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A Study on Earthquake Detection Using Machine Learning

N. NIRMALA[1], K. REKHA[2]

PG-Student[1], Assistant Professor[2],

Department Of Computer Science,

Jeppiaar Engineering College,

Chennai-119.

Abstract

Seismology is the scientific study of earthquakes & the propagation of seismic waves through the earth. The large improvement has been seen in seismology from around hundreds of years. The seismic data plays important role in the seismic data acquisition. This data can be used for analysis which helps to locate the correct location of the earthquake. The more efficient systems are used now a day to locate the earthquakes as large improvements has been done in this field. In older days analog systems are used for data acquisition. The analog systems record seismic signals in a permanent way. These systems are large in size, costly and are incompatible with computer. Due to these drawbacks these analog systems are replaced by digital systems so that data can be recorded digitally. Using different sensor to indentify the natural disaster, MEMS, VIBRATION sensor is used to monitor the earth condition , the different values of the different sensor is given to the ADC to convert the values in digital format, if any changes occurs or in abnormality condition BUZZER will ring.

1. **Introduction**

In the previous year, it is more tedious to predict the earth quake unless and until we come to know through any broadcast system. People and human beings losses their lives since they don't have much knowledge about the environment and the earth quake. Ground shaking is a term used to describe the vibration of the ground during an earthquake. Ground shaking is caused by body waves and surface waves. As a generalization, the severity of ground shaking increases as magnitude increases and decreases as distance from the causative fault increases.

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Many earthquake alarm systems have been proposed. The recent ones are using a Smartphone to detect an earthquake event. Smartphone capabilities have expanded from just a communication tool to become a multipurpose tool such as entertainment and health monitoring. Accelerometer has become a common part of a smart phone. One possible way to reduce the number of victim is to provide a system that can give a quick warning when the earthquake happens. This system must be easy to use, quick response and embedded in their daily equipment. The possibility to use a single cell phone to detect an earthquake event.

2. Related Work

According to the survey, we know seismic data acquisition is important role to detect earthquake detection before it arrival. In previous a method to determine the absolute orientation of the device to estimate the direction of first motion of a seismic event. By designing and fully implementing system architecture, developing signal processing techniques unique to mobile sensing and conducting tests to conform the validity of the sensing platform [1]. In the structure health monitoring device which achieves the features of low cost and data synchronization of three 1-axis accelerometers. He also develops a packet acquisition program to receive the sensed data and classify it based on time and date [2]. To developed a system for measurement and real time visualization of vibration. The measured value is transmitted to the visualization software which provides quantitative and qualitative information about the vibration phenomena [3]. A novel method based on support vector machine technique. This method starts from data acquired from accelerometer and magnetometer and uses a set of features extracted from a processing of two signals. Hence a good performance is achieved based on the sensitivity [4]. It is essential to keep record of environmental factors such as pressure, vibration, acceleration, and temperature for any device's Prognostics and Health management. These factors are helpful in estimation of process failure. The system based on MEMS sensors, ARM and FLASH is used to keep record of all these parameters. The data collected by MEMS sensors is stored in a memory and via wireless module transmitted to computer. This system offers advantage of reduced size and power consumption [5]. This system consists of accelerometer sensor for sensing seismic signal. This system is capable of saving the data's in the memory which can be used for further analysis. A cost effective, small size seismic data acquisition system is suggested [6]. The real time interactions of events such as earthquakes in twitter and an algorithm is proposed to monitor tweets and to detect target event. This system detects earthquake and send e-mails to the registered users [7]. A host- agent based structure to control standby power of consumer electronics effectively. Host manages the entire system while the agent steer activator according to the command received from the host. It prevents human's life from earthquake disaster [8]. A novel and general architecture for an early monitoring system. It also describes the implementation of this architecture or real scenario. It users twitter as source of information for the detection of earthquakes [9]. A measure of the trade-off between the warning time and the shaking intensity. A number of strong earthquake scenarios, together with anticipated shaking intensities at important targets, namely cities with high populations, are considered. The scenarios demonstrated in probabilistic terms how the alarm effectiveness varies depending on the target distance from the epicenter and event magnitude [10]. The Indian Ocean Tsunami Warning and mitigation System (IOTWS) which is rapidly established after the Indian Ocean Tsunami of 2004. One of the major elements of the IOTWS is the concept of a Regional Tsunami Service Provider (RTSP). An RTSP is a centre that provides an advisory tsunami forecast service to one or more National Tsunami Warning Centers (NTWC) [11]. The use of wavelet transform (WT) as the common processing tool for earthquake's rapid magnitude determination and epicentral estimation. The goal is to use the same set of wavelet coefficients that characterize the seismogram (and especially its P-wave portion) to use one technique (WT) for double use (magnitude and location estimation) [12]. The establishment, development and management process of this early warning system, with particular emphasis on tsunami hazards. This system also identify, assess and monitor disaster risks and enhance early warning has been established as one of the five priority areas of action as well as the recognition of the "early warning as an effective tool to reduce vulnerabilities, save lives and help protect livelihoods and national development gains, and to improve preparedness and response to natural hazards [13]. The estimation of tsunami-wave parameters (propagation direction, propagation speed, and wavelength) using the Global Navigation Satellite System (GNSS) reflectometry (GNSS-R)-based sea surface height (SSH) measurements [14]. The Experiments to learn the pattern of an earthquake signal recorded from smart phone's accelerometer. The signal is processed using N-gram modeling as feature extractor for machine learning. For the classifier, this study use Naïve Bayes, Multi-Layer Perceptron (MLP), and Random Forest [15].

3. System Description

1. UC BERKELEY iShake

This system designs a mobile client-backend server architecture that uses sensor equipped mobile devices to measure earthquake ground shaking. iShake provides the general public with a service to more easily contribute more quantitatively significant data to earthquake research.

2. Bridge Health Monitoring

This system proposes the real time diagnosis system for bridge damage monitoring which can be conducted effectively. The accelerometer is used to measure the vibration of the bridge in many civil bridge structure systems. This system achieves the features of low cost.

3. Vibration Measurement

This system is required for the analysis of physical condition of machines, engines as well as in scientific researches, earthquake amplitude measurement. This system also measures the real time visualization of vibration. The performance analysis confirms the stability and reliability of the system in vibration analysis for frequency range up to 5 kHz.

4. Support Vector Machine

This technique is addressed to android low cost Smartphone. After a initial training the classification of fall events and non fall events is performed by support vector machine algorithm. A cellular network is used for sending the notifications and alerts incase of falls.

5. Dynamic power management

This system is designed carefully so that when equipment's storage and transportation status is change the data sampled sensors (MEMS) can be stored temporarily and can be transmitted to host by wireless communication. This system is suitable for limited workspace.

6. Data Acquisition

The seismic data plays important role in the seismic data acquisition. This data can be used for analysis which helps to locate the current location of the earthquake. A cost effective, small size seismic data acquisition system is based on ARM. This system is capable of sensing seismic data and can be saved in the memory.

7. Twitter

This is a micro blogging service which has received much attention. An important characteristic of twitter is its real time nature. When an earthquake occurs people make tweet related to earthquake. Here each twitter users are consider as a sensor who applies Kalman filtering and particle filtering which are used for location estimation.

8. Micro-Electro Mechanical System

A wireless sensor network is proposed for monitoring buildings to assess damage. A sensor node use micro electro mechanical system (MEMS) and vibration sensor to assess the damage. These sensors are fixed at the building to measure the seismic response of buildings during earthquake.

9. Early Warning System(EWS)

A system which can be able to detect timely events that are of social concern can be referred to as early warning system. This describes the implementation of real scenario. It shows an high ability of the system in timely detection of events with magnitude equal or greater than 3.5 Richter with only 10% of false positives.

10. Earthquake early warning system(EEWS)

This earthquake early warning system provides alarms for schools and colleges. A network configuration was chosen, consisting of a staggered line of ~100 stations along the main regional faults: the Dead Sea fault and the Carmel fault, and an additional ~40 stations spread more or less evenly over the country. A hybrid approach to the EEWS alarm was suggested, where a P-wave-based system will be combined with the S-threshold method.

11. Tsunami Warning System(TWS)

The tremendous loss of life results emphasizes the necessity of establishing and improving tsunami warning systems. One of the major elements of the IOTWS is the regional Tsunami Service Provider (RTSP). An RTSP is a centre that provides an advisory tsunami forecast service to one or more National Tsunami Warning Centre(NTWC).

12. Wavelet magnitude estimation(WME)

Wavelet magnitude estimation (WME) is used to derive a scaling relation between earthquake's magnitude and wavelet coefficients for South Aegean using data from 469 events with magnitudes from 3.8 to 6.9. The epicentral estimation is achieved by wavelet epicentral estimation—WEpE which is based on the combination of wavelet azimuth estimation and two stations' sub array method.

13. Disaster Recognition

This disaster recognition "Identify, assess and monitor disaster risks and enhance early warning" has been established as one of the five priority areas of action. As well as disaster the recognition of the "early warning as an effective tool to reduce vulnerabilities, save lives and help protect livelihoods and national development gains, and to improve preparedness and response to natural hazards".

14. Global Navigation Satellite System

Global Navigation Satellite System focuses on the estimation of tsunami-wave parameters propagation direction, propagation speed, and wavelength. By exploiting multiple surface specular reflection tracks of GNSS signals as well as the geometry of wave propagation direction and the multiple tracks, concise mathematical expressions are derived to determine the propagation direction and speed and wavelength of a tsunami wave.

15. Multi-Layer Perceptron (MLP)

The possibility of using smart phone accelerometer to detect earthquake is investigated in this research. Experiments are designed to learn the pattern of an earthquake signal recorded from smart phone's accelerometer. The signal is processed using N-gram modeling as feature extractor for machine learning. For this classifier Multi-Layer Perceptron (MLP).

4. Result & Discussion

In this survey paper i have listed many approaches based on earthquake early warning system use of low cost MEMS accelerometer has made the designed system a cost effective solution for vibration analysis up to 1.6 kHz. This MEMS technology provides adequate accuracy. It also provides good performance and more sensitivity near high end accelerometers and low manufacturing cost. Wireless system for building monitoring is the unique features of MEMS sensors and VIBRATION sensors are combined to an optimized network to realize a solution which offers long battery lifetime and low cost in manufacturing and maintenance.

TABLE:4.1 Error Rate

S.No	METHOD	ERROR RATE in %
1	1-axis Accelerometer	0.37
2	Particle Filter	0.2
3	Support Vector Machine	0.1
4	Data Acquisition	0.1
5	i-shake	0.07

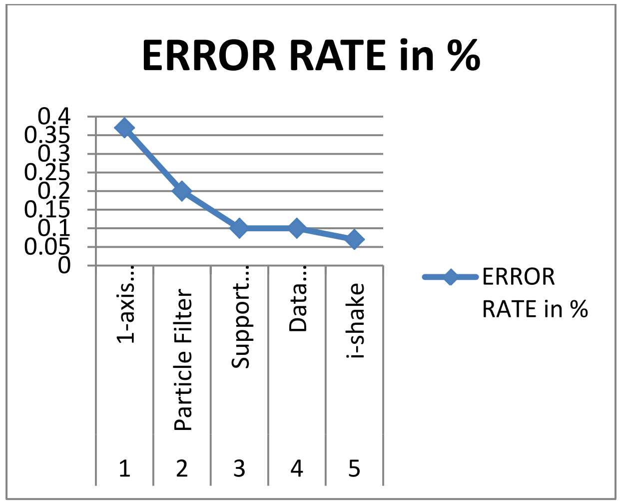

Figure 4.1 Comparison Of Error Rate

Detecting earthquakes in real time may lead to false detection which reduces the system efficiency. The Error rate of different methods for detecting earthquakes are analyzed here. Reduced error rate improves the efficiency of the system thereby provides good performance. The 1-axis accelerometer technique suffers an error rate of 0.37. The existing data acquisition systems are costly and large in size. It is difficult to maintain and are not compatible with other computer. iShake system allows anyone with an iphone or ipod touch device to participate in seismic sensing. It provides the scientific community and emergency responders with a dense array of groundmotion data rapidly.

5. Conclusion

In this paper I have discussed various methods to detect an early earthquake warning system. According to the literature survey, the data acquisition systems already available are costly, large in size and cannot be modified or altered. So these systems are difficult to maintain and not compatible with other system. Use of MEMS sensor reduces the cost and size. The data is stored in the memory which can be analyzed the seismic signals. There are many approaches for measurement and visualization of vibration signals.

The high speed and more precise sensors are used to design a vibration instrumentation system. It is used to improve the hardware speed and memory. This is important to speed up the earthquake detection process. In order for the algorithm to run efficiently, a better and faster approach for symbolization method will be needed. One of the bottlenecks in our experiment is the mapping of features cluster to its corresponding character which is left for future work.

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