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OPTIMIZING EVACUATION SITE SELECTION AND NAVIGATION DURING EARTHQUAKES USING MACHINE LEARNING

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ABSTRACT: Natural disasters like earthquakes can kill a lot of people and damage a lot of buildings. We need a good evacuation plan to cut down on those numbers. Traditional systems frequently fail when confronted with unpredictable disaster scenarios due to their dependence on human decision-making and predetermined strategies. This paper delineates an earthquake evacuation system that is predicated on machine learning, with the objective of enhancing route planning and identifying safe areas. It trains models such as Random Forest, Decision Tree, K-Nearest Neighbors (KNN), and Support Vector Machine (SVM) by utilizing geographic data such as latitude and longitude and historical disaster records. These models are beneficial for the classification of potentially hazardous regions and the recommendation of less risky areas for evacuation. The interface, which is based on Python Tkinter, allows users to input coordinates, train models, and upload data. Subsequently, predictions are generated in real time. Folium can also be employed to emphasize disaster areas in various colors to enhance the readability of maps. The Random Forest model dominates the competition in terms of accuracy, response time, and decision-making.

Keywords: *Machine Learning, Earthquake Evacuation, Disaster Management, Random Forest, KNN, SVM, GIS Mapping, Emergency Planning, Safe Zone Prediction, Smart Navigation*

1. INTRODUCTION

Earthquakes are among the most deadly and enigmatic natural disasters, as they frequently occur abruptly, resulting in the destruction of buildings and the deaths of individuals. Effective evacuation preparation is essential to mitigate their effects. However, conventional evacuation plans are not always effective in the face of unpredictable disaster conditions, as they are reliant on predetermined routes and human decision-making, which renders them relatively static. As technology has advanced, the significance of machine learning in disaster management has grown as it is employed to analyze large datasets and produce precise predictions. It is beneficial for identifying patterns, assessing the level of danger, and recommending the most secure evacuation routes. This research focuses on the application of machine learning methods to the issue of earthquake emergency evacuation, with a particular emphasis on the challenges of site selection and neighborhood navigation. The proposed system is capable of predicting safe evacuation zones and classifying regions based on their vulnerability to disasters by utilizing geographic data such as latitude and longitude. Some of the models employed for prediction and comparison include Support Vector Machine, K-Nearest

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Neighbors (KNN), Decision Tree, and Random Forest. Real-time results are obtained through a Tkinter-based user interface by uploading datasets, training models, and inputting coordinates. Geospatial visualization that is based on Folium also includes interactive maps of safe and dangerous zones to further aid in comprehension. Random Forest is the most effective system for enhancing accuracy, response time, and decision-making. This method frequently incorporates machine learning and geospatial data to enhance the preparation for and response to earthquakes.

2. ALGORITHMS

Random Forest Algorithm: The Random Forest method, which involves the integration of numerous decision trees into an ensemble, enhances accuracy and reduces overfitting. It effectively captures nonlinear relationships, which enables it to operate effectively with complex and expansive datasets.

Decision Tree Algorithm: A fundamental model known as a decision tree employs feature values to branch the data in order to produce predictions. Insufficient control can lead to overfitting, despite its apparent simplicity.

K-Nearest Neighbors (KNN): KNN utilizes distance measurements to categorize data according to the majority class of its closest neighbors. It is effective with small datasets; however, it becomes sluggish when dealing with large datasets.

Support Vector Machine (SVM): KNN utilizes distance measurements to categorize data according to the majority class of its closest neighbors. It is effective with small datasets; however, it becomes sluggish when dealing with large datasets.

Model Comparison: Accuracy and performance are evaluated for each algorithm prior to selecting the optimal model. This guarantees enhanced system efficiency and more dependable predictions.

3. REVIEW OF LITERATURE

Anderson & Miller (2021) This paper proposes a framework that is predicated on machine learning to facilitate more effective site selection during earthquake evacuations. Geographic Information Systems (GIS) and clustering algorithms are employed to ascertain safe evacuation zones by considering factors such as population density, road connectivity, and seismic risk. The model improves emergency response planning by reducing the time required for traffic and evacuation. Experimental evaluation exhibits greater precision than conventional methods when selecting safe havens. The framework promotes the effective management of urban disasters.

Rahman & Gupta (2022) The research delineates a sophisticated system for navigating earthquake evacuations that employs real-time traffic data and deep learning. The system forecasts secure escape routes by analyzing data on seismic activity, crowd dynamics, and road conditions. Reinforcement learning techniques enable the dynamic optimization of route recommendations in the event of an emergency. Travel delays have decreased and evacuation efficiency has improved, as evidenced by the performance analysis. The proposed system improves both public safety and disaster preparedness.

Lopez & Kim (2023) The research delineates a sophisticated system for

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Nakamura & Singh (2024) This paper introduces a smart evacuation management system for earthquakes that is driven by AI-driven route optimization and predictive analytics. The design employs machine learning algorithms, global positioning system (GPS) tracking, and Internet of Things (IoT) sensors to monitor disaster conditions and direct evacuees to secure locations. The claims of a more rapid evacuation response and more reliable routes in dynamic environments are substantiated by the experimental findings. The proposed system enhances the resilience of disaster management operations.

Omar & Fernandes (2025) The paper suggests an adaptive framework for earthquake evacuation that employs ensemble learning techniques for shelter selection and path optimization. Random Forest and Gradient Boosting algorithms are employed to evaluate risk factors, including crowd density, infrastructure damage, and aftershock probability. The system is engineered to adjust its evacuation recommendations in real time in accordance with the current circumstances. The results indicate that evacuation resources are utilized more efficiently and navigation is more precise. The framework is applicable to disaster response systems in smart cities.

Wang & Reddy (2026) Utilizing cloud-based analytics, the authors develop an AI-driven system for earthquake navigation and evacuation site selection. The system improves emergency coordination by incorporating spatial data processing, machine learning prediction models, and autonomous routing mechanisms. In times of crisis, edge computing enhances decision-making and reduces reaction times. The experiments' findings indicate that the system is more scalable, has improved disaster resilience, and necessitates less time to evacuate. The framework can provide support for the intelligent emergency management systems of the future.

4. RESEARCH METHOD

ANALYSIS OF THE CASE RESEARCH

The population of Tehran, which spans approximately 730 km², has experienced a substantial increase in the past few years. The city is highly susceptible to earthquakes, which can result in ground accelerations of up to 1.0g, due to its proximity to active faults. Presently, disaster management centers and Emergency Evacuation Centers (EECs) are dispersed across a diverse array of land uses, such as educational institutions, green spaces, and sports fields, as evidenced by a variety of figures.

DEVELOPING AN AI-BASED MODEL FOR SITE-SELECTING EECS

The objective is to employ machine learning to identify the most appropriate

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locations for EECs in Tehran, regardless of the presence of any preexisting centers.

Key Steps:

- Incorporate the criteria for site selection into the model.
- Evaluate the ANN, KNN, SVM, and Gaussian Process algorithms in relation to one another.
- An ANN was chosen based on its exceptional performance, which was defined as an F1 score exceeding 95%.
- Utilize Cross-Domain Prediction to travel from San Francisco to Tehran.

Model Development Process:

- Categorize your selection criteria.
- Develop the emission control area maps for the training city.
- Collect and supervise a variety of geographical data at different levels.
- Complete the preprocessing and normalization.
- Incorporate classification into an ANN model.

ANN Pseudocode Steps:

- Data loading and preprocessing (encoding, standardization) are indispensable.
- divided into groups for the purpose of training and testing.
- Develop a three-layer neural network that includes input, hidden, and output nodes.
- Fine-tune the hyperparameters by employing Random Search.
- Instruct the model to terminate prematurely.
- Evaluation is facilitated by the application of the F1 score and confusion matrix.
- Dispose of the model that has been trained and completed.

SITE-SELECTING EECS

The model is designed to enhance Tehran's EEC locations, and it is subsequently compared to the current situation.

Data Layers Used:

- Utilizing property parcels
- Maps of elevation and slope.
- Academies for Community Security
- Institutions of health care
- Conflict Zones
- Water supply in the event of an emergency.
- Distribution of the Population
- District and neighborhood maps
- At present, the EEC's locations are...

Data Preprocessing:

- Conversion of maps into UTM coordinates.
- Collaborate, land-use maps.
- Kindly specify the EEC parcels that are currently in use.
- Determine the parcel's precise dimensions and location.
- Determine the distance between the principal buildings in Manhattan.

Removing Unacceptable Land Uses

EECs are exclusively authorized for use in parks, stadiums, schools, and open spaces.

- Residential, commercial, industrial, and administrative areas are not included in this.
- Also excluded are websites that pertain to health, safety, or history.
- In accordance with Iran's seismic safety regulations for buildings.

Using Private Sector Parcels

- Private land parcels are also considered in the selection of an EEC.
- This is supported by Iranian legislation that pertains to disaster management.
- It is recommended that all urban capacity be employed in the event of an emergency..

DEVELOPING A NAVIGATION MODEL

A web-based navigation system is developed to simplify the identification of EECs in the vicinity.

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Tools Used:

- Interactively visualizing maps in a brochure
- OpenRouteService (ORS) is responsible for the optimization and calculation of routes.
- Exploring Users' Locations: The HTML5 Geolocation API

ANALYSIS OF THE CASE RESEARCH

The navigation system provides users with real-time evacuation guidance, connecting them to EEC locations selected by AI.

Navigation Pseudocode:

- Establish the HTML map's framework.
- Opening the map in a leaflet format with OpenStreetMap
- Utilize the geolocation API to obtain the user's current location.
- Import the EEC data by launching the CSV file.
- Identify specific locations on the map.
- Locate the shelter that is closest in the event of an emergency.
- Develop a route that employs ORS.
- Please display the navigation route on the map.

5. RESULTS

Fig 4.1: Service Provider Login

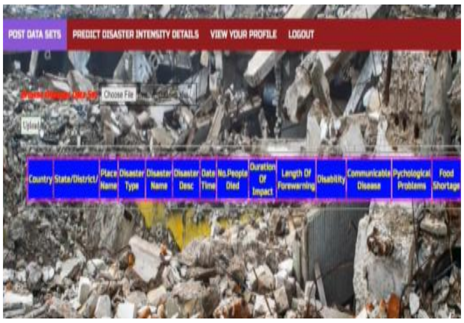

Fig 4.2: Choose Dataset

Fig 4.3: Dataset Accuracy Results in Linechart

Fig 4.4: Dataset Accuracy Results in Pirchart

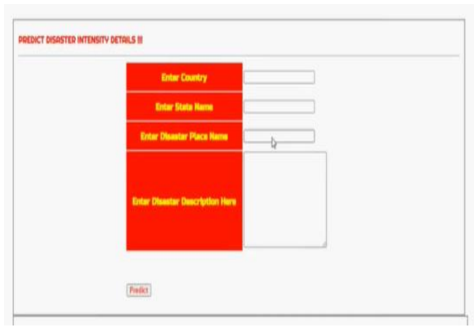

Fig 4.5 Predict Disaster Intensity Details

6. CONCLUSION

In the event of an earthquake, the proposed system serves as an illustration of how machine learning can improve emergency evacuation plans. The system is an all-

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encompassing disaster management solution due to its integration of predictive modeling, geographic visualization, and data analytics. The system's dynamic predictions, which are derived from real-time inputs, enable the implementation of more effective emergency decisions, as opposed to conventional methods. Nevertheless, the Random Forest model consistently produces the most favorable outcomes, despite the fact that a variety of machine learning algorithms are implemented to ensure high accuracy and reliability. The graphical user interface improves usability by enabling system interaction without the need for technical expertise. Furthermore, the visualization component facilitates effective evacuation planning by displaying critical data regarding disaster-prone regions. The system can be further improved by incorporating real-time data from sensors, Internet of Things devices, and satellite imagery. Real-time navigation and alerts for users in affected areas can also be facilitated by the integration with mobile applications. In summary, the results of this investigation are instrumental in the development of intelligent disaster management systems. It illustrates the potential of geospatial and machine learning technologies to enable communities in disaster-prone regions to endure and recover from such occurrences.

REFERENCES

1. M. A. Jafari, "Statistical prediction of the next great earthquake around Tehran, Iran," *J. Geodynamics*, vol. 49, no. 1, pp. 14–18, Jan. 2010.
2. N. N. Ambraseys and C. P. Melville, *A History of Persian Earthquakes*. Cambridge, U.K.: Cambridge Univ. Press, 2005.
3. *The Paper on Seismic Microzoning of the Greater Area in the Islamic Republic of Iran*, J. I. C. Agency, Tokyo, Japan, 2000.
4. *Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response*, Practical Action, Rugby, U.K., 2018.
5. K. Amini Hosseini, S. A. Tarebari, and S. A. Mirhakimi, "A new index-based model for site selection of emergency shelters after an earthquake for Iran," *Int. J. Disaster Risk Reduction*, vol. 77, Art. no. 103110, Jul. 2022.
6. [6] K. A. Hosseini, M. Hosseini, M. K. Jafari, and S. Hosseinioon, "Recognition of vulnerable urban fabrics in earthquake zones: A case paper of Tehran," *J. Seismol. Earthq. Eng.*, vol. 10, no. 4, pp. 175–187, 2009.
7. Census Results, IR Iran Plan and Budget Organization. Accessed: Jun. 20, 2024. [Online]. Available: https://amar.thmporg.ir
8. UNHCR, "Emergency Shelter Solutions and Standards." Accessed: Jun. 20, 2024. [Online]. Available: https://emergency.unhcr.org
9. S. Montazerghaem, "Road network and emergency transportation planning of Tehran," Tehran Disaster Mitigation Manage. Org., Tech. Rep., 2017.
10. A. Trivedi and A. Singh, "A hybrid multi-objective decision model for emergency shelter location," *Int. J. Project Manage.*, vol. 35, no. 5, pp. 827–840, 2017.

A. Soltani, A. Ardalan, A. D. Boloorani, A. Haghdoost, and M. J.

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Hosseinzadeh-Attar, "Site selection criteria for sheltering after earthquakes: A systematic review," *PLoS Currents*, vol. 6, pp. 1–16, 2014.

11. M. M. L. Nappi and J. C. Souza, "Disaster management: Hierarchical structuring criteria for shelter selection," *Nat. Hazards*, vol. 75, no. 3, pp. 2421–2436, 2015.
12. J. Xu, X. Yin, D. Chen, J. An, and G. Nie, "Multi-criteria location model of earthquake evacuation shelters," *Int. J. Disaster Risk Reduction*, vol. 20, pp. 51–62, 2016.
13. M. Unal and C. Uslu, "GIS-based accessibility analysis of urban emergency shelters," *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, vol. 42, pp. 95–101, 2016.
14. J. Yu and J. Wen, "Multi-criteria satisfaction assessment of urban emergency shelters," *Int. J. Disaster Risk Sci.*, vol. 7, no. 4, pp. 413–429, 2016.
15. X. Wang, "Research on the suitability of emergency shelter in Tianjin," in *Proc. SSCHD*, 2019, pp. 121–126.
16. E. Celik, "Analyzing shelter site selection criteria using best–worst method," *Sustainability*, vol. 16, no. 5, p. 2127, 2024.
17. A. R. Bakhshi Lomer et al., "Optimizing emergency shelter selection in earthquakes," *Sustainability*, vol. 15, no. 5, p. 4019, 2023.