NatDisP – An Intelligent Natural Disaster Predictor

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NatDisP – An Intelligent Natural Disaster Predictor

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Abstract. Natural disasters are adverse actions that happen due to the natural processes of the earth. In today's world with so much pollution, global warming and because of so many reasons, natural disasters are happening far more than they used to happen before and many people in the world face problems, lose their houses, livelihoods and even their houses. It is really painful to get to know the effects of these natural disasters. So, this paper proposes a model which helps us predict natural disasters before they happen using wireless technologies. In this paper modern technologies like IOT, artificial intelligence and machine learning are used. Here for the prediction of each disaster, data/signals given by nature are used , for example for the earthquake module the seismic signals from the earth are used, systems like UNITE are used where the sensors placed in the earth to get the seismic data. For the other disasters also such data is taken from signals given by nature. A detailed explanation on how disasters are predicted based on these simple signals and data from nature is given. In this paper solutions based on wireless technologies to solve some after effects of these natural disasters are also suggested. So, basically our idea is to have all disasters predicted in one place using modern computer science technologies.

Keywords—Natural disaster, earthquake, flood, sensors, tsunami.

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1. Introduction

A natural disaster is a disastrous action that happens due to the natural processes of the Earth. Natural disasters disrupt the lives of people in a very huge way, they destroy property, take away lives and livelihoods and cause many injuries. Millions of people are affected by these disasters annually, thereby slowing down all the development goals of that region. A large number of fatalities , displacement of communities, and detrimental economic impact are caused by these natural disasters. Often with very little information, researchers, policy makers and industry professionals require tools to assess the possible impact and to provide sustainable solution options. Not only slowing down future development, but they also take back the development that has been earned due to years of work. According to the WHO every year natural disasters take away around 90000 lives in the world. These natural disasters have so many diverse and disastrous impacts not only to humans but to all other species as well, like they affect the habitats of species, they destroy vegetation, open the forests's canopy, thereby modifying the characteristics of the particular area, like the availability of light, water etc. So, basically a natural disaster or a natural hazard is an atmospheric, hydrological or geological incident/action that can cause harm or loss to the world for example, landslide ,tsunami, earthquake , floods and drought. So, as stated earlier, there are so many adverse effects of these natural disasters like loss of revenue, destruction of property, and so many more intangible losses including effects that are not only physical but also physiological[1]. Even major cities in extremely developed countries like the United States these natural disasters cause numerous fatalities and loss of billions of dollars of public and private property and infrastructure every year. Disasters take place in many major american states like Florida, Mexico etc. Also California in which many earthquakes take place each year cause huge losses[2].

Even caribbean countries are at risk of natural disasters creating a lot of loss in aspects of environmental, social and economic circumstances. Almost four million carribean citizens are estimated to have been affected by natural disasters in the duration of 1990-2006[3]. For GDP (Gross domestic product) to have a long term steady growth, it is really important for the country to have a steady growth in the economy and it becomes very difficult to keep up the rate of growth if natural disasters keep affecting the people and thereby the economy. Not just that millions of lives are affected when there is a natural disaster occuring and it is really painful to see the poor getting poorer. So many people lose their homes and become homeless, people lose everything in some situations, even their lives. At least countries with huge technological and human development should be able to stop these natural disasters and reduce the impact of these disasters caused by nature. Thereby making natural disasters an important field of research. [4]

NatDisP proposes a wholesome application that can predict upto five natural disasters based on the environmental conditions and situations in this model; this is done using wireless technologies. Our main goal is to predict when the natural disaster is going to happen so that some kind of steps can be taken to reduce the impact and the effect of these disasters and thereby reduce the loss for the people as well as the country. For example in NatDisP prediction of earthquakes using seismic data. Our sensors placed at different locations continuously take seismic data from the earth and send it to our servers and the servers using machine learning algorithms predict when an earthquake may happen. Similarly NatDisP proposes solutions for other natural disasters like tsunamis, floods and droughts. In this proposed model also compare the various algorithms that can be used for each purpose and suggest the best one. In this paper the difficulties faced in predicting natural disasters are also discussed. Some directions for future research are suggested. NatDisP also suggests some measures to take care of the after effects of natural disasters using wireless technologies. Therefore, to help the society from the poorest of the poor to the richest, our paper aims at serving and helping people from all walks of life at various economic levels and makes their overall lives in the long term, better.

2. Related works

In this section the work that already exists in the domain of natural disasters is discussed.

Y. Sherki et. al. , in the work they proposed “Design of real time sensor system for detection and processing of seismic waves for earthquake early warning system” have in detail given information about how sensors can be used for the purpose of getting seismic data. In this paper the authors have designed a special system of sensors and have given the techniques that can be used for the processing and detections of signals from the earth at all times. They have added two planer Azimuth angles; this is the main difference between their method and the conventional earthquake tracking methods. Generally triangulation of distance is the method that is used for the prediction of earthquakes. The problem is that it is not very accurate[5].

R. Mallouhy et. al. , have proposed in their work "Major earthquake event prediction using various machine learning algorithms," their view on the two types of earthquake predictions that exist according to them there are two categories of earthquake predictions they are forecast predictions and short-term ones. Basically forecast predictions are the ones that are predicted in years or months in advance while the short term predictions are the ones that are made in days or hours in advance. Most predictions are done in the method, taking into consideration the history of earthquakes and specific areas and countries but in their paper they have predicted an earthquake event positive or negative by applying different machine learning algorithms. They have selected the huper parameters for every model and the production results have been obtained and they have compared the results between various algorithms using various metrics which led to the prediction that is reliable[6]

A. Fikri Aji et. al. , say smartphones are nowadays used for everything. The idea of using a smartphone sensor that is its accelerometer to detect and record the earthquake signal could be very helpful. The signal obtained from the accelerometer can be then processed using machine learning. The use of Multi-Layer Perceptron and Random Forest is done. The random forest method has proven to be the most efficient giving us an accuracy of 93. 15%. With this type of accuracy, smartphones can definitely be used for earthquake detection[7].

A. Hassini wt. al. , in the work they proposed, "Thermal method of remote sensing for prediction and monitoring earthquakes," they've described that one of the most common methods to detect and predict earthquakes is by analysing the previous earthquakes and their characteristics. The tectonic activities cause pressure to be built up and also the temperature under the crust might change due to the thermal regime that takes place under the earth. Passive thermal satellite sensing is the technique that they have used in their paper, a method using MSG-SEVIRI which can detect anomalous increases in the temperature of the surface before an earthquake. Previously one of the earthquakes on June 6, 2008 in Oran was analysed for studying example changes after and before the earthquake. It was a successful study and the study predicted the anomalous rise in temperatures that occured prior to the earthquake[8].

M. Burgy Tsunamis are a major problem for many coast lines around the world, to give an early alarm the NTWC and the PTWC worked with each other and provide us with the information. They determine the earthquakes in the waters and also the tendency that it will form tsunamis, they also forecast the tsunamis arrival times and their strengths. These initial warnings are based on seismic analysis. The algorithms used are ATFM, SIFT, and RIFT to predict flooding[9].

N. Jain et. al. , in their proposed work, “Did They Sense it Coming? A Pipelined Approach for Tsunami Prediction Based on Aquatic Behavior Using Ensemble Clustering and Fuzzy Rule-Based Classification”,have given that, out of the dreadful disasters that are prevalent in the world Tsunami is one of them and early and effective warning system for tsunamis is there intermediate goal seismic data collected from under the water can be of great help in the process of predicting tsunamis but in many cases these warning systems fail and are not able to give alerts early enough for performing the required evacuation so that is the reason they in their paper have proposed an approach for designing a tws which sequenced and it is based on ECG i. e ensemble classification and clustering this is also done by taking the behavioral data sets of three aquatic animals fishes earthworms and turtles this will be the input and they use already existing methods. [10].

Fauzi et. al,. in the work they proposed, “Machine Learning Algorithms for Real-time Tsunami Inundation Forecasting: A Case Study in Nankai Region” have given that one of the most acceptable and useful method to estimate some Tsunami is conducting lab Tsunami simulations, that is just like how lab earthquakes are conducted in a similar way, tsunami simulations can be done and the data can be collected. Once the data is collected they used multilayer perceptron techniques to create the model to develop the model and after they got the best fit, the model can then predict tsunamis accurately. They have conducted experiments based on the data from overseas bases in Japan and have studied the cases there and the results show that their method is very fast and effective[11].

J. K. Roy et. al. , in their proposed work have given that Internet of Things (IoT) technology can be used with some other hardware for prediction of natural disasters like floods. Nowadays algorithms-based approaches are used to do such things. To device these prediction algorithms, artificial neural networks (ANN) are used, keeping enhancing the reliability and scalability as our main aim. Using the data like humidity, pressure, rainfall, temperature, water level for flood prediction. The use of sensors, communicating over Wi-Fi and ANN approach make it a very reliable prediction system[12].

A. Basak et. al. , “Prediction Future Disaster Using Convex Hull & K-Mean, An Approach" have given that, the technique to find a data pattern from a large set of data is called data mining. A set of data which will include the time, date and place of the previously occurred disasters can be collected and can be divided location wise. Then it can be further divided into two parts namely: Natural and man-made disasters and then a convex hull can be used to find out the outer region of unstructured data. Based on the month of occurrence, the collected data set is passed K-mean the further the clustered data is passed through priority-based protocol, the result from this can be effectively used to predict the future disasters[13].

Belayneh et. al. , in the work they proposed “Drought forecasting using new machine learning methods. Journal of Water and Land Development” have explained that droughts are also very impactful; they affect the crop production and the lives of people in most agrarian countries. Droughts must be prevented and mitigated in order to have good and effective agricultural production so in their paper they have used support vector regression artificial neural networks coupled wavelet ANN coupled wavelet neural networks were the most accurate models for this purpose according to the results of their study. [14]

Pozdnoukhov et. al. , “Applying machine learning methods to avalanche forecasting” have used nearest-neighbor methods to support vector machines on the data set that they've got from UK Scotland and lochaber to predict and forecast avalanches which is a very complicated process[15].

3. Proposed Architecture

In this paper what is aimed is to build an extremely accurate, easy to use application that predicts when the next natural disaster in a particular location is going to take place. The application can accurately predict most major natural disasters like earthquakes, cyclones, tsunamis, avalanches, floods and droughts. This application can not only be used by government officials but can also be used by common citizens to take their own self care measures apart from the ones the government takes for them. Our main aim for this application named NatDisP is that it should be a wholesome application that can give early warnings for all the major natural disasters at one place. This will not only make it easy for the government officials but also give the citizens a sense of security and make them feel that everything is under control and they will know that they will know if something is going to happen. No disaster will hit them unexpectedly. Which will be of great relief for the citizens of anyplace. Our application makes use of deep and machine learning algorithms for all the models i. e. , for the models of each natural disaster. So, basically each module of NatDisP has a separate architecture and all together they form one wholesome natural disaster predictor. The various modules of our paper are clearly explained in their respective subsections below.

3. 1 Earthquakes

One of the most dangerous natural disasters that exist is an earthquake. Mainly because there is no time to react and they occur all of a sudden with no warning. It is because of this fact that accurate early predictions of earthquakes have a very high importance for ensuring that mankind is safe. There are many techniques that people follow to accomplish this[16]. In NatDisP sensors are used to get the seismic data using sensors like the seismic sensor. Seismic sensors are instruments that measure the motion in the earth when the earth is shaked or the seismic plates move. The sensor and the dynamic motion should also give a physical dynamic variable which previously used to be the displacement of a stylus but in modern day instruments it is voltage, as voltage can be used in a better way for processing and calculations. Apart from this modern wireless technologies like the UNITE system can be used to get the seismic data, these systems are also called wireless seismic exploration systems[17].
Simultaneously the trained machine learning model would have been made ready by us, using the dataset that has been procured. The data is collected for the dataset from the earthquakes that have occurred before. Once the data is taken from the sensors it is passed through the machine learning model and the next earthquake is predicted. The data will be very dynamic and when the user of the application clicks on the predict button data from the sensors at that particular time is used , at that location and the earthquake situation is predicted. The architecture of the model is given in figure-1. The same methods can be used for predicting and warning tsunamis as tsunamis are basically caused by earthquakes happening on the seabed[18].

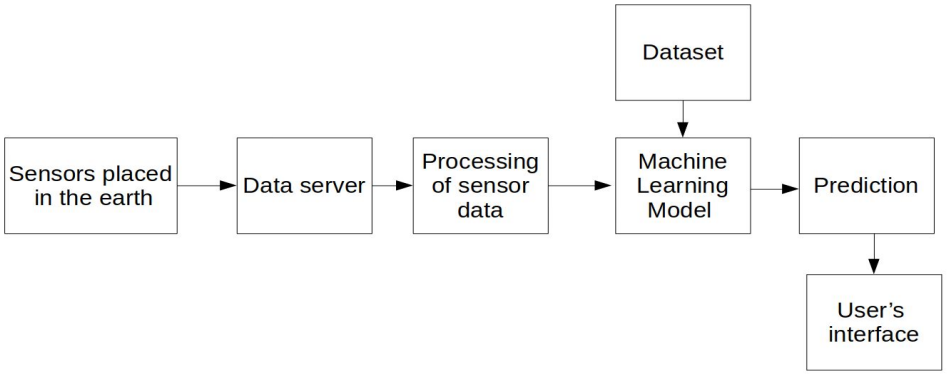

Fig - 1 - Proposed architecture for the earthquake prediction module

3. 2 Floods

The most destructive of natural disasters are floods. Flood models are highly complex to generate. Most

research in the field of floods takes place in aspects of risk reduction, reduction of deaths and suggestions in policy changes and reducing the loss of property. In the past twenty years a lot of research happened in this field and ML, DL has been used for the prediction and early warning of floods. Because machine learning has become extremely famous and proven to be extremely useful, the idea of it being used for building prediction and early warning systems for floods has come into existence[19]. Therefore, in NatDisP using machine learning algorithms are used to predict floods based on a given set of features. If a good quality dataset is there, ML algorithms are greatly promising and that is why, among hydrologists, its popularity is increasing at a very high rate. Today's researchers are greatly interested in introducing and using these machine learning algorithms and hybridizing them with existing ones to get better results/prediction models. So in the proposed model NatDisP machine learning algorithms are used to predict floods. The major features that can be used are Temperature, rainfall, volume of soil water layer and runoff water quantity, total column water vapour.

First the data of the required features is collected, then NatDisp uses machine learning algorithms to model them and finally build our machine learning model. Then the model is trained. Our various runtime data sources will be rain gauges placed at different locations, The river height data from the height measurers are placed at different positions of the river, the hygrometers are placed at different locations etc. When the user clicks on check now, the data that has been backed up at our data servers is got from the different runtime data sources and is passed through our machine learning model and the result is given. Also on the backend at a particular time interval machine learning model is kept running with data at that time, in order to give warning and alarms in case it gets too late. The architecture diagram of the flood prediction module is given in figure - 2 .

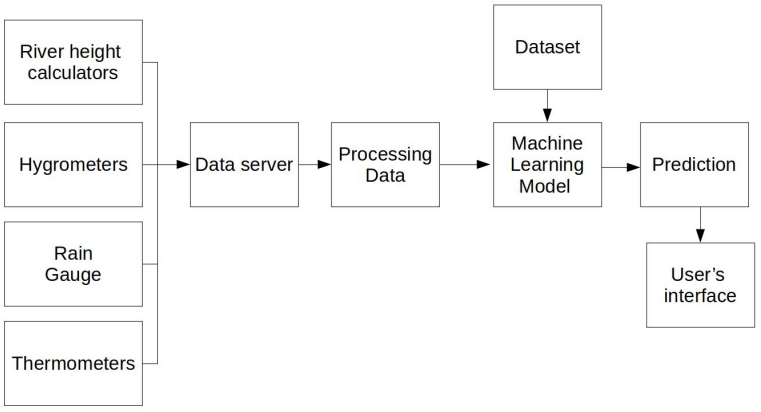

Fig - 2 - Proposed architecture for the Flood prediction module

3. 3 Drought

Droughts have become more common, the frequency and the severity have increased a lot due to climate change making adverse effects and a early warning system extremely necessary for the world to prepare for the adverse impacts[20]. In NatDisP the machine learning algorithms are used to predict and warn for droughts as well. So, the features that are here are majorly rainfall, soil quality, water level in the closest river and distance to the closest river, agricultural produce the previous year and irrigation percentage. These data are obtained and machine learning algorithms are used to train the model and once the model is trained, the data is obtained from the data server at runtime and given the output to the user stating whether there will be drought or not in that particular year. First the data with features is collected that are required by the ML model and then using an appropriate algorithm our model has to be designed and then trained l. The measuring rainfall is done using the rain gauge for measuring rainfall, and then find out the river levels, then soil quality is found using the sensors placed in different locations. These sensors tell us the quality of the soil in the particular area. There are many technologies that can be used for the purpose, like Time Domain Reflectrometry,Frequency Domain Reflectrometry (FDR),Temperature and humidity sensor etc[21]. There are also many full soil monitoring systems that are capable of giving us full details about the soil quality[22][23]. After getting these data at regular intervals they are stored them

in our server. When the status is enquired by a user the data at that point of time is taken from the servers and it is passed through our machine learning model and the drought situation is predicted and given to the user. So in NatDisP our aim is to use these sensors and wireless technologies for getting the data for predicting the possibility of drought in a particular year or even a shorter period of time. The architecture diagram of this particular module is given in figure - 3.

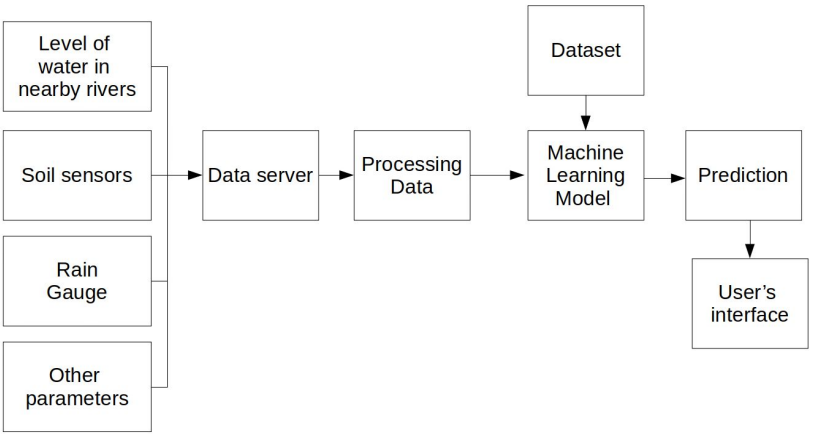

Fig - 3 - Proposed architecture for the Drought prediction module

3. 4 Tsunami

Tsunami is one of the most dreadful for humanity. The need for developing an effective and early system of warning for tsunami is very important, researchers across the world are working for it. Seismic water from under the water got by different methods can be used here in order to develop a warning system for tsunamis[24]. Here using machine learning and fuzzy algorithms to predict the tsunamis and plan well in advance for it. The major cause for a tsunami are earthquakes below the water surface so by getting information of that earthquake, the distance from the shore, the direction of the waves,depth of the ocean, the shape of the ocean floor and the shape of the coastline then an early warning of tsunami can be given. In NaDisP all the data can be obtained with the use of sensors which can be passed through the machine learning model built to get a final prediction. The features used here are the seismic wave details that are obtained from the seismic sensors. The architecture is the same as the earthquake module.

3. 5 Avalanche

Snow falling in heavy masses are known as Avalanches, that is why they create a danger for anyone who lives on the sides of mountains. These avalanches are so dangerous mainly because of their unpredictability and their high intensity. Majority of the avalanches that occur are human caused ones. Almost 40 people die every year in north america alone on an yearly basis. These people are majorly skiers, snowmobiles and climbers. They can be the major audience of this module of our application as they would like to check the odds of such an event to take place before they start their adventure. Avalanches cause a lot of destruction every year and avalanches are basically catastrophic. Thereby making accurate predictions of avalanches is very important and helpful as at least reduction of the effects can be done by predicting them. Here using machine learning is used to find out the possibility of an avalanche to happen and also take precautions well in advance [25]. The features that are being used here are Snowdrifting, Foot penetration, Snow temperature, Rain at 900 m, Cloud cover, Cumulative snow index, New-snow index. The architecture diagram of the avalanche module is given in figure - 4.

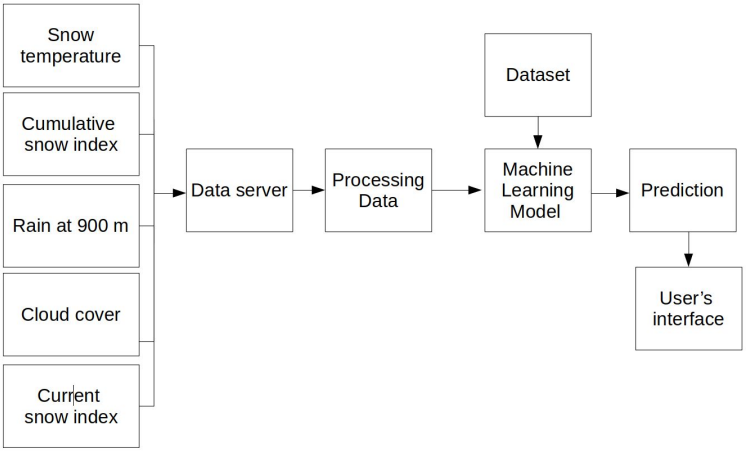

Fig - 4 - Proposed architecture for the Avalanche prediction module

So, these are the different modules of NatDisP and it is felt by us that it will be of great use if put into application. There are all the modules in NatDisp, i. e. , most of the highly frequently occurring natural disasters can be predicted accurately in one application using wireless technologies. IOT, AI, ML and other modern technologies are being used for the development of this application. The overall proposed architecture of NatDisP is shown in figure - 5.

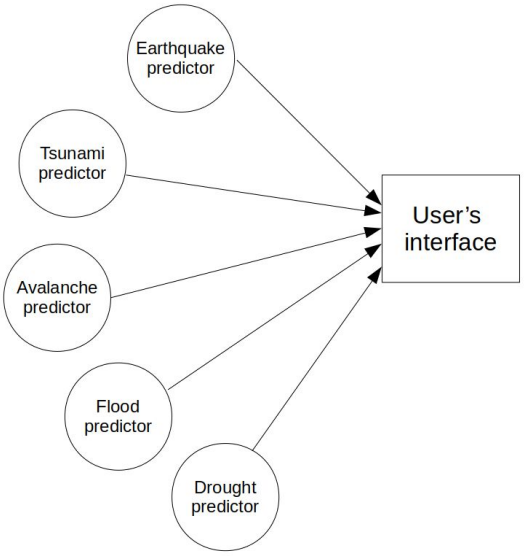

Fig - 5 - Proposed architecture for NatDisP

4. Methodology

In this paper, the main aim is to build all modules using machine learning and deep learning algorithms to predict natural disasters. After comparing the algorithms, the one that fits the best is chosen and used in our application to predict the chance or time of the disaster. Also, our aim at making the application as simple as possible to use so that everyone can use this application easily and predict when the next natural disaster may happen, and keep themselves and their families safe.

The first step of the process of prediction for all the modules is the preprocessing of the data, the data is preprocessed the data, One of the most important and significant steps of supervised machine learning algorithms is the preprocessing of data. And one of the most difficult steps of these is noise elimination. Even after removing the noise still a lot of preprocessing is left to be done, like the rows that have null values in most of their columns have to be removed. Along with this, if our dataset is very large,a sample dataset from that may have to be selected. Discretization of data is also very important as

real-time data has both numerical as well as symbolic data. Overfitting and underfitting also should be considered while our data is preprocessed. The amount of data that is existing has to be considered while deciding on the features. If there is a lot of data, more features can be taken else the number of features should be reduced. Apart from this redundancy has to be reduced, columns which have too much correlation have to be removed. Sometimes there may be to construct new features from pre-existing ones as sometimes transformed features provide better results[26]. So the earthquake dataset has only one feature that is the seismic values. So, not much preprocessing is required in this case as there is only one feature. Only the null rows of data have to be dropped and the size of the dataset that is going to be used has to be decided in order to prevent overfitting and underfitting. Then moving on to the flood prediction module, the dataset that has the features temperature, rainfall, volume of soil water layer and runoff water quantity, total column water vapour, and in this the null values are removed. Then our dataset is ordered according to requirements and other parameters. Similarly, in the next module of drought prediction the data is preprocessed first and then the model is fine tuned based on the features rainfall, soil quality, water level in the closest river. Similarly in all the other modules the dataset is preprocessed, algorithm is developed and the module is fine tuned according to the respective features.

So,once the preprocessing is done, and all our features have been decided and our datasets ready for training, the appropriate machine learning algorithm can be chosen and our model can be trained.
As discussed before, natural disasters cause a lot of destruction and economic loss every year and predicting them beforehand can be of great help. AI and machine learning along with the help of IOT seem to give the best possible solution for this purpose. NatDisP has five modules.
First for the earthquake prediction module, once the dataset is collected with the required features, the algorithm required is chosen. Here algorithms KNN, random forest,SVM,Regression and Naive bayes are taken in order to compare them and decide which one best fits our requirements and gives us the highest accuracy. Similarly, the data for all our modules is collected, preprocessed, and built into our machine learning models once the best algorithm to be used is decided based on its efficiency, accuracy and speed. Our algorithms have been tested and designed. Then the machine learning model has been developed and deployed using a web framework in python known as django, providing a good interface for the users. The users can then choose the disaster they want to check and click the check button. The data at that particular time in the servers will be loaded into the machine learning model and the prediction will be displayed. The user can also enter their own data to check if they want to. Once they get the result they can take the precautionary measures. The data can't be collected by users individually, so to solve this problem NatDisP uses technologies of IOT, and the data is collected automatically and sent to the server using technologies like WSN etc. All the datasets have been collected and our machine learning models are developed and deployed so the users can use the application.

5. Result Analysis and Discussion

Our model has achieved an accuracy of 92. 1 % using the SVM algorithm. The comparison of the accuracies of all the algorithms are in table - 1. So here are the four basic machine learning algorithms to find out which one best fits our models and also have tabulated the results in table - 1. It can be seen that SVM has given us the highest accuracy and so, this support vector machines algorithm from scikit-learn is used for deploying our models in the application. This table has averaged the results for all the modules.

Algorithm	Accuracy
KNN	86. 5
Ensemble	88. 2

SVM	92. 1
Regression	85. 7

Table - 1 - Comparison of algorithms with respect to accuracy

The entire application was built using django. The home page of the user interface is shown in figure - 6. This home page has a dashboard where you can choose the disaster whose prediction is to be checked, i. e, the disaster who's next occurance wants to be found out.

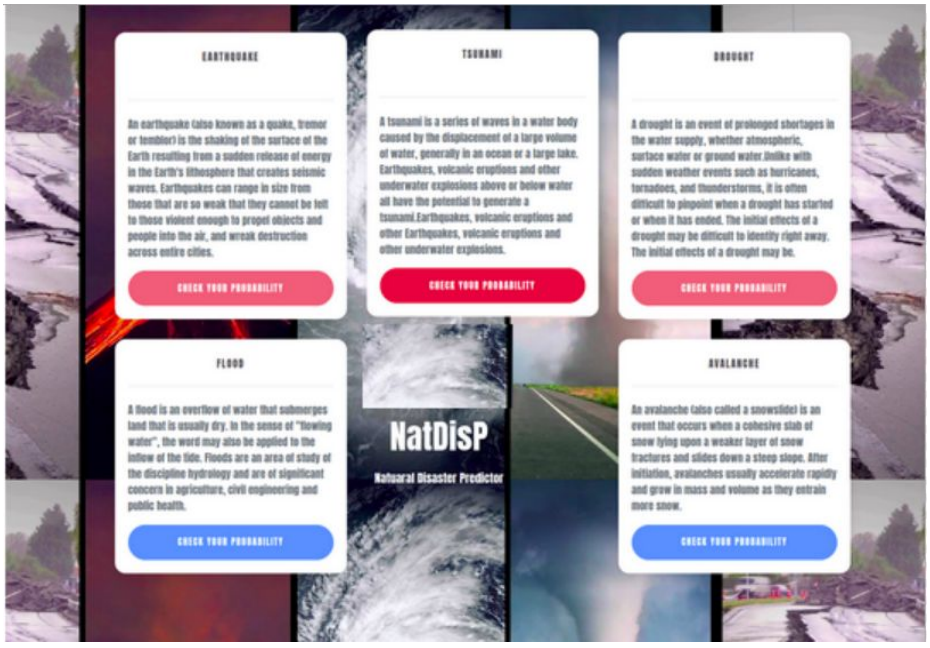

Fig - 6 - Home page of NatDisP

Once the disaster is chosen, a particular page of the disaster comes up. The homepage for the earthquake module is shown in figure - 7. On this page details can be either filled by the user and they can check for the results or click on check directly where it will take the data from the server where the data came from the sensors and other data sources and it predicts the next occurance of the disaster. The sample outputs for the earthquake module are also given in figure - 8 and for all the other modules also similar steps have been implemented and here is a basic UI and sample outputs for the flood prediction module in figure - 9 and figure - 10.

Fig - 7 - Earthquake module UI

Fig - 8 - Earthquake prediction results

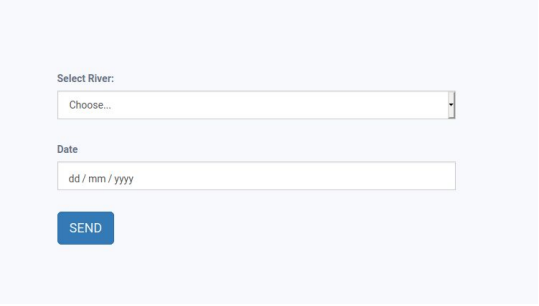

Fig - 9 - Flood prediction module UI

Fig - 10 - Flood prediction module results

6. Future Scope

Various new facilities and innumerable enhancements can be developed further to make our application a better and a more efficient one. This application can further be extended to more natural disasters like hurricanes and volcanoes. Centralized servers can be placed at different parts of the world to have our data transfer faster and easier. It can also be enhanced by better machine learning algorithms if any are developed and at the rate technology and research in the field is going now, there definitely would be many new and more efficient algorithms. So, basically the base for future research has been set by us, on top of which more and more research can take place. And finally humans will be able to build a system that can predict all possible natural disasters with enough time ahead so as to make the damage as minimal as possible. At a later time drones and such other modern and upcoming technologies to monitor can also be used to find out people stuck in natural disaster affected areas and save them, i. e., bring them to protection/safe areas.

7. Conclusion

To conclude it can be said that if this application comes into the deployment, it will be of great help to the world. So much damage control can be done using it . IOT,AI and ML techniques that are the most researched areas in the computer science field and in the world today were applied by us in this paper. By using these amazing technologies all our modules and the whole application of NatDisP have been built. This application is highly accurate and all the signals given by nature are being used here to make predictions of natural disasters. As per our knowledge this is one of the first applications that can be used to predict so many natural disasters at one place. This wholesome application will be of some real use as people like government officials etc can see all updates of any natural disaster in this one application. The results that have been shown are sufficient for people to think of this as an actual application that can be put into deployment and use at a wider range. The results also suggest that using these natural features and signals given by nature are better than using location and time data to predict natural disasters. Our methods remove the chance of human errors or biases. This can also be extended to other forms of natural disasters as well. At the rate technology is improving today and the rate at which natural disasters are becoming more common, applications like this will be of great use as technology improvement will help the application to become faster and more efficient and as the natural disasters are increasing, more and more efficient approaches and methods are needed to control and limit the damage as much as possible.

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Figures

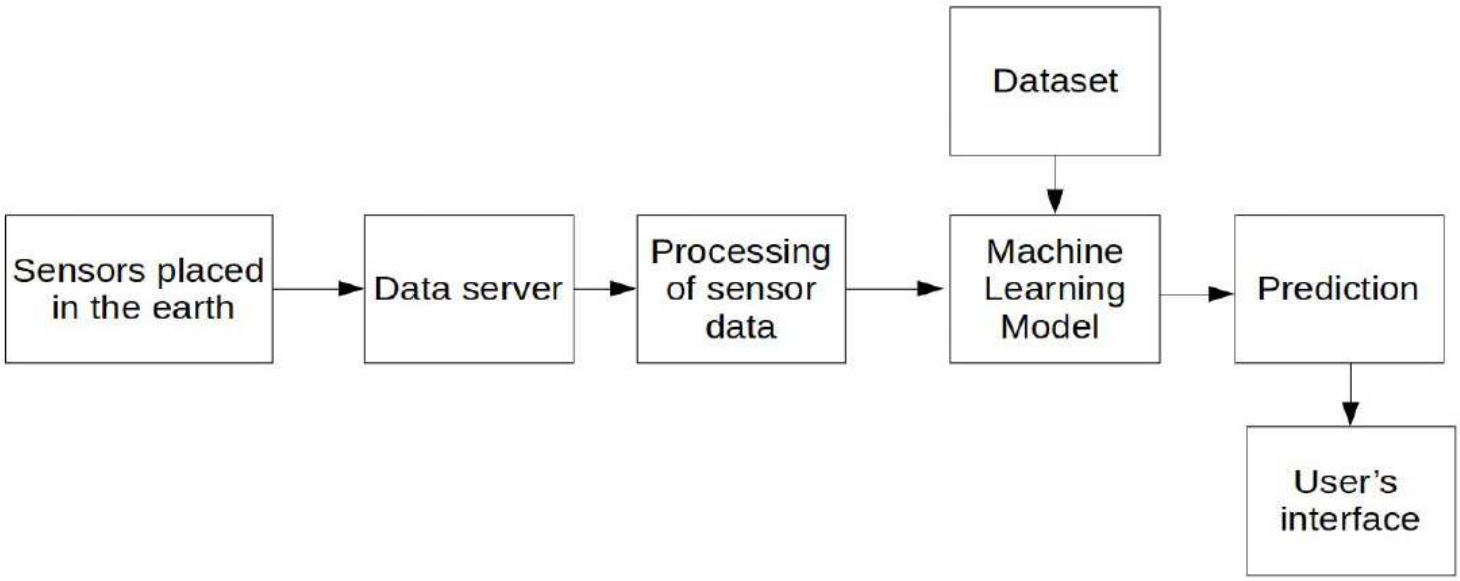

Figure 1

Proposed architecture for the earthquake prediction module

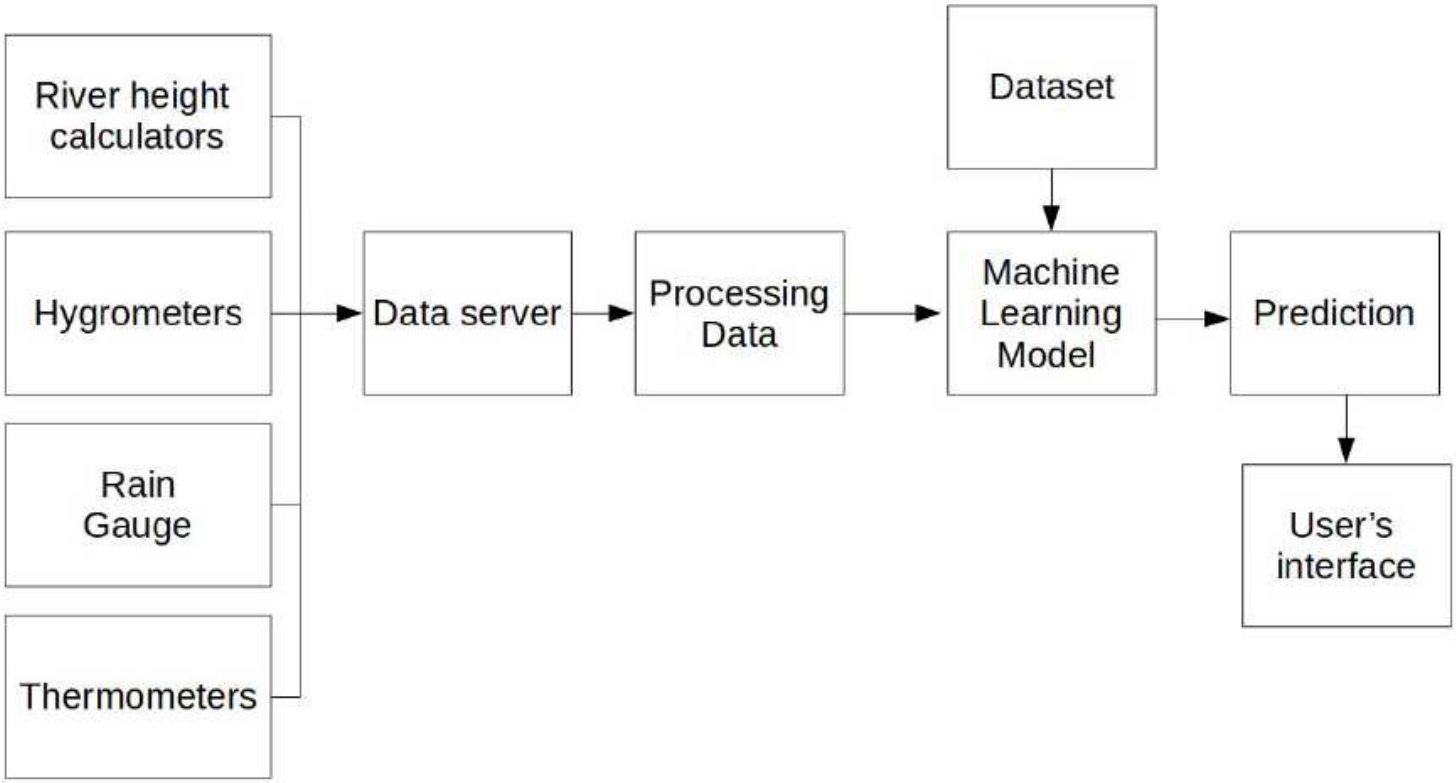

Figure 2

Proposed architecture for the Flood prediction module

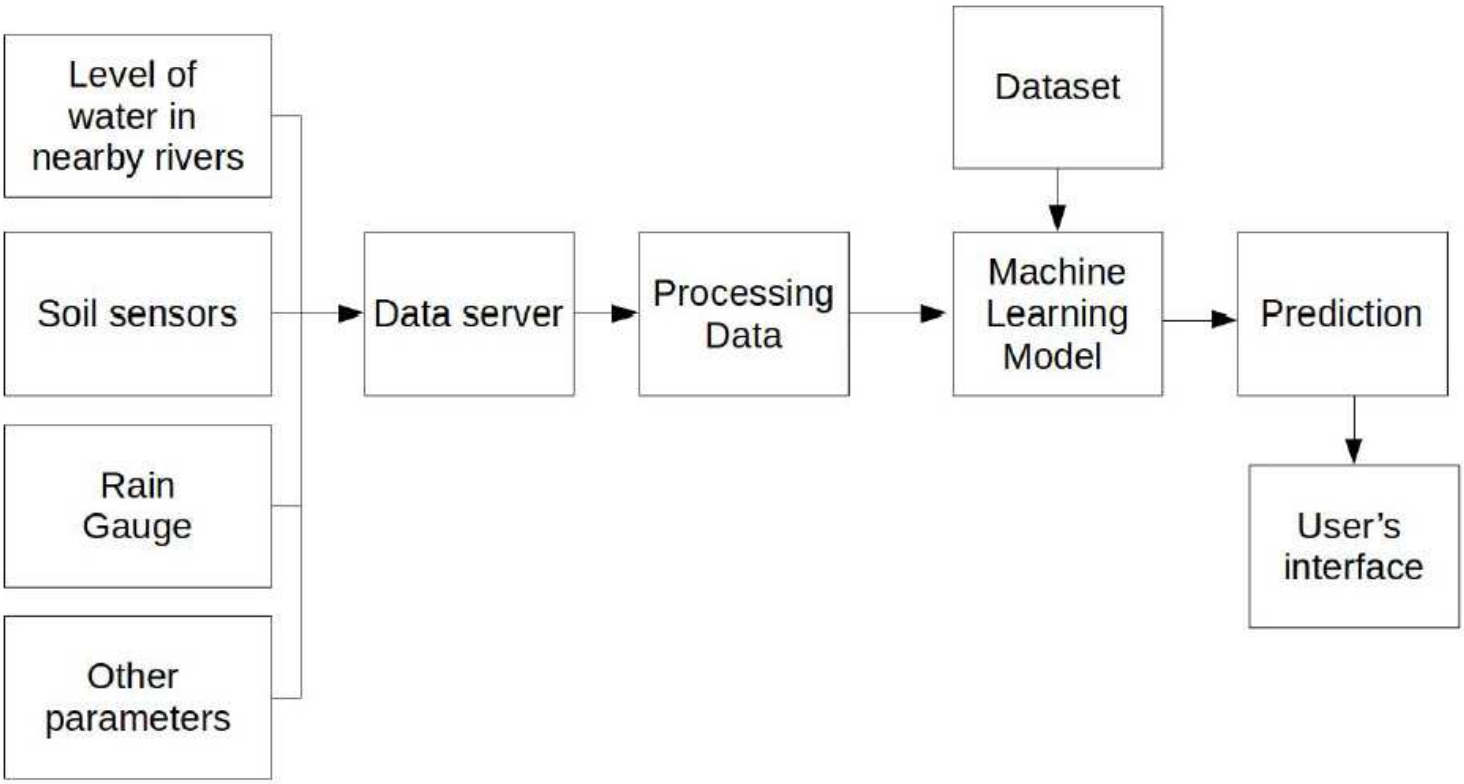

Figure 3

Proposed architecture for the Drought prediction module

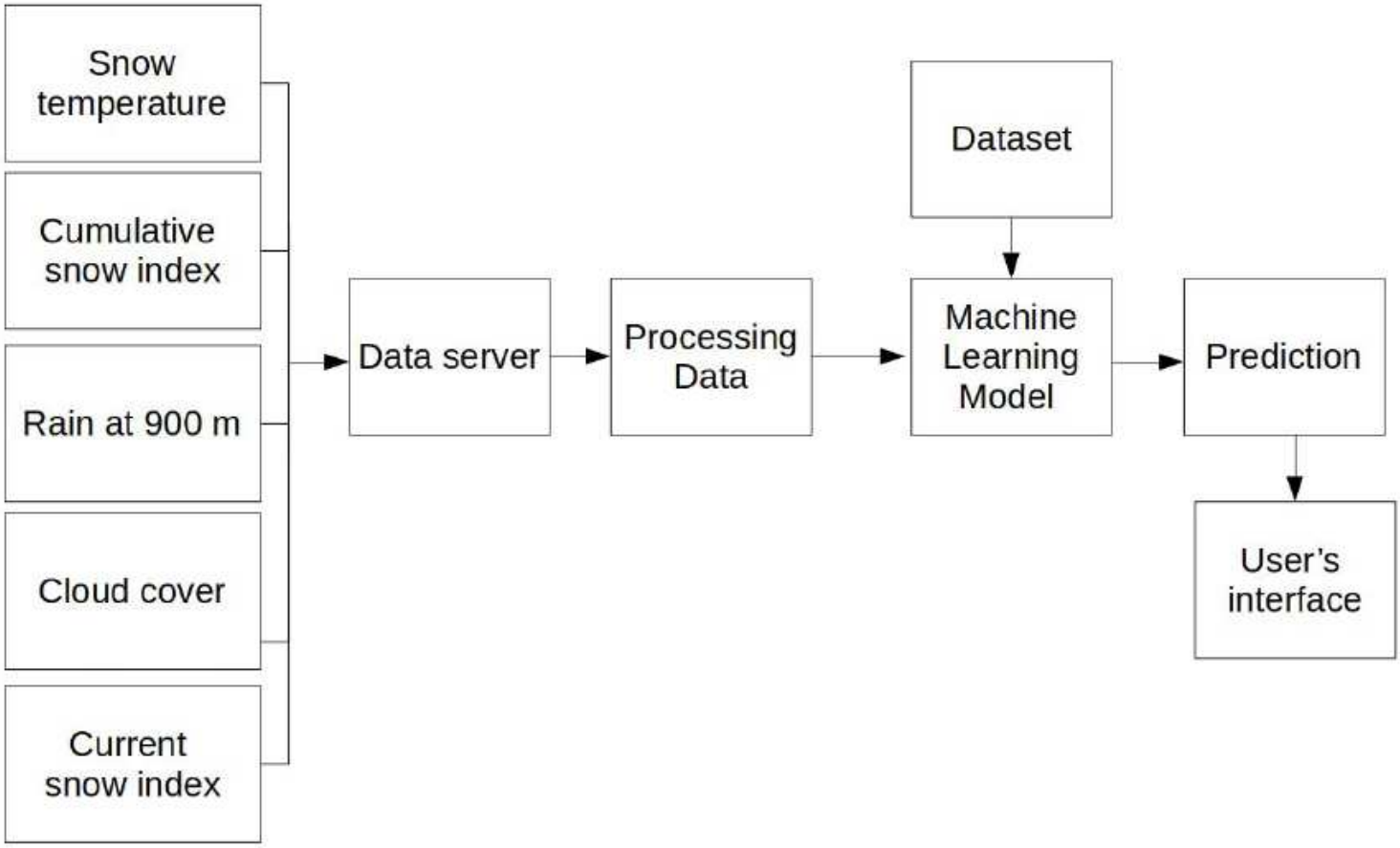

Figure 4

Proposed architecture for the Avalanche prediction module

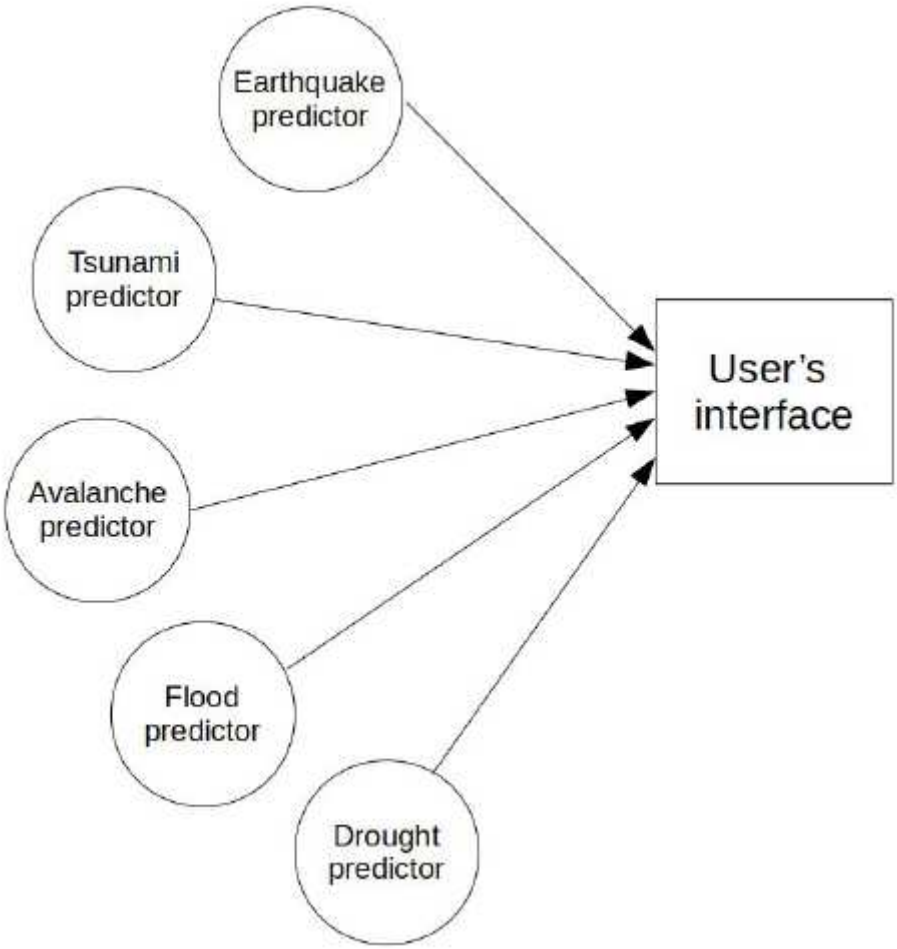

Figure 5

Proposed architecture for NatDisP

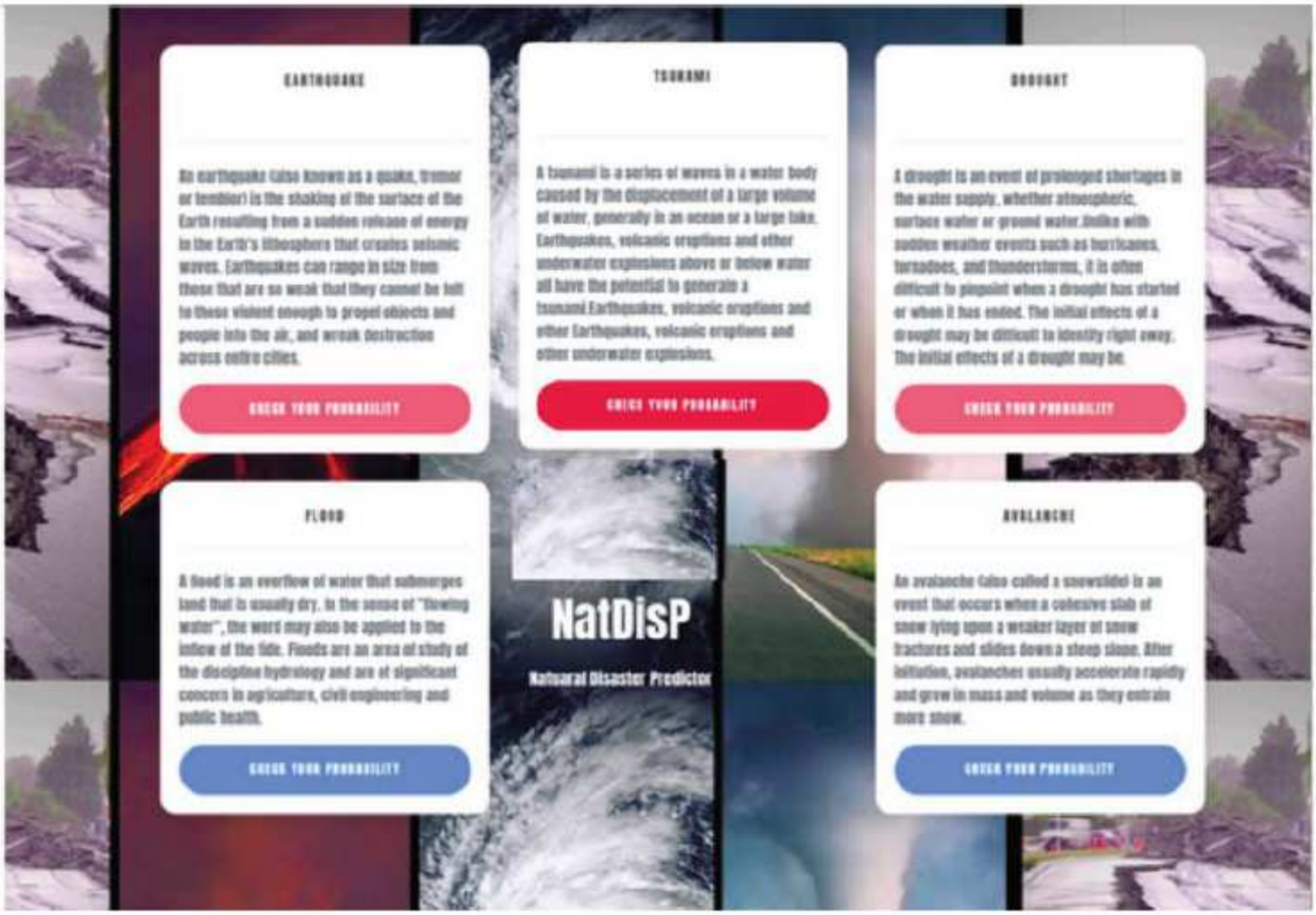

Figure 6

Home page of NatDisP

Figure 7

Earthquake module UI

Figure 8

Earthquake prediction results

Figure 9

Flood prediction module UI

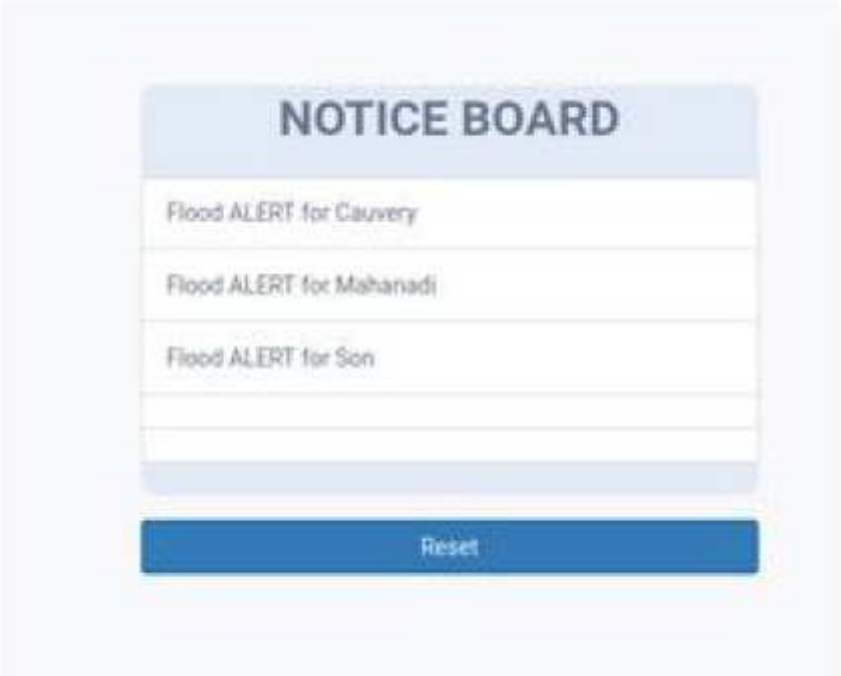

Figure 10

Flood prediction module results