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MACHINE LEARNING APPROACH FOR EARTHQUAKE PREVENTION AND REDUCTION

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ABSTRACT— Earthquakes can cause disastrous casualties and infinite economic loss worldwide. People have tried various means to ease earthquake disasters. Machine learning (ML) is one efficient instrument for the above exploration, with its excellent implicit relationship extraction and complex task processing capabilities. In the past few decades, many effective machine learning methods have been applied to reduce the impact of earthquake disasters, and have achieved breakthrough achievements. However, as the number of accomplishments continues to grow, more overall and newer surveys and discussions about earthquake prevention and reduction based on ML should be presented. Based on this, we aim to provide a more fine-grained and up-to-date review of the advances in earthquake prevention and reduction based on ML from the perspectives of the effectiveness of earthquake forecasting and prediction, the development of anti seismic structure, the ability, and quality of the post-earthquake rescue and emergency, the employment and combination of multi-type earthquake data, the improvement of the data quality and availability, etc. By the goal, we explored all existing literature on the theme of earthquake prevention and reduction based on ML, where screening for article titles, abstracts, keywords, and primary coverage from six academic databases. At last, 2,271 relevant articles were collected.

Index Terms – Earthquake prevention and reduction, earthquake engineering and risk, machine learning, scoping review.

I. INTRODUCTION

Earthquake hypocenter localization is essential in the field of seismology and plays a critical role in a variety of seismological applications such as tomography, source characterization, and hazard assessment. This underscores the importance of developing robust earthquake monitoring systems for accurately determining the event origin times and hypocenter locations. In addition, the rapid and reliable characterization of ongoing earthquakes is a crucial, yet challenging, task for developing seismic hazard mitigation tools like earthquake early warning (EEW) systems.

While classical methods have been widely adopted to design EEW systems, challenges remain to pinpoint hypocenter locations in real-time largely due to limited information in the early stage of earthquakes. Among various key aspects of EEW, timeliness is a crucial consideration and additional efforts are required to further improve the hypocenter location estimates with minimum data from 1) the first few seconds after the P-wave arrival and 2) the first few seismograph stations that are triggered by the ground shaking. stations that are triggered by ground shaking. Among various network architectures, the recurrent neural network (RNN) is capable of precisely extracting information from a sequence of input data, which is ideal for handling a group of seismic stations that are triggered sequentially following the propagation paths of seismic waves. This method has been investigated to improve the performance of real-time earthquake detection and classification of source characteristics. Other machine learning based strategies have also been proposed for earthquake monitoring. Comparisons between traditional machine learning methods, including the nearest neighbor, decision tree, and the support vector machine, have also been made for the earthquake detection problem. However, a common issue in the aforementioned machine learning based frameworks is that the selection of input features often requires expert knowledge, which may affect the accuracy of these methods.

Convolution neural networks-based clustering methods have been used to regionalize earthquake epicentres or predict their precise hypocenter locations. In the latter case, three-component waveforms from multiple stations are exploited to train the model for swarm event localization.

In this study, we propose a RF-based method to locate earthquakes using the differential P-wave arrival times and station locations. The proposed algorithm only relies on Pwave arrival times detected at the first few stations. Its prompt response to earthquake first arrivals is critical for rapidly disseminating EEW alerts. Our strategy implicitly considers the influence of the velocity structures by incorporating the source-station locations into the RF model.

II. LITERATURE SURVEY

A. *Intelligent real-time earthquake detection by recurrent neural networks*

Taiwan that is located at the junction of the Eurasian Plate and the Philippine Sea Plate is one of the most active seismic zones in the world. Devastating earthquakes have occurred around the island and have caused severe damages from time to time. To avoid the severe loss, earthquake early warning (EEW) is of great importance, and one of the most critical issues of EEW is fast and reliable detection for the presence of earthquakes.

Traditional methods for earthquake detection usually use criterion-based algorithms to detect the onset of the earthquake waves. Currently, the thresholds for those criteria are usually decided empirically and may result in excessive false alarms. Obviously, false alarms can cause undue panics and diminish the credibility of the system. In this article, the recurrent neural network (RNN) models are adopted to develop a real-time EEW system. The developed system is designed to identify the occurrence of an earthquake event, and the duration of the P-wave and the S-wave. It was trained and tested using the seismograms recorded in Taiwan from 2016 to 2017.

B. *Learn to detect: Improving the accuracy of earthquake detection*

Earthquake early warning system uses high-speed computer network to transmit earthquake information to population center ahead of the arrival of destructive earthquake waves. This short (10 s of seconds) lead time will allow emergency responses such as turning off gas pipeline valves to be activated to mitigate potential disaster and casualties. However, the excessive false alarm rate of such a system imposes heavy cost in terms of loss of services, undue panics, and diminishing credibility of such a warning system. At the current, the decision algorithm to issue an early warning of the onset of an earthquake is often based on empirically chosen features and heuristically set thresholds and suffers from excessive false alarm rate. In this paper, we experimented with three advanced machine learning algorithms, namely, K-nearest neighbor (KNN), classification tree, and support vector machine (SVM) and compared their performance against a traditional criterion-based method. Using the seismic data collected by an experimental strong motion detection network in Taiwan for these experiments, we observed that the machine learning algorithms exhibit higher detection accuracy with much reduced false alarm rate.

C. *Deep learning approach for earthquake parameters classification in earthquake early warning system*

Magnitude determination of earthquakes is a mandatory step before an earthquake early warning (EEW) system sends an alarm. Beneficiary users of EEW systems dependon how far they are located from such strong events. Therefore,determining the locations of these shakes is an important is sue for the tranquility of citizens as well.

In light of that, this article proposes a magnitude, location, depth, and origin timecategorization using earthquake Ml magnitudes between 2 and 9.The dataset used is the fore and aftershocks of the great Tohokuearthquake of March 11,2011, recorded by three stations fromthe Japanese Hi-net seismic network. The proposed algorithmdepends on a convolutional neural network (CNN) which hasthe ability to extract significant features from waveforms thatenabled the classifier to reach a robust performance in the required earthquake parameters. The classification accuracies ofthe suggested approach for magnitude, origin time, depth, andlocation are 93.67%,89.55%,92.54%,and 89.50%, respectively.

III. PROPOSED SYSTEM

The overview of our proposed system is shown in the below figure.

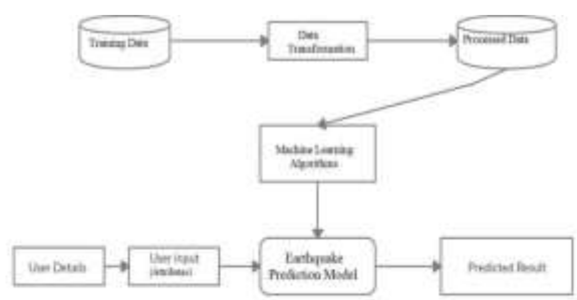

Fig. 1: System Overview

Implementation Modules

Service Provider:

- In this module, the Service Provider has to login by using valid user name and password. After login successful he can do some operations such as Browse Datasets and Train & Test Data Sets, View Trained and Tested Accuracy in Bar Chart, View Trained and Tested Accuracy Results, View prediction earthquake type, View prediction earthquake type ratio, Download Predicted Data Sets, View prediction earthquake type Ratio Results, View All Remote Users.

Remote User:

- In this module, there are n numbers of users are present. User should register before doing any operations. Once user registers, their details will be stored to the database.
- After registration successful, he has to login by using authorized user name and password. Once Login is successful user will do some operations like register and login, prediction earthquake type, View your profile.

Train and Test Model

- In this module, the service provider split the Used dataset into train and test data of ratio 70 % and 30 % respectively. The 70% of the data is consider as train data which is used to train the model and 30% of the data is consider as test which is used to test the model.

Graphical Analysis

- In this module, display the graphs like accuracy and predicted ratio of the system. Various factors take into consideration for the graph analysis. In this phase plot the charts like bar chart and so others.

IV. RESULTS

Fig.2: Service Provider Login

Fig.3: Model Accuracy

Fig.4: Model Accuracy Results

Fig.5: Predicted Results

V. CONCLUSION

We use the P-wave arrival time differences and the location of the seismic stations to locate the earthquake in a real-time way . Random forest (RF) has been proposed to perform this regression problem, where the difference latitude and longitude between the earthquake and the seismic stations are considered as the RF output. The Japanese seismic area is used as a case of study, which demonstrates very successful performance and indicates its immediate applicability. We extract all the events having at least five P-wave arrival times from nearby seismic stations. Then, we split the extracted events into training and testing datasets to construct a machine learning model. In addition, the proposed method has the ability to use only three seismic stations and 10% of the available dataset for training, still with encouraging performance indicating the flexibility of the proposed algorithm in real-time earthquake monitoring in more challenging areas. Despite the sparse distribution of many networks around the world, which makes the random forest method difficult to train an effective model, one can use numerous synthetic datasets to compensate for the shortage of ray paths in a target area due to insufficient catalog and station distribution.

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