A Study to Discriminate Earthquake from Mining Blast Using Neural Network

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Abstract:-**The paper describes the study of different techniques applied for the discrimination of earthquake and the mining blast in the regions of Turkey and Tehran. The methods include neural networks trained on the basis of past available data and implementing different interfaces using fuzzy logic. Different parameters like maximum amplitude S/P, Complexity C, Spectral ratio and Time Frequency analysis are incorporated to differentiate the Earthquake from the Mining Events that contaminate the event catalogue recorded by the seismograph networks.**

Keywords:- **Earthquake, mining blast, quarry blast, neural network.**

I. INTRODUCTION

Earthquakes are the most fearsome pests to man as they strikes without warning, in any unpredictable places, at any irregular intervals and causing terror effect [6]. Gujarat has a seismic network of 60 Broadband Seismographs and 50 Strong Motion Accelerographs since 2006. Data of 36 broadband stations is processed in real-time through VSAT and Auto location software round the clock to determine the epicentre and magnitude of earthquakes within minutes of arrival of the seismic waves and the information is spread widely to administrators for taking appropriate measures [5].

A large number of quarry blasts have been exploded all around Gujarat. When these blasts are recorded by seismic stations, they contaminate the regional earthquake catalogue.It is necessary to Discriminate quarry blast records from the earthquake catalogues in order to determine the real seismicity of the region.

Artificial Neural Networks ***(ANNs)*** are computational models capable of exploiting massive computational parallelism. ***ANNs*** contain a high number of computing elements, called neurons;they are(often densely) connected by weighted links (called synapses***),*** through which neurons exchange information [4].

Neural technologies are appealing solutions toafford the design of an innovative seismograph due to uncertain algorithms, noise in the signal, adaptability to environmental conditions, classification, sensors fusion, and high parallelism for real-time operation [4].

II. LITERATURE REVIEW

Study as in [1] shows identifying the underground nuclear explosions that occur along with a large number of natural earthquakes. The method uses image compression neural network that has a data compression capability of mapping original data to a feature space of reduced dimensionality. The feedforward backpropagation learning algorithm is used in training the neural network.

The method firstly selects one or more examples of each earthquake and explosion and transforms these time signals into frequency domain. Then converts the spectral domain to earthquake and explosion respectively. Using this procedure, unknown events can be processed and identified in near-real time. The study concludes that an Explosion wave generates only compressional waves, while an Earthquake generates shear wave along with a compressional wave. Explosions have a significant fraction of their total signal energy concentrated in the early, mostly compressional-wave portions of the signal, whereas earthquakes have relatively more energy concentrated in the later portions comprised mostly of shear waves and surface waves.

Meanwhile in [2] shows a study that discriminates quarry blasts from earthquakes in the eastern Black Sea region of Turkey using 186 seismic events recorded by the Karadeniz Technical University and Bogaziçi University Kandilli Observatory Earthquake Research Institute stations.

For the discrimination of quarry blasts from earthquakes, both statistical methods (calculation of the maximum ratio of S to P waves (S/P), complexity (C)) and spectral methods (spectrogram calculation) are used. These methods included measuring the maximum amplitude S/P, C, spectral ratio, and time frequency analysis.

Here first method used in the analysis plots the amplitude peak ratio of the S to P waves versus the logarithm amplitude peak of the S wave in the time domain of the seismogram. Then, linear discriminant function (LDF) analysis is used to distinguish earthquakes from quarry blasts.

In the study a second method was employed plotting complexity (C) versus the spectral ratio of the seismogram (Sr). Here, C is the ratio of the seismogram's integrated powers s2 (t) in the selected time windows (t1–t2 and t0–t1). Sr is the ratio of the seismogram's integrated spectral amplitudes a(f) in the selected frequency bands (high-frequency band, h1–h2, and low-frequency band, l1–l2). C and Sr can be written as:

$$C = \int_{t1}^{t2} s^2\,(t)dt / \int_{t0}^{t1} s^2\,(t)dt$$

$$Sr = \int_{h1}^{h2} a(f)d(f) \,/ \int_{I1}^{I2} a(f)d(f)$$

In the TFA method, two criteria are considered to separate earthquakes and explosions:

The first criterion is to observe the maximum released energy.

For quarry blasts, energy is released suddenly and maximum amplitudes are observed in the beginning of the record in the time. The maximum energy spreads through large frequencies in the frequency domain and is concentrated in the first part of the TFA, while in earthquake records, S wave amplitudes are much larger than P wave amplitudes. Maximum amplitudes are observed in the S wave train arriving later than the P wave train in the time domain. The maximum energy spreads through lower frequencies than those of P waves in the frequency domain and is not concentrated in the first part of the TFA.

The second criterion of discrimination is the observation of the Rg phase. The Rg phase, often observed on the vertical component records of quarry blasts and very shallowly focused earthquakes, has a spectral peak at 0.5–2.0 Hz.

Besides this in [3] a study was conducted and presented an adaptive neuro-fuzzy inference system (ANFIS) for classification of low magnitude seismic events used to evaluate seismic discriminants. For this features like origin time of event, distance (source to station), latitude of epicentre, longitude of epicentre, magnitude, and spectral analysis (fc of the Pg wave) were used as inputs to increase the rate of correct classification and decrease the confusion rate between weak earthquakes and quarry blasts.

In feature selection with the forward selection method, CCR and rank of every feature are calculated separately and then mixed them together, for example, first only time then, time with latitude; next, time, latitude, magnitude and so on.

To develop the ANFIS architecture, two fuzzy "if–then" rules were considered based on a first order Sugeno model:

Rule 1: If (x is A1) and (y is B1), then (f1 0 p1x + q1y + r1)

Rule 2: If (x is A2) and (y is B2), then (f2 0 p2x + q2y + r2) where x and y are the inputs; Ai and Bi are the fuzzy sets; fi is the output within the fuzzy region specified by the fuzzy rule; and pi, qi, and ri are the design parameters determined during the training process

A hybrid algorithm is developed combining forward and a backward pass. The least squares method (forward pass) is used to optimize the consequent parameters with fixed premise parameters. Once this optimal consequent parameters are found, the backward pass begins. The gradient descent method (backward pass) is used to optimally adjust the premise parameters corresponding to the fuzzy sets in the input domain.

Vertical components show reasonable discrimination power for classifying earthquakes and explosions. It is also evident that spectral corner frequency (fc) for quarry blasts was less than that for weak earthquakes. The mean fc for Pg waves (vertical component) for all of events are about 4.4 and 2.0 Hz for earthquakes and quarry blasts, respectively.

ANFIS has automated identification algorithm and easier design, it has less number of parameters and faster adaption hence being an appropriate method developed for discrimination of earthquake and blast by combination of the advantages of both fuzzy rule-based system and neural networks.

III.COMPARATIVE STUDY

	Title	**Limitation**
1.	Spectral discrimination between mining blasts and natural earthquakes: Application to the vicinity of Tunçbilek mining area, Western Turkey	Although considerable overlap was not found for the mining blast and earthquake populations, they were not completely discriminated by both ratios
2.	Adaptive neuro-fuzzy inference systems for semi-automatic discrimination between seismic events: a study in Tehran region	Used only spectra for Pg phases. Data contains small explosions, not strong explosions. There was a problem for reading other phases like Rg , because their diagnosis was not easy for all events
3.	A Neural Network approach to Seismic event identification using reference Seismic Images	Frequency-slowness or frequency velocity reference images with high signal-to-noise ratio (SNR) that have been normalized at each frequency are used to train and test the data compression neural network
4.	Discrimination of earthquakes and quarry blasts in the eastern Black Sea region of Turkey	Discrimination of earthquakes from quarry blasts using simple methods, i.e., satellite images, occurrence times, may not be accurate if quarries are located along active fault zones

IV. FUTURE WORK

All this study show that there are different methods used to classify the Earthquake and Mining Blast, but the most effective found is using neural network, and amongst them Radial basis function neural network can be more effective due to its benefits over backpropagation neural network.

V. CONCLUSION

Discrimination of Earthquake and Quarry Blast from the seismic catalogue is a necessity as it contaminates the list of events. Using the neural network for this purpose increases the accuracy. Using Compressional images neural network the process of calculating the parameters manually decreases but at the same time the complexity of training the network increases. Hence adaptive neuro fuzzy classifiers are implemented as the help to design a classifier. Generally the parameters used for classifications are amplitude ratio, Spectral ratio, origin time and Complexity. Using all this parameters the events can be classified and used further in the calculating the properties of soil and strength of land.

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