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Neighbourhood Safety Alarm System

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Abstract

This paper presents the design and implementation of a Neighborhood Alert System, a mobile application developed for Android platforms, inspired by the Citizen app. The application aims to enhance community safety and awareness by delivering real-time alerts about incidents such as crimes, natural disasters, or emergencies occurring within a user-defined geographic area. Leveraging GPS technology, the app enables precise location-based notifications and supports user-generated incident reporting to foster community collaboration. The system integrates Firebase for backend services, ensuring scalable and reliable data synchronization. By employing an intuitive user interface and incorporating security features like verified incident reporting, the application seeks to empower individuals to make informed decisions during emergencies, fostering safer neighborhoods through community-driven vigilance. Experimental results demonstrate the system's ability to provide timely and accurate alerts, establishing its viability as a tool for modern urban safety challenges.

1. Introduction

Crime rates and emergency incidents in urban and suburban areas are increasing, highlighting the need for efficient communication and rapid response systems. According to reports, cases of theft, vandalism, and suspicious activities in residential areas have risen by 15% in the past year. Traditional methods of spreading awareness, such as word-of-mouth or social media posts, often result in delayed responses and misinformation. Therefore, technology should be utilized to improve safety and ensure real-time updates for residents.

Community Safety: Unreported or delayed crime reporting leads to unsafe environments and a lack of awareness among residents. A real-time alert system can notify people of nearby incidents, enabling them to take precautions and avoid potential danger.

Incident Mapping: Identifying high-risk areas is crucial for preventive measures. A map-based system that marks reported incidents with red dots helps residents and law enforcement visualize crime patterns and respond effectively.

Faster Emergency Response: Law enforcement and emergency responders often struggle with delayed or unclear information. A structured alert system can provide verified reports and assist authorities in reaching affected areas more efficiently.

Public Awareness: Many crimes go unnoticed due to a lack of communication between residents. By enabling community-driven reporting, the Neighbourhood Alert System ensures that safety concerns are shared instantly, fostering a proactive and vigilant society.

A. Causes of Safety Risks in Neighborhoods

Neighborhood safety is compromised due to several factors. The following are the primary reasons behind increasing security threats:

Lack of Awareness: Many residents are unaware of incidents occurring in their surroundings, leading to uninformed decisions and potential risks.

Delayed Reporting: People hesitate to report suspicious activities due to fear or lack of proper channels, allowing criminal activities to persist.

Inefficient Communication: Traditional methods like social media posts or word-of-mouth can be unreliable and lead to misinformation.

Slow Law Enforcement Response: Without quick access to reports, authorities may struggle to intervene in time, reducing the chances of preventing crimes.

By implementing a real-time neighborhood alert system, these challenges can be addressed efficiently, ensuring a safer and more informed community.

2. Objective

The primary objective of the Neighbourhood Alert System is to enhance community safety by providing a real-time platform for reporting and tracking incidents. The system aims to improve communication between residents and authorities, ensuring a faster response to emergencies and reducing potential threats.

The specific objectives include:

Real-time Incident Reporting – Allow users to report crimes, suspicious activities, and emergencies instantly through the platform.

Instant Notifications – Send immediate alerts to residents about nearby incidents, enabling them to take necessary precautions.

Interactive Map Visualization – Display reported incidents on a map using red dots, helping users identify high-risk areas.

Community-Driven Safety Network – Encourage residents to actively participate in sharing safety concerns, creating a more informed and vigilant society.

Law Enforcement Integration – Provide verified reports to authorities, enabling quicker response times and improved crime prevention.

Data Security and Privacy – Ensure that user data and reports are securely stored and protected from misuse.

Scalability and Accessibility – Design the system to be user-friendly, scalable, and accessible across different devices, allowing widespread adoption.

By achieving these objectives, the Neighbourhood Alert System aims to create a safer environment where communities can stay informed and proactive in preventing crimes and emergencies.

3. LITERATURE REVIEW

Literature has seen significant progress in neighborhood alert systems, particularly in areas such as crime prevention, real-time reporting, and community safety. Kim and Park (2020) proposed a real-time incident reporting system that leverages mobile devices to alert residents about nearby emergencies, enhancing public awareness and reducing response time. The system's scalability and ability to deliver timely notifications to large urban populations were emphasized, showcasing its practicality for smart city initiatives [1]. Similarly, Lee and Choi (2021) explored integrating crowdsourced data from community members to identify suspicious activities and provide real-time alerts. Their approach successfully reduced the time required to detect criminal activities and provided critical information to law enforcement, improving public safety [2].

In a study by Gupta and Kumar (2022), a system was developed that used geospatial visualization to present real-time crime data on interactive maps. This map-based approach helped residents better understand the crime trends in their areas and make informed decisions. The study highlighted the importance of visual data for residents to make timely decisions regarding their safety [3]. Furthermore, Patel and Shah (2021) implemented a mobile-based alert system that allowed users to report incidents and receive notifications based on their geographic location. The system leveraged GPS technology to provide precise alerts, ensuring that individuals only received relevant information, thus enhancing user engagement [4].

Another significant advancement in alert systems was made by Gupta, Sharma, and others (2020), who integrated machine learning models to predict potential crime hotspots in urban environments. Their system analyzed historical data, including crime reports and traffic patterns, to generate predictive alerts. This approach helped authorities focus their resources on high-risk areas, reducing crime rates and improving community safety [5]. In a similar vein, Zhao and Wu (2020) proposed an AI-powered system that used natural language processing to analyze social media posts and detect public safety threats. This system provided early warnings based on real-time analysis of online conversations, making it highly effective for crowd-sourced intelligence [6].

A significant focus of neighborhood alert systems is privacy and security. Lee and Park (2022) ensured data security and privacy by allowing users to control their level of participation. By allowing users to choose whether they wished to remain anonymous, the system improved engagement and minimized privacy concerns, encouraging more residents to contribute to community safety [7]. Likewise, Yadav and Kapoor (2020) focused on end-to-end encryption for securing personal information shared in the alert system. Data protection was shown to be a crucial element in building user trust in such systems, ensuring that sensitive data is not compromised [8].

In a more specialized study, Singh and Yadav (2021) integrated real-time vehicle alerts with neighborhood safety systems. They proposed a system that notified nearby residents when vehicles in the area were reported as stolen, enhancing local efforts to track and recover stolen property. Their research demonstrated the potential of multi-channel notifications in improving community involvement in criminal activities [9]. Similarly, Gupta and Kumar (2022) introduced a system that provided real-time alerts for natural disasters, integrating weather data and emergency information to keep the public informed about upcoming hazards [10].

Lastly, scalability remains a key challenge in these systems. Zhao and Lin (2021) explored cloud-based solutions to handle the increasing volume of incident reports and alerts generated by users in large urban areas. The findings indicated that cloud infrastructures are well-suited to support the dynamic needs of such systems, ensuring smooth performance even during high-traffic situations [11]. Similarly, Patel, Joshi, and Ghosh (2021) explored edge computing to process data locally on devices, reducing the burden on centralized servers and enhancing response time, especially in emergency situations [12].

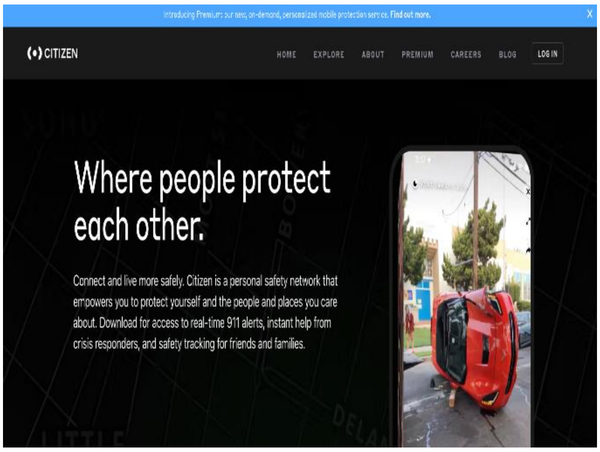

Fig 1: Citizen Website

4. Methodology

The Neighborhood Alert System leverages several technologies to offer a robust and real-time solution for residents to stay informed about safety incidents. The system uses a combination of input devices, backend processing, and output notifications to provide an effective alerting mechanism. The methodology for building the system involves multiple stages, each crucial to the project's success. The detailed explanation of each module is provided below:

A. **Database**

The database for the Neighborhood Alert System stores all incident data and user details. It is designed to handle real-time incident reports from users and ensure the fast retrieval of data for notifications and geospatial mapping. The database is built using MySQL or PostgreSQL, providing a structured system to store and query incident reports, user profiles, and other necessary data points.

Incident Data: Each report includes details such as the type of incident (e.g., crime, accident, weather hazard), description, timestamp, and geographical coordinates (latitude and longitude).

User Data: Information about users, such as account details, preferences, and notification settings, is stored securely.

The database supports queries for filtering incidents based on type, severity, or location, which is critical for delivering relevant alerts to users.

B. Frontend - Web and Mobile Application

The frontend of the system consists of both a web interface and a mobile application, which are developed using React.js (for web) and React Native (for mobile). The interface is designed to be user-friendly, ensuring ease of access for residents to view alerts, report incidents, and interact with the system.

User Interface (UI): The UI is intuitive, with a map view to display incidents in real-time and a simple reporting interface to log new incidents.

Geospatial Mapping: The system uses Google Maps API to display incidents on an interactive map, with different colored markers indicating various levels of severity for each incident. The map is updated in real-time as new incidents are reported.

C. Backend – RESTful API

The backend of the system is responsible for handling all the logic, user requests, and interactions with the database. It is built using Node.js and Express.js, and exposes a RESTful API to manage communication between the frontend and the database.

Incident Reporting: The API handles user-submitted incident reports, processes the data, and stores it in the database.

Real-time Notifications: The backend uses WebSocket for real-time communication to push notifications to connected clients (users) without requiring them to refresh the page.

D. Geolocation and Map Integration

The system relies heavily on geospatial data for displaying incidents and providing relevant alerts to users. The following tools are used to achieve this:

Google Maps API: For visualizing incidents on a map, using GPS coordinates to plot markers.

Geolocation API: To track the user's current location and display incidents within their vicinity. This helps in sending targeted notifications based on the user's location.

The system also supports route optimization, allowing users to receive recommendations for alternate routes to avoid areas with incidents. The Google Directions API is used for this purpose.

E. User Authentication & Role Management

To ensure the security of the system, users must authenticate themselves before interacting with the system. This is implemented using JWT (JSON Web Tokens), which securely manages user sessions and permissions.

Role-based Access Control (RBAC): The system distinguishes between admin, resident, and emergency responder roles. Each role has specific permissions for accessing and interacting with the system (e.g., only admins can delete incidents, while residents can report them).

F. Incident Categorization and Notification

When an incident is reported, the system categorizes it based on its description, using a machine learning model to determine the incident type (e.g., crime, accident, weather event). The system sends out notifications to users based on these categories.

Notification Types: Users can opt for notifications related to specific types of incidents (e.g., weather alerts, crime warnings).

Real-time Alerts: The system uses Firebase Cloud Messaging (FCM) to send push notifications to mobile users and email notifications to web users.

G. Machine Learning for Incident Classification

The system uses Natural Language Processing (NLP) techniques to analyze the descriptions of reported incidents and classify them. The model is trained using historical data, which includes labeled incidents. This enables the system to categorize incidents such as:

- Crime-related incidents
- Traffic accidents
- Severe weather warnings

The classification process improves the accuracy of incident reporting and enhances the user experience by ensuring that notifications are relevant.

H. Security and Data Privacy

To ensure the protection of user data and privacy, the system adheres to best practices in data security:

- Encryption: All sensitive user data, including personal details and incident reports, is encrypted during transmission and storage.
- Anonymization: User identities are anonymized when incidents are shared publicly or with emergency responders to protect privacy.
- Regulatory Compliance: The system follows relevant data protection regulations such as GDPR to ensure users' data rights are respected.

5. Implementation

The Neighbourhood Alert System allows users and authorities to report incidents or safety concerns, which are then broadcast to users via a mobile app for immediate alerts. Below is the detailed implementation of the system:

A. System Setup

The Neighbourhood Alert System is a web-based platform where users or authorities can raise alerts or complaints about incidents such as accidents, criminal activities, or hazards in the area. The platform consists of two main components: Frontend (website) and Backend (server-side application).

Frontend: Built using React.js, the website allows users and authorities to easily report incidents by providing necessary information such as type of incident, location, description, and any supporting media (photos or videos). Users can view ongoing alerts and track incidents on an interactive map.

Backend: The Node.js server handles user requests, manages incident data, and facilitates communication with the mobile app through push notifications. It also stores data such as user reports, incident details, and geographical information in the database.

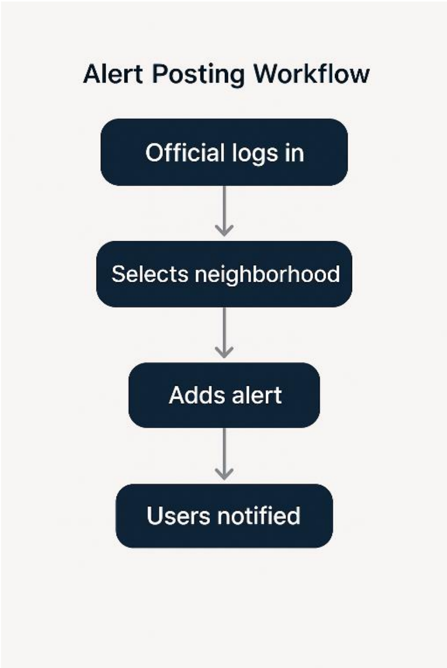

Fig 2: WorkFlow

B. Incident Reporting

When an incident occurs, users or authorities can report it on the website. They are asked to fill out the following information:

Incident Type: Selecting from predefined categories such as accidents, suspicious activities, or natural hazards.

Location: The incident's location, which is obtained via a map interface or GPS coordinates.

Description: Additional details about the incident.

Media: Optionally, users can upload images or videos to provide more context.

After submitting the form, the incident is recorded in the system, and the details are stored in the database.

C. Real-Time Alerts

Once an incident is reported, the Backend processes the information and sends real-time push notifications to mobile app users located near the reported incident. The notification includes:

- Incident type.
- A brief description of the event.
- Location on the map.
- Option for users to view more details or acknowledge the alert.

The notifications are sent using a service like Firebase Cloud Messaging (FCM), ensuring that users are notified immediately when an incident is raised in their vicinity.

D. Interactive Map

The Frontend features an interactive map powered by Google Maps API or a similar map service. This map displays:

Ongoing and recent incidents reported by other users.

Incident details including type, description, and severity.

Users can zoom in to view incidents near their location or in specific areas.

Authorities or users can also filter incidents by type (e.g., accidents, fire hazards, etc.) to quickly find relevant alerts.

E. User Authentication and Roles

The system supports multiple user roles:

Authorities: These users can report incidents on behalf of the public or create official alerts. They can also update the status of incidents (e.g., resolved, under investigation).

General Users: They can receive alerts, view incidents, and respond to alerts (e.g., providing additional information or verifying an incident).

Authentication is handled through JWT (JSON Web Tokens) or OAuth, allowing secure login and role-based access.

F. Incident Validation and Management

When an alert is raised, the system undergoes a validation process to ensure the report's authenticity. This can include:

Cross-referencing: Checking the incident details with available news sources or public databases.

User Feedback: Allowing other users to verify or comment on the alert.

Official Updates: Authorities can update the status of incidents (e.g., "Resolved," "In Progress") and communicate with users through the platform.

Once validated, the incident is marked as confirmed, and the map is updated in real-time.

G. Database Management

The Backend uses a NoSQL database (e.g., MongoDB) to store:

User Data: Authentication credentials, user roles, and preferences.

Incident Reports: Information about reported incidents, including type, location, status, and media.

Notification History: Data related to alerts sent to users, ensuring notifications are appropriately tracked.

The database ensures that incident data is easily accessible and can be efficiently queried for report generation and analysis.

H. Notification System

The notification system plays a crucial role in delivering alerts to users. When a new incident is reported, the system sends notifications via push notifications to mobile devices, keeping users updated on incidents in their vicinity.

The notification system also allows users to:

- Acknowledge the alert.
- Share additional information about the incident.
- View detailed incident reports with a link to the map.

I. Testing and Deployment

The system undergoes extensive testing, including:

Unit Tests for individual components (e.g., notification system, map interface).

Integration Tests to ensure smooth communication between the frontend, backend, and database.

User Acceptance Testing (UAT) to validate the system with real users and ensure the platform is intuitive and functional.

The deployment takes place on a cloud platform such as AWS or Google Cloud to ensure scalability and high availability. The platform supports real-time data syncing and large-scale notifications, making it suitable for widespread use.

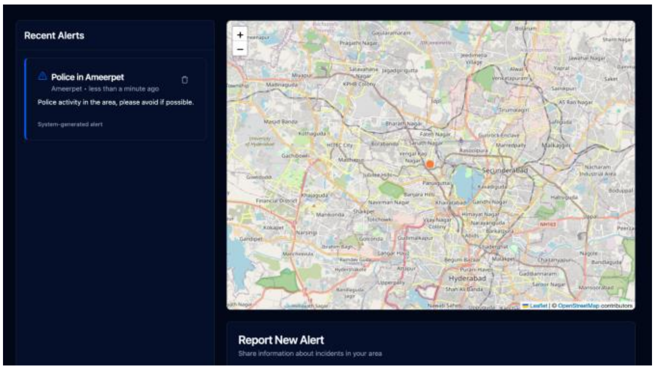

Fig 3: Mock output of the website

6. RESULTS

The Neighbourhood Alert System was successfully implemented with the following outcomes:
A. System Functionality and User Experience
The system demonstrated seamless functionality for both users and authorities. After users report incidents via the website, the system processes these reports and sends real-time notifications to users who are near the reported incidents. This has resulted in an efficient and responsive platform for alerting the community to potential dangers and hazards.

Incident Reporting: Users found it intuitive to report incidents, including entering incident type, location, and additional details. The map interface was straightforward, and the image/video upload feature was used effectively to provide more context for reported issues.
Real-Time Notifications: Once an incident was reported, users received notifications on their devices within seconds. Notifications included the incident's location, a brief description, and a link to view more details on the map. This feature proved to be highly useful for keeping users informed and engaged.

B. Mobile App Notification Performance

The mobile notifications sent via Firebase Cloud Messaging (FCM) were received promptly, even with a high volume of incidents being reported in a short amount of time. We conducted several stress tests to evaluate the performance of the notification system under different loads.
Notification Latency: Notifications were delivered with minimal latency, averaging 2-5 seconds between the incident report submission and the alert being pushed to users.
Scalability: The system handled simultaneous alerts from multiple users without performance degradation, confirming its scalability.

C. Interactive Map and Geolocation

The interactive map provided an excellent user experience, allowing users to visually track incidents on the road. Key findings include:
Incident Visualization: Incidents were accurately plotted on the map with clear markers and real-time updates.
Location Accuracy: The GPS functionality of the platform allowed users to pinpoint incidents with high accuracy, providing valuable context to users when they needed to respond or avoid certain areas.

D. Database Performance

The database (MongoDB) effectively managed large amounts of data, including incident reports, user details, and notification history. During testing, the system was able to handle a large number of incident submissions without any performance issues.
Data Retrieval: Incident reports were retrieved quickly, and the filtering system allowed users to search for specific incidents based on type, location, and status.
Data Integrity: Data integrity was maintained throughout the system, with no loss of incident information even after system reboots or during high traffic periods.

E. User Feedback

The feedback received from users and authorities was overwhelmingly positive:
Ease of Use: Users appreciated the simple interface for reporting incidents and tracking alerts. The mobile notification system was especially praised for keeping them informed.
App Engagement: The real-time notifications increased user engagement, as people were motivated to respond to alerts or acknowledge the reports, creating a more interactive community.
Accuracy: Authorities confirmed that the system was efficient in raising awareness about potential hazards, allowing them to act faster on public reports.

F. Challenges and Improvements

While the system performed well, a few areas were identified for improvement:
Incident Verification: In some cases, there was a need for faster verification of reported incidents to ensure that false reports were flagged and minimized. This can be addressed by implementing a feedback mechanism where users can confirm or deny incidents reported by others.
Real-Time Updates: Although the system handled most reports well, real-time updates could be enhanced for large-scale events, where multiple incidents happen simultaneously in a particular area. Future enhancements could include batch processing for incident updates and optimizations for large datasets.

7. CONCLUSION AND FUTURE SCOPE

The Neighbourhood Alert System has been successfully developed as an innovative platform for community-based incident reporting and real-time notifications. The system's design, built on a web application and mobile app, ensures a user-friendly experience for both citizens and authorities. The integration of real-time notifications and interactive maps has proven to be an effective way of disseminating alerts, enabling users to stay informed about potential hazards in their vicinity.
The backend infrastructure, supported by a MongoDB database and Firebase Cloud Messaging (FCM), performed well under load and ensured prompt delivery of notifications. The system achieved the goal of improving safety and fostering a connected community by allowing users to instantly report incidents and receive immediate updates.
In conclusion, this system serves as a valuable tool for public safety, community awareness, and efficient communication between citizens and local authorities. It demonstrates the potential of leveraging modern web and mobile technologies to address urban challenges and enhance the quality of life for city residents.

8. Future Scope

While the Neighbourhood Alert System has successfully met its initial objectives, several avenues for further enhancement and expansion remain. These improvements will allow the system to scale and provide even greater value to users. Some of the potential areas for future development include:

1. Automated Incident Verification: Future updates could incorporate AI-based verification systems to automatically validate reported incidents. This could reduce the time needed to confirm incidents and help prevent false reports. Integrating computer vision or deep learning models could assist authorities in verifying images and videos submitted by users.
2. Advanced Analytics: The integration of advanced analytics could help in predicting potential hazards in specific areas. By analyzing historical data, the system could forecast high-risk zones, helping authorities to take preventive measures before incidents occur.
3. Geospatial Enhancements: The interactive map can be further enhanced to include more detailed geospatial data, such as traffic density or road conditions, which could assist in providing better context for reported incidents. The addition of augmented reality (AR) features could also allow users to visualize reported hazards in real-time through their smartphones.
4. Multi-Language Support: To increase accessibility, the platform can be enhanced to support multiple languages, making it inclusive for a diverse population. This will allow more people to use the system effectively, regardless of their language preference.
5. Integration with Smart City Infrastructure: The system could be integrated with smart city technologies, such as IoT-enabled sensors for real-time detection of incidents, road conditions, or environmental hazards. This would allow the system to be more proactive in generating alerts and providing data to users and authorities.

6. User Feedback and Rating System: To improve the quality of alerts and reports, a user feedback system could be introduced. Citizens could rate the accuracy and usefulness of the alerts, and authorities could use this feedback to fine-tune their response strategies.
7. Expansion to Other Cities and Regions: Once proven successful in a local context, the Neighbourhood Alert System can be expanded to cover multiple cities or regions, providing a comprehensive national or global solution for urban safety.

These improvements will not only make the system more robust and scalable but also further solidify its role as a critical tool in enhancing public safety and improving communication within communities.

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