Rakshak: A Multi-Layered Intelligent Framework for Offline-Capable Proactive Emergency Response in Women's Safety Systems

[1]Suvarna Patil, [2]Sneha Kanawade, [3]Yashwant Karnawat*, [4]Karansinh Deshmukh, [5]Siddhesh Chaudhari, [6]Chinmay Karodpati

[1]School of Engineering, Management and Research, D. Y. Patil International University, Akurdi, Pune, India
[2, 3, 4, 5, 6]Department of Artificial Intelligence and Data Science, Dr D. Y. Patil Institute of Engineering, Management and Research, Akurdi, Pune, India
[3]yashwantkarnawat@gmail.com

Abstract. In today's fast-paced society, women's safety is still a major concern despite the tremendous improvements in technology. In addition to having a physical and psychological impact on victims, the rise in harassment, assault, and gender-based violence also imposes broader socioeconomic difficulties by limiting people's freedom of movement and ability to engage in public life. While there are many safety applications available, the majority rely on manual activation techniques, like panic buttons, and need consistent internet access to work properly. Victims may not always be able to manually set off alarms in real-life emergencies, and network constraints in busy or remote locations further diminish the dependability of such systems in dire circumstances. These issues are addressed by the AI-powered mobile safety software Rakshak, which offers real-time support via a clever multi-triggered SOS mechanism. The system recognizes distress situations and automatically generates emergency warnings using AI-driven detection techniques like voice instructions, eye-blink patterns, and tap-based triggers. sponseTo ensure a quicker reaction time, Rakshak promptly notifies registered emergency contacts of the user's location and sends alarm messages upon detection. With the goal of offering a dependable, self-sufficient, and intuitive safety solution for women in public areas, the proposed system aims to reduce reliance on manual intervention by incorporating a multi-trigger detection mechanism.

Keywords: Women's Safety, Artificial Intelligence, Emergency Response, SOS Detection, Mobile Safety Application, Real-Time Monitoring, Multi-Trigger System, Smart Surveillance, Personal Security.

1 Introduction

1.1 Related Work

Despite numerous social measures that have been implemented, women's safety in public and private spaces remain a major issue of concern in society. The utilisation of

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smart safety technologies has contributed to a gradual shift from reactive response systems toward more preventive and intelligent safety solutions [1]. Technological progress in the mobile and wearable gadget industry has made it feasible to do uninterrupted supervision and provide immediate support [2], and therefore, the popularity of AI-based safety applications and wearables has not only been due to their convenience, but their influence has also increased exponentially.

1.2 Main Contribution of the Paper

The paper describes the AI-driven system for women's safety and points out a trend of AI tech from manual triggers to comprehending whisper, gesture, and physiological signal recognition as well as providing protection. Among the examples presented by the Rakshak app, the features like voice commands, eye gestures, and tap patterns coming together, aiming to create smart, safe, and dependable frameworks, are mentioned [3]. The study points out how relevant such innovations are for the Sustainable Development Goals and how keeping a lookout for the existing research issues might help future progress.

1.3 Organization of the Paper

The structure of this document is as follows: Section 2 discusses the literature review, the current trends, the existing conditions, and the gaps in the women’s safety systems. Section 3 explains the methodology for the selection and analysis of the literature and the context for the system architecture of the Rakshak system. Section 4 explains the analytical discussion of the proposed system. Section 5 introduces the reader to the results of the Rakshak system. Section 6 discusses the performance evaluation of the system. Finally, Section 7 concludes the study by highlighting the findings and the development directions.

2. Literature Review

This is a comprehensive study of existing research concerning technologies for the safety of women. It involves integrating the main studies' findings to outline the current stage of development and identify gaps in the research, as highlighted in Table 1. The examination has been organized through an in-depth tabular comparison of the related works, which is then followed by a brief discussion of the uncovered limitations and, lastly, by a performance evaluation.

2.1 Tabular Analysis of Existing Research

Table 1. Literature Review

Ref.	Platform/Dataset	Key Features	Models/Algorithms	Evaluation Parameters	Research Gaps

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Table 1. Literature Review

Ref.	Platform/Dataset	Key Features	Models/Algorithms	Evaluation Parameters	Research Gaps
[3]	Android-based app	Police call & WhatsApp SOS, real-time location sharing	Kotlin, Haversine formula, Google Maps API	Functional testing, user feedback (76.9% trust)	Manual activation, not AI automation, requires internet.
[4]	FRNDY mobile app	Shake-to-activate SOS, fake calls & safe-zone heat maps	GPS tracking, Agile development	User perception survey, system testing	False alarms, no AI features, limited evidence support
[5]	Shakthi Band Wearable	1080p camera & audio recorder, loud alarm, cloud evidence sync	Hardware-software integration	Scenario-based evaluation	High cost, bulky design, stored evidence only
[6]	Survey	Feature comparison (audio, GPS, live streaming)	Waterfall model (proposed design)	Comparative analysis	No new model lacks implementation.
[1]	Raksha app	Community chat & self-defence hub, legal rights info	Standard app stack	Feasibility study	No intelligent triggers, user-dependent features
[2]	SafeRoutes	ML-based safe route prediction, real-time deviation alerts	K-Means, GMM, correlation analysis	Silhouette, CH Index	Predictive only, no crisis-time response
[7]	Real-time intelligence framework	Expert legal system, multi-contact alert, evidence storage	Machine Learning	Prototype testing	Manual evidence input, no threat prediction
[8]	AI-based app	Automatic audio threat detection, cloud evidence backup	ML for audio processing	Accuracy, alert speed	Insufficient model metrics, cloud-dependent
[13]	Go fearless.	Panic/cautious/update modes, police locator & crisis line access.	Standard Android stack	UX evaluation	All manual triggers, no passive detection

2.2 Identification of Research Gaps in Existing Systems

Research on safety technologies for women shows that the main issues raised in the present literature relate to the numerous gaps in the types and qualities of the proposed solutions, which can seriously hinder their effectiveness. One major concern is the over-dependence of such devices on the manual activation mechanisms, for example, button presses, shakes, or single-mode triggers, which may not function in a situation where the user is physically restrained. Similarly, Go Fearless [9] offers specific modes like Panic and Cautious, yet it remains limited by its total reliance on manual activation. Most existing safety systems lack automated threat detection capabilities. As a result, AI-based distress detection using voice, gestures, or physiological indicators is rarely implemented. Additionally, a significant number of applications are dependent to a great extent on the internet connection for their essential operations, e.g., location sharing and messaging, which in such places where network quality is low or the risk is high due to insufficient offline fallback provisions, such as SMS-based alerts, they are of little use [3]. In addition, the current systems' reactive behaviour is another significant issue. It is sometimes possible for certain platforms to provide a manual process of evidence storage, but this is usually without any intelligent analysis being done for legal and investigative purposes [10]. These days, multi-modal trigger systems are a completely different type of input integration that let users use their health data, voice commands, gestures, and taps. However, many existing systems exhibit limitations in reliability, feature integration, and response effectiveness during emergency situations. Furthermore, proactive or predictive systems that can conduct a real-time risk assessment and go beyond the role of guaranteeing the route's safety are still in their infancy. To put it succinctly, these open doors highlight the need for highly developed intelligent, multimodal, offline-capable, and automated frameworks that support women's situational awareness in addition to immediate protection and evidence management [6].

3. Methodology

In order to properly evaluate the literature on the application of artificial intelligence for female safety, the present analysis needed a methodical and systematic approach. It began by searching some of the most widely used research libraries, including IEEE Xplore, ScienceDirect, SpringerLink, ACM Digital Library, Google Scholar, and Scopus, to find relevant works. In the research they conducted, the researchers used keywords related to wearable technology, AI, mobile applications, women's safety, and real-time alerts [11]. The current work reviewed studies published between 2014 and 2024 and was limited to peer-reviewed articles published in the domain of AI-based women's safety systems, real-time emergency response systems, and mobile safety applications. The studies were excluded based on the absence of direct relevance to the above domains and the absence of technical implementation details. The main focus of this analysis was the technical part of the study, specifying the works that were performed through various communication, location tracking, and threat identification, while the writers of policy-only or non-technical works were not taken into account. The research moved on to a thematic analysis to delve into the cited literature describing different aspects of the discussion, such as how the devices were activated (manually or automatically), what the main functionalities of the systems were (alerting, tracking, and evidence collection), their architecture (standalone apps, hybrid hardware, and cloud), and their intelligence level (rule-based vs AI/ML-powered) [5]. Such significant work contributed to discovering the array of women's safety technologies since it paved the way for their categorization according to features, similarities, and the available gaps in research.

3.1 Identification of Research Gaps in Existing Systems

Rakshak system architecture is a detailed AI-powered conceptual design for an Android-based women's safety app that focuses on multi-modal trigger detection, correct location tracking, and trustworthy communication channels as a means of ensuring that the emergency responses are the timely ones, even in cases where the network is down. The design is stepwise in its function, starting with user triggers, passing through the core application processing, and finally, to the sight of notifications at the emergency responders and trusted contacts. The system is designed to operate all the time using foreground services and Work Manager, which are responsible for the efficient use of the device's battery while at the same time providing reliability and fallback in case of a bad network. The 'User Triggers' stage is the first point of interaction that enables both manual and automated methods of activation. Voice commands (e.g., predefined "Help" keywords), eye gestures (three blinks), tap gestures on the back of the phone, and a traditional SOS button are the supported triggers [6]. For immediate processing, these triggers are embedded in the core Android application. The Rakshak Android application, which was created in Kotlin and follows the MVVM architecture, is the main control center. With the help of Google Speech-to-Text for voice, Google ML Kit Face Detection for eye state analysis, and a light TensorFlow Lite model for tap gesture detection. Location services through the Google Maps API offer up-to-date latitude and longitude [12], while Room Database and state management methods take care of local storage for offline support. Considering the efficient delivery of alerts, the users' details and location are packaged.

Reliability is the main concern when designing open communication channels. To address this, the designers have chosen to employ two independent routes. The primary internet-based channel uses cloud functions and Firebase Cloud Messaging to send real-time notifications with live location links to responders. The offline secondary channel is a means of communication, such as SMS or WhatsApp via Twilio, which sends alerts even if the location is an area without internet connectivity [13]. Their decision is made automatically based on the network status, whether it is offline or online. On the other hand, emergency responders and trusted contacts are the ones who get the data along with the live location.

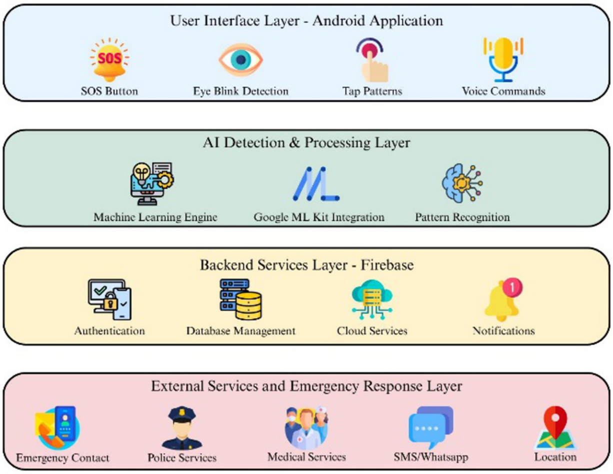

Fig. 1. System Architecture of Rakshak

Therefore, in Fig. 1, there is a feedback loop for immediate intervention that, to a great extent, is made possible because the authorities, the family, or friends may get, acknowledge, and thus act on the received alerts. The Rakshak system architecture implements the idea of modularity, resilience, and efficiency as a way of making it easier to add AI modules or triggers in the future with a minimal computational load. The proposed system also tries to contribute to SDG 5 (Gender Equality) by offering women safe and context-aware solutions through proactive safety features, support for offline operations, and smart alert features.

4. Critical Analysis and Discussions

Literature mentions the evolution of AI-based women's safety systems and how their features gradually changed from the initially manually activated apps to AI-based, multimodal, and automated platforms. By nature, manual systems are simple and highly predictable, similar to the ones described in the studies by [1] and [5], but the problem of these systems is the situations when users cannot operate them. On the other hand, automated systems like SafeRoutes [2] and Rakshak make use of AI/ML along with multi-modal triggers to not only detect but also anticipate the threats, which thereby allow quick escalations. Some issues that these systems can have are false alarms, the problem of privacy, and the consumption of more energy. The next trend in this field appears to be a combination of context-aware automation and dependable manual triggers that ensure robustness and redundancy. From the literature provided, it is evident that the usage of apps will be increased with the help of wearables, cloud analytics, and multiple sensor inputs to provide a complete safety system rather than a standalone product. It is very easy to understand the evolution of the safety industry from a reactive "panic button" system to a proactive system with features like evidence collection and safe path recommendation.

Even though the technology has been enhanced and improved over time, there have been certain limitations that exist. As mentioned in the paper, one of the most important issues is the issue of privacy since the process of continuous monitoring will definitely intrude on the individual's privacy to a very small degree. Additionally, poor system design may cause users to feel anxious rather than confident while using the system. Research works like that of [2] have been based on exercises and have used quantitative measures like Silhouette and BIC Scores. Research works like that of [1] and [4] have been based on the prototype and have used surveys. Several important research gaps are human-centric AI explainability, cross-platform interoperability, integrating psychological and trauma-informed guidance, and low-resource edge-centric AI for offline on-device threat detection. In addition to increasing system accessibility and dependability, filling these gaps will have a significant influence on the women's safety technology industry.

5. Results

We developed an Android application that caters to the given features, such as location sharing, nearby mapping of hospitals and other emergency services, fake calls from emergency contacts, safe route planning, and SOS detection using multiple trigger mechanisms. The application also provides a 24x7 chatbot that can help users interact with the system, and it can be clearly seen in the Fig. 2.

Fig. 2. Landing page of Rakshak

5.1 Personal Information

This module is responsible for collecting and securely storing the user's personal details, including name, phone number, and registered emergency contacts. The information provided by the user is used across various safety features such as SOS alerts, fake calls, and emergency notifications. The personal information dashboard is depicted in Fig. 3.

Fig. 3. Personal Information Details.

5.2 Nearby Emergency Services

The Nearby Emergency Services module enables users to locate essential emergency facilities such as hospitals, police stations, and other safety services in their vicinity, as shown in the Fig. 4.

Fig. 4. Emergency Services.

5.3 Fake Call Scheduling

This feature allows users to schedule or instantly trigger a fake incoming call from a predefined emergency contact. The fake call feature acts as a preventive safety mechanism, helping users escape uncomfortable or threatening situations by simulating a genuine phone call with customizable caller details and timing, as shown below in Fig. 5.

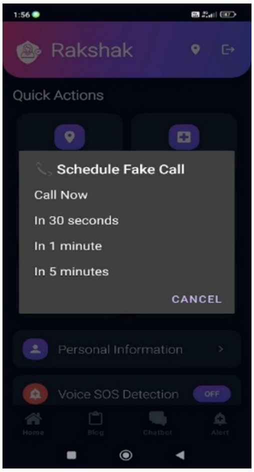

Fig. 5. Fake Call Mechanism.

5.4 Safe Route Planning

The Safe Route Planning analyses available routes between a source and destination and suggests safer paths to the user. The safety analysis is performed based on factors such as crowd density, previously identified risk zones, and time of travel, as we see in Fig. 6.

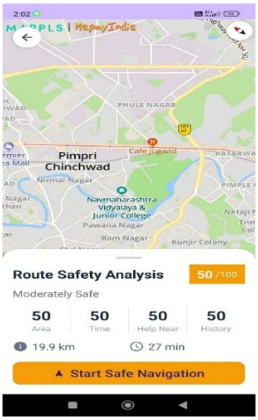

Fig. 6. Safe Route Analysis.

5.5 SOS Trigger Mechanism

This module provides multiple SOS activation mechanisms to ensure accessibility in emergency scenarios. The SOS can be triggered through screen taps, eye-blink detection, or voice-based distress commands. Once activated, the module immediately sends alerts along with the user's real-time location to registered emergency contacts and relevant services, as shown in Fig. 7.

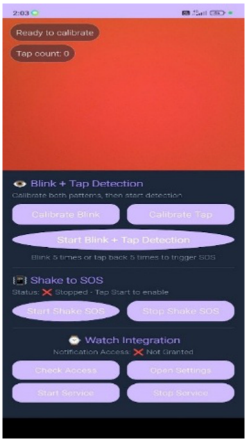

Fig. 7. Multi-trigger SOS.

5.6 SMS based alert module

To ensure effective functionality even in areas with no internet, this module allows the sending of SOS messages through SMS, as the system automatically switches to SMS-based communication in case there is no internet connectivity, ensuring effective sending of messages and location information to emergency contacts we see in Fig. 8.

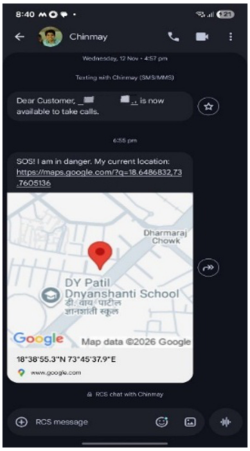

Fig. 8. SMS received by emergency contact.

5.7 24*7 Chatbot Assistance

This module offers continuous support to the user through continuous interaction with the application in real-time. This helps the user to effectively utilize the application's features, emergency guidance, and general safety queries, as shown in the Fig. 9.

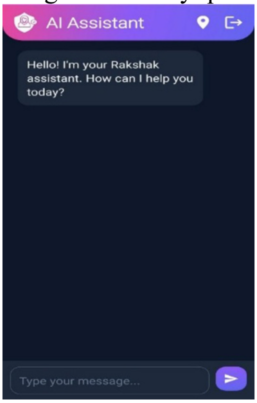

Fig. 9. Chatbot assistance.

6. Performance Evaluation

6.1 Prototype Testing

The system validation was carried out through prototype execution using real-time Firebase logs. The evaluation was performed under different usage scenarios, including internet-enabled and low-connectivity conditions, where multiple trigger events were generated and observed. The validation focuses on system behavior and response rather than formal experimental evaluation, and all the evaluations we can see are in Fig. 10.

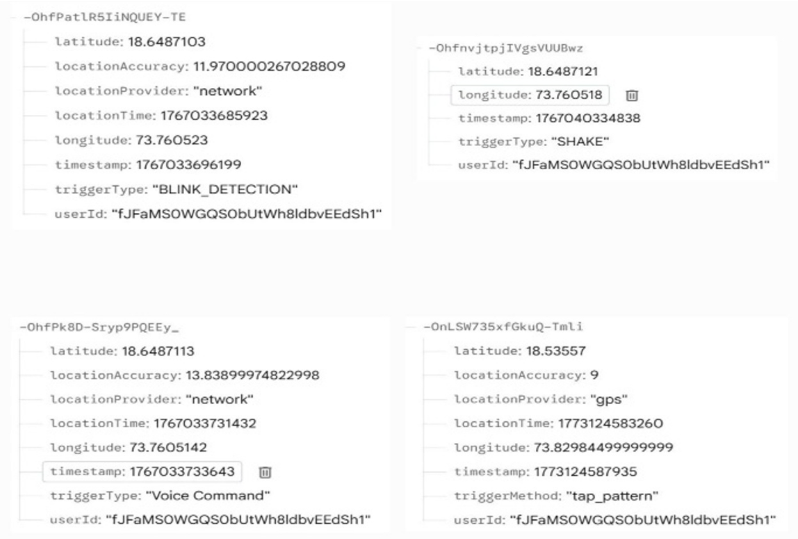

Fig. 10. Firebase database logs showing different SOS trigger events and corresponding system responses during prototype execution.

6.2 24*7 Chatbot Assistance

Multiple activation methods, including voice commands, eye-based detection, tap gestures, manual SOS activation, and wearable-triggered inputs, were validated through system behaviour and recorded logs. The system successfully detected trigger inputs such as "SHAKE" and "tap_pattern" and initiated emergency alerts accordingly, as shown in Table 2.

Table 2. Functional Validation of SOS Trigger Mechanisms

Trigger Mechanism	Functionality Status
Voice-based SOS command	Successfully triggered alerts
Eye-blink gesture detection	Successfully activated SOS
Tap gesture trigger	Successfully detected and activated SOS
Manual SOS button	Functional

6.3 Communication Reliability

The communication module was demonstrated under both internet-enabled and low-connectivity scenarios. In internet-enabled conditions, the system successfully transmitted alerts along with the user's real-time location through Firebase-based notification services. In low-connectivity scenarios, alerts were delivered using SMS-based communication, ensuring continuity of emergency response. The evaluation is based on observed system behavior during prototype execution rather than formal time-based measurement, as shown in Table 3.

Table 3. Response Time for SMS-Based Communication

Communication Method	Status (Observed)
With Internet Connectivity	Alert successfully delivered
With Low/No Internet (Offline)	Alert successfully delivered via SMS

6.4 System Functionality Verification

The trigger mechanisms were validated using real-time Firebase logs generated during prototype execution. The logs captured multiple trigger events (e.g., SHAKE and tap_pattern) along with corresponding system responses. These events were generated through repeated input attempts, and the system's ability to detect and respond to each trigger was observed, as indicated in Table 4.

Table 4. Small-Scale Experimental Validation of SOS Trigger Mechanisms

Test	Result
Voice Command Test	16/20 detected
Tap Trigger Test	17/20 detected
Blink Pattern Trigger	17/20 detected
SMS Alert Delivery	100% delivered

6.5 Battery Consumption Analysis

The battery consumption was analyzed in order to ensure that the continuous monitoring does not affect the performance of the smartphones, as shown in Table 5.

Table 5. Battery Consumption Life

System Activity	Average Battery Usage
Background Monitoring	3-4% per hour
Active SOS Processing	6-7% per hour

7. Conclusion and Future Scope

7.1 Conclusion

The Rakshak represents the evolution of conventional women's safety solutions to intelligent, AI-based, and multi-modal safety solutions. It shows the need for real-time monitoring, intelligent alert generation, multi-trigger emergency, and mobile, wearable, and surveillance-based safety solutions. Although Rakshak has overcome many of the current limitations, there are still many challenges to be addressed, such as offline safety solutions, automatic evidence collection, and integration with emergency and legal services. The research has shown how it is essential to consider user trust and privacy in the development of intelligent safety solutions for women.

7.2 Future Scope

The system may also be able to evolve to provide intelligent communication systems that use cellular networks, internet networks, and peer-to-peer networks to ensure emergency alerts are delivered in low-connectivity zones. Other areas for further research include federated learning for intelligent systems to provide enhanced privacy, legal-tech integration for enhanced evidence handling, and so forth. Moreover, future research directions also include ethics in AI, balancing proactive safety with user privacy, and providing a totally integrated, adaptive, and socially acceptable women's safety solution rather than safety tools in isolation.

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