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An Intelligent System for Flood Prediction Using Machine Learning Approach

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Abstract – *Flood is one of the major natural disasters that lead to human hardship and economic loss. Establishing a suitable flood forecasting and warning system can decrease these adverse effects. However, creating an accurate flood forecasting system is still challenging due to the lack of information about the effective variables in forecasting. Nowadays, machine learning (ML) methods are highly contributed in the advancement of prediction systems. These methods are providing better performance as well as cost-effective solutions.*

In this system rainfall amount is being used to produce a model by using Neural Network. Neural Network architecture is used to produce a model to where future water level is produced by using data of past water level. This system developed an intelligent system for flood prediction using machine learning approach to predict the incoming flood based on neural networks. Therefore early warnings can be given to the public that will surpass the danger level that will lead to flood.

Key Words: **Machine Learning, Neural Network, Flood Prediction**

1. INTRODUCTION

Natural disasters can create lot of hazards including risk to human life, disturbance of transport and communication networks, damage to buildings and infrastructure, and the loss of agricultural crops. Flood disaster is one of the natural disasters that result in economic paralysis of 40% in a country. Flood occurs when river bursts its banks and the water spills on top of the floodplain. It is caused by heavy rainfall, when absorption of water is low and overflows are not controllable by river channels. The faster the rainwater reaches the river channel, paved the way for occurring flood. There is no mechanism to prevent flood but only a prediction can reduce damages and secure the life of inhabitants. While preventing flood is not a practical task, but prevention and protection policies are required that aim to reduce the damages of people and public as well as private property.

An increase in the risk of a flood can be lead to several factors, such as deforestation and rapid urbanization. Numerous other factors are likely to be the root causes of flood disasters.Due to the flash-flooding and bacterial contamination the quality of water is very poor.

Two types of measures can be taken for flood protection,ie structural(dams and reservoirs) and non-structural(flood forecasting and warning).To predict the flood, the factors such as amount of rainfall, present river water level, etc. are to be need. If a forecast is issued after the prediction, it paves to warn the public about the possibility of the flood, and to give time to people move out of the area. If forecasts can be made with long time between the storm and peak discharge, it reduce the damages in great scale.

Flood forecasting and prediction capabilities evolved slowly during the past years. The accuracy of flood prediction is very important as a future reference in predicting flood disasters. Water level upstream would greatly affect the water level in the downstream. Rainfall data is the parameter that becomes the reference. The data is analysed to find out the patterns of past variations that can be used to predict the value for the future. Presently, neural networks are widely applied to systems such as:

- Support for medical diagnosis
- Financial market prediction
- Voice and handwriting recognition
- Flood prediction
- A variety of signal processing systems.

However, recent technologies like neural network have had a major role in forecasting methodologies. Neural network is a subset of machine learning, where it is inspired by the structure and functional characteristics of biological neural networks. They are mainly used in fields such as prediction and classification.

1.1 Flood Prediction Model

Flood prediction model can play a main role in providing appropriate information of possible impending floods in populated locations. The development of such models can reduce the damage in such areas. More importantly, a prediction system developed, it can effectively lower the risk of harm and loss of life. If neural network models can provide sufficiently accurate forecasts, even one day ahead, the lead time for flood warning can be extended and the possible flood emergency measures can be better planned and executed.

This system is applied to one region, as a proof of concept. It is primarily focused on the use of neural networks trained on historical rainfall values to predict the future values. The

advantage of the proposed method is that it requires very few variables and very little knowledge.

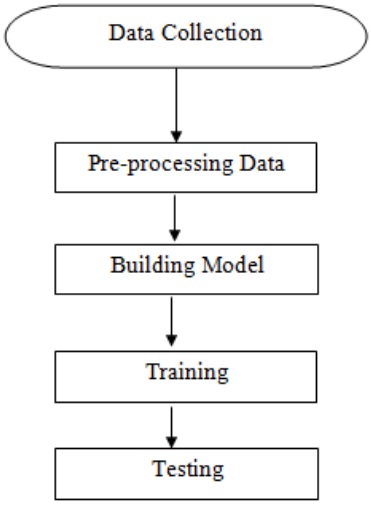

Figure -1: Basic flow for building the machine learning model

Thus, building a prediction model based on a rainfall dataset was reported to provide higher accuracy in general. Whether using a rainfall amount dataset to create a prediction model, the historical dataset of hourly, daily, and monthly values is divided into individual sets to construct and evaluate the models. The individual sets of data are under the process of training, validation, verification, and testing. Figure 1 represents the basic flow for building a machine learning model. The major machine learning algorithms applied to flood prediction include linear regression used in neural networks.

More importantly, a prediction system developed, it can effectively reduce the risk of harm and loss of life. The models can provide possible accurate forecasts, even one day ahead; the lead time for flood warning can be extended. After that the proper flood emergency measures can be planned as well as executed.

2. RELATED WORK

Early flood warning systems can be applied in order to provide an effective warning for natural disasters that can be caused by floods. This can be achieved by the combination of technologies such as Geographical Information Systems (GIS), remote sensing, and Information and Communications Technologies that translate data into useful information. Floods cannot be prevented, but due to proper planning can reduce the damages. Flood prediction is a complex process influenced by geographic location, amount of rainfall, type of soil and size of catchments that affect river water levels. Models such as Quantitative Flood Forecasting (QFF) and Artificial Neural Networks (ANN) have been developed and implemented over the past years in different locations to help in weather forecasting.

A real time urban flood monitoring system for Metro Manila was conducted by Garcia, Retamar and Javier (2015). In this study, two streets in Metro Manila are the locations of the system that consists of ground-based pressure sensor and a rain gauge connected to a data logger with telemetry feature using the GRPS network. A TCP server collected the data from the stations and then processed to provide visual information and real time updates through mobile and web services. Random Forest Algorithm was implemented to estimate the flood ahead of time to warn motorist and users of the system [1].

A flood warning system for critical region was demonstrated through a research that is based on E-noe project. The system checks the water level of a river or a runway. If the level is at warning level, it warns the authorities through phone calls and text messages. It uses sonar and microcontroller. The microcontroller manages the data which are then stored through cloud computing [2].

Another study states that prediction flood occurs if convective rains occur within the confines of more than 9 hours of continuous rain [4]. A new model for a flood warning system was developed using wireless sensor nodes (WSN) and artificial neural network (ANN). It involves six hydrological parameters such as change in speed of water, moisture in air, rainfall, pressure of the atmosphere, water level and wind velocity. These parameters are measured by the WSN. These vectors are theoretically tested and verified [8].

In mobile areas, automated wireless flood warning system was presented in another paper to inform people during floods. A wireless sensor was used to measure the level of flood water. The data will then be sent to the raspberry pi with the aid of RF signals. Ad hoc network, a set of mobile devices, is created once the water level reaches its threshold limit. This network can be installed in smart phones which are used as a device for broadcasting the flood warning messages [7].

3. PROPOSED SYSTEM

Proposed System aims to develop a web site for finding out the influence of climatic parameters on flood in a particular station .This system work entitles the research and development of models for improving the flood prediction. We study the application of neural networks; a non-linear auto-regressive machine learning technique trained on patterns of past years rainfall values in order to predict the chances of future flood.

Machine learning algorithms are used for the building purpose of this system. This system learns the dataset and trained based on the previous year's rainfall amount. While user enters the rainfall amount i.e., the previous year's rainfall data to the system, it trains and tested the upload data. After that system predicts the chances of occurring flood in that particular region.

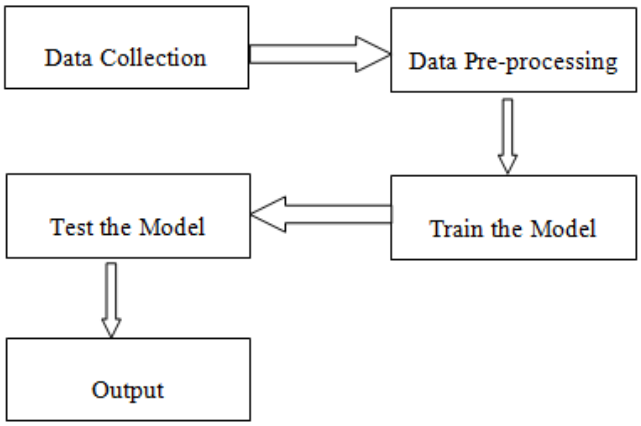

Figure -2: Methodology of Proposed System

The proposed system explores the use of artificial neural network models to predict the onset of floods. Figure 2 shows the methodology of proposed system. Rainfall is considered as the primary factor influencing the chances of flood.

4. SYSTEM OVERVIEW

The system is designed to predict future floods based on previous rainfall data. Overview of the system that can be seen in figure 3.

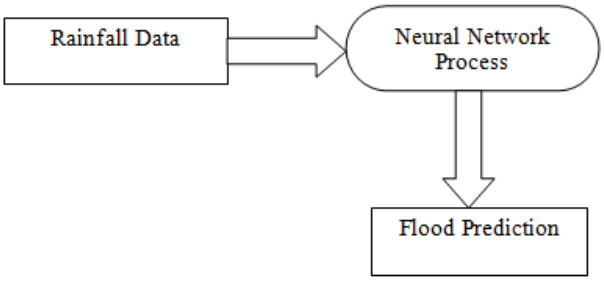

Figure -3: System overview

The method used for this system is using neural network. The steps taken are the search and data collection of rainfall data that will be used as training data and test data. After the data collected the process of cleaning the data and then transformed the data so that the data is easier to process. Then the data is divided into training data and test data. A training dataset in machine learning is a set of data used to identify potential relationships between data. A test set is the set of data used to assess the effectiveness of a predictive relationship.

Linear regression uses in neural network for predicting the incoming flood.Linear Regression is a machine learning algorithm based on supervised learning, where it performs a regression task. These models a target prediction value based on independent variables. It is commonly used for finding out the relationship between variables and forecasting.

4.1 Concept of Neural Network

Neural network is a computer program that is designed to model the human brain and its ability to learn tasks. It is trained to recognize and generalize the relationship between a set of inputs and outputs. Neural networks retain two characteristics of the brain as primary features are the ability to learn and generalize from limited information. Both biological and artificial neural networks works, interconnected simple processing elements and neurons. The knowledge stored in the interconnecting weights in neural networks is modified through a process called learning, using a learning algorithm.

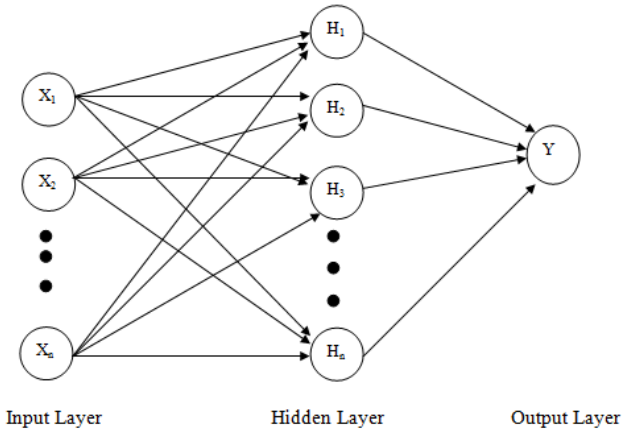

Figure -4: Artificial Neural Network Structure

The artificial neural network structure consists of three layers of units. First layer of input units is connected to second layer of hidden units, which is connected to the third layer of output units (Figure 4). The input units represent the information that is fed into the network. The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units. The behaviour of the output units depends on the activity of the hidden units and the weights between the hidden units and output units.

When using a neural network to solve a problem, the first step is to train the neural network to learn the relationship between the input and outputs. This action is accomplished by presenting the network with examples of known inputs and outputs. The neural network maps the relationship between the inputs and outputs, and then modifies its internal functions to determine the best relationship that can be represented by the neural network.

4.2 Linear Regression

Linear regression is one of the most well understood and well-known algorithms in the statistical and machine

learning world. Linear regression has been developed in the field of statistics, which has been studied as a model for understanding the relationship between input and output of numerical variables. And now it has been borrowed by machine learning. It is a statistical algorithm also a machine learning algorithm.

In linear regression, the relationships are modelled using linear predictor functions whose unknown model parameters are estimated from the data. Such models are called linear models.

It is a very simple approach for supervised learning. Though it may seem, there are several other best practice and most used algorithm compared to linear regression, but still is a useful and widely used statistical learning method. It is used to predict a quantitative response Y from the predictor variable X. In linear regression it is assumed that there is a linear relationship between X and Y. The mathematical equation is look like this:

$$y= \beta_0+ \beta_1x_1+ \beta_2x_2+..... \beta_nx_n$$

Where:

- y is the response
- β values are called the model coefficients. These values are learned during the training step of model.
- β_0 is the intercept
- β_1 is the coefficient for X_1
- β_n is the coefficient for X_n

4.3 Neural Network Process

There are mainly three steps involved in artificial neural network process. They are training, testing and finally the prediction part (figure 5). After doing the process of data transformation where the data has been normalized, then the next step is to conduct the data training process using artificial neural network. In the prediction process required training data to get the value of weight and other values in order to perform testing process in neural network system.

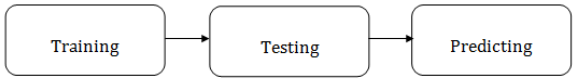

Figure 5 -: Neural Network Process

After the values of the parameters that have been obtained through the training process, the next stage is the parameter values are used for the testing process. The weight value that has been obtained in the training process will be used to get the output value. And then system performs the data denormalization.

Finally the prediction process, it is the process by which the system predicts the chances of occurring flood in a particular area using rainfall data.

5. CONCLUSIONS

The application of neural networks, a non-linear auto-regressive machine learning technique that trained on patterns of preceding rainfall values in order to predict the chances of flood. A flood prediction system will be very useful because it would enable the populace to prepare against the dangers of flood. It would help in the reduction of the damages of flooding. This system used neural network to develop a flood prediction system using data such as amount of rainfall. This work provides an effective flood prediction model which shows how possible it is to accurately predict flood using linear regression algorithm in neural networks. In order to create flooding awareness, it paved to reducing the impacts of flooding. . Due to the characteristics of the neural network, our predicting algorithm has good accuracy and credibility.

Neural networks have the advantage of simplicity when compared to other more complicated models. The performance evaluation reveals that the proposed system accurately sends flood alert compared to the existing flood alert system. After that the proper flood emergency measures can be planned as well as executed.

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