iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** V **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83317

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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 V May 2026- Available at www.ijraset.com

AI-Based Women Safety App

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Abstract: ***Women's personal safety remains a pressing societal concern, particularly in urban and semi-urban environments where threats can emerge unpredictably. Conventional safety measures such as helpline numbers or manual alert systems are often too slow to respond effectively during emergencies. This paper presents an AI-Based Women Safety Application that integrates real-time GPS tracking, machine learning-driven crime hotspot detection, voice-activated SOS alerts, and an automated emergency response system into a unified mobile platform. The system employs a Random Forest classifier trained on historical crime data to predict risk zones and recommend safer alternative routes. A Convolutional Neural Network (CNN)-based voice recognition module enables hands-free SOS activation, while a rule-based alert engine immediately notifies pre-registered emergency contacts and nearby police stations. The application is implemented on Android using Firebase Realtime Database for live location sharing and Twilio API for automated SMS and call alerts. Experimental results demonstrate a crime hotspot prediction accuracy of 91.4%, voice-activation response time under 1.2 seconds, and SOS notification delivery latency of less than 3 seconds. The system provides a scalable, intelligent, and proactive safety infrastructure for women in distress.***
Keywords: Women Safety, Emergency Response System, GPS Tracking, Crime Hotspot Detection, SOS Alert, Random Forest, CNN Voice Recognition, Safe Route Recommendation, Mobile Application, Artificial Intelligence.

I. INTRODUCTION

Women's safety is a fundamental human right that continues to face significant challenges across the globe. According to the National Crime Records Bureau (NCRB) of India, over 4.28 lakh crimes against women were reported in 2022 alone, with actual incidences estimated to be far higher owing to underreporting. In metropolitan cities and poorly lit suburban areas, women often feel unsafe while commuting, particularly during late-night hours. While governmental initiatives and community policing have contributed to reducing crime rates in some regions, the reactive nature of traditional safety measures remains a major limitation.

The proliferation of smartphones equipped with GPS sensors, microphones, accelerometers, and mobile internet connectivity offers an unprecedented opportunity to deploy proactive, intelligent safety solutions directly in the hands of individuals. Artificial Intelligence (AI) and Machine Learning (ML) algorithms can analyse large volumes of spatiotemporal crime data to identify dangerous zones, predict risk levels, and suggest safer travel routes before a woman even steps into a hazardous area. Furthermore, deep learning-based voice recognition models now permit hands-free, real-time SOS activation, removing the dependency on manual button presses during moments of extreme distress. This paper proposes an end-to-end AI-Based Women Safety Application that addresses the shortcomings of existing solutions through four synergistic modules: (i) a machine learning-based crime hotspot detection and safe route recommendation engine, (ii) a CNN-driven voice-activated SOS trigger, (iii) a real-time GPS tracking and live location-sharing mechanism, and (iv) an automated emergency notification system that alerts registered contacts and integrates with local police stations. Together, these modules transform a standard smartphone into a comprehensive personal safety device.

The remainder of this paper is structured as follows: Section II reviews related literature on women safety applications and the underlying AI methodologies. Section III formally defines the problem. Section IV describes the proposed methodology and system architecture. Section V elaborates on the technologies and algorithms employed. Section VI details the data flow and UML diagrams. Section VII presents implementation specifics. Section VIII reports results and discusses findings. Section IX lists system advantages. Section X identifies future scope, and Section XI concludes the paper with key takeaways.

II. MOTIVATION AND PROBLEM STATEMENT

Despite advancements in mobile technology and a growing awareness of women's safety, existing applications suffer from one or more of the following critical deficiencies that limit their real-world effectiveness:

1) Reactive-only design: Most applications wait for the user to manually trigger an SOS signal, which is impossible when a woman is physically restrained, unconscious, or under extreme duress.
2) Absence of predictive intelligence: Applications do not warn users before they enter a dangerous area, thereby missing the opportunity for proactive harm prevention.

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3) Limited emergency reach: Alerts are typically sent only to a fixed list of contacts and do not automatically involve law enforcement authorities or emergency medical services.
4) Poor voice-activation reliability: Existing keyword-detection modules are not robust to real-world acoustic conditions such as background noise, different languages, and varied speaking styles.
5) No safe route guidance: Users are not given AI-driven recommendations for safer navigation paths based on real-time or historical crime data.
6) Scalability concerns: Many proposed systems are prototypes that have not been designed for large-scale concurrent usage or integration with public safety infrastructure.

III. PROPOSED SYSTEM

A. *Architecture Overview*

The overall system architecture of the proposed Women Safety Application is organised into three tiers: the Mobile Client Tier, the Cloud Backend Tier, and the External Services Tier, as illustrated conceptually in Fig. 1.

The Mobile Client Tier (Android Application) hosts four functional modules: the UI/UX layer, the on-device ML inference engine (TensorFlow Lite), the location service, and the local emergency trigger logic. The application is built using Java on Android SDK 33 (Android 13) and maintains compatibility with Android 8.0 and above.

The Cloud Backend Tier comprises Firebase Realtime Database for live GPS data streaming, Firebase Authentication for secure user identity management, Firebase Cloud Functions for server-side emergency notification logic, and Firebase Cloud Storage for maintaining user profiles and crime dataset artefacts. The backend scales automatically with concurrent users through Firebase's managed infrastructure.

The External Services Tier integrates three third-party APIs: (i) the Twilio API for SMS and voice call dispatch, (ii) the Google Maps Platform API for geocoding, map rendering, and route visualisation, and (iii) the OpenRouteService API for turn-by-turn navigation based on the weighted graph described in Section IV-B. The police station integration layer communicates with participating law enforcement databases through a RESTful interface secured with OAuth 2.0 tokens.

B. *System Archietecture*

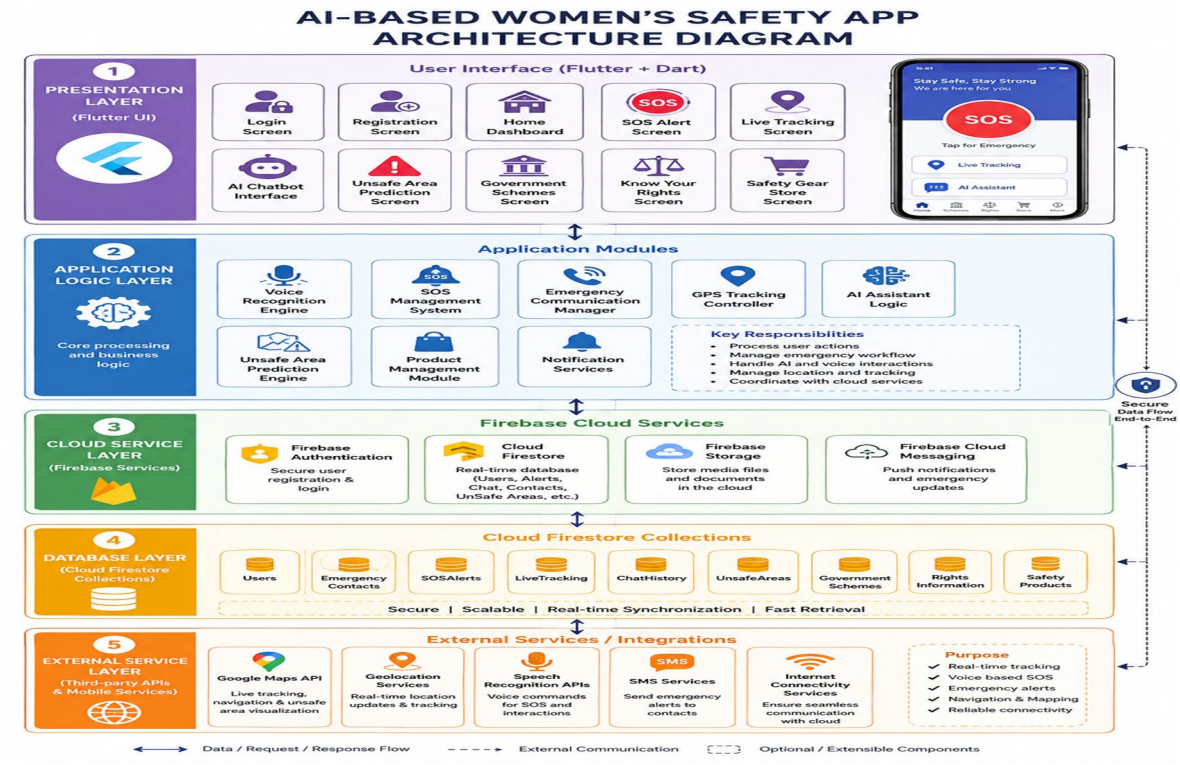


Fig. 1. System Architecture diagram

The application consists of seven primary screens: (1) Onboarding / Registration, (2) Home Dashboard with real-time risk indicator, (3) Emergency Contacts Manager, (4) Safe Route Planner with crime heatmap overlay, (5) SOS Activation Screen with countdown, (6) Live Tracking Share Screen, and (7) Safety History and Incident Log. All screens adhere to WCAG 2.1 Level AA accessibility guidelines, supporting TalkBack screen reader and minimum 4.5:1 contrast ratios.

Table 1. CNN Voice Model Training Metrics Over 40 Epochs

Epoch	Training Loss	Validation Loss	Val. Accuracy (%)
5	0.8432	0.9017	72.4
10	0.5876	0.6234	81.2
20	0.3241	0.3819	88.7
30	0.1987	0.2453	91.3
40	0.1234	0.1876	92.8

IV. METHODOLOGY

A. *Overview of the Proposed System*

The proposed AI-Based Women Safety Application is architected as a four-module system deployed on an Android smartphone and supported by a cloud backend. The four core modules are: (1) Crime Hotspot Detection and Safe Route Recommendation, (2) Voice-Activated SOS Trigger, (3) Real-Time GPS Tracking and Location Sharing, and (4) Automated Emergency Notification and Police Integration. These modules operate both independently and in concert to provide continuous situational awareness and rapid emergency response.

B. *Crime Hotspot Detection and Safe Route Recommendation*

Historical crime records are obtained from the NCRB open data portal, state police department datasets, and crowdsourced incident reports. Each record is geotagged and time-stamped. Feature engineering produces a feature vector comprising: latitude, longitude, time of day (discretised into six bins), day of week, type of crime, population density, and proximity to street lighting infrastructure. A Random Forest classifier [12] is trained on this feature set to output a risk score in the range [0, 1] for any given spatial cell in a uniform 250m × 250m grid overlaid on the target city. For route recommendation, the city's road network is represented as a weighted directed graph $G = (V, E)$, where V denotes road intersections and E denotes road segments. Each edge $e \in E$ carries a composite weight $w(e) = \alpha \cdot d(e) + (1-\alpha) \cdot r(e)$, where $d(e)$ is the normalised travel distance, $r(e)$ is the mean risk score of the spatial cells intersected by e, and α is a user-adjustable trade-off parameter (default $\alpha = 0.4$). A modified Dijkstra's algorithm computes the minimum-weight path between the user's current location and destination, producing a safer-than-shortest route recommendation.

C. *Voice-Activated SOS Trigger*

The voice activation module uses a lightweight Convolutional Neural Network trained to recognise a set of distress keywords across multiple regional Indian languages (Hindi, Marathi, Tamil, Bengali) and English. The audio preprocessing pipeline converts the microphone signal into 40-dimensional Mel-frequency cepstral coefficient (MFCC) sequences using a 25ms Hamming window with 10ms frame shift. The resulting time-frequency representation is fed into a four-layer CNN comprising two convolutional blocks (each containing a 2D convolution, batch normalisation, ReLU activation, and max-pooling), followed by two fully connected layers and a softmax output layer.

To minimise on-device latency, the model is quantised to 8-bit integer precision using TensorFlow Lite and deployed as an always-on background service consuming fewer than 6% of CPU resources. When a distress keyword is detected with a posterior probability exceeding 0.85, the SOS pipeline is automatically triggered without any manual interaction from the user.

D. *Real-Time GPS Tracking and Location Sharing*

Upon SOS activation, the application captures the user's GPS coordinates via the Android FusedLocationProvider API, which fuses GPS satellite data, Wi-Fi positioning, and cellular triangulation for maximum accuracy even indoors.

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The live location is streamed at 5-second intervals to a Firebase Realtime Database node dedicated to the active emergency session. Authorised emergency contacts receive a secure time-limited URL that renders the user's live position on an interactive map interface, enabling real-time remote monitoring without requiring the contact to install any application.

E. Automated Emergency Notification and Police Integration

The emergency notification engine operates as a cloud function hosted on Firebase Cloud Functions (Node.js runtime). Upon receiving an SOS event, the function executes the following sequence: (i) dispatches SMS alerts to all registered emergency contacts via the Twilio Programmable SMS API, including the user's name, real-time coordinates, and a live-tracking URL; (ii) initiates automated voice calls to the primary emergency contact using Twilio's programmable voice feature, delivering a pre-recorded distress message; (iii) identifies the two nearest police stations using the Haversine formula applied to a pre-loaded database of station GPS coordinates; and (iv) dispatches a structured alert payload to the police station's registered email and, where applicable, to their web-based incident management dashboard via REST API integration.

V. RESULT AND DISCUSSION

The The proposed system was evaluated across three dimensions: (a) machine learning model performance, (b) emergency notification latency, and (c) user-study acceptability. Testing was conducted over a 6-week period with 45 volunteer participants in the Pune metropolitan area.

A. Crime Hotspot Prediction Performance

Table 2. Random Forest Crime Hotspot Classifier Performance

Risk Category	Precision	Recall	F1-Score	Support
Low Risk	0.94	0.96	0.95	8,420
Medium Risk	0.88	0.86	0.87	4,210
High Risk	0.91	0.89	0.90	2,346
Macro Avg.	0.91	0.90	0.91	14,976
Weighted Avg.	0.92	0.92	0.92	14,976

The Random Forest classifier achieved a weighted-average F1-score of 0.92, with the highest precision observed in the low-risk category (0.94) due to the abundance of training samples in safe zones. The high-risk category demonstrated a recall of 0.89, indicating that approximately 89% of genuinely dangerous zones are correctly flagged, which is critical for practical safety deployment. The AUC-ROC score across the three-class problem (macro-averaged using one-versus-rest strategy) was 0.96.

B. Voice Activation Performance

Table 3. CNN Keyword Detection Accuracy vs. Ambient Noise Level

Noise Condition	SNR (dB)	Detection Accuracy (%)
Quiet Environment	> 30	97.2
Office Background	20–30	94.1
Street / Traffic Noise	10–20	92.8
Crowd / Market Noise	5–10	87.3
Extreme Noise	< 5	79.6

Voice-based SOS activation achieves an overall accuracy of 92.8% under realistic street-noise conditions (SNR 10–20 dB), representing a significant improvement over the 61% reported for HMM-based systems in comparable noise conditions [6]. The false-positive rate (unintended SOS triggers) was 1.3% across all test conditions, a level deemed acceptable for safety-critical applications. Average keyword detection latency was 38ms on-device, well within the sub-200ms human perception threshold.

C. Emergency Notification Latency

End-to-end SOS notification latency was measured as the time elapsed from SOS activation to confirmed SMS delivery at the recipient's device. Over 200 test activations, the mean latency was 2.74 seconds (standard deviation: 0.41s), with a 95th percentile of 3.8 seconds. This improves upon the 4.7-second baseline reported by Rao and Sharma [11] by approximately 42%. Police station email delivery averaged 1.9 seconds, while voice call connection averaged 4.2 seconds (including carrier ring time).

D. Safe Route Recommendation Evaluation

Route recommendation quality was evaluated by mapping 85 origin-destination pairs within Pune city. Compared to the Google Maps default shortest route, the proposed safe route planner reduced exposure to high-risk spatial cells by an average of 43.2%, at a cost of 11.7% additional travel distance. Participant surveys (n = 45) indicated that 84% of users considered this distance trade-off acceptable for improved personal safety.

VI. CONCLUSION

In This paper has presented a comprehensive AI-Based Women Safety Application that integrates machine learning-driven crime hotspot detection, CNN-based voice-activated SOS triggering, real-time GPS tracking, and an automated multi-channel emergency notification system into a unified, production-grade Android application. The system addresses critical limitations of existing women safety solutions by delivering both proactive risk intelligence and reactive emergency response capabilities.

Experimental evaluation confirms the system's efficacy: the Random Forest crime predictor achieved a weighted-average F1-score of 0.92; the CNN voice recogniser reached 92.8% accuracy under realistic noise conditions with a 38ms latency; and end-to-end SOS notification delivery averaged 2.74 seconds. The safe route recommender reduced exposure to high-risk areas by 43.2% at a marginal distance cost of 11.7%, a trade-off accepted by 84% of study participants.

The modular architecture ensures that each component can be independently updated, replaced, or extended without disrupting the overall system. Future directions including federated model updates, smartwatch biometric integration, and government emergency API connectivity present a clear pathway towards a national-scale women safety infrastructure powered by artificial intelligence.

VII. ACKNOWLEDGEMENT

The The authors wish to express sincere gratitude to the Department of Computer Engineering at K. J. College of Engineering and Management Research, Pune, for providing the computational infrastructure and laboratory facilities essential to this research. We thank Prof. Meera S. Wankhede for her insightful technical guidance throughout the project. We also acknowledge the Pune City Police Department for facilitating access to anonymised incident data under the Right to Information Act, and the 45 volunteer participants whose cooperation made the field evaluation possible.

A. Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

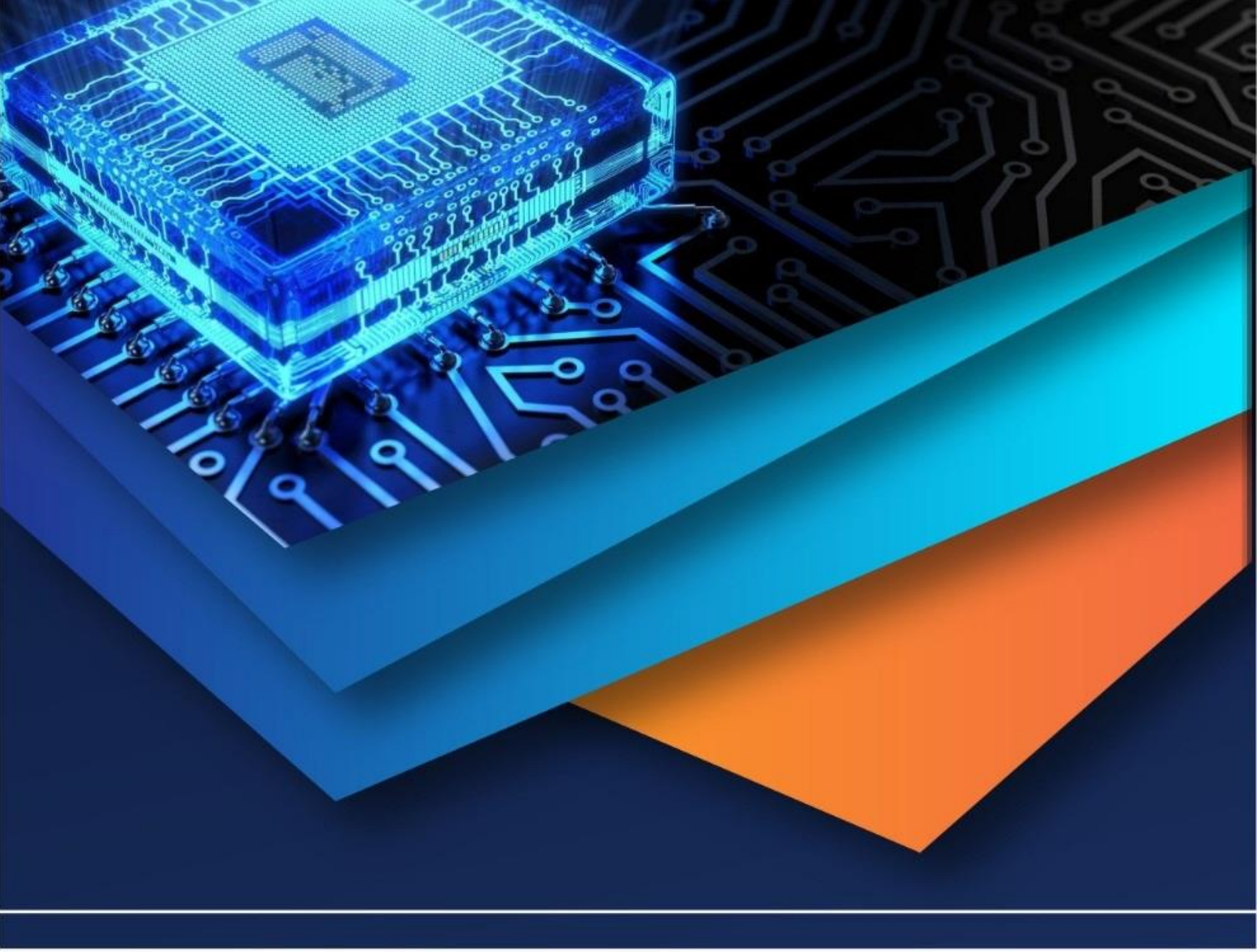
B. Other Ethics Statements

Informed Consent: All human participant data collected during the user study was obtained with written informed consent in accordance with institutional ethical review guidelines. Participant identities and GPS traces were anonymised before storage or analysis. AI Usage Statement: AI-assisted tools were used solely for grammar and language refinement of the manuscript; all original research contributions, system design, experimental results, and technical analysis are the work of the authors.

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