Women Safety System with two main parts: one is a small, wearable emergency gadget that uses internet-of-things (IoT) tech, and the other is an Android app that connects to cloud and machine learning services. These two parts can work on their own, but they also work together. This way, the system stays reliable even when the internet isn't great.

The IoT gadget is all about getting help right away, using physical buttons to send alerts. The Android app, on the other hand, lets users interact, manages information, and offers features that can predict danger. We designed the whole system in separate pieces so it's easy to grow and maintain.

A. IoT Device Implementation

We built the IoT device to be small and easy to carry, using a tiny computer chip called ESP32. It connects to a GPS module (Neo-6M) to find your exact spot right away, and a GSM module (SIM800) to send messages. We also added a button you can push and a buzzer that makes a sound for emergencies and local alerts.

The device's software was created using Arduino IDE. When you first turn it on, all its parts, like the GPS and GSM modules, get set up, and it starts talking to them. The device keeps an eye on the emergency button all the time. If you press it, the system quickly grabs your current GPS location. If it can't get your live location, it uses the last place it knew you were to avoid any delays.

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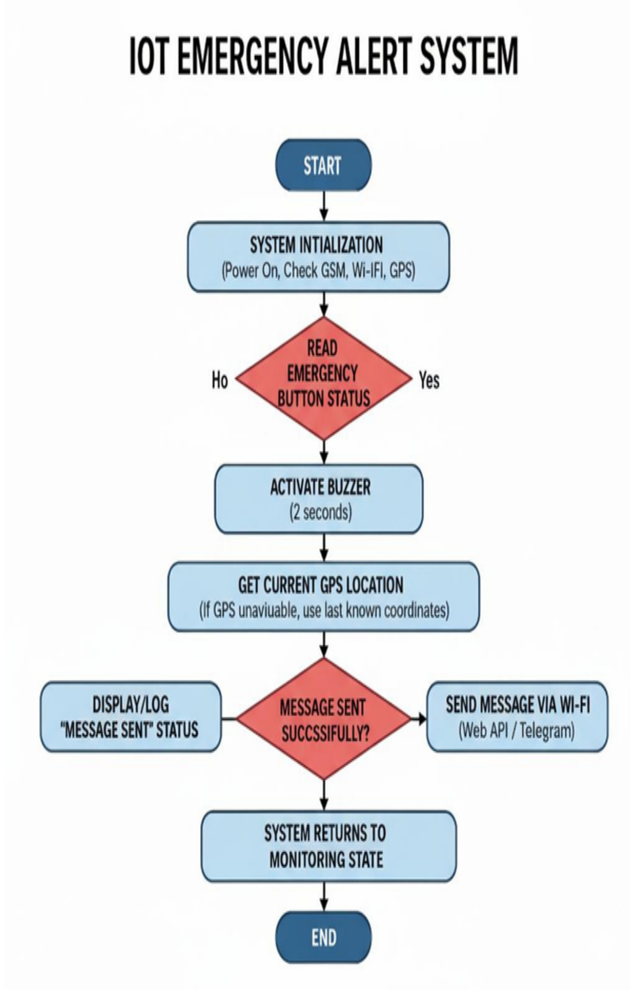

Fig 5.1 : IoT System Design

After it gets your location, it creates an emergency message with your coordinates and a link to a map. It sends this message to your chosen contacts using the GSM module. At the same time, the buzzer beeps briefly so you know it's working.

As you can see in the diagram on Fig 5.1, the system then goes back to watching, ready for the next time it might be needed.

We made sure it doesn't use much power, responds fast, and works without the internet, which is crucial for real emergencies.

B. Android Application Implementation

We built the Android app using Flutter; it's the main way users interact with the system. It lets people use the system, handle emergencies, and see information about safety.

The app has a secure login process, using Firebase Authentication, so users can sign up and get in safely. After logging in, users can manage their emergency contacts, which are saved in the Firebase Realtime Database.

The main thing the app does is send emergency alerts. You can trigger an alert yourself by pressing an SOS button, or it can happen automatically if you, for example, shake your phone. When an alert goes off, the app finds your phone's current location using its services and sends warnings to your saved contacts. These alerts are also saved in a cloud database
for later review.

The app also tracks your location all the time or now and then. This helps with emergencies and gathers data for analysis. There's also a way to report incidents, which helps build up information we can use to predict potential dangers.

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Fig 5.2: Heatmaps

One important feature of the app is showing you dangerous areas using "heatmaps." We take incident data from the backend, process it, and show it on a map, so users can easily see places that might be risky. The heatmap, which you can see on fig 5.2, uses different colors to show how risky an area is.

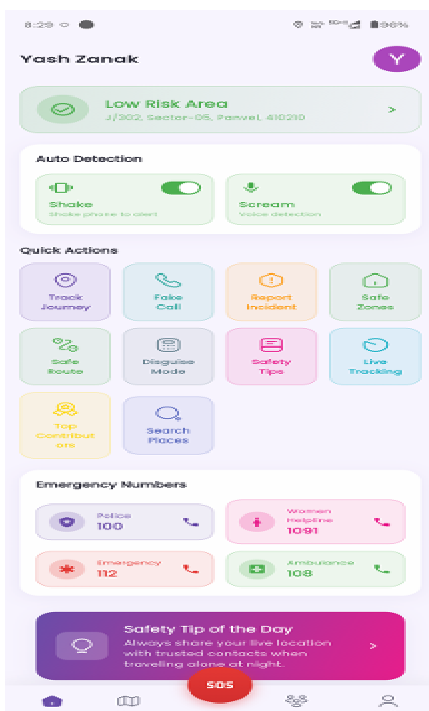

Fig 5.3: Application Dashboard

As you can see in Fig 5.3, we made the app's look and feel simple and easy to use, so you can activate emergency features quickly. The main screen has all the important stuff like the SOS button, live tracking, and other safety tools.

C. Backend Implementation

The system's backend runs on Firebase services, which is a platform that handles data in real time and can grow as needed. We use Firebase Authentication to keep user accounts secure, and the Realtime Database to save user profiles, emergency contacts, and incident reports.

This backend makes sure that the mobile app and all the saved information stay in sync, so everything updates instantly. Plus, Firebase Cloud Messaging sends notifications to users and their emergency contacts when an alert is sent out.

Using the cloud like this makes it easier to set up and manage the app, especially since it's always changing.

D. Machine Learning Integration

We added a machine learning part to the system to help it predict potential dangers. We save incident reports from users in the database and then use them to spot patterns for unsafe places.

We clean up and analyze this data with special models to create those safety heatmaps. We can use methods like looking at sequences or grouping data together to find these high-risk areas. What the model finds then shows up in the app as a heatmap layer over the map.

This means the system doesn't just react to emergencies; it actually helps users be aware of risks beforehand.

E. System Integration and Testing

By bringing together the IoT device, the mobile app, backend services, and the machine learning part, we make sure the whole system works together smoothly. The IoT device takes care of spotting emergencies right away and sending messages, while the mobile app lets users interact and see all the data.

We tested the system in several ways. We checked each part on its own, like how accurate the GPS is, if messages go through, and if alerts trigger correctly. Then, we did integration testing to make sure the app talks properly to the backend and that the IoT device works reliably with everything else. Last, we did a full end-to-end test to confirm that the entire emergency process works as it should.

The system has shown it performs consistently, sending alerts quickly and working reliably even when the network signal isn't strong.

VI. CONCLUSION

Theproject “Machine Learning and IoT-Based Smart System for Women Safety and Emergency Response” successfully demonstrates how emerging technologies can be leveraged to address one of the most critical social challenges—women’s safety. The integration of IoT and Machine Learning provides

a powerful combination of real-time monitoring, automated alert generation, and intelligent risk prediction. The developed system enables users to send instant emergency alerts, share real-time GPS locations, and record audio evidence, ensuring timely assistance and legal support. The inclusion of ML- based heatmaps further enhances safety by identifying and predicting unsafe areas, promoting preventive awareness among users. The prototype’s low power consumption, ease of use, and standalone functionality make it both practical and reliable for real-world application. Overall, the system achieves its objectives by providing a smart, efficient, and user-friendly solution that enhances personal security, reduces emergency response time, and empowers women with greater confidence in their mobility.

VII. FUTURE SCOPE

The Machine Learning and IoT-Based Smart System for Women Safety and Emergency Response has significant potential for future enhancement and real-world implementation. As technology continues to advance, several improvements can be integrated to make the system even more efficient, intelligent, and accessible. Future developments may include AI-based voice recognition and gesture control, enabling hands-free activation during emergencies. The system can also be expanded with cloud integration to store and analyze large volumes of safety data, improving predictive accuracy through advanced data analytics and deep learning models.

Collaboration with law enforcement agencies and public safety networks could allow automatic routing of alerts to nearby police stations for faster response. Additionally, the system can be adapted for other vulnerable groups such as children, elderly individuals, and night-shift workers, thereby broadening its social impact. Enhanced wearable designs using compact sensors, battery optimization, and real-time camera streaming can further improve usability and reliability. In the long term, the project can evolve into a nationwide smart safety ecosystem, integrating IoT and AI with public infrastructure to ensure continuous surveillance, proactive risk management, and safer environments for all.

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