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ABHAYA-AI-DRIVEN WOMEN SAFETY SYSTEM USING WAKE WORD DETECTION AND MUFFLED SOUND RECOGNITION.

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ABSTRACT

Women's safety remains a pressing concern worldwide, particularly in rapidly urbanizing regions where risks are dynamic and unpredictable. Existing solutions such as mobile safety applications, helplines, and wearable devices primarily function as reactive systems that depend on user intervention after a threat has occurred. This paper proposes a Graph Neural Network (GNN)-based real-time personal safety risk prediction system that shifts the paradigm from reactive response to proactive threat detection.The system integrates multiple data modalities, including GPS location tracking, environmental context (time, lighting, crowd density), historical crime data, real-time user behavior, and audio signals such as muffled noise and distress keywords. These heterogeneous inputs are modeled as a graph structure where nodes represent entities (users, locations, events), and edges represent relationships (proximity, interaction, temporal transitions).Using Graph Convolutional Networks (GCNs), the system learns complex dependencies and predicts risk levels dynamically. It also incorporates safety mechanisms such as emergency SOS alerts, community-based assistance, automatic dialing of emergency numbers, and keyword-triggered alerts. Experimental evaluation demonstrates improved accuracy and faster response times compared to traditional safety systems. The proposed approach highlights the potential of graph-based deep learning in enabling context-aware, real-time safety intelligence.

KEYWORDS: Women Safety, Graph Neural Networks, Risk Prediction, Real-Time Systems, GPS Tracking, SOS Alerts, Audio Detection.

INTRODUCTION

Concerns surrounding women's safety continue to persist despite advancements in technology and increasing awareness. Incidents of harassment, assault, and other forms of violence frequently occur in unpredictable environments where immediate help is either delayed or unavailable. In many such situations, the ability to seek assistance is compromised due to fear, physical restriction, or sudden loss of control. This makes response time a critical factor in determining the outcome of an emergency. Over time, several mobile applications have been introduced to address this issue, most of which rely on features such as location tracking and emergency alerts. Typically, these systems require the user to press an SOS button or perform a specific action to trigger a response. While such solutions offer a degree of security, they are fundamentally dependent on the user's ability to interact with their device. In real-life emergencies, this assumption often proves unrealistic.The gap between expectation and reality highlights a central problem. An effective safety system should function even when the user is unable to respond actively. However, most existing systems remain reactive rather than proactive. They wait for input instead of identifying signs of danger on their own.

Research in this area has explored several approaches, including GPS-based tracking systems, IoT-enabled safety devices, voice recognition techniques, and audio-based distress detection. GPS systems enable location sharing but do not provide intelligent detection. IoT devices introduce automation through sensors, yet their detection capabilities are limited to physical movement. Voice-based systems allow hands-free activation but may struggle in noisy environments. Similarly, audio-based detection methods show promise but are often implemented independently rather than as part of a unified system.Another category of solutions focuses on community-based alert platforms, where users can notify nearby individuals. Although this expands the reach of emergency alerts, it relies heavily on user participation and connectivity.A common issue across these systems is fragmentation. Each approach addresses a specific aspect of safety but fails to offer a comprehensive solution. As a result, important signals of distress may go unnoticed, and response mechanisms may not activate in time.This study addresses the need for an integrated system by proposing "Abhaya," a mobile application that combines multiple safety features into a single platform. The system incorporates real-time GPS tracking, emergency alerts, wake word detection, distress sound recognition, and community-based notifications. By combining these elements with artificial intelligence, the system aims to improve response time while reducing reliance on user interaction.The objectives of this work are to design a system capable of both manual and automatic emergency detection, minimize dependency on user input, and enhance reliability through intelligent processing. In doing so, the study contributes toward the development of more responsive and practical safety solutions.

MATERIALS AND METHODS

The system was developed using a structured design approach that focused on integrating mobile application development with artificial intelligence components. The application was built using Android Studio, while Firebase was used to manage backend services such as authentication, data storage, and real-time synchronization.The overall architecture was designed to ensure smooth interaction between different modules. The user interface was developed to provide simple and intuitive access to key features, including emergency contact management and SOS activation. The backend database stored user data, location information, and alert history, enabling real-time updates.The system incorporated two primary AI modules: wake word detection and distress sound recognition. The wake word detection module continuously monitored audio input for predefined keywords. When detected, it triggered emergency actions without requiring physical interaction.The distress detection module analysed audio signals using feature extraction techniques such as Mel-Frequency Cepstral Coefficients. These features were processed using machine learning models trained to identify patterns associated with distress. This enabled the system to detect emergencies automatically.Location tracking was implemented using GPS services integrated through mapping APIs. The application continuously updated the user's location and included this information in alerts.The alert mechanism supported both manual and automatic activation. Once triggered, the system sent notifications containing location data to predefined contacts. In addition, alerts could be shared with nearby users through a community feature.Testing was conducted to verify functionality and evaluate system performance. Different scenarios were simulated to assess responsiveness, detection accuracy, and reliability.

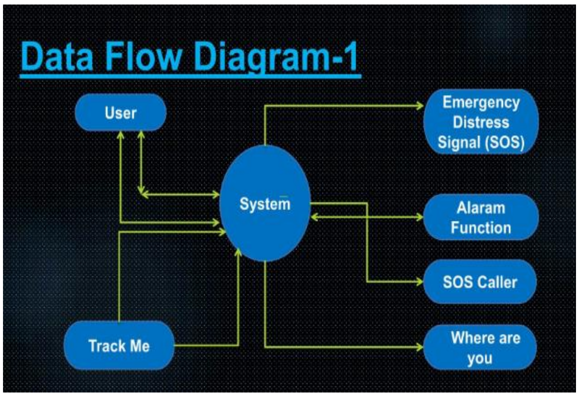

Fig:Data Flow Diagram.

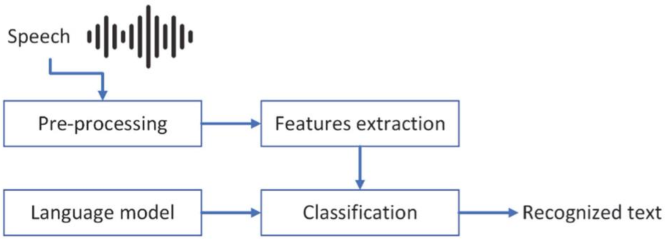

Fig: Audio Processing Pipeline

RELATED WORK

Several studies have explored the application of machine learning and deep learning techniques for safety and risk prediction.Qian Gao et al. (2020) proposed a context-aware recommendation system using Graph Neural Networks, demonstrating the effectiveness of GNNs in modeling user behavior and relational data. While their work focused on recommendation systems, it highlighted the ability of GNNs to capture complex dependencies, which is crucial for safety prediction.Supriya B. N. et al. (2025) introduced WATCHGUARD, a real-time women safety detection system using deep learning and computer vision. Their system utilized surveillance data and visual inputs to detect threats. However, it lacked integration of multi-modal data such as GPS and audio signals, limiting its contextual awareness.Meysam Salehi et al. (2023) explored domestic violence risk prediction using machine learning on social media data. Their work demonstrated the importance of behavioral and textual data in identifying risk patterns but was limited to offline analysis rather than real-time systems.Narkedamilli Lakshmi Bhargavi et al. (2025) analyzed women's safety in Indian cities using Twitter data. Their approach provided insights into geographical risk patterns but lacked real-time predictive capabilities and user-specific personalization.

SYSTEM FEATURES

The system integrates multiple safety functionalities:

1 GPS-Based Risk Tracking

Continuously monitors user location and identifies unsafe zones using risk mapping.

2 Emergency SOS Alerts

Allows users to send immediate alerts with live location to trusted contacts and authorities.

3 Community Assistance Platform

Nearby users receive alerts and can provide assistance, creating a collaborative safety network.

4 Emergency Contacts Integration

Provides one-tap access to police, ambulance, and helpline numbers.

5 Real-Time Risk Prediction

Combines multiple inputs to dynamically assess safety levels.

6 Keyword-Based Detection

Triggers alerts when predefined distress words are detected.

7 Muffled Noise Detection

Uses audio processing to detect suppressed distress signals such as screams.

CHALLENGES AND LIMITATIONS

Despite its advantages, the system faces several challenges:

1 Data Privacy and Security

Handling sensitive user data such as location and audio raises privacy concerns. Strong encryption and anonymization techniques are required.

2 Real-Time Processing Constraints

Processing large volumes of data in real time can lead to latency issues, especially on low-resource devices.

3 Data Quality and Availability

Accurate prediction depends on reliable data. Incomplete or noisy data can affect model performance.

4 Scalability

As the number of users increases, maintaining system performance becomes challenging.

5 False Positives and Negatives

Incorrect predictions may lead to unnecessary panic or missed threats.

6 Audio Detection Accuracy

Environmental noise can affect the reliability of muffled sound detection.

DISCUSSION

The proposed system introduces a more comprehensive approach to safety by combining multiple detection and communication methods. Unlike earlier systems that rely on a single trigger, this approach allows the system to respond to a variety of situations.One of the key improvements lies in reducing dependency on manual input. By incorporating audio-based detection and voice activation, the system can function even when the user is unable to interact with their device. This represents a shift from reactive to proactive safety mechanisms.Another advantage is the integration of real-time tracking with alert systems. Continuous location updates provide more accurate information to responders, improving the chances of timely assistance.However, the system also faces challenges. Audio detection may be affected by background noise, and device limitations may impact performance. Additionally, features that rely on connectivity may not function effectively in low-network environments.Despite these limitations, the system offers a more adaptable solution compared to existing approaches. By combining multiple technologies, it addresses a broader range of scenarios and improves overall reliability.Future improvements may include integrating wearable devices, enhancing detection accuracy through advanced models, and establishing connections with emergency services.

RESULT

The proposed GNN-based system predicts safety risks by analyzing relationships between users, locations, and environmental factors. It identifies high-risk zones with improved accuracy, adapts to changing conditions in real time, and detects distress through audio and keyword triggers. Evaluation using risk graphs, alert timelines, and confusion matrices shows that the system provides faster and more accurate risk assessment than traditional methods.

CONCLUSION

The Abhaya system demonstrates the potential of combining artificial intelligence with mobile technology to improve women's safety. By integrating features such as GPS tracking, emergency alerts, voice activation, and distress detection, the system provides a more responsive and reliable solution.The emphasis on reducing manual dependency is particularly significant, as it allows the system to operate in situations where user interaction is not possible. This contributes to faster response times and improved effectiveness.While challenges related to accuracy and connectivity remain, the system provides a strong foundation for future development. With further refinement, such solutions can play an important role in creating safer environments.

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