

# Predicting the Location of a Possible Earthquake in Khorasan Razavi Province by Using Artificial Neural Network

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## 1. Introduction

Khorasan Razavi province is located in northeast of Iran, and it had the population of 5,994,402 people in 2011 census. According to land use in Khorasan Razavi province, 71% of the total area of the province is in moderate to high hazard which 24 cities with a population of 2,900,000 and 1,063 villages with a population of 580,000 are in relatively high-risk zones. The province has more than 5,500 large and small faults detected that 60% area, 75% of towns and 35% of villages are in the privacy of these faults. This is when the fact that only 28% of houses in the province have a steel and concrete structure and 72% of houses also used other materials that will seriously damage in earthquake. The situation indicates that in the event of a large earthquake, the province of Khorasan Razavi will be faced with disaster; therefore, in this study we have tried to use the features of occurred earthquakes in Khorasan Razavi in the years 1900-2014, and the places that are more likely to have earthquake are identified and have prioritized planning.

## 2. Study Area

The current research area is in Khorasan Razavi province in I. R. Iran which the following are the most important characteristics of earthquakes happened and the seismic situation with regard to faults privacy are pointed out.

- 40% of the area of Khorasan Razavi province is in the safe range and about 60% of its area is located near fault lines.
- Checking the focal depth of earthquakes occurred in the region shows that more than 90% of these earthquakes had focal depth of less than 40 kilometers long and 79% of them also have a focal depth between 10 and 40 km respectively.

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- The least of depth of the earthquake occurred in 1 km surface of the earth, the maximum depth was 64 kilometers and an average depth was 20.96 km of surface of the earth.

### 3. Material and Methods

A model of neural networks that was used in the classification and clustering of used data was Self Organization Feature Maps (SOM or SOFM). This was first presented by Kohonen and is known as Kohonen model. The root of Kohonen learning rule dates back to 1962 and unsupervised clustering issues. The primary goal of unsupervised Kohonen self-organizing neural networks is converting the input pattern with optional dimensions into a discrete model with one or two dimensions. The reason for selecting Kohonen neural network is that these networks are capable of categorizing large amounts of input data simultaneously and in parallel and recognizing seismic patterns. Using Kohonen neural network is due to internal statistical models in algorithms and unlike most statistical methods does not require many assumptions. It should be noted that the data used in the study through the information available on the website of International Institute of Earthquake Engineering and Seismology have been extracted from the characteristics of earthquake location (latitude), hours after the earthquake, the earthquake magnitude and depth of the earthquake in Khorasan Razavi province since the beginning of 1900 until the end of 2013. As well as a large number of earthquakes occurred in the area between 4-8 on the Richter scale are 199. Also, to evaluate the accuracy of neural network model used in the study, the statistical methods root mean square error (RMSE), mean bias error (MAE) and mean absolute error (MAE) are used.

### 4. Results and Discussion

After spatial prediction of a possible earthquake with a neural network, the predicted data have been processed by statistical analysis. Therefore, the Gaussian Mixture Model (GMM) was used. From seismic zoning maps percent it can be concluded that the maximum possibility of earthquake is predicted in the central region toward the west and the south east region of Khorasan Razavi province with a probability of 30% higher than other regions. Based on the model predictions it was good in cities of Mashhad, Fariman, Khaf, Gonabad, Kashmar, Khalil Abad, Torbat Heydarieh, Rashtkhar, Sabzevar, and Ghouchan and in other cities it is average. However, the total RMSE error model for Khorasan Razavi province is 0.460 that represents a model is a good fit. The results of MBE and MAE also confirm the results of RMSE criteria. The total amount of MBE model error is 0.274 and MAE model is 0.418 models that represent a good forecast.

### 5. Conclusion

The findings show that 12% of the urban population and 10% of rural population in zones with relatively high risk and most possibility of earthquake occurrence is in the central region toward the west of Province (Kashmar city and southeast of Sabzevar), southeast of Bardeskan and in southeast region (Khaf city) with 30% more than other

predicted regions, this is while in cities of Kashmar, Sabzevar, Bardaskan and Khaf, respectively 10, 16, 17 and 18 percent of houses have used steel and reinforced concrete materials and 89, 83, 82 and 80% of houses in the cities have used stone, brick, wood, clay and mud that in case of a possible earthquake could cause irreparable damages to life and property. The Kohonen neural network model could predict the probability of earthquakes in areas which are higher than other regions of the province.

**Key words:** Predicting the location of an earthquake, Neural networks method, Khorasan Razavi province

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