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FORECASTING OF EARTHQUAKE USING RECURRENT NEURAL NETWORK

Introduction

- Earthquake forecasting involves methods that provide information about the location, time and magnitude of the occurrence of the event.
- Though statistical models, like Gutenberg-Richter relationship, are based on the distribution of earthquake magnitude in the space-time domain describe the frequencies of occurrence of the earthquake events, there is an element inherent uncertainty associated with the forecasts. Hence
- In the present study the occurrence or non-occurrence of an earthquake event of a certain magnitude of fixed time interval .

Dataset

- The USGS, IMD catalogs and the catalog at EERC were used in the study. The dataset consists of 8683 seismic events for a time duration of from 01-01-1818 to 31-12-2017. The parameters considered are location in form of latitude and longitude, magnitude and the time of occurrence.

Table 1: Number of events based on magnitude

Number of Events	Magnitude
86	<3 M_w
2303	3 – 4 M_w
4110	4 – 5 M_w
1854	5 – 6 M_w
285	6 – 7 M_w
42	7 – 8 M_w
5	> 8 M_w

Table 2: Earthquake magnitude categories.

Group	Range
Minor Magnitude	≤ 4 M_w
Moderate Magnitude	4 M_w – 6 M_w
Strong Magnitude	> 6 M_w

Table 3: Number of events in each category

Number of Events	Category
2389	Minor Magnitude
5964	Moderate Magnitude
332	Strong Magnitude

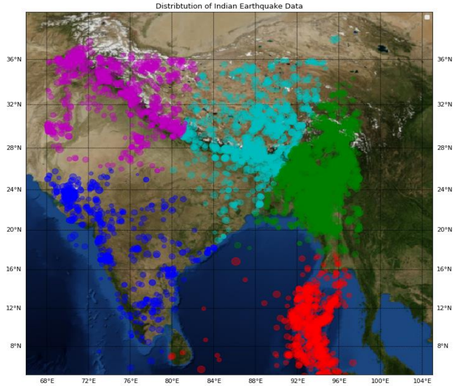

Figure 1 : Clusters of Indian seismicity

Methodology

- K-means clustering algorithm is applied on the epicenters of the data and the optimum clusters obtained are five. The clustered data rightly represents the division of the seismicity of India.
- Two approaches are explored in the study. In “Approach 1”, Recurrent Neural Networks (RNN) has been used to the data of the each of the clsuters and the maximum magnitude of the earthquake that are likely to occur in the next 15 days , 30 days , 60 days, 90 days and 180 days.
- In “Approach 2”, the data in each cluster has been further classified into minor , moderate and strong magnitudes. Recurrent Neural Networks (RNN) has been used to the data to predict the earthquake of each classification that are likely to occur in the next 15 days , 30 days , 60 days, 90 days and 180 days.
- The training and the test data has been divided as 90% and 10% respectively.

Table 4: Details of each cluster

Clusters	Number of Events	Latitude Range	Longitude Range
Cluster 1	617	05.80^0 N to 26.03^0 N	68.07^0 E to 84.03^0 E
Cluster 2	1638	19.00^0 N to 37.80^0 N	80.10^0 E to 95.70^0 E
Cluster 3	845	04.01^0 N to 17.47^0 N	79.05^0 E to 97.30^0 E
Cluster 4	4414	17.62^0 N to 34.38^0 N	86.28^0 E to 97.99^0 E
Cluster 5	1172	25.85^0 N to 37.60^0 N	68.01^0 E to 84.42^0 E

Results

Table 5: Approach 1 Prediction accuracy in each cluster.

Clusters	Time Period				
	15 Days	30 Days	60 Days	90 Days	180 Days
Cluster 1	84.04	76.06	64.79	56.34	45.07
Cluster 2	56.25	62.92	75.83	82.50	22.50
Cluster 3	51.21	33.33	31.73	31.88	17.14
Cluster 4	60.77	73.48	82.42	75.41	61.29
Cluster 5	43.01	40.32	49.46	66.13	58.06

Table 6: Approach 2 Prediction accuracy in each cluster.

Clusters	Magnitude Class	Time Period				
		15 Days	30 Days	60 Days	90 Days	180 Days
Cluster 1	Minor	100	100	100	100	100
	Moderate	85.98	76.15	61.67	48.75	37.5
	Strong	98.92	98.08	96.15	94.96	92.86
Cluster 2	Minor	100	63.75	100	100	100
	Moderate	58.66	61.90	79.31	89.61	NA
	Strong	97.11	94.23	89.42	84.43	74.29
Cluster 3	Minor	100	100	100	100	100
	Moderate	52.17	32.85	83.65	15.94	94.29
	Strong	95.65	91.30	84.06	76.09	65.22
Cluster 4	Minor	100	100	100	100	NA
	Moderate	67.13	80.11	94.51	95.08	100
	Strong	94.90	90.48	82.43	75.51	56
Cluster 5	Minor	100	100	100	NA	23.33
	Moderate	44.62	23.12	92.47	95.16	100
	Strong	92.82	85.71	77.36	71.43	55.56

Conclusions

- The overall results in the approach 2 shows better results over approach 1. Exploring in the direction of features that represent earthquake phenomenon will yield results.

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