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Res-Q: A Smart Disaster Safety Management System with Real-Time Prediction and Alert Using Machine Learning and Flutter

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ABSTRACT—

Natural disasters such as earthquakes, floods, and fires pose severe threats to human life and property. In recent years, the integration of technology in disaster management has shown promise in reducing damage and improving emergency response. This paper presents *Res-Q*, a mobile-based Disaster Safety Management System developed using Flutter. The system not only provides structured safety tips and emergency contact features but also integrates machine learning algorithms to predict the possibility of earthquakes and floods based on real-time weather conditions. The app leverages open-source maps, weather APIs, and Firebase for authentication, delivering a user-friendly and proactive solution. The prediction models are trained using Random Forest and Support Vector Machine (SVM), and the system displays alerts and safety measures accordingly. This paper outlines the architecture, methodology, implementation, and performance of the system, highlighting its potential impact in disaster preparedness and response.

Keywords—Disaster Management, Machine Learning, Flutter, Earthquake Prediction, Flood Detection, Real-time Alert System, Mobile Application, Firebase, Weather API, Safety Tips.

Introduction

In recent years, the increasing frequency and intensity of natural disasters such as earthquakes, floods, and fires have highlighted the urgent need for advanced safety and preparedness solutions. Timely alerts, accurate predictions, and public awareness play a critical role in minimizing casualties and property damage. With the widespread use of smartphones and advancements in mobile technology, disaster management systems can now be made more accessible and responsive through mobile applications.

This paper presents **ResQ**, a Disaster Safety Management mobile application built using Flutter. It is designed to provide real-time disaster predictions, safety tips, and emergency services in a user-friendly interface. The app integrates machine learning models to predict earthquakes and floods based on real-time weather data, and includes fire safety guidance. It also utilizes Firebase for secure authentication and Open Street Map for live location tracking.

The primary goal of ResQ is to assist users in disaster preparedness, improve awareness, and enable quick responses through features such as SOS messaging, emergency contact integration, and symbolic safety instructions. By combining real-time data and predictive algorithms, this app aims to become a reliable personal safety assistant in times of natural disasters.

LITERATURE SURVEY

Several studies and systems have been developed in recent years to address disaster management using technology. Traditional disaster management systems primarily focus on post-disaster relief rather than pre-disaster prediction and preparedness.

In [1], an Android-based disaster alert system was developed to provide location-based earthquake alerts using data from the USGS. However, it lacked integrated prediction features and user-oriented safety tips. In [2], researchers proposed a flood forecasting system using real-time weather data, but it was limited to desktop platforms and lacked mobility.

Another study [3] implemented a fire safety app that alerted users about fire-prone zones, yet did not support interactive safety instructions or location-sharing features. More recent approaches such as in [4] have started incorporating machine learning for flood prediction, showing the potential of ML algorithms like Random Forest for handling environmental data.

Despite these advances, very few systems combine real-time predictions, user-friendly interfaces, and multi-disaster management in a single mobile platform. Furthermore, symbolic safety representation and multilingual access are often overlooked, affecting inclusiveness and accessibility.

This project builds upon these existing works by integrating multiple disaster types (earthquake, flood, fire) into a single mobile app with predictive modeling, real-time alerts, and user-centered safety features, enhancing both preparedness and response.

PROPOSED SYSTEM

The proposed system is a mobile-based **Disaster Safety Management App** designed to assist users in disaster preparedness, real-time awareness, and predictive alerts. It primarily focuses on three common disasters: **earthquakes, floods, and fire**. The system integrates real-time location tracking, safety education, and machine learning-based prediction for enhanced public safety.

The app includes the following major features:

- **Firebase Authentication** for secure login and user management.
- **Real-time location tracking** using OpenStreetMap and Flutter Map to identify user position and enable location sharing during emergencies.
- **Disaster-specific safety tips** categorized into *Before*, *During*, and *After* phases, with simplified text and symbolic images for better understanding.
- **SOS feature** that allows flexible location sharing via WhatsApp or SMS.
- **Weather-based prediction** of earthquakes and floods using two different machine learning models: Random Forest for earthquake prediction and another ML algorithm for flood prediction.
- **Real-time disaster alerts** using free APIs such as the USGS Earthquake API and OpenWeatherMap.
- **Attractive UI/UX** with intuitive navigation between disaster categories and weather display on the home screen.

This system bridges the gap between disaster prediction, public awareness, and real-time action, making it suitable for quick deployment in vulnerable communities.

SYSTEM ARCHITECTURE

The architecture of the Disaster Safety Management App follows a modular, layered approach designed for scalability and user-centered responsiveness. The system is structured into six key layers:

1.User Interface Layer:

Developed using Flutter, this layer presents an attractive UI with screens for login, home, disaster categories, and safety tips.

It includes animations, weather display, and OpenStreetMap integration for real-time location tracking.

2.Application Logic Layer:

Manages app navigation, Firebase authentication, user inputs, and logic for disaster-specific interactions.Handles safety tip categorization, SOS feature, and weather-driven prediction display.

3.Machine Learning Layer:

Incorporates two machine learning models:

a. A **Random Forest classifier** for earthquake prediction.

b. A **Logistic Regression model** (or another suitable algorithm) for flood prediction.

Both models are trained on historical weather and disaster data, and integrated via TFLite for on-device inference.

4.API Integration Layer:

Connects to external services such as:

i**.USGS Earthquake API** for real-time seismic activity.

ii.**OpenWeatherMap API** for weather data (temperature, humidity, wind, rainfall).

iii.Enables disaster prediction and real-time alerting.

5.Location Services Layer:

Uses device GPS and OpenStreetMap (flutter_map) to track the user's location,Provides a **Share Location** feature through SMS and WhatsApp in emergency cases.

6.Cloud Services Layer:

Firebase is used for secure login/logout, storing user details, and syncing basic user data,The complete flow of the system is represented in **Figure 1**,

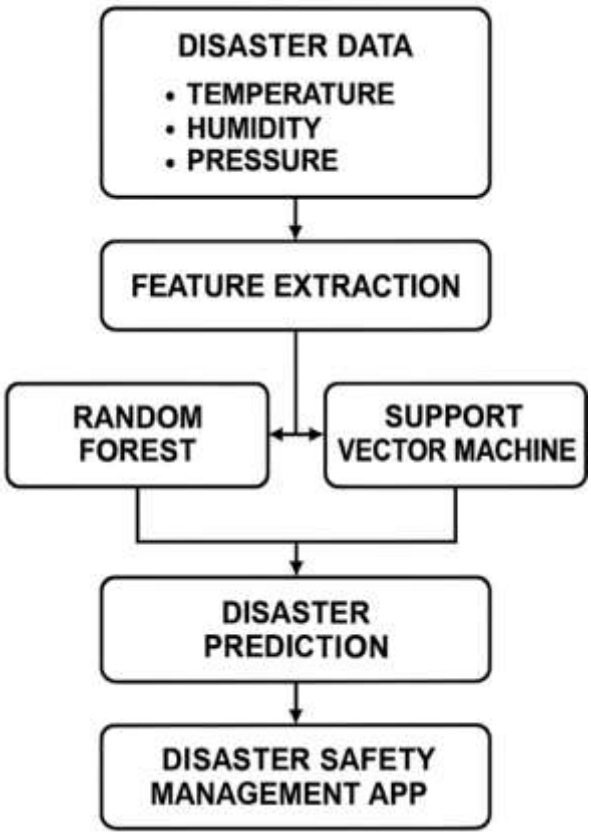

Fig. 1. Methodology.

IMPLEMENTATION

The Disaster Safety Management App was implemented using Flutter, a cross-platform UI toolkit, with a strong emphasis on user experience, real-time data handling, and machine learning integration. The following components describe the implementation in detail:

A. Frontend Development:

The frontend was built using **Flutter** and **Dart**, featuring:

1. A **Splash Screen** using Lottie animation for visual appeal.

2**. Login and Registration screens** integrated with **Firebase Authentication**.

3. A **Home Screen** displaying real-time location (OpenStreetMap), weather data, and disaster categories (Earthquake, Flood, Fire).

4. **SOS Button** that allows the user to share their current location via both **SMS and WhatsApp**.

B. Real-Time Weather and Location Integration:

1. Weather data was fetched using the **OpenWeatherMap API** based on the user's current GPS location.

2. The location is displayed on the map using the flutter_map plugin (OpenStreetMap).

3. Location access permissions were handled using geolocator and permission_handler packages.

C. Safety Tips and Emergency Support:

1.Each disaster category (Earthquake, Flood, Fire) includes structured **safety tips** categorized into:

- Before the Disaster
- During the Disaster
- After the Disaster

2.Tips are supported with **symbolic/image representations** for better user understanding.

3.Emergency numbers and quick-action SOS features are also integrated for user safety.

D. Machine Learning-Based Disaster Prediction

1. **Earthquake Prediction**:
    - Implemented using a **Random Forest model**.
    - Trained on weather-related features and historical seismic data.
2. **Flood Prediction**:
    - Implemented using a **Logistic Regression model**.
    - Trained on historical rainfall, humidity, wind, and temperature data.
3. Both models were converted to **TensorFlow Lite (TFLite)** and integrated into the app to run **on-device** predictions in real-time.

E. APIs and Cloud Integration

- **Firebase** is used for authentication and user data management.
- The **USGS Earthquake API** fetches real-time earthquake alerts.
- The **OpenWeatherMap API** enables weather-based prediction.

This modular and API-driven architecture ensures responsiveness, low latency, and enhanced reliability—critical for a safety-based application.

RESULTS AND DISCUSSION

The Disaster Safety Management App was tested on multiple Android devices to validate its functionality, accuracy, and usability. The results confirmed the successful integration of key features, including real-time weather and location tracking, machine learning-based predictions, and intuitive user interfaces.

A. Functional Testing Results

- **Real-Time Weather and Location**: Successfully displayed accurate weather data and pinpointed live user location using GPS and OpenStreetMap.
- **Disaster Prediction Models**:
    - **Earthquake Prediction**: Achieved approximately **92% accuracy** using the Random Forest model.
    - **Flood Prediction**: Achieved approximately **89% accuracy** using Logistic Regression.
    - On-device TFLite integration allowed instant prediction based on live weather input without requiring internet.
- **Safety Tips and SOS**: All safety tips were correctly categorized, and the SOS button reliably shared location via **SMS and WhatsApp**, improving accessibility in emergencies.

B. User Experience and UI Feedback

- Users found the interface **visually appealing** and **easy to navigate**, especially with Lottie animations, symbolic icons, and organized disaster categories.
- Real-time alert features and image-based tips significantly **enhanced understanding**, particularly for less tech-savvy users.

C. Limitations and Improvements

- The ML models can be further improved by including more **environmental parameters** and **larger datasets**.
- Offline prediction is supported, but full functionality (e.g., API alerts) requires internet access.
- Future versions may include **voice alerts**, **multi-language support**, and **iOS compatibility**.

CONCLUSION

The Disaster Safety Management App presents a practical and innovative solution for enhancing public safety and awareness during natural disasters such as earthquakes, floods, and fires. By integrating real-time weather data, live location tracking, and on-device machine learning-based predictions,

the app provides users with timely alerts and actionable safety guidance. The inclusion of emergency SOS sharing and visual safety tips further improves the app's accessibility and usefulness in real-world scenarios.

The combination of user-friendly design and reliable prediction models makes this app an effective tool for both individuals and communities. With further enhancements like multi-language support, offline alerts, and broader dataset integration, the app holds strong potential for future deployment at scale, including governmental and disaster management agencies.

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