Estimating the Occurrence Probability of Earthquake In Bangladesh

Nurul Absar, Shamsun Nahar Shoma , Aklima Akter Chowdhury

Abstract— Earthquake has become a common problem in Bangladesh and as well as all over the World. Data mining software also is one of the analyzing tools for the data. Our neighbor countries like Japan, Nepal are seriously victims of serious earthquake. Every year many people died for earthquake and also loss their property. So scientists are working continuously for reducing the loss of earthquake. Although we cannot stop the earthquake or cannot see any sign before earthquake. But scientists are still working for earthquake. There are several research have been completed to predict the earth quark based on many theoretical method especially statistical method in Bangladesh also in the world. We were made prediction software to the estimating the occurrence probability of earthquake which helps to find out the safe or risky area based on some factor such as distance from epicenter, communication links, population density, development and severity which is different from previous study. Here, severity is used as the magnitude of Richter scale and other factors is used as present condition of its numeric level. Naive Bayes classifier algorithms were used to predict the result. We were used many geospecial data on the database and the algorithm were analyzed over the data. If the users fill up all factor that are in the input field then they can identify the location is safe or risky for earthquake within a few moment. It is a system of software where included sign in or registration system with password protection bearing dynamic database.

Keywords: Data mining, Earthquake, Earthquake Factors, Naive Bayes classifier, Database, Prediction, Bangladesh

1.1 Introduction

Bangladesh is the world's eighth-most heavily populated country, with over 160 million people, and among the most densely populated countries. The Latitude and Longitude of Bangladesh is 23.685 and 90.3563 respectively. The country has an area of 147,570 square kilometers and extends 820 kilometers north to south and 600 kilometers east to west. Bangladesh is bordered on the west, north, and east by a 4,095-kilometer land frontier with India and, in the southeast, by a short land and water frontier (193 km) with Burma (Myanmar). On the south is a highly irregular deltaic coastline of about 580 kilometers, fissured by many rivers and streams flowing into the Bay of Bengal. The territorial waters of Bangladesh extend 12 nautical miles (22 km), and the exclusive economic zone of the country is 200 nautical miles (370 km). Due to its geographic location and population density, it experiences different types of natural disasters which cause losses to lives and properties every year. It is one of the most disaster prone countries in the world.

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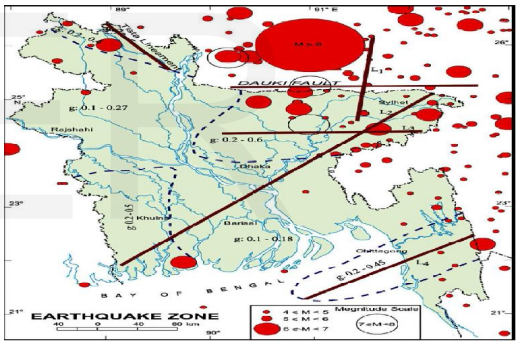

Figure 1: Different magnitude levels of Earthquake zones in Bangladesh (Source: Banglapedia).

An earthquake is the result of a 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 by Richter magnitude (ML) scale and moment magnitude (MW) scale. Earthquakes are classified by the depth at which they occur. There are two types of earthquakes: shallow and deep. Shallow earthquakes, which compose the majority of earthquakes, occur at depths down to 300 kilometers. Deep earthquakes occur at depths from 300 to 680 kilometers. Shallow earthquakes produce more damage **[1].**

An earthquake is tedious because they strike without warning. There is much debate on the extent to which we will ever be able to properly predict (with accuracy) future earthquakes. If better methods could be found to predict earthquakes, people could be given

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ISSN 2229-5518

advance warning of an earthquake, and lives could be saved. Earthquake prediction is inherently statistical. Earthquake prediction is customarily classified into long-term, intermediate-term and short-term **[2]**. Long-term earthquake prediction is to predict the possible shocks occurring in a special region for the period of several years to over ten years in the future. The reality is that the earthquake prediction starts from long-term forecasts of place and magnitude, with very approximate time constrains, and progresses, at least in principle, to a gradual narrowing of the time window as data and understanding permit. A method of long-term prediction, which has been studied extensively in connection with earthquakes, is the use of probability distributions of recurrence times on individual faults or fault segments.Due to its destructive potential, humankind has long been searching for an earthquake prediction method. Predicting an earthquake implies stating the exact time, magnitude and location of a coming earthquake. A successful prediction, specifying the time, location, and magnitude of an earthquake, would save lives and billions of dollars in housing and infrastructure costs. Unfortunately, successful earthquake predictions are extremely rare. There are two basic categories of earthquake predictions forecasts (months to years in advance) and short term predictions (hours or days in advance) **[3].** It is important to introduce earth earthquake prediction with modern technology. We have tried to make a perfect dynamic software to estimating the occurrence probability of earthquake with some specific factors with the help of geospecial database.

1.2 Objectives

The objective of our project is estimating the occurrence probability of earthquake in Bangladesh. It is software that finds out the occurrence probability of earthquake successfully.

1.3 Methodology

As the nature of research in data mining is difficult to confine to specific disciplines. The following steps are followed to make our software perfectly.

1. Gather information and collect Data.
2. Store the
nd predict the data using algorithm.
4. Give the input factors in the home page and then submit.
5. Show the probability result to the users.
Thdata and information into the databases.
3. Analyze ae overall methodology has been shown as system architecture of our project below

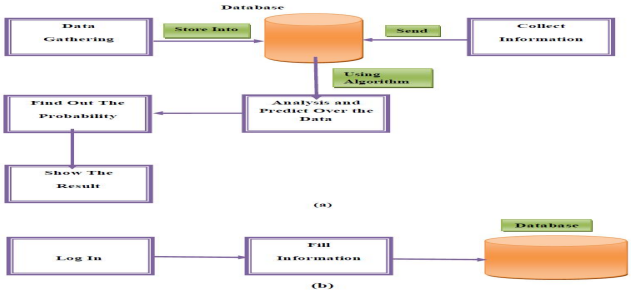

Figure 2: System architecture of our project

1.4 Goal

The goal of our project is to find out the probability of occurring the earthquake in a specific area by collecting information and data of the factors that are responsible for the earthquake and showing the result of this probability. Provide efficient software to the people of Bangladesh to predict the earth quakes.

2 System Tools

The tools that are used for our project are given below:
1.HTML
2.CSS
3.PHP
4.mySQL

3 Literature Review

Earthquake, which is the greatest disaster and cause more harm to our country and all over the world for example the Nepal tragedy on 25th April 2015 where the highest measure of the tremor was 7.9 on the Richter scale with a minimum of 6.6 **[4]**. The scope of the research is vast, there are a number of researches carried out on earthquake in the world. Some such types of literature which is related to our topic are given below.

A. Biswas *et al.* (2016) in his study he focused the response to an earthquake in Bangladesh: Experiences and lesson learnt. This study described the country's response to the earthquake. This experience and the lessons learnt highlight the importance for national earthquake-proof building regulations and systems to lessen the damage and devastation of any future earthquake **[4].** E.Florido *et al.* (2016) in this study earthquake magnitude prediction based on artificial neural networks: A survey has been studied. This article reviewed the use of artificial neural networks for earthquake prediction in response to the increasing amount of recently published works and presenting claims of being effective **[5].** B. K. Chakravorti *et al.* (2015) in his study earthquake is discussed about earthquake forecasting in Bangladesh and its surrounding region. Their goal was to forecast waiting times until the next earthquake in Bangladesh and its surrounding regions for a magnitude of earthquake (). 6.0≥sm **[6].** S. Roy (2014) was taken the research on probabilistic prediction for earthquake in Bangladesh: Just how big does the earthquake have to be next years? The statistical analysis has been described through the study of "Region of Bangladesh". A sample result from the statistical analysis which gives intermediate term prediction of earthquakes is given **[1].** E.Amar *et al.* (2014) discussed about the intelligent earthquake prediction system based on neural network. The article compares between simulation data result from trained BP and RBF neural network versus actual output result from the system calculations. Therefore, this article focused on analysis of data relating to real earthquakes. Evaluation results were shown better accuracy and higher speed by using radial basis functions (RBF) neural network **[7].** S. Sultana *et al.* (2013) her study revealed earthquake, cause susceptibility and risk mitigation in Bangladesh. According to her study as Bangladesh is the world's most densely populated area, any future earthquake shall affect more people per unit area than any other seismically active regions of the world. So that proper hazard mitigation measures may be undertaken before it is too late **[8].** M M Rahman *et al.* (2011) was carried out about earthquake and Dhaka city an approach to manage the impact. They were suggested that the policy issues regarding disaster like earthquake could be handled mostly at the national level but planning and implementation issues are to be handled at the local

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ISSN 2229-5518

community level. The earthquake hazards can never be resisted but the severe damages of earthquake disaster in Dhaka city can be reduced by increasing capacity as it reduces the risk and vulnerability **[9].** Akhtar *et al.* (2010), in his study focused the vulnerability and risk mitigation of Dhaka city **[10].** M. L. Sharma *et al.* (2008) was taken the research about the conditional probabilities of occurance of moderate earthquakes in Indian region. The conditional probabilities of occurrence of earthquakes have been estimated for the seismogenic sources in Indian region using the Weibull distribution **[11].** V.F. Grassoa *et al.* (2007) in this study explained an automated decision procedure for earthquake early warning. In this work, a decision procedure is presented that accounts for the uncertainty in the predicted ground shaking intensity at a site of a facility by deciding whether or not to take a mitigation action based on the probabilities of false and missed alarms. It uses a cost-benefit analysis of the consequences of making a wrong decision. It is shown how the method may be extended to other predictors, such as expected losses, that may be more effective parameters for rational decision making from the perspective of facility stakeholders **[12].** Nelson Lam *et al.* (2004) carried out the research about the displacement modeling of interpolates earthquakes. This paper presented the case for a displacement-based approach for the seismic design and performance assessment of structures in intraplate regions. A newly established model for predicting seismic displacement demand is introduced **[13].** Jamilur R. Choudhury (1993) in his research he showed different maps which indicate seismic zone, seism tectonic, isoseismics etc **[14].**

4 Factors of Earthquake

The factors for the Earthquake are given below:

1. Distance from Epicenter
2. Communication Links
3. Population Density
4. Development
5. Severity

How the earthquake depends on the above all factors is given below:

4.1 Distance from Epicenter

The point of origin of an earth quark is called its hypocenter where earthquake's starts**.** The epicenter is the point at the surface of the hypocenter right above where the earthquake originates and is usually the place where the earthquake's intensity is the greatest **[15].** Earthquake intensity is affected by both the distance along the surface of the earth and how deep the earthquake is below the earth. There have been earthquakes that were very severe but didn't cause much damage, because they occurred a long way from places that humans live.

Table 1. Major earthquake in Bangladesh the last 100 years including date, magnitude, and epicenter.**[1]**

Date	Name of earthquake	Magnitude	Epicenter
8 July, 1918	Srimangal earthquake	7.3	Bangladesh-Tripura border
9 September, 1923	Meghalaya earthquake	7.1	Bangladesh-India border (Meghalaya)
2 September, 1930	Dubri earthquake	7.1	Dabigiri
6 March, 1933	India Bangladesh earthquake	7.6	India Bangladesh border
15 January, 1934	Bihar Nepal earthquake	8.3	Bihar-Nepal borde
11 February, 1936	Bihar earthquake	7.5	North Bihar
16August, 1938	Manipur Earthquake	7.2	Monipur near of Bangladesh
23 October, 1943	Assam earthquake	7.2	Hojai Assam
21 March, 1954	Monipur-Maynmar earthquake	7.4	Monipur-Maynmar border
21November,1997	Bandarban earthquake	7.1	Maynmar border
26 December, 2004	Cox's Bazar earthquake	7.0	Bonda Aceh, Indonesia
12 September, 2007	Tsunami due earthquake (Cox's Bazar)	8.5	Bengkula, Sumatra

Earthquakes can also hit anywhere from the surface to about 450 miles below the surface. By the time a deep earthquake has reached us, its energy has often dissipated through the ground, leaving little left to do damage. The effects of an earthquake are more severe at its centre. The major earthquake in Bangladesh the last 100 years including date, magnitude, and epicenter is given in Table1.

4.2 Communication Links

Communication means accessibility for rescue teams. Communications may be physical or logical, wireless or wired. Communication systems may be underdeveloped, so the population may not be well educated about what to do in the event of an earthquake. If the communication system of a specific area is underdeveloped then the area is more risky for earthquake. The immediate resilience after the earthquake is becoming an important aspect worth being investigated **[16].** Emergency relief is the top priority. According to the Japan Kobe earthquake statistics, after the earthquake, 60% of buried people died shortly, while 40% of buried people are still alive and waiting for rescue **[17].**Thus, after the earthquake, residents in disaster areas actively and efficiently involved inmutual aid in the earthquake zone are the most effective means to reduce casualties.

4.3 Population Density

Another big deal is population density. If the earthquake hits in an area where people are spread out, the impact will be much smaller, since fewer people will be affected. However, if it occurs in a dense metropolitan area, a larger number of people will be affected. The more densely populated an area, the more likely there are to be deaths and casualties. Population vulnerability is a key category of

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ISSN 2229-5518

vulnerability analysis defined as the degree of population losses from a natural disaster, such as an earthquake. The fatalities due to large-scale earthquakes mostly result from buildings collapse **[17].** The extent of damage from an earthquake increases dramatically with increases of population growth, in particular in large cities. Earthquakes cause death and injuries in different ways. Building collapse is the main cause of human fatalities in earthquakes worldwide, accounting for about 75 percent of deaths **[18].**

4.4 Development

In order to establishment of urban centers in high-risk earthquake zones, these cities put potentially at risk of serious injury. Most of the harmful effects caused by earthquakes are due to developing urban patterns in the fault zones. Non-considered development of urban areas in near fault regions has caused the occurrence of earthquake leads to a human tragedy**[19].** Perhaps the most well documented factor is development level. When an earthquake hits a poor country, the impacts tend to be disastrous. There are many reasons for this. The buildings in poor countries are typically not earthquake-proof, because building such structures is expensive. This causes a large number of deaths when buildings collapse. But the aftermath can often be the worst part. With limited funds and resources, cleaning up after an earthquake can be a daunting prospect and can take a very long time. If electricity and water supplies are not fixed quickly enough, the death toll can rise. Even the strongest buildings may not survive a bad earthquake, but architecture plays a huge role in what and who survives a quake. The January 2010 Haiti earthquake, for example, was made far worse by poor construction, weak cement and unenforced building codes**[20].**

4.5 Severity

The severity of the impact of natural disasters increases with an increase in the impact to humans and their possessions and with an increase in intensity of an event for a given population density. Existing scales measure the destructive power of the disasters. If existing scales also demonstrate the severity of a given disaster, then there should be relationship between the existing scale and the impact parameters such as fatalities, injuries, economic damage. Otherwise, a different scale is mandated to measure the severity of a disaster **[21, 22].** Some earthquakes are just bigger than others. In fact, earthquakes hit the United States every single day, but most are too small to notice. We know they occur because of seismographs, sensitive devices that detect tremors in the ground, and the application of the Richter scale, which rates earthquakes on a scale of 1 to 10. The most severe earthquake ever recorded was in Valdivia, Chile, in 1960 and registered at 9.5 on the Richter scale, though, strictly speaking, the scale doesn't have an end point. Severity means the magnitude of Richter scale. If severity or magnitude of Richter is high then the risk of earthquake is also high.

5 Prediction Algorithms

Earthquake prediction software stand for a successful tool for determine timely information about potentially disastrous hazards to the public, industrial facilities, and public buildings including schools and government offices, and private residences.There are three categories of Prediction algorithm. They are:

1. Supervised Learning Algorithm
2. Statistical Modeling Algorithm
3. Sentiment Analysis Algorithm

5.1 Supervised Learning Algorithm

Supervised learning is a type of machine learning algorithm that uses a known dataset (called the training dataset) to make predictions. The training dataset includes input data and response values. From it, the supervised learning algorithm seeks to build a model that can make predictions of the response values for a new dataset. A test dataset is often used to validate the model. Using larger training datasets often yield models with higher predictive power that can generalize well for new datasets.

Supervised learning includes two categories of algorithms:

- Classification**:** for categorical response values, where the data can be separated into specific “classes”
- Regression**:** for continuous-response values

Common classification algorithms include:

- Support vector machines (SVM)
- Neural networks
- Naïve Bayes classifier
- Decision trees
- Discriminant analysis
- Nearest neighbors (*k*NN)

Common regression algorithms include:

- Linear regression
- Nonlinear regression
- Generalized linear models
- Decision trees
- Neural networks

5.2 Statistical Modeling Algorithm

Predictive modeling uses statistics to predict outcomes. Most often the event one wants to predict is in the future, but predictive modeling can be applied to any type of unknown event, regardless of when it occurred. For example, predictive models are often used to detect crimes and identify suspects, after the crime has taken place. In many cases the model is chosen on the basis of detection theory to try to guess the probability of an outcome given a set amount of input data, for example given an email determining how likely that it is spam. Models can use one or more classifiers in trying to determine the probability of a set of data belonging to another set, say spam or 'ham'.

5.3 Sentiment Analysis Algorithm

Sentiment Analysis (SA) is an ongoing field of research in text mining field. SA is the computational treatment of opinions, sentiments and subjectivity of text. This survey paper tackles a comprehensive overview of the last update in this field. Many recently proposed algorithms' enhancements and various SA applications are investigated and presented briefly in this survey. These articles are categorized according to their contributions in the various SA techniques. The related fields to SA (transfer learning, emotion detection, and building resources) that attracted researchers recently are discussed. The main target of this survey is to give nearly full image of SA

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ISSN 2229-5518

techniques and the related fields with brief details. The main contributions of this paper include the sophisticated categorizations of a large number of recent articles and the illustration of the recent trend of research in the sentiment analysis and its related areas.
Although there are so many researches were done previously for the earthquake prediction by using above mentioned algorithms system, our prediction software was made by using Naive Bayes classifier which has some unique feature. Bayesian classifier is also a mining technique by using a large set of data. It helps to predict the result of specific data based on a large set of geospecial data.
The Naive Bayes algorithm is a classification algorithm based on Bayes rule, that assumes all the attributes $X1,\ldots,Xn$ are conditionally and mutually independent given Y. The value of this assumption dramatically simplifies and reduces the complexity and representation of $P(X|Y)$ **[23]** and the problem of estimating it from the training data. Considering the case where $X = (X1, X2)$.
$P(X|Y) = P(X1, X2|Y)= P(X1|X2,Y)P(X2|Y)= P(X1|Y)P(X2|Y)$
This can be represented as

$$P(X1 \ldots Xn|Y) \prod_{i=1}^{n} = P(Xi|Y)$$

Let, Y is any discrete-valued variable and the attributes $X1\ldots Xn$ are any discrete or real valued attributes, the equation for the probability that Y will take the kth possible value, according to Bayes rule, is

$$P(Y = yk|X1 \ldots Xn) = \frac{P(Y = yk)P(X1 \ldots Xn|Y = yk)}{\sum jP(Y = yj)\, P(X1 \ldots Xn|Y = yj)}$$

$$P(Y = yk \,|\, X1 \ldots Xn) = \frac{P(Y = yk) \prod i\,(P(Xi|Y = yk)}{\sum jP(Y = yj) \prod i\,(P(Xi|Y = yj)}$$

$$P(Y = yk \,|\, X1 \ldots Xn) = \frac{P(Y = yk) \prod i\,(P(Xi|Y = yk)}{\sum jP(Y = yj) \prod i\,(P(Xi|Y = yj)}$$

The selected factors for earthquake in our software were used as Naive Bayes classifier as given below. Firstly we were considered occurrence probability of earthquake any place in Bangladesh or not be

P(1)=0.5
P(0)=0.5
We were calculated mean and variance of column distance from epicenter, communication links, population density, development, severity after that we were calculated the probability of every column by using the Naive Bayes classifier. One sample is given below:
P(Distance from epicenter/1)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2*ð^2)
P(Distance from epicenter/0)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2*ð^2)
P(Communication Links/1)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2*ð^2)
P(Communication Links/0)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2*ð^2)
P(Population density/1)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2* ð^2)
P(Population density /0)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2* ð^2
P(development/0)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2* ð^2
P(development/1)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2* ð^2
P(Severity/1)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2* ð^2
P(Severity/0)=1/√2*3.1416* ð^2Exp(-(6- µ)^2/2* ð^2

Here µ is the mean of the column distance from epicenter, population density, communication links, development, severity and ð^2 is the variance of all columns.

The all factors probability was calculated like this way. Then we have to find out the evidence by using following formula

Evidence = P(1)*P(Distance from epicenter/1)* P(Communication Links/1)* P(Population density/1)* P(development/1)* P(Severity/1) + P(0)*P(Distance from epicenter/0)* P(Communication Links/0)* P(Population density/0)* P(development/0)* P(Severity/0)
We also determined the posterior value for 0 and 1 by using following method
Posterior (1) = (P(1)*P(Distance from epicenter/1)* P(Communication Links/1)* P(Population density/1)* P(development/1)* P(Severity/1)) ÷ evidence
Posterior(0)= (P(0)*P(Distance from epicenter/0)* P(Communication Links/0)* P(Population density/0)* P(development/0)* P(Severity/0)) ÷ evidence
From the calculative value we were seen that if the posterior value of 1 is greater than the posterior value of 0 then the result is "earthquake risky area". Some tested data from our database are given in Table2.
If the Naive Bayes conditional independence assumption actually holds, a Naive Bayes classifier will converge quicker than discriminative models like logistic regression, so we need less training data. And even if the Naive Bayes assumption doesn't hold, a Naive Bayes classifier still often performs surprisingly well in practice.

Table2: Some tested data from our database which were used to predict Earthquake.

ID	Distance fromepcenter	CommunicationLinks	Population Density	Development	severity	Prediction
1	88	78	60	50	40	1
2	70	40	80	76	60	0
3	78	65	88	45	56	1
4	77	77	40	35	32	1
5	54	79	90	58	36	0
6	54	79	90	45	86	0
7	79	55	86	26	56	1
8	81	84	78	84	45	0
9	80	81	87	65	75	1
10	78	77	56	85	76	0

6 Designs and Implementation

The login and registration page for user were made as figure2 by which a user can start. First of all, users have to sign up on the registration page then they have to give a user name, a valid email, and a password and they can also add their profile picture.

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ISSN 2229-5518

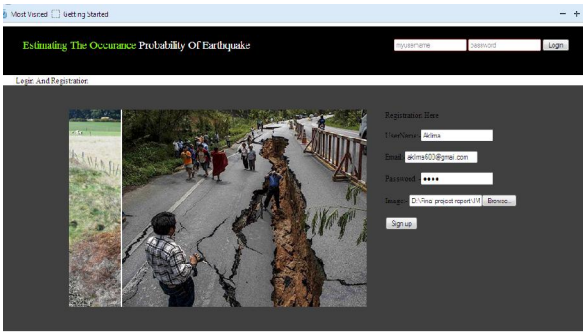

Figure2: Snapshot for registration page

When users complete their registration they can see the welcome page where we were designed a link page like click the link Continue for your prediction then they go to the home page or form page. The login page as shown in figure3.

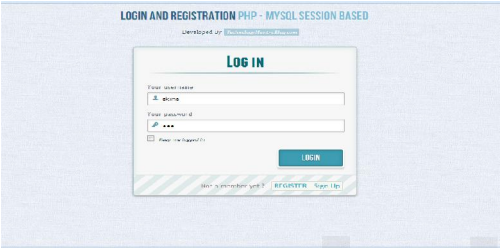

Figure3: Snapshot for login page

In that page user can see some input field of the earthquake factor. They have to fulfill the input field with some integer values like distance from epicenter = 22, communication links=40, population density=23, development=22, severity=24.Here the 1 is the value of prediction which is used to pass the data into database then they have to click the submit button. After clicking the submit button they can see the result of prediction. The snapshot for home page and result page as shown in figure 4 and figure 5 respectively.

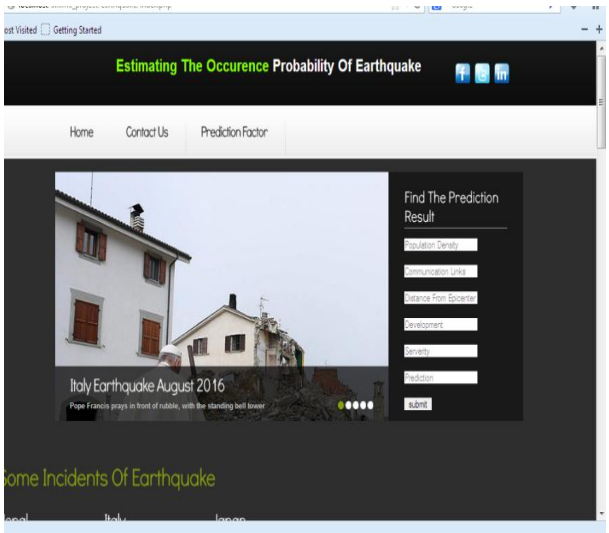

Figure4: Snapshot for home page

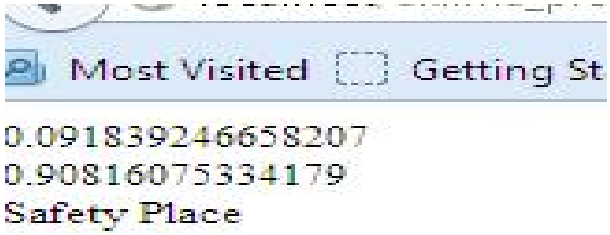

Figure5: Snapshot for result page

7 Conclusions

The main data mining techniques used for earthquake prediction are logistic models, neural networks, the Bayesian belief network, and decision trees, all of which provide primary solutions to the problems inherent in the prediction of earthquakes, tsunamis, landslides and other micro seismic activities. Data mining process can helps us to evaluate the overall data and predict the result. Mining algorithm is the easiest way to find the probability of anything by analyzing the huge amount of data. In mining process, we can easily find the specific answer. We were used Naive Bayes classifier algorithm for our earthquake predictive software. Since earthquakes are caused for several factors which are used to find out the earthquake dangerous zone, firstly we were made the database with many geospacial data where the earthquake factors were kept as the column. Then we were implemented our used prediction algorithm. When users give the value of the factor of earthquake in the input field of our software then they can see the result of the prediction easily. This software can help easily to estimate the occurrence probability of earthquake any place of Bangladesh. So it will be used to find out the safe or risky location for earthquake in this modern age. This research also aims to encourage additional research on topics, and concludes with several suggestions for further research because accurate prediction of earthquakes can help people to take effective measures to minimize the loss of personal and economic damage, such as large casualties, destruction of buildings and broken of traffic, occurred within a few seconds

7.1 Future work

In the future we want to show the probability result into the google map and we also want to do this data mining task with real and big data for Bangladesh as well as in the world.

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ISSN 2229-5518

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