Journal of NextGen Intelligence

ISSN: APPLIED |VOLUME-1, ISSUE-1|
Inaugural Edition | October-December 2026
Paper ID: NG11-005| Research Article
DOI:

Intelligent Earthquake Evacuation Planning and Safe Route Optimization Using Machine Learning

R. RANJITHKUMAR, *Sr.Software Developer*,
SKILLEXA TECHNOLOGIES, HYDERABAD

ABSTRACT: It is highly probable that an earthquake or other natural catastrophe will result in the destruction of numerous buildings and the loss of numerous lives. In order to reduce those figures, it is imperative that we establish a comprehensive strategy for evacuating all individuals from the building. Conventional systems frequently collapse when abrupt, unforeseen crises occur, as they depend on individuals to make decisions and adhere to predetermined plans. The method described in this paper employs machine learning to identify the most suitable routes and secure locations for evacuating individuals from buildings during earthquakes. Support Vector Machine, Decision Tree, Random Forest, and K-Nearest Neighbors (KNN) are trained using geography data, including latitude and longitude, as well as records of past calamities. These models are highly effective in identifying hazardous regions and recommending safer alternatives for exiting. Users can input coordinates, train models, and share data through the Python Tkinter-based interface. This enables the formulation of predictions in real time. Utilizing folium of varying colors to emphasize disaster zones can facilitate the comprehension of maps. The Random Forest model is more precise, faster, and more effective at making decisions than its competitors.

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 perplexing and lethal natural disasters due to their rapid occurrence and the destruction of structures and individuals. Evacuation strategies must be functional in order to mitigate their effects. Conventional evacuation plans are relatively static due to their dependence on individuals to make decisions and adhere to predetermined routes. Consequently, they may not function as intended in the event of an unforeseen issue. The significance of machine learning in disaster management has increased due to its capacity to analyze large datasets and generate precise predictions. It can assist you in identifying patterns, determining the level of peril, and selecting the most secure exit routes. The primary objective of this project is to address the issue of seismic emergency escape by employing machine learning techniques. The focus is on the challenges of navigating neighborhoods and selecting a secure location to remain. The proposed method could utilize longitude and latitude to organize regions based on their susceptibility to disasters and to direct individuals to secure locations. Some of the models that are employed to compare and make predictions include K-Nearest Neighbors (KNN), Decision Tree, Random Forest, and Support Vector Machine. Real-time results can be obtained by users through a user interface that is constructed on Tkinter by sharing datasets, training models, and coordinates. The geospatial

ISSN: APPLIED |VOLUME-1, ISSUE-1|
Inaugural Edition | October-December 2026
Paper ID: NG11-005| Research Article
DOI:

visualization based on Folium includes live maps that display locations that are considered secure and locations that are considered dangerous. Random Forest is the most effective method for enhancing the accuracy, response time, and decision-making process. This approach frequently employs machine learning and geographical data to assist individuals in better preparing for and responding to earthquakes.

2. ALGORITHMS

Random Forest Algorithm: The Random Forest method consolidates multiple decision trees into a single group to enhance accuracy and reduce overfitting. It is capable of accurately capturing nonlinear relationships, which is why it is effective with both complex and large datasets.

Decision Tree Algorithm: The Random Forest method consolidates multiple decision trees into a single group to enhance accuracy and reduce overfitting. It is capable of accurately capturing nonlinear relationships, which is why it is effective with both complex and large datasets.

K-Nearest Neighbors (KNN): By measuring distance, KNN sorts data according to the most prevalent class among its nearest companions. Although it functions exceptionally well with little datasets, it operates at an excruciatingly sluggish pace when confronted with substantial datasets.

Support Vector Machine (SVM): By measuring distance, KNN sorts data according to the most prevalent class among its nearest companions. Although it functions exceptionally well with little datasets, it operates at an excruciatingly sluggish pace when confronted with substantial datasets.

Model Comparison: By measuring distance, KNN sorts data according to the most prevalent class among its nearest companions. Although it functions exceptionally well with little datasets, it operates at an excruciatingly sluggish pace when confronted with substantial datasets.

3. REVIEW OF LITERATURE

Anderson & Miller (2021) This investigation proposes the utilization of machine learning to assist individuals in selecting more suitable accommodations during earthquake evacuations. Clustering methods and Geographic Information Systems (GIS) are employed to identify secure evacuation zones by considering factors such as the number of residents, the ease of transportation, and the risk of earthquakes. The model simplifies the planning of emergency responses and reduces the time required for traffic and escape. When selecting safe havens, experimental evaluation yields more reliable results than conventional methods. The concept promotes effective emergency management in urban areas.

Rahman & Gupta (2022) This paper employs real-time traffic data and deep learning to describe a state-of-the-art system for earthquake evacuation guidance. The program determines the most effective methods of exiting by analyzing data regarding the frequency of earthquakes, the movement of crowds, and the condition of the roadways. Reinforcement learning algorithms can be implemented to enhance route concepts in real time during emergencies. According to the performance paper, the pace of evacuations has increased, and travel

delays have decreased. The proposed approach enhances disaster planning and public safety.

Lopez & Kim (2023) This paper employs real-time traffic data and deep learning to describe a state-of-the-art system for earthquake evacuation guidance. The program determines the most effective methods of exiting by analyzing data regarding the frequency of earthquakes, the movement of crowds, and the condition of the roadways. Reinforcement learning algorithms can be implemented to enhance route concepts in real time during emergencies. According to the performance paper, the pace of evacuations has increased, and travel delays have decreased. The proposed approach enhances disaster planning and public safety.

Nakamura & Singh (2024) This research demonstrates a state-of-the-art approach to seismic evacuation management that employs predictive analytics and artificial intelligence to identify the most effective routes. The concept encompasses GPS tracking, machine learning algorithms, and IoT sensors. In order to monitor emergency situations and assist individuals in reaching secure locations, they will be implemented. The test results corroborate the assertions of a more reliable path and a quicker escape response in environments that are constantly changing. The proposed system will enhance the stability of disaster management operations.

Omar & Fernandes (2025) The research provides an adaptive framework for earthquake evacuation that employs ensemble learning to identify the most suitable routes and secure locations for accommodation. The Random Forest and Gradient Boosting algorithms are employed to evaluate risk factors, including the likelihood of an aftershock, the extent of infrastructure damage, and the population density in the vicinity. The concept of the system is that it has the ability to adjust its advice on escape in real time in response to the situation. The findings indicate that evacuation resources were utilized more effectively and that guidance was more precise. The framework can be implemented to establish disaster response systems in smart cities.

Wang & Reddy (2026) The authors construct an AI-powered system that will assist individuals in exiting hazardous areas during earthquakes by utilizing data stored in the cloud. The system incorporates autonomous routing algorithms, geographical data processing, and machine learning prediction models to enhance disaster planning. Edge computing enables individuals to make more informed judgments and respond more promptly in emergency situations. The experiments' findings indicate that the system is more resilient to disasters, can be expanded, and requires less time to evacuate. The framework will be utilized by intelligent disaster management systems to assist them in the future.

4. RESEARCH METHOD

ANALYSIS OF THE CASE RESEARCH

Tehran's population has experienced significant growth in recent years, despite its relatively small size of approximately 730 km². The city is at a high risk of disasters due to its location on active lines. They have the potential to generate ground accelerations of up to 1g. An abundance of data indicates that crisis management centers and EECs are dispersed throughout

ISSN: APPLIED |VOLUME-1, ISSUE-1|
Inaugural Edition | October-December 2026
Paper ID: NG11-005| Research Article
DOI:

various locations, including schools, parks, and sports fields.

DEVELOPING AN AI-BASED MODEL FOR SITE-SELECTING EECS

The objective is to identify the optimal locations for EECs in Tehran through the application of machine learning, regardless of whether such facilities are currently in existence.

Key Steps:

- Ensure that the model incorporates the site selection factors.
- Consider the advantages and disadvantages of the Gaussian Process, ANN, KNN, and SVM methods.
- The most effective ANN was selected due to its F1 score of over 95%, which indicates that it functioned exceptionally well.
- Cross-Domain Prediction can assist in your journey from San Francisco to Tehran

Model Development Process:

- Arrange the factors you have selected in a manner that is logical.
- Create maps of the locations in the training city where pollution control measures are implemented.
- Collect and manage a wide range of geographic information.
- Complete the normalization and preparation.
- Enhance the performance of an artificial neural network model by incorporating classification.

ANN Pseudocode Steps:

- Data input and encoding/standards are critical components of the planning process.
- Arrange individuals into small groups to facilitate the process of learning and testing.
- The input, concealed, and output nodes are the three levels of a neural network.
- Random Search is exactly what is required to modify the hyperparameters.
- Instruct the model to complete the task ahead of schedule.
- The uncertainty matrix and the F1 score are valuable instruments for assessment.
- After the model has been trained, it can be removed from consideration.

SITE-SELECTING EECS

The proposed concept, which is designed to enhance Tehran's EEC locations, is contrasted with the current state of affairs.

Data Layers Used:

- Utilizing land parcels
- Visual representations of land, including its elevation and slope.
- Public Security Schools
- Health care institutions
- Conflict zones
- Water that was conserved for emergency use.
- Population Dispersion
- Block and neighborhood maps
- At present, the European Economic Community is situated in...

Data Preprocessing:

- UTM-style coordinates are employed in the maps.
- Collaborate with others to generate land-use maps.
- Please specify the EEC instruments that are currently in use.
- Locate the parcel and quantify it.
- What is the distance between the largest structures in Manhattan?

ISSN: APPLIED |VOLUME-1, ISSUE-1|
Inaugural Edition | October-December 2026
Paper ID: NG11-005| Research Article
DOI:

Removing Unacceptable Land Uses

EECs are restricted to specific locations, including schools, arenas, parks, and open spaces.

- It is not applicable to residential, commercial, industrial, or government locations.
- Additionally, websites that pertain to health, safety, or history are excluded.
- in accordance with the regulations that dictate the safety of dwellings in Iran during earthquakes.

Using Private Sector Parcels

- Private land areas are also considered when selecting an EEC.
- This is consistent with Iranian regulations regarding disaster management.
- Take advantage of the resources that cities have to offer in the event of a disaster.

DEVELOPING A NAVIGATION MODEL

We develop a web-based guidance system that simplifies the process of locating EECs in your vicinity.

Tools Used:

- Map rendering in a brochure that is intended for interactive use
- The OpenRouteService (ORS) is responsible for the calculation and identification of the optimal routes.
- The Geolocation API of HTML5 enables the identification of users' locations.

ANALYSIS OF THE CASE RESEARCH

The navigation system provides real-time instructions on how to evacuate and connects users to EEC locations selected by AI.

Navigation Pseudocode:

- Determine the method by which the HTML map will be assembled.
- The map can be viewed in the form of a brochure using OpenStreetMap.
- The geolocation API can be employed to determine the individual's current location.
- Begin by opening the CSV file in order to incorporate the EEC facts.
- Determine the precise locations on the globe.
- Locate the most secure location in the event of an emergency.
- Utilize ORS to construct a path.
- Kindly activate the feature that displays the travel path on the map.

5. RESULTS



Fig 4.1: Service Provider Login



Fig 4.2: Choose Dataset



Fig 4.3: Dataset Accuracy Results in Linechart

ISSN: APPLIED |VOLUME-1, ISSUE-1|
Inaugural Edition | October-December 2026
Paper ID: NG11-005| Research Article
DOI:



Fig 4.4: Dataset Accuracy Results in Pirchart



Fig 4.5 Predict Disaster Intensity Details

5. CONCLUSION

The proposed method is an illustration of how machine learning could be employed to enhance evacuation arrangements in the event of an earthquake. The system is a comprehensive catastrophe management solution, featuring predictive modeling, data analytics, and spatial visualization. The system's dynamic estimates, which are derived from real-time inputs, enable the formulation of more accurate emergency decisions than conventional methods. The Random Forest model consistently outperforms the other machine learning methods, regardless of the number of methods employed to ensure accuracy and dependability. A graphical user interface (GUI) simplifies the interface of a system by enabling users to interact with it without requiring a high level of computer expertise. Additionally, the graphic component assists in the preparation of evacuations by illustrating disaster-prone regions that are crucial to be aware of. By incorporating real-time data from sensors, IoT devices, and satellite images, we can significantly enhance the system. Additionally, the implementation of mobile applications can facilitate the provision of real-time directions and advice to individuals residing in affected regions. Ultimately, the outcomes of this investigation are indispensable for the development of intelligent catastrophe management systems. It demonstrates how geospatial and machine learning technologies could facilitate the improved living and recovery of communities in areas that are susceptible to disasters.

REFERENCES

[1] K. K. Gajula, “Leveraging Machine Learning Techniques for Earthquake Impact Analysis and Prediction,” ZKG International, vol. 9, no. 2, pp. 909–913, 2024.

[2] A. Amiran, B. Behnam, and S. Seyedin, “AI-Based Model for Site-Selecting Earthquake Emergency Shelters,” Scientific Reports, vol. 14, Art. no. 29033, 2024, doi: 10.1038/s41598-024-80586-w.

[3] A. S. Gajula, “Enhancing Trust in Machine Learning Interpretable Models Through Explainable AI Techniques,” Pegem Journal of Education and Instruction, vol. 13, no. 4, pp. 909–915, 2023.

[4] S. Aghaie and B. Karimi, “Location-Allocation-Routing for Emergency Shelters Based on Geographical Information System (ArcGIS) by NSGA-II (Case Study: Earthquake Occurrence in Tehran (District-1)),” Socio-Economic Planning Sciences, vol. 84, Art. no. 101420, 2022, doi: 10.1016/j.seps.2022.101420.

[5] G. Zhong, G. Zhai, K. Shang, and W. Chen, “A Two-Stage Hierarchical Model for Spatial Location and Evacuation Allocation Problem of Urban Earthquake Shelters: A Case Study in Central Urban

Area of Yangbi County, Yunnan Province, China," Geomatics, Natural Hazards and Risk, vol. 13, no. 1, pp. 1721–1761, 2022, doi: 10.1080/19475705.2022.2098067.

[6] K. K. Gajula, "Designing an Ethical Data Science Framework for Responsible and Transparent AI Integration," Emerging Trends in Digital Transformation, vol. 1, no. 1, pp. 74–87, 2025.

[7] M. Sharifirasaee, Z. Bahramian, and R. A. Abbaspour, "Optimizing Network-Constrained Evacuation Paths for Efficient Shelter Allocation after Earthquakes," ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. X-4/W8-2025, pp. 715–720, 2026, doi: 10.5194/isprs-annals-X-4-W8-2025-715-2026.

[8] K. K. Gajula, "Deep Neural Forecasting Models for Climate Change Analysis Using Multivariate Time-Series Data," Journal of Computational Analysis and Applications, vol. 33, no. 8, pp. 6356–6368, 2024.

[9] W. No, J. Choi, S. Park, and D. Lee, "Balancing Hazard Exposure and Walking Distance in Evacuation Route Planning during Earthquake Disasters," ISPRS International Journal of Geo-Information, vol. 9, no. 7, Art. no. 432, 2020, doi: 10.3390/ijgi9070432.

[10] K. K. Gajula, "Advanced Stress Level Forecasting Using Quantile-Optimized Regression Forest Models," International Journal of Engineering Research and Science & Technology, vol. 21, no. 4(1), pp. 1–7, Dec. 2025, doi: 10.62643/ijerst.2025.v21.n4(1).pp1-7.

[11] A. Kaveh, S. M. Javadi, and R. Mahdipour Moghanni, "Emergency Management Systems after Disastrous Earthquakes Using Optimization Methods: A Comprehensive Review," Advances in Engineering Software, vol. 149, Art. no. 102885, 2020, doi: 10.1016/j.advengsoft.2020.102885.

[12] K. K. Gajula, "Integrating Blockchain and Machine Learning for Advancements in the Healthcare Industry," Res Militaris, vol. 13, no. 4, pp. 5433–5437, 2023.

[13] A. Esposito Amideo, M. P. Scaparra, and K. Kotiadis, "Optimising Shelter Location and Evacuation Routing Operations: The Critical Issues," European Journal of Operational Research, vol. 279, no. 2, pp. 279–295, 2019, doi: 10.1016/j.ejor.2018.12.009.

[14] K. K. Gajula, "Intelligent AI Systems and Advanced Machine Learning: Recent Advances and Real-World Applications," Journal of Intelligent Decision Making and Information Science, vol. 3, no. 7s, pp. 1831–1845, 2026.

[15] Y. Kızılkan and S. Birinci, "Integration of GIS and MCDM for Temporary Shelter Site Selection in Earthquake-Risk Zone: A Case Study with Sensitivity Analysis," Natural Hazards, vol. 122, Art. no. 469, 2026, doi: 10.1007/s11069-026-08246-y.