# INTELLIGENT SYSTEM FOR PREDICTING EARTHQUAKE USING WAVELET TRANSFORM AND HMM

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**Abstract:** In this paper we are focusing about the prediction of earthquake using Continuous Wavelet Transform (CWT) and Hidden Markov Models (HMM). As we know in the past few decades wavelet transform has drawn attention by mathematicians and researchers for its multiple outputs at different frequency bands called scales. We are also using the HMM for observing the animal behavior as we know animals how the capability to sense the wave on the radiation which comes out before the earthquake.

**Keywords:** Continuous Wavelet Transform, HMM(Hidden Markov Model), Wavelet, Wavelet Transform.

**Introduction:** In the field of climatology the prediction of earthquake has always been a very challenging task. Based on several Geo-Mathematical analysis and theories scientists, climatologists, geologists have developed various earthquake prediction methodologies. But predicting earthquake in well advance so that the inhabitants of a geographical location could vacant the place has failed in so many cases. Cases of false alarms, absence of information to predict earthquake did cost much to humankind. In the perspective of our country specific parts of central Himalayas, north Bihar, Andaman Nicobar islands are marked as Zone V for earthquake affinity. Our idea is to develop a methodology, based on the unknown/ less explored datasets and analyzing them with the help of Continuous Wavelet Transform (CoWT), that will reflect the working principle of marine creatures' instinct to predict the earthquake well in advance.

**Background:** *Wavelet Transformation:* A wavelet is a wan like oscillation with amplitude that stars out at zero increases and has gained lots of importance with the subject to understand, in part the enthusiasm its proponent's toward its potential application to various numerical general Wavelet Transform are to several types,

i. Discrete Wavelet Transform
ii. Continuous Wavelet Transform
iii. Complex Wavelet Transform
iv. Functional Wavelet Transform
v. Steerable Wavelet Transform

As for our project we need CoWT, it is discussed below.

*Continuous Wavelet Transform(CoWT):* This type of wavelet gives a complete representation of a signal when the other parameters for the analysis are constantly varying with time. Mathematically CoWT is represented as,

$$C(a,b;f(t)\psi(t)) = \int_{-\infty}^{+\infty} f(t)\frac{1}{a}\psi * \frac{(t-b)}{a}dt$$

where the symbols are used as standard.

On the other hand HMMs are especially known for their application in temporal pattern recognition such as speed, hand writing, gesture recognition, part-of-speech tagging, musical score following partial discharges and bioinformatics. A simple example of an HMM is predicting the weather (hidden variable) based on the type of clothes that someone wears (observed). An HMM can be viewed as a Baye's net unrolled through time with observation made at a sequence of time steps being used to predict the best sequence of hidden states.

*Geographical Background:* Earthquake refers to sudden vibration or shaking or displacement of the earth's crust along lines of weakness caused due to tectonic forces. The point from where earthquake tremors start is called the seismic focus while the point on the earth's crust, vertically above the seismic focus where the disturbances occur, is called the Epicenter. Earthquake occurs when molten magma rises through cracks or joints and displaced the rocks causing tremors or vibrations. It can also occur along the faults or lines of weakness, in areas of volcanic eruption and along the boundaries of tectonic plates. The frequency of earthquakes is recorded by an instrument called the Seismograph while the intensity of an earthquake is measured on the Richter and Modified Mercalli scale. There are four main types of earthquake waves: (Compressions Primary Longitudinal)P-waves and (shear secondary transverse)S-waves (which are body waves),and Rayleigh waves and Love waves tend to cause the most damage due to their large amplitude and P- waves the least, but P-waves are the first to arrive.

**Case Study:**

*Case 1:* Salam Al Hashmi, Adrian Rawllins and Frank Vernon proposed an algorithm that automatically detects particular classes of seismic wave, the software has been developed to detect P and S-phases in three component seismic data. They have developed an algorithm which is then tested with real seismic data which are recorded during some multiple and regional local data. They compare the software with real human analysis and with the software which the STA/LTA ( short term average/ long term average). But the software with STA/LTA fails in detection where as this algorithm successfully detect the P and S-phase arrivals which is also compared with human analysis.

*Case 2:* Satish Sinha, Partha Routh, Phil Anno and John Castagna in their paper proposed to use Time Frequency Continuous Wavelet Transform (TFCWT) in order to resolve the issues of time frequency domain representation of the available signals. In order to convert the Scalogram they faced some problems with its time-frequency representation. As we know TFCWT is fundamentally derived from the continuous wavelet transform so it is able to give accurate signals. They also give certain examples on single frequency sections and maps from the TFCWT which is can be used in direct hydrocarbon indicators and to further utilization in improved stratigraphic visualization.

*Case 3:* Lionel J. Woog, Igor Popovic, and Anthony Vassilious in their paper proposed to use the ideas and technologies behind GeoEnergy's noise attenuation services. They exposes the GeoEnergy's patented adaptive Wavelet Packets(WP) technology compared with commonly used filtered tools together with extend adaptive WP technology. Their main objective is to increase the signal noise ratio in the data by processing seismic data. They use the common practice methods to develop a practical methodology. The methods are:

i. Apex-shifted multiples
ii. Migration noise
iii. Land Data.

*Case 4:* Yangkang Chen, Tingting Liu, Xiaohang Chen, Jinggye Li and Erying Wang in their paper they uses the Time frequency decomposition to characterized the relation between time and instantaneous

frequency which is non-stationary , to process and interpret seismic data. Their time- frequency analysis is based on Synchro-squeezing Wavelet Transform (SSWT) . They gave examples which show that the SSWT based Time- Frequency (TF) can able to capture the exact variable frequency components. They also use this technique to detect deep layered weak signals which is usually smeared in seismic data which helps to detect the deserted gas and oil.

**Discussion & Conclusion:** We have done a comprehensive study of different research paper based on wavelet transform and seismic waves and data related to it. After studying different cases we have concluded that it is possible to predict earthquake with the help of wavelet transform including both discrete and continuous wavelet but continuous is more useful in prediction. Wavelet Transform involved when time/frequency representation was a challenging phenomenon. Reliable reconstruction of signal with minimum loss with respect to PSNR and MSE are appreciable factors. The use of wavelets in science engineering and medicine has increased because of its interpretation of data and multi resolution features representation. This paper deals with the prediction of earthquake based on detection of different types of waves which emerged during earthquake.

**Future Scope:** After studying all these paper our new idea is to detect the P-waves as these P-waves are the first to arrive. We are going to use HMM for observing the animals have the capability to sense the earthquake before it occurs. From studying various paper and about animals like fishes, elephant, bats, etc. have the capability to detect the electric field .And fishes also can sense the earthquake from which we say that the P-waves have some electric field . As we have already seen that P waves can be detected by using wavelet transform signals with the help of software. So we are going to observed the animals behaviors using the HMM and we will use the software products developed earlier then we will be able to predict the earthquake before sometime of its occurrence which will help to save millions of live.

**References:**

1. H. Dai and C. MacBeth, “Application of Back-Propagation Neural Networks to identification of Seismic Arrival Types,” Physics of the Earth and Planetary Interiors, Vol. 101, No. 3-4, 1997, pp. 177-188. doi: 10.1016/S0031-9201(97)00004-6.
2. H. Dai and C. MacBeth, “The Application of Back-Propagation Neural Network to Automati picking Seismic Arrivals from Single-Component Recordings,” Journal of Geophysical Research, Vol. 102, No. B7, 1997, pp. 1510515113. doi:10.1029/97JB00625.
3. R. Allen, “Automatic Phase Pickers: Their Present Use and Future Prospects,” Bulletin of the Seismological Society of America, Vol. 72, No. 68, 1982, pp. S225-S242.
4. M. Baer and U. Kradolfer, “An Automatic Phase Picker for Local and Teleseismic Events,” Bulletin of the Seismological Society of America, Vol. 77, No. 4, 1987, pp. 1437-1445.
5. Cichowicz, “An Automatic S-Phase Picker,” Bulletin of the Seismological Society of America, Vol. 83, No. 1, 1993, pp. 180-189.
6. P.S. Earle and P. M. Shearer, “Characterization of Global Seismograms Using an Automatic-Picking Algorithm,” Bulletin of the Seismological Society of America, Vol. 84, No. 2, 1994, pp. 366-376.
7. D. Patane and F. Ferrari, “ASDP: A PC-Based Program Using a Multi-Algorithm Approach for Automatic Detection and Location of Local Earthquakes,” Physics of the Earth and Planetary Interiors, Vol. 113, No. 1-4, 1999, pp. 57-74. doi:10.1016/S0031-9201(99)00030-8

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