International Journal of Future Generation Communication and Networking
Vol. 13, No. 2, 2020 pp.1050-1057

Tracking of Earth Tremors for Earlier Prediction of Earthquake

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Abstract

Among the countless natural disasters, earthquakes are capable of inflicting vast devastation to a large number of human lives, buildings and constructions at the blink of an eye. Our project aims at the tracking of earth tremors for earlier prediction of earthquakes and to warn the people to take necessary precautions. The prediction is based on the observation of several underwater factors like temperature, pressure and tilt of sea rocks. The sensor setup is placed under the sea surface and this is enabled through submarine communication cable. Then the readings from the sensor are compared with the predefined earthquake datasets which are classified through Deep-Q learning method which uses deep neural networks..If the observed readings are matched with the pre-defined readings, then the people will be alerted that the earthquake will be occurred. By this approach we have introduced a novel solution which gives golden time to preserve human lives and mitigate economical loss by the mentioned elaborated process to predict earthquakes.

Keywords: *tremor detection, shaking, faults, timely warning*

1. Introduction

Earthquakes are one of the most devastating natural calamities which causes sudden shaking of the earth's surface usually for a short period of time. The surface of the earth is like a puzzle. It's not a single piece of land but approximately 20 pieces of puzzle that constantly moves quite slowly. Those puzzle pieces are called tectonic plates so whenever those plates hit and slide on another plate an earthquake is caused. It simply means shaking of the earth, it is caused due to release of energy which generates waves that travel in all directions. The surface where these plates slipped is called the Fault Line. It happens all the time. Most of the time we do not feel the earthquake reach us. But sometimes they are so strong that they can be felt over a 1000 miles away.

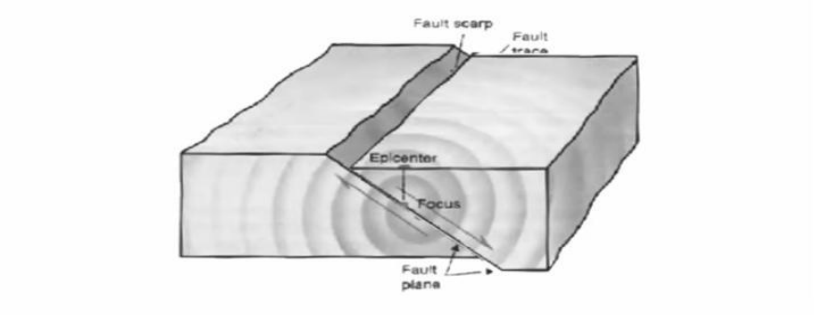

Figure 1. Science of an Earthquake

The place where the earthquake originates is called the Hypocenter**,** and the place it occurs in the earth is called Epicenter**.** There are three types of earthquake such as Convergent Boundary, Divergent Boundary, Transform Fault.One plate is forced over another during an earthquake which causes a Thrust Fault. Many oceans and mountains have been found due to the convergent boundary. Here plates are encrypted apart from each other forming a Rift Zone. This kind gives birth to new ocean floors.Here the plates are lifted by each other and this is also called Strike Slip.Therefore, the Earthquakes are nothing but the shaking, rolling or sudden shock of the earth surface.If a fault has a sharp break in the crustal rocks, rocks near a fault tend to move in the opposite direction that creates friction in some point of time the movements overcome the friction. As a result they slide on another this causes a release of energy and the energy waves

ISSN: 2233-7857 IJFGCN

travel in all directions.The point where the energy is released is called the Focus point of an earthquake and the term given to is Hypocenter.The energy waves travelling in different directions reach the point on the surface nearest to the focus is called Epicenter. This place is the first one to experience the waves.All natural earthquakes take place in the Lithosphere. The lithosphere refers to the portion of depth upto 200 km from the surface of the earth. An instrument called seismograph records the waves reaching the surface. The curves or waves show three distinct sections. Each represents different types of wave patterns. Earthquake waves are basically of two types such as body waves and surface Waves**.**

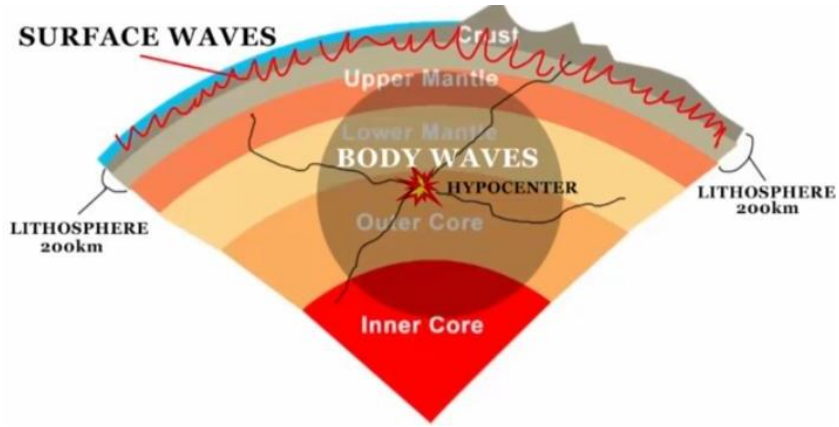

Figure 2.Different layers of earth

Body Waves aregenerated due to the release of energy that focusi.ethe epicenter which moves in all directions travelling through the body of the earth like a tremors.Now that these body waves move towards the surface they will come in contact with the surface rocks and generate new centered waves and these are called Surface waves.The velocity of waves changes as they travel through material with different densities. The material with higher density resides downwards. Therefore, the denser the material the higher is the velocity. The direction also changes as they reflect as refract when coming across material with different densities. That's why when the seismic waves reached towards the sea surface of the earth then there the materials are the lower density and that slowest on the intensity of the waves living behind fault.

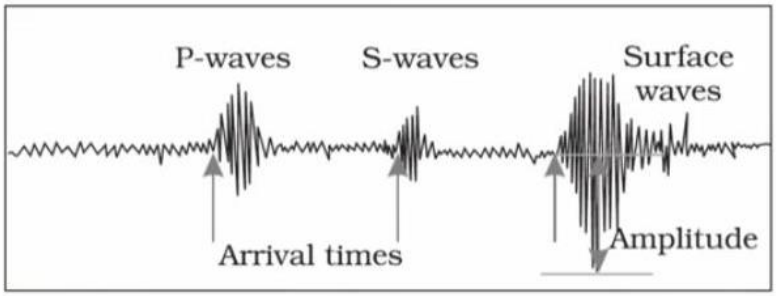

Figure 3. Earthquake

There are two types of body waves called P and S waves. Let P stands for Primary waves and S stands for Secondary waves.When it comes to Primary it is the first one that is recorded on the seismograph the instrument and comes to secondary.The P waves that is Primary or Pressure wave is a pulse of energy that travels quickly through solid material as well as liquid. It forces the ground to move backward and forward and it gets compressed and expanded.The Secondary or Shear wave follows and moves slowly with slowing, rolling motion that shakes the ground back and forth , the pendicular to the direction of the wave.The Surface waves are the last to

ISSN: 2233-7857 IJFGCN

report on seismographs. It spread across the surface of the earth. These waves are also more destructive and damaging which can cause damage to man-made structures such as buildings, bridges, etc., and it can also trigger other natural hazards such as tsunamis, landslides, avalanches and so on. However researches are being made to determine the earthquake foreshock earlier to save human lives and minimize the damages to the environment.

2. Short Survey

1.A survey on Prediction of an Earthquake using DEMETER and Seismic Tremor Expectation have been proposed by Fangzhouxu, et al. In this paper, The Detection of Electro-Magnetic Emission Transmitted from Earthquake Regions (DEMETER) satellite is the first solar synchronous satellite have been specially made for monitoring the electromagnetic radiations. An Artificial Neural Network and Backpropagation Neural Network have been used to find the relations between various signs that observe changes in the earth. It also find a sequence of physical quantities have been measured by the DEMETER. Finally tests have been validated using seismic belt information.

2. A survey on Real time earthquake Prediction has been presented by NavidRajabi, et al. In this paper, Cross correlation Analysis and Transfer function Model have been used to calculate the seismic wave propagation and foreshock time using mathematical calculations. After a long period of continuous monitoring, the information have been relayed to the main server to collect data and store it for future use. Finally it shows the seismic output waveform result.

3. A survey on Early Detection of Earthquakes has been suggested by Akhter Al Amin, et al .This paper presented the Satellite based Quantum Computing method for observing the gravity changes continuously using two photons. One is placed on the earthquake prone area and the other is in the satellite orbiting around the earth. The subsequent analysis of the changes in the earth's gravity helps in the detection of the forthcoming earthquakes of that particularized location. The major drawback is that it detects earthquakes only in the photon placed area,that is it does not work well for a long distance.

4. A survey on Short Term Prediction of Earthquake has been proposed by Mario Maya, et al. In this paper, the Neural Network and Meta Learning mechanisms are used to predict earthquakes in a short span of time using some factors like magnitude and the inter-event time. The magnitude is normally termed as the Richter Measurement and the inter-event time is the time period between two successive earthquakes in specified areas. These are used to train the machine for improved time series prediction of the earthquake.

5. A survey on A Low Complexity Algorithm For Earthquake Detection System has been suggested by Meng Yun Hsu, et al. Herein this system, the detection of earthquakes is based on seismic waves observation .The waves penetrating through the surface are divided into two such as primary waves and secondary waves. The primary waves are denoted as P-Waves and the secondary waves as S-Waves. This system provides a solution that if the penetrating speed of the primary waves are found, then it will be easy to predict the occurrence of the earthquake. Here the major drawbacks of this system is that it measures only the vertical acceleration of the waves.

6. A survey on Classification of Seismic Data using Machine Learning has been presented by Wenrui Li, et al. Here the data about the particular earthquake prone area are continuously monitored and even the minor changes under the earth surfaces are being observed by the system. The appearance of the primary wave and the secondary wave are continuously monitored using acceleration sensors. The vibrating direction of the primary waves are directly propagation directions of waves whereas the vibrating direction of the secondary waves are indirectly proportional to the propagation direction. Based on these findings, it detects the place where the earthquake actually happens.

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3. Implementation

In the implementation phase, the quake data collected from different sources are integrated together having factors like latitude, longitude, temperature, pressure, date, time, magnitude, tilt value, flex value and seismic value. Those are collectively called Earthquake datasets. The integrated data may contain non-uniform data formats, missing values, outliers, and features with very different ranges. In short, the data would not be ready to be used as training data for the model. For this reason, the earthquake data are preprocessed in various ways to remove those unwanted data from the Earthquake datasets. Methods that can accurately predict earthquakes are greatly needed and good prediction techniques can help to predict earthquakes more accurately. In this study, we used three important functions such as feature selection, feature extraction and classification. The feature selection is the process which extracts only six from the quake dataset such as Magnitude (M), Temperature (T), Pressure (P), Seismic value (Z), Tilt (X) and Flex of the rocks (Y). The feature extraction is the method that selects and /or combines variables of the earthquake datasets into features, effectively reducing the amount of data that must be processed, while still accurately and completely describing the original earthquake dataset.

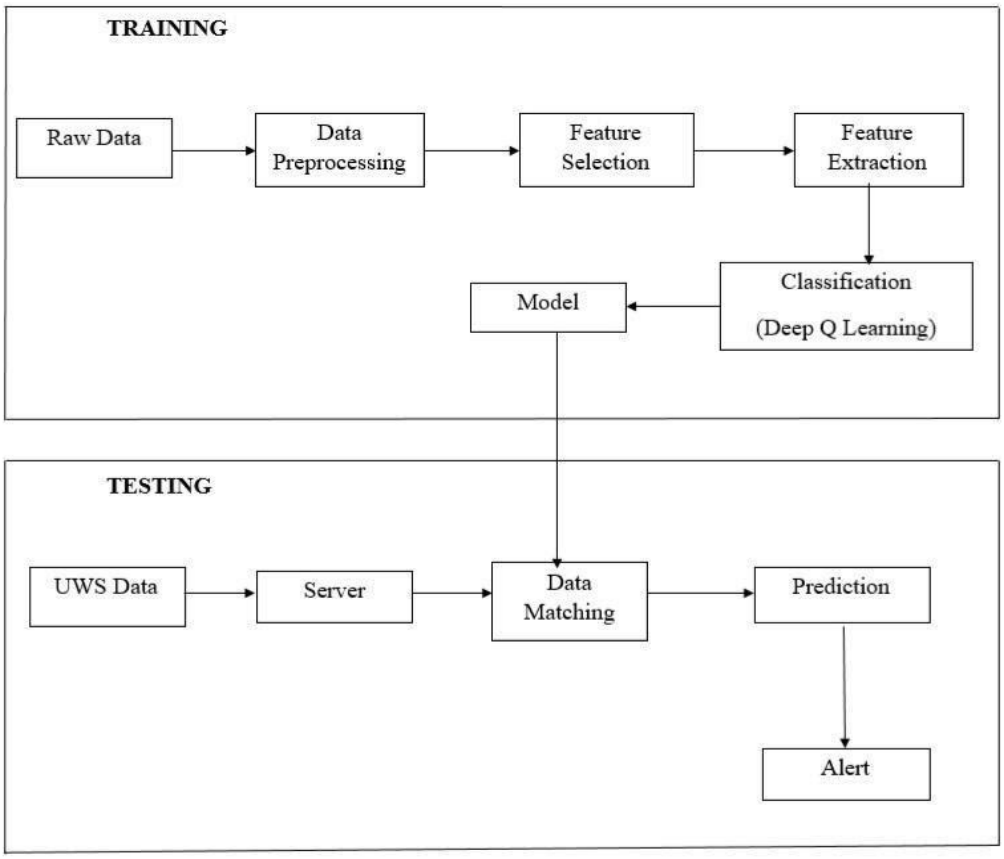

Figure 4. Block Diagram

The datasets are then classified into three different categories such as severe, moderate and mild earthquakes and stored in the database server. The classification of data is done based on the knowledge gained through the Deep Q Learning algorithm which classifies the datas in accordance with the magnitude, temperature, pressure and seismic range of the earlier earthquakes. The classification of the datas is done through the deep q learning algorithm. Here, the processing platform where the sensor readings are processed is the environment and the

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agent is the sensor which is responsible for observing the changes under the sea. Deep Q Learning involves three different functionalities such as state, action and reward. The state is the numerical value of what the agent i.e the sensor is observing whereas action is responsible for classifying the input being provided by the agent to the environment by applying the policy to the current state and the reward is the feedback signal from the environment, reflecting how well the agent is performing the goal of prediction of the earthquake. After this, a model is created for the datasets as severe, moderate and mild earthquakes which is the result of learning from the previous datasets to predict the earthquake occurrence.

The UnderWater Data (UWD) i.e, the observed readings from the sensor which are directly passed to the base station through the submarine communication cable. The encountered data from the sensor are analyzed in accordance with the model created through the classification function. Based on the analysis prediction is made whether the earthquake will occur or not. If there is a possibility of an earthquake, then the administrator of the base station will be given an alert about the occurrence of the upcoming earthquake which is a reward of the Q learning algorithm. After that the forecasting about the occurrence of the earthquake are given to common people, rescue teams, press and other concerned persons.

4. Pin Diagram

The pin configuration of the sensor setup is as follows. In this, the pressure sensor and an integrated sensor for measuring temperature and humidity, tilt and flex positions of the rock are connected to the ESP8266MOD as per the configuration in order to get the observed readings from sensor.

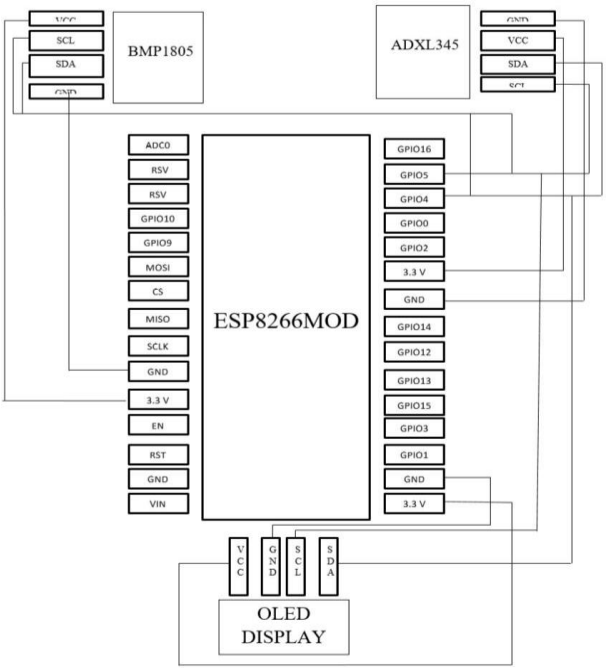

Figure 5. Pin Diagram

5. Result

Here is a result comparison of various methods for the prediction of Earthquake. We could see that prediction of the earthquake by observing underwater changes has more accuracy than the previous methods.

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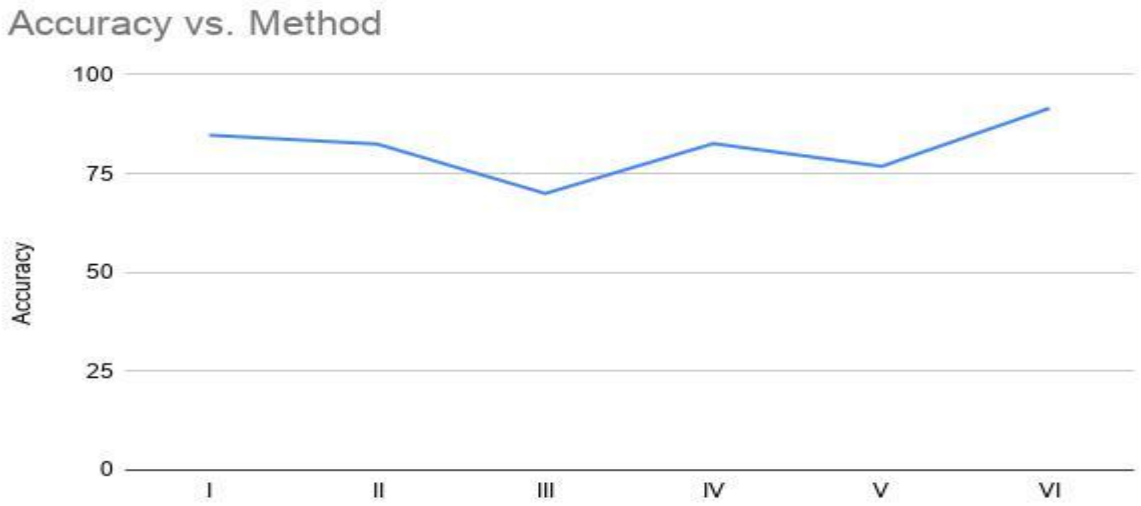

Figure 6. Earthquake Prediction Result

METHOD	ACCURACY (%)
Detection of an Seismic Tremor based on Quantum Computing	84.71
Real time earthquake prediction by cross-correlation analysis	82.47
Earthquake prediction using DEMETER and seismic belt information	69.96
Short term prediction of an earthquake using Meta Learning mechanism	82.59
Earthquake detection based on seismic waves observation	76.83
A low complexity algorithm to predict earthquake	63.12
Tracking of the earth tremors for earlier prediction of the earthquake	**91.52**

Table.6.1. Accuracy Comparison of Various Methods

6. Conclusion

Earthquakes are generally unavoidable natural forces of destruction. In order to predict its occurrence, many solutions have been proposed aiming to design an early warning system to warn the people about the upcoming earthquakes for the purpose of taking necessary measures and to manage the losses. Based on this we proposed a solution to predict the earthquake occurrence earlier than the existing methods by observing the changes in the underwater surface of the sea. In our method, the accuracy level of the earthquake occurrence has been improved

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and the prediction timing is earlier compared to the other methods. Even though many solutions have been proposed for this natural disaster, there is no conclusive solution till date.

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