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RAKSHAK: A Multimodal Android Safety Platform Integrating Discreet Emergency Triggers and Responsible AI-Driven Support

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Abstract

Women's safety apps have traditionally employed conventional panic button designs, which are immediately rendered ineffective as soon as the user finds herself in a situation where she cannot openly touch her screen. This paper proposes RAKSHAK, a native Android platform based on two unconventional, low-probability emergency triggering techniques—a computer vision pipeline for detecting deliberate eye blink patterns and an accelerometer-based signal processing pipeline for detecting deliberate triple tap rhythms. Along with these low-probability emergency triggering techniques, RAKSHAK also offers proactive assistance in the form of live sharing, a facility-finding mechanism based on proximity, informative content, and a scope-bound AI-powered chat assistant based on the Gemini large language model. The efficacy of RAKSHAK was validated through a study involving twenty participants, with results indicating a range of 85.5% to 99% for the true positive rate of the emergency triggering techniques and a SUS score of 82.5. An ethical architecture for the scope-bound AI-powered chat assistant offered in RAKSHAK serves as a reusable template for the safe deployment of generative AI in safety-critical mobile applications.

Keywords: Women Safety; Android Application; Blink Detection; Accelerometer Pattern Recognition; Large Language Model; SOS Alert; Emergency Response.

How to Cite This Article

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Introduction

Background and Motivation

One of the most intractable and pervasive problems in the field of global health is violence against women. International bodies have indicated that "nearly one in three women will experience some form of physical or sexual assault in her lifetime" [1]. Mobile phones are a natural fit for safety tools because they are always with the person. However, the dominant interaction pattern—pressing a button that is clearly visible—is the opposite of effective in the situation where it is needed the most. A person who is bound, closely observed, or overcome with extreme fear is unlikely to be able to open the phone and press a button.

Furthermore, safety tools are almost exclusively passive tools. They provide no way of preparing the person in advance of the situation and provide no guidance afterwards. This is the reason for the need for a completely different approach that conceals the activation mechanism from the would-be perpetrator and provides the person with an empowering experience in the aftermath of the emergency situation.

Research Objectives

RAKSHAK was designed to address the technical and support gaps in one go. Five objectives guided the development:

- Design covert alert triggers that function without any screen interaction.
- Make the trigger mechanisms physically independent so that one constraint cannot disable both.
- Develop a layered architecture that provides proactive content, legal awareness, community information, and facility search in addition to reactive emergency tools.
- Provide a well-documented and reproducible framework for incorporating large language models into safety-critical applications.
- Validate the experience through a thorough controlled study.

Key Contributions

Four specific advancements can be identified:

- A blink recognition system based on an algorithmically determined duration threshold for identifying intentional SOS signals versus involuntary eye movements.
- An orientation-agnostic tap recognition system based on both magnitude domain processing and finite state pattern recognition.
- A multi-layered AI chatbot guardrail system based on scope, determinism in crisis escalation, and honest user dialogue.
- A set of experimental results regarding trigger performance/usability in six different controlled environments with twenty users.

Related Work

Mobile Safety Application Landscape

The evolution of smartphone-based safety applications has mirrored the evolution of mobile devices as a whole. Initial applications sent an SMS and activated the siren on the phone with the click of a single button . Later versions integrated GPS coordinates to allow the recipient to navigate to the sender's location. Other applications, such as My Safetipin, use crowd-sourced information to provide dynamic neighborhood danger maps [6]. Other applications, such as Circle of 6, emphasize peer-based assistance networks [9]. Government applications, such as the one launched by the Delhi Police under the name "Himmat Plus," indicate the seriousness with which the government has committed to mobile-based safety infrastructure in the region [8].

A 2021-based analysis of shake-based applications reported the constant failure of gesture-based alert systems in the course of everyday movement [5]. A further analysis by feminist media studies argued that the responsibility being placed on the end-user could lead to the entrenchment of gender-based labor without effectively addressing the underlying factors [7]. RAKSHAK tackles both issues: the triggering mechanism minimizes the end-user's responsibility, and the content layer directly addresses the awareness needs.

Sensor-Based Covert Triggering

Smart jewelry and smart wristbands provide the best sensing capabilities in the most unobtrusive fashion but come with the disadvantages of additional expense, the need for charging, as well as cultural acceptability in various societies [4]. Software-based triggering using the front camera or the inertial measurement unit removes the disadvantages mentioned above but comes with the disadvantages of poor lighting as well as the difficulty in distinguishing purposeful taps from ambient noise. RAKSHAK tackles both disadvantages: the camera-based approach uses adaptive normalization, and the inertial-based approach uses multi-stage frequency filtering.

AI Chatbots in Crisis-Adjacent Roles

The use of chatbots has significant appeal as a 24/7 solution without the social stigmas associated with it. However, the possibility of providing incorrect information, the provision of shallowly empathetic responses, as well as the entrenchment of the habit of relying on the chatbots as a solution to underlying issues are significant challenges in the use of chatbots in crisis-adjacent applications. RAKSHAK tackles this as a hard engineering problem by designing the chatbot module from the ground up.

Table 1. *Comparative Overview of Women Safety Application Categories*

Feature	**Conv.**	**Wearable**	**AI-Only**	**RAKSHAK**
Covert Activation	✗	✓	✗	✓
Screen-Off Operation	✗	✓	✗	✓
AI Conv. Support	✗	✗	✓	✓
Proactive Content	Part.	✗	Part.	✓
Ethical Guardrails	✗	✗	Part.	✓
No Extra Hardware	✓	✗	✓	✓

System Architecture

Three-Tier Technical Stack

RAKSHAK has a clear division of responsibilities across three tiers, each designed to optimize for a unique set of performance, security, and offline requirements.

- Client Tier. The Android app is built using Kotlin and XML for layout, providing direct access to the camera, accelerometer, and GPS radio without the need for any bridge layer. The real-time sensor processing and face detection code executes on this tier, keeping the blink trigger alive even in offline scenarios.
- Cloud Services Tier. The app utilizes Google Firebase for cloud storage and notification services. The Firebase Authentication service is used for managing user accounts, while Cloud Firestore is used for storing contact lists with field-level security rules. Cloud Functions host server-side code for alert dispatching, ensuring sensitive routing code is not embedded in the app.
- AI Inference Tier. The conversational AI service is only exposed through the Firebase AI Logic SDK, which wraps the Gemini API. The API key is stored server-side, avoiding any possibility of it being embedded in the APK, which is all too easy in Android binaries.

Functional Modules

The feature set is segmented across four modules:

- Emergency Response: Live location using Fused Location Provider API, SOS messages through Cloud Functions, and a Nearby Facility finder using Google Places API.
- Novel Triggers: Blink detection pipeline and accelerometer tap recognizer (IV).
- Empowerment Content: A feed of legal rights and safety information and support services through a dynamic feed of links to UN Women and associated entities.
- AI Assistant: A chatbot for resource lookup and empathetic acknowledgment and crisis escalation (V).

(a) Home dashboard (b) Blog highlights (c) UN Women feed (d) Hospital locator (e) Emergency calls

Fig. 1. *RAKSHAK application screens: (a) Home dashboard with prominent SOS button and quick-access tiles for Location Sharing, Nearby Hospital, and Emergency Contacts; (b) Empowerment blog feed showing curated women's rights content; (c) Embedded UN Women content feed; (d) Proximity-based hospital locator powered by MapmyIndia; (e) Pre-loaded national emergency helpline directory.*

Novel Emergency Trigger Mechanisms

Dual Modality Design Philosophy

The basic safety requirement is that a physical state should not disable all activation pathways. For instance, in one case, a perpetrator holds the victim's hands, leaving her face accessible. In another case, he observes the victim's gaze, leaving her hands free. By designing one trigger for each case that is mechanistically independent of each other, at least one pathway will be available. An optical and an inertial trigger are examples of this design philosophy.

Eye Blink Pattern Detection

Physiological Basis:

The duration of an involuntary blink is between 100 and 400 ms. A prolonged eye closure is beyond this range and indicates a deliberate action. RAKSHAK takes advantage of this to distinguish between a deliberate and an involuntary action.

Detection Pipeline:

- Continuous frame-by-frame analysis is applied to the front camera feed:
- Each frame is processed by a face detection model running locally. Each eye is classified as open or closed.
- A timer is initiated when the eyes are closed. When this state exceeds 500 ms, this is classified as a long blink.
- Two long blinks within any 3-second window trigger an SOS signal.

The 500 ms threshold ensures that involuntary blinks are distinguished from voluntary blinks under any stress. The two long blinks reduce spurious detection under normal circumstances.

Environmental Robustness:

Histogram equalization is used to normalize pixel values to account for variations in lighting. In cases where one eye is obstructed, single-eye detection is used. Intermittent lack of landmark detection due to rapid head movements merely suspends the timer without resetting it. This ensures that a temporary interruption does not force the user to reinitiate the blinking sequence.

Calibration Screen:

One-time personalization is done for every individual. A viewfinder of the camera is visible while a tap count is used to monitor progress towards completion of five blinks. These measured times are used to set individual thresholds for that person. This is because there is natural variation in the speed of deliberate blinks.

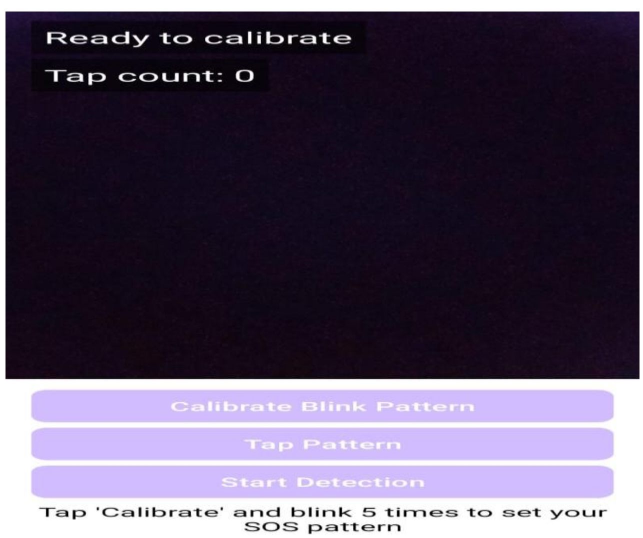

Fig. 2. *Blink-pattern calibration screen. After tapping "Calibrate Blink Pattern" the user performs five deliberate long blinks; the app records their closure durations to build an individual-specific detection threshold. "Tap Pattern" switches to accelerometer calibration; "Start Detection" then activates background monitoring.*

Accelerometer Tap-Pattern Recognition

The tap module filters raw three-axis accelerometer data from a three-axis accelerometer sensor through a series of four stages:

- Stage 1 - Magnitude Computation: The three-axis readings are collapsed to a magnitude $M = \sqrt{x^2 + y^2 + z^2}$ that is independent of orientation and rotation of the device.

- Stage 2 - High-Pass Filtering: A high-pass filter is applied to filter gravity and walking cadence that would otherwise obscure the sudden impulse of a deliberate tap.
- Stage 3 - Peak Detection: Peaks in the data that are above a certain calibrated level are detected and recorded.
- Stage 4 - Finite State Matching: A state machine is used to confirm a tap event if three peaks are detected within a 1.5 s window. This is sufficiently long to allow a triple tap and sufficiently short to exclude ambient jolts.

The amplitude level was calibrated through a series of experiments; similarly, the 1.5 s window was calibrated through a series of experiments**.**

AI Conversational Assistant

Secure Integration Architecture

The RAKSHAK application exclusively depends on the Firebase AI Logic SDK to access the Gemini language model and does not send any direct HTTP requests. By doing so, it bypasses three common mobile AI security issues:

1. No API key is embedded in the APK binary; rather, it is stored and managed by the server.
2. Firebase App Check validates that requests are coming from a legitimate and genuine application instance.
3. Rate limiting at the SDK boundary prevents bulk generation of requests that can increase costs and degrade service quality.

Defined Functional Scope

The RAKSHAK chatbot explicitly denies any role in acting as a therapist, doctor, or legal advisor. Three valid scenarios are conveyed to users and are optimised in the prompt configuration:

- Resource Navigation The chatbot interprets user queries in plain language and fetches information from a verified list of shelters, legal services, counseling services, and government schemes.
- Emotional Acknowledgement In non-emergency scenarios, the chatbot maintains a positive and non-judgmental attitude that allows users to express their issues freely.
- Crisis Escalation. High-risk language will immediately stop the generative response; a pre-approved message will be sent instructing the user to click the SOS button or seek alternative emergency services.

Guardrail Architecture and Ethics

- Content filtering uses a system prompt that precedes every turn in the conversation, instructing the AI to decline medical diagnoses, legal decisions, and off-topic or dangerous content suggestions. Since it is injected at the API level, it cannot be overridden by the user through clever prompt design.
- Crisis detection uses a keyword match that operates separately from the language model. If words related to immediate danger, such as “attack,” “threatened,” or “help now,” are present in a message, it will interrupt the response before it is generated by the language model.
- Transparency is maintained by a notice always present on the screen that informs the user the assistant is AI-powered, that it has limitations, and that the user should always seek alternative services in emergency situations.

This notice will always be present and cannot be dismissed, guarding against the user becoming too comfortable with the assistant and potentially making the wrong choice in a life-threatening situation by not making a phone call to the emergency services.

Evaluation

Study Protocol

The study used twenty volunteers from a university campus. There were two parallel tracks in this study: a controlled trigger performance assessment over six different conditions, and a usability evaluation by employing the System Usability Scale, think-aloud, and exit interviews.

For each trigger, ten trigger events were conducted under a given condition, followed by five minutes of normal activity, from which false positive rates were determined. There were six conditions in total: blink in stationary/bright, blink in walking/bright, blink in stationary/dim; tap when device is in hand in stationary, tap when device is in hand in walking, and tap when device is in a closed purse in walking.

Trigger Performance

Tap pattern recognition was superior to blink detection in terms of both accuracy and response time in all conditions where both were implemented. The worst condition for the vision module was when the user was walking in bright light, where motion blur and intermittent loss of landmarks were issues. Stationary conditions in dim light were easier on the blink trigger than motion, implying that histogram equalization is successful in compensating for lighting variance. The worst false positive rate, at 4.0%, was for tap in purse in walking, and this was still within acceptable limits for a safety application.

Table 2. *Trigger Mechanism Performance Across Test Conditions*

Condition	TPR	FPR	Time (ms)
Blink — Stat./Bright	96.5%	0.5%	3,250
Blink — Walk./Bright	88.0%	1.5%	3,870
Blink — Stat./Dim	91.0%	1.0%	3,610
Tap — Hand/Stat.	99.0%	0.2%	1,850
Tap — Hand/Walk.	94.5%	2.5%	2,100
Tap — Purse/Walk.	85.5%	4.0%	2,450
Baseline — Button	100%	0.0%	850

Usability Results

The overall SUS score of 82.5 puts RAKSHAK in the "Excellent" category. The exit interviews showed that participants preferred the discretion offered by the novel triggers more than the speed of activation, thereby directly validating the design hypothesis. The low score for the triggers compared to the blog content can be explained by the need for a one-time calibration, which was cited as the biggest friction point. The scores for the chatbot were affected by the remaining uncertainty regarding AI reliability in critical situations.

Table 3. *System Usability Scale (SUS) Scores by Application Component*

Component	Mean SUS	Std. Dev.	Rating
Overall Application	82.5	10.1	Excellent
Novel Triggers	75.0	12.4	Good
Educational Blog	88.5	6.3	Excellent
AI Chatbot	71.5	13.2	Good

Acknowledged Limitations

There are three constraints that bound the interpretation of this result. One is that a laboratory environment cannot replicate the adrenaline and cognitive stress of a real emergency. Second is that a single-campus recruitment pool does not allow for demographic breadth in terms of age range, physical abilities, and cultural context. Third is that environmental factors such as battery state, network reliability, and noise were not modelled and deserve dedicated longitudinal investigation.

Conclusion And Future Directions

Summary

As RAKSHAK shows, well-designed discrete and hardware-independent emergency triggering is feasible on a regular Android device and naturally fits into a larger empowerment framework. Good measured results were obtained for the blink and tap approaches, and their structural independence ensures that removing one option would not impact the other. An overall SUS score of 82.5 confirms that the system is easy to use for untrained users. The guardrail framework that was developed for the AI assistant has the potential to be used directly by others working on LLM-based tools in safety-critical domains.

Future Work

Four research avenues appear to be the most promising in terms of immediate productivity. For instance, integrating wearable sensors, such as accelerometers on smartwatches, could enhance blink strength in extreme lighting conditions and tap detection when the phone is away from the user. Fine-tuning models on crisis support dialogue corpora, developed in a manner that is ethical and includes survivor communities, could further develop empathetic alignment beyond what is possible through system prompts. Sensor fusion of fall detection, passive audio, and inertial pattern matching could enable high-confidence alerts without user intervention. Community features, such as crowdsourced safety scoring, peer support, and incident reports, could transform RAKSHAK from a personal safety assistant to a community safety infrastructure for entire communities.

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