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Earthquakes: Precursors and Prediction

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Abstract— **Earth quake prediction research is being carried out since two decades. But the amalgamation of Geographical or spatial data, realtime systems and Earth Quake prediction algorithms still remain as a challenge. This article explores the precursors for earthquakes , earlier efforts of earthquake prediction and role of soft computing in this arena.**

Index Terms — **Earthquakes, Precursors, Soft computing, Prediction.**

I. EARTHQUAKES: AN INTRODUCTION

Earthquakes, the most devastating natural calamity has stirred interest among researchers in the recent past. And with the recent happening of major earthquakes and Tsunami in Japan, India plans to delve deep in earthquake prediction as reported by Physics today on May 4, 2011. This important research area has kept association with the field of soft computing for more than a decade. This research paper brings an overview of earthquakes, its precursors and prediction, earlier and current efforts and the involved role of soft computing in this area of research.

II. EARTHQUAKES AND PRECURSORS

An earthquake [1] is the result of sudden release of energy in the Earth's crust that creates seismic waves. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale. Magnitude 3 or lower earthquakes are mostly almost imperceptible and magnitude 7 and over potentially cause serious damage over large areas. The largest earthquakes in historic times have been of magnitude slightly over 9 and the most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in March 2011 and it was the largest Japanese earthquake since records began. A precursor [1] in the context of an earthquake is an indicator of approaching events. Periodic variations in the earth's variations of electrical and magnetic fields at the Earth's surface. Fluctuations in the Magnetotellurics signal may be able to predict the onset of seismic events. Thermal anomalies have been identified, associated with large linear structures and fault systems in the Earth's crust, on the basis of satellite infrared thermal images of the Earth's surface. Increased levels [3] of radon gas (222Rn) in wells is a precursor of earthquakes recognized by the IASPE. Over the years, scientists[2] have explored a number of techniques for trying to determine with some precision, when and where a quake will strike.

Radon, a naturally occurring radioactive gas, has been listed as one of several possible indicators of an impending trembler. An Italian scientist Giuliani has said in March 23, 2009 that radon gas as seismic precursor manifests itself between six and twenty four hours ahead of a quake.

In the last decade, several studies [5] have concluded that elevated concentrations of radon gas in soil or groundwater could be the sign of an imminent earthquake. It is believed that the radon is released from activities and cracks as the Earth's crust is strained prior to the sudden slip of an earthquake. In order to test this hypothesis, however, researchers would need to deploy several detector devices along an fault zone. Although several commercial devices could, in theory, perform this task, these devices are too expensive for large scale application. In addition it is not clear whether many of these devices could still work in the presence of water. Now, a group of physicists, led by physics Nobel Laureate Georges Charpak, has developed a new detector that could measure radon gas emission, has come to the rescue of Earthquake research. Also soft computing methodologies facilitate further earthquake prediction research and is being dealt in the next section.

III. SOFT COMPUTING AND EARTHQUAKE PREDICTION

Soft computing became a formal computer science area of study in the early 1990s.Earlier computational approaches could model and precisely analyze only Relatively simple systems .And soft computing deals with imprecision, uncertainty, partial truth and approximations to achieve tractability, robustness and low solution cost. Components of soft computing include neural networks, fuzzy systems, evolutionary computation and swarm intelligence. Many of these soft computing methods are used for earthquake prediction. A survey of existing literature on Earthquake prediction using soft computing models follows.

IV. EARTH QUAKE RESEARCH: EARLIER EFFORTS

In [8] scheme of Earth quake prediction is iterated as follows. Prediction of a strong earthquake was based on the rise of seismic activity in the medium magnitude range. The total

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area of rupture surfaces in the earthquake sources was chosen a measure of seismic activity defined by the function.

$$\sum(t) = \sum 10^{B\, m_i}, m_i < M \quad -(1)$$

Here , m_i is the magnitude of i^{th} earthquake (a logarithmic measure of energy release) and M is the magnitude of a strong earthquake targeted for prediction. summation is taken over the earthquakes that occurred within the sliding time window (t-s,t) in the region considered. The value of parameter B was chosen from condition that each term under summation is coarsely proportional to the rupture area in a source. The premonitory seismicity pattern ∑ was diagnosed by the condition $\sum(t) \geq C_{\sum}$. The threshold $C_{\sum}$ is self adapting to a target magnitude M .It is proportional to the rupture and in the source of a single strong earthquake. The emergence of pattern ∑ before 20 strong earthquakes worldwide was demonstrated by Keilis Borok & Malinovskaya. They have considered prediction as a pattern recognition problem: Given is the dynamics of seismicity in a certain area prior to amount t ;to predict whether a strong earthquake will or will not occur within that area during the subsequent time interval (t, t+▲), In terms of pattern recognition the "object of recognition" is a moment t. the problem is to recognize whether or not it belongs to the time interval ▲ preceding a strong earthquake. Next an overview of prediction algorithms based on premonitory seismicity patterns are dealt with. And these algorithms, are composite prediction algorithms, which are a combination of individual precursors. Algorithm M8 was designed by retrospective analysis of seismicity preceding the greatest (M≥8) earthquakes world wide, hence its name. It successfully predicted all size strong earthquake that occurred from 1992-2000. Algorithm M.Sc., of " Mendicino scenario" was developed by retrospective analysis of seismicity prior to the Eureka earthquake (1980, M=7.2) near Cape Mendocino in California. Algorithm CN was developed by retrospective analysis of seismicity preceding the earthquakes with M≥ 6.5 in California and the adjacent part of Nevada. Algorithm SSE (second strong earthquake) aims at predicting a second earthquake in the region, aftermath of an occurrence of a strong earthquake in the region. Current earthquake predictions have limited accuracy. The attributes of an earthquake prediction are

- Content of a current alarm (what is predicted and where)
- The probability of a false alarm. And
- The cost / benefit ratios of disaster preparedness measures.

Existing research converge on the goal: development of the next generation of prediction algorithms, 5 to 10 times more accurate than existing ones.

V.CURRENT APPROACHES

VI.

Fangzhow xu [7] et al, have developed a Neural Network Model for Earth quake prediction using data through DMETER satellite observation and data of the year 2008. In Research paper [9], Fuzzy systems by learning from examples are used in seismic prediction and pre-warning of time series of the earth quakes of maximum magnitude in northern China. In [4] discusses earthquake time series analysis method and theory, studies genetic neural networks application in earthquake forecasting . Its facility and validity are proved by experiments using MATLAB. In [6] an application of Neuro Fuzzy classifier for short term earthquake prediction using saved seismogram data is investigated. In [10] review papers which analyzed earthquake precursors and historic earthquake data. Apart from the linear monitoring studies concerning the relationship between radon and earthquake, an ANN model approach is presented in the research work [11] .

VII. CONCLUSION

Earthquake prediction is pivotal for reduction of the chaos from earthquakes. This problem is of urgent practical importance because earthquakes pose a rapidly growing threat to survival and sustainable development of human civilization. This is due to the well known inter related developments : proliferation of radioactive waste disposals, high dams, nuclear power plants, whose damage poses an unacceptable risk; self destruction of megacities and destabilization of the environment; Earthquake prediction is necessary to undertake disaster preparedness measures, reducing the damage from the earthquakes. This requires that the accuracy of prediction be known, but to belief, a timely prediction of low accuracy may be very useful.

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BIOGRAPHY

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