EARTHQUAKE PREDICTION BY USING EVIDENTIAL REASONING APPROACH

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Abstract

Earthquake is considered as one of the biggest threats for the modern civilization. It ruins a large number of buildings throughout the world. Many people die and huge amount of property is destroyed because of this dangerous natural disaster. This is not possible to stop earthquake. So, the only way to save lives and properties from earthquake is the early prediction of it. Many researches have been conducting on it and an expert system has been developed. But the developed system cannot handle uncertainties which provides some inexact results. However, this paper presents a system that predicts earthquake from some signs and patterns by using Evidential Reasoning Approach. The proposed system deals with uncertainties and produces the most accurate results.

Key Words: *Earthquake; natural disaster; Evidential Reasoning Approach; Signs and patterns.*

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1. INTRODUCTION

Earthquake is one of the most audacious natural calamities. An earthquake is defined as the shaking of ground because of large sections of the earth's outermost crust .Earthquake is considered as the most dangerous disaster which killed a large number of people and destroyed a large amount of properties. According to statistics 332723 earthquakes occurred from 2000 to 2012 and 813856 people died in these earthquakes [1]. Researchers say that only early prediction of earthquake can minimize the number of death. So, it is necessary to predict earthquake. This paper represents a system that will predict earthquake from some signs and patterns.

The paper is organized as follows: Section 1 provides the introduction where section 2, 3, 4, 5 present background study, literature review, proposed methodology and prediction of earthquake, Section 6 represents the results and discussion where section 7 concludes the paper.

2. BACKGROUND STUDY

As earthquake is considered the most dangerous natural disaster, a number of researches have been conducted over it. An expert system has also been developed to predict the earthquake magnitude by Aojjatadell and panakkat[2]. But this system is not capable of handling uncertainty which provides inexact results.

However, this paper proposes a system that predicts earthquakes from some signs and trends by using ER approach. This system is capable of dealing with uncertainty which provides the most correct results.

3. LITERATURE REVIEW

One of the most important branches of seismology is earthquake prediction. Prediction of earthquake provides some sufficient warning about the issue that verily happens before earthquake [3].

Earthquake prediction can be the probabilistic assessment of general earthquake branch. It is said that, earthquake prediction is not yet precisely possible. But researches argued that, there are some signs which predict earthquake, for which they emphasis on some empirical analysis. Identification of distinctive to earthquakes and geographical trend or pattern in seismicity can make the prediction of earthquake. An effective warning of earthquake can be done by an earthquake precursor [4]. Precursor includes animal's behavior, changes in VP/VS, random emissions and electromagnetic variation. The unusual behavior of animal are referred to as the response to p-wave [5]. This is very often observed before the earthquake. Changes in VP/VS are an important issue of earthquake prediction. VP denotes the velocity of seismic "p" (primary/pressure) wave passing through the rock and VS is the symbol for the velocity of the "s"(secondary/shear) wave. Some earthquake laboratory examination show that earthquake occurs when the ratio of VP and VS changes – from the normal values [6]. Radon is one of the most-important gases that are contained by the most of rocks. The random emission of Radon occurs before earthquake. Another important issue of precursors is the variation in electro-resistive or magnetic phenomenon.

Another approach of predicting earthquakes is predicting earthquake by looking for trends or pattern that leads to an earthquake which include elastic rebound, seismic gap and

seismicity patterns. Earthquake may occur due to fluid intrusion and stress triggering which is known as seismicity patterns.

4. OVERVIEW OF EVIDENTIAL REASONING

Evidential Reasoning Approach is developed based on Dempster Shafer Theory. This approach works on Multiple Attribute Decision Analysis (MADA). In this approach, the basic attributes of Architectural Theory Diagram (ATD) are aggregated. For that, weights and belief are assigned for each basic attribute by the domain expert. The mass of each attribute are calculated by using the following formula.

$$m_{j,k} = w_k * \beta_{ij}, j = 1, \ldots\ldots, N \quad (1)$$

and

$$m_{D,k} = 1 - \sum_{j=1}^{N} m_{j,k} \quad (2)$$

Here, $\bar{m}_{D,k}$ is the probability mass unassigned to any individual consequent. This $\bar{m}_{D,k}$ is decomposed into $\tilde{m}_{D,k}$ and $\bar{m}_{D,k}$ [7] where $\bar{m}_{D,k} = 1 - w_k$ (3)

and $\tilde{m}_{D,k} = w_k * 1 - \sum_{j=1}^{N} \beta_{j,k}$ (4)

Then the overall aggregated degree of belief β_j and D_j is generated as:

$$\{Dj\}: m_{j,I(k+1)} = K_{I(k+1)}[m_{j,I(k)}m_{j,k+1} + m_{j,I(k)}m_{D,k+1} + m_{D,I(k)}m_{j,k+1}] \quad (5)$$

$$m_{D,I(k)} = \bar{m}_{D,I(k)} + \tilde{m}_{D,I(k)} \quad k = 1, \ldots\ldots, L$$

$$\{D\}: \tilde{m}_{D,I(k+1)} = K_{I(k+1)}[\tilde{m}_{D,I(k)}\tilde{m}_{D,k+1} + \tilde{m}_{D,I(k)}\bar{m}_{D,k+1} + \bar{m}_{D,I(k)}\tilde{m}_{D,k+1}] \quad (6)$$

$$\{D\}: \bar{m}_{D,I(k+1)} = K_{I(k+1)}[\bar{m}_{D,I(k)}\bar{m}_{D,k+1}] \quad (7)$$

$$K_{I(k+1)} = [1 - \sum_{j=1}^{N}\sum_{t=1, t\neq j}^{N} m_{j,I(k)} m_{t,k+1}]^{-1} \quad (8)$$

Here, k=1……L-1.

$$\{D_j\}: \beta_j = \frac{\bar{m}_{j,I(L)}}{1 - \bar{m}_{D,I(L)}} \quad (9)$$

$$\{D\}: \beta_D = \frac{\tilde{m}_{D,I(L)}}{1 - \bar{m}_{D,I(L)}} \quad (10)$$

Here, β_D is the remaining belief degree unassigned to any Dj.

5. PREDICTION OF EARTHQUAKE

Prediction of earthquake is done by using ER approach .For that, the user provides the inputs for some linguistic term say high, medium or low. The results of the system are shown in percentage. The unknown results are also shows in this system.

(Presentation) (Application) (Data Processing)

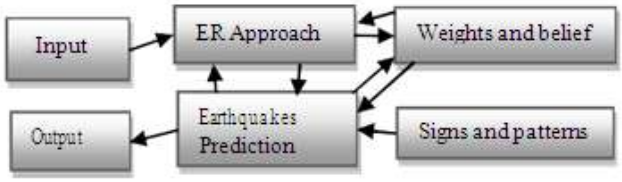

Fig-1: System Architecture to predict Earthquake

Here, presentation layer takes input and Provides output. Application layer consist of application logic and prediction method. Data process layer consist of database and prediction parameters.

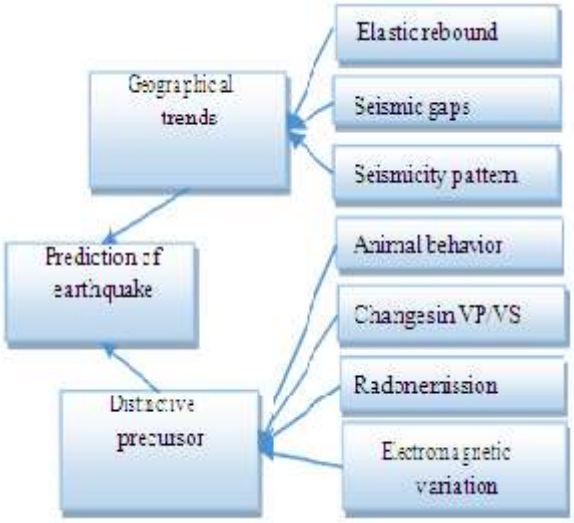

Fig-2: System framework

The framework of this system is shown in figure 2 as an ATD. This prediction is done by using formula from (1) to (9). The unknown results are calculated by using formula (10).

6. RESULTS AND DISCUSSION

The proposed system aggregates the values provided by the user for each attributes. These values are the belief of the user. User needs to provide inputs for high, medium and low for each attribute. The total input will be 1 or less than 1 for each attribute.

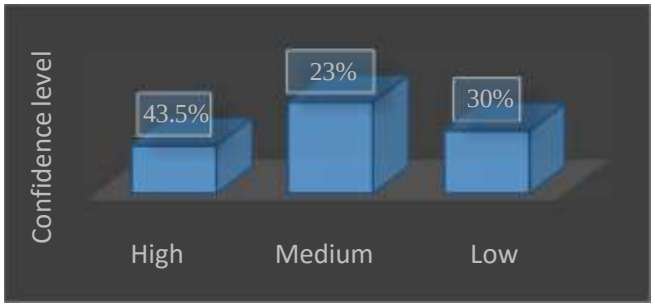

Fig-3: Earthquake prediction results

The system shows the output for high, medium and low in percentages. The total output will be 100% or less than 100%. If the results are less than 100%, then the remaining values will be the unknown values which are actually the uncertainty that the system handles. Manual system provides the inexact results as it cannot handle uncertainties. A ROC (receiver operating characteristics) curve is used to show that the proposed system performs better than the manual system.

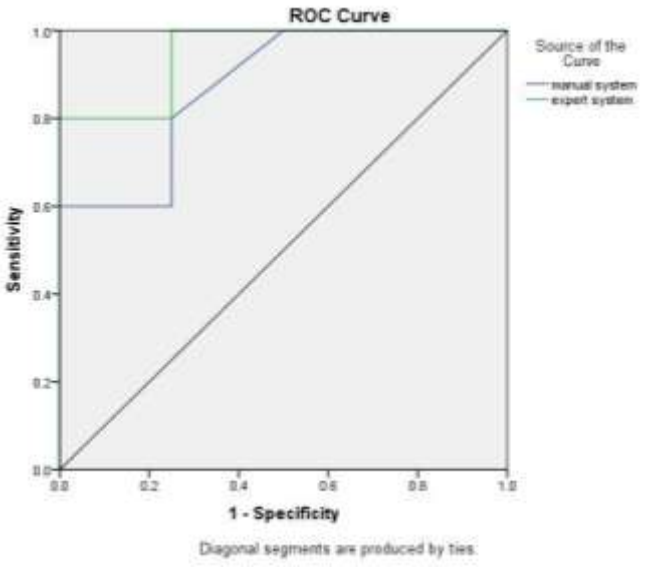

Fig-4: Performance comparison between the manual system and proposed system by ROC curve

Here, the green curve shows the expert system's earthquake prediction performance and the blue curve shows the prediction performance of the manual system. The AUC (area under curve) of the green curve is 0.975 where the AUC of blue curve is 0.850. So, it becomes clear that, the proposed system is more efficient in earthquake prediction than the manual system.

7. CONCLUSION

ER approaches is used to predict earthquakes from some signs and patterns. ER approached can handle uncertainties which are the big limitation of the existing systems.

Prediction of earthquake is possible if the signs and patterns can be observed in time. But this not necessary to observe all the signs and patterns to predict earthquake. If any sign or pattern is not seen then the user may provide a minimum value say 0% or 0.1% for that sign or pattern.

In future, the system will be developed by using Rule Base Interface Methodology using Evidential Reasoning (RIMER) Approach. Then, the system will be more reliable and provide more accurate results.

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