Smart Flood Prediction System

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Abstract— Flood occurrences are the most hated environmental hazard around the world. This is due to floods threaten human life and furthermore affect the economy of the involved country. Floods are usually due to the season monsoon and heavy rains causing flash floods usually in urban area. Therefore, it is a must for researchers around the world to find a solution for this problem. A reliable and practical flood prediction model is in need to predict flood occurrence ahead of time. Thus, this paper proposes the modelling of flood prediction system using Extended NNARX (Neural Network Autoregressive with Exogenous Input) with EKF (Extended Kalman Filter). Various environmental parameters required for flood prediction such as temperature, humidity, water level, water quality are obtained by using various sensors. The data continuously obtained from these sensors are used to train the Extended NNARX model. The trained Extended NNARX model can predict the occurrence and non-occurrence of flood by taking the current climatic conditions as input and comparing it with the previous values. Weather prediction is also possible from the sensor readings. Alert notifications are sent to the authorities as well as the public whenever occurrence of flood is predicted. Public is also alerted through a buzzer. The sensor values and its graphical representation are displayed through a LCD and a monitor respectively that are placed at public locations so that the public will be aware of the current climatic conditions of their location in real time.

Keywords: Flood, Hazard, Flood Prediction Model, NNARX, EKF

I. INTRODUCTION

World Meteorological Organization has stated that floods are the most severe disaster out of all disasters in the world. Floods are influenced by various factors, both hydrological and meteorological. It causes great damages to agricultural lands, residential areas, properties, human and animal lives and thus leads to social and economic losses in those areas. About 12% of land in India is prone to flood conditions. The Indian monsoon ranges from June to September. During these months, the rivers discharge water heavily that increases the water level in surrounding areas and leads to flood. A number of researches have been done in the area of flood disaster management. For a country like India to grow as a smart nation, it is important to shift from individual monitoring and prediction frameworks to smart flood prediction systems which include all the affecting people equally with recent expansion of technology. Here an IoT framework with Artificial Neural Networks has been rendered for the development of flood prediction system. The system consists of sensors that sense the surrounding environment, a microcontroller which processes the sensed data, a Wi-Fi based communication infrastructure, a cloud server and data analytics algorithm that would finally help to predict flood disaster situations.

II. MOTIVATION

Floods are the most severe disasters out of all the disasters in the world. It causes destruction and devastation of life, agriculture, property and infrastructure every year. Specifically in India, about 12% of land is prone to flood conditions. The rivers in the country discharge water heavily during monsoon increasing the water level in surrounding regions and leads to flood conditions. For a country like India, it is important to shift from relief and recovery framework to integrated flood management system. A reliable and practical flood prediction model is essential for an early prediction of flood occurrences so that it will be possible to relocate people from flood prone areas to safer places and thus save human lives and valuable properties.

III. LITERATURE SURVEY

Sometimes the level of flood rises rapidly and the people may have only limited time to prepare for their evacuation. Flood Level Indicator and Risk Warning System for Remote Location Monitoring using Flood Observatory System proposed by S. K. Subramaniam et al. (2010) [1] states that the flood alert systems are used for providing early warning to citizen, but most of them are usually intended for the respective organizations. Moreover, the system can only cover a limited distance. So when flooding happens, it will take time to reach the people living nearby, and they cannot save most of their belongings as water rises quickly. Generally, flooding cannot be stopped and it is unavoidable, but early detection or warning system can be used to reduce losses faced by the citizen and government. The flood observatory system communicates with the monitoring station via GSM modem in order to send information about flood level and receive commands from the monitoring station. The Development of Smart Flood Monitoring System using Ultrasonic Sensor with Blynk Applications proposed by Nor Anum Zuraimi Md Noar et al. (2017) [2] presents a smart flood monitoring system that uses Blynk platform as a medium for transmitting data. This system contains two NodeMCU development boards integrated by using Blynk application (IOS or android). The first NodeMCU is placed at the flood area and the second NodeMCU acts as the control unit. Transmitter unit that contains first NodeMCU has an ultrasonic sensor attached to it that measures the water level during flood and display it on the LCD. Then, the measured values from the ultrasonic sensors will be sent to the Blynk application using wireless connection. The data is continuously collected and then stored in a dedicated database for recording purposes. This data will be send to the second NodeMCU through Blynk bridge to trigger the buzzer and the LED in order to notify the person in charge of the control unit.

A Novel Approach for Early Flood Warning using Android and IoT proposed by Jayashree S et al. (2017) [3] explores different flood warning systems and it is found that the possible drawbacks of the studied systems are internet dependency, information sent to government first and then to common man makes a delay, towers may become inoperable due to power shortage, complex calculations and excessive power consumption by the alert system. So a system that overcomes these drawbacks is proposed. The proposed system consists of level sensor and flow sensor that monitors the level and speed of flow of water respectively. If the level exceeds from the limit alert messages are broadcasted through Zigbee automatically. All the measured values are sent to the server through ZigBee transceiver. An android app is installed in all the mobiles of the Public in which a Zigbee hardware is connected through OTG for communication. This system works well even in the absence of network. Public can communicate to the regional server to collect the information. Users can make emergency calls, send SMS to the pre-stored numbers like hospitals, corporation, police, relatives if network is available. User can also find safe zone live mapping with internet and in case of absence of internet stored images of safe zones can be accessed.

Pre-Flood Warning System Based on User Mobility proposed by Fateen et al. (2015) [4] consists of three main systems, data processing, data presentation and data broadcast. Data processing involves collection of values from ultrasonic sensor, which will be deployed at riverbanks to measure water levels. Data collected from the ultrasonic sensor will be sent to a microcontroller that compares the water levels (i.e. low, medium and high) with a predetermined threshold values. There are two major disadvantages in this system. First, this system measures the water level by using ultrasonic sensors which float on the surface of water. But during heavy rainfall the sensors may get damaged. Second, this system uses mobile towers for communication. Mobile towers may become inoperable due to loss of power and also if suppose few towers are operable, they can alert only subscribed customers and not all people.

Smart Flood Disaster Prediction System using IoT and Neural Networks proposed by Swapnil Bande et al. (2017) [5] is an IoT based flood monitoring and artificial neural network (ANN) based flood prediction system that is designed with the objective of enhancing the scalability and reliability of flood management system. The system consists of sensors that sense the surrounding environment, a single board computer which processes the sensed data, a Wi-Fi based communication infrastructure, a cloud server, and data analytics algorithm that would help to predict the flood situations. The environmental parameters like temperature, relative humidity, atmospheric pressure, rainfall etc. are sensed by an array of sensors and the measured values are sent to the microcontroller through Wi-Fi (IEEE 802.11 protocol). Further the relationships between the input data received and the output rainfall is modelled using ANN techniques. A continuous monitoring of changes in environment is done by replacing the old values with new ones after a determined time interval. A flood event is predicted in advance using ANN model and it notifies the people about upcoming disaster according to the increase in rainfall and corresponding rise in the water level of the low-lying areas near river. The collected data is uploaded to cloud database and the information is shared to the people through the smart phone in the form of SMS or tweet notifications.

IV. PROPOSED SYSTEM

The proposed system is based on IoT and artificial neural network techniques. ANN techniques are suitable for solving non linear problems. The dynamics of flood water flow is extremely non linear. Here an ANN model called Extended Neural Network Autoregressive Model with Exogenous Input (NNARX) along with a non linear state estimator called Extended Kalman Filter (EKF) is used.

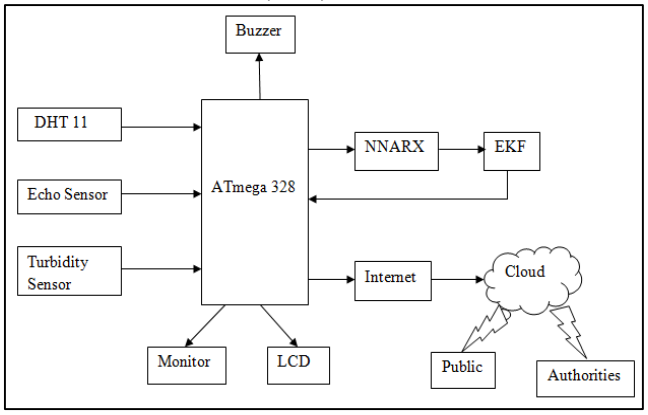

Fig. 1: Architecture Diagram

Various sensors are used to measure the environmental parameters. DHT 11 measures the temperature and humidity of the environment. Echo sensor measures the level of flood water. Turbidity sensor measures the turbidity of the water and thus determines the quality of water. The sensors are connected to the microcontroller, ie ATmega 328. The sensor values are displayed in the LCD and its graphical representation is shown through a monitor. Extended NNARX model is trained with the sensor values. Trained Extended NNARX model can predict the occurrence and non-occurrence of flood by considering current climatic conditions as input and comparing it with the previous values. Weather prediction is also possible from the sensor readings. Output of Extended NNARX model is given to EKF. EKF filter is used to improve the efficiency of the extended NNARX model by removing noises from the output of Extended NNARX. Whenever flood occurrence is predicted, then alert notifications are sent to the authorities as well as public. Public is also alerted through the buzzer placed at public location.

V. METHODOLOGY

A. Technologies

1) IoT

IoT (Internet of Things) is the concept of connecting everything to internet. It brings in a new type of communication between things and people and between things. IoT has wide range of applications across industries through its unique flexibility and ability to be suitable to any environment. It enhances data collection, automation and operations through smart devices. IoT has various applications in environmental monitoring such as

environmental protection, extreme weather monitoring, water safety, commercial farming, etc.

2) Neural Network

In predictive analytics, artificial neural networks (ANNs) provide better results than other methods. In flood management system, it is of utmost importance that data analysis be done for flood prediction. Many artificial neural network algorithms are being studied and deployed for prediction purposes. ANN techniques are suitable for solving non linear problems. The dynamics of flood water flow is extremely non linear. Therefore ANN techniques can be used for flood prediction.

B. Algorithms

1) Extended NNARX

Neural Network Autoregressive with Exogenous Input (NNARX) is one kind of recurrent neural network model that is developed to solve discrete-time nonlinear systems. The outputs of NNARX depend on current or previous inputs, outputs or states of the network. It has memory and can be trained to learn sequential or time varying patterns. The environmental parameters required for flood prediction are obtained through various sensors. These values are used to train the Extended NNARX model. Normal and abnormal values are mapped separately. The trained Extended NNARX model can predict the occurrence and non-occurrence of flood by taking the current climatic conditions as input and comparing it with the previous values. If the current values match the previous abnormal values, then occurrence of flood is predicted. If the current values match the previous normal values, then non-occurrence of flood is predicted.

2) EKF

Kalman Filter is widely known as linear estimator. Thus, Kalman Filter usually handles complex system with linear characteristic of behavior. However, complex system with nonlinear behavior cannot be handled by Kalman Filter. Therefore, the original Kalman Filter need to be extended. This extended version of Kalman Filter is known as Extended Kalman Filter (EKF). The algorithm has mainly three steps, namely next step, prediction step and update step. In next step, the next value of NNARX output is taken. In prediction step, noise is removed from the output. Finally, in update step the filtered value is updated. Static noise reduction is done by EKF. Thus it improves the efficiency of the Extended NNARX model.

3) Local Beam Search

Local beam is a search algorithm that finds a solution by expanding the most promising node among the limited set in a graph. The algorithm uses breadth-first search to build its search tree. It generates all successors of the states at the current level and sort them in increasing order of heuristic cost and repeats it for each level. Only a predetermined number of best states called beam width are expanded next. The algorithm returns the first solution found. The beam width can be fixed or variable. The procedure is repeated until a solution is found. Only one feature of this algorithm is used in this project, ie selection of k random states. Various sensors are used to measure environmental parameters required for flood prediction. Sensors continuously provide values. The algorithm will select the sensor values randomly.

VI. SYSTEM IMPLEMENTATION

Implementation begins with the selection of preferred OS. Operating system selected is Linux. Configuration settings are done according to the users' needs. The language used is python and Embedded C. Embedded C is used for the IoT section and the remaining part is implemented using Python. Python program is created using the IDE Pycharm.

Package manager is ANACONDA. It simplifies the package management and deployment. Various packages are installed from the ANACONDA repository. Packages installed are GPIO, Plotly, OpenPyxl, SciPy, NumPy, GeoPy, Serial Monitor, PyOWM and Twilio.

Microcontroller used is ATmega 328 that is placed on the Arduino board. Three sensors are attached to it namely, DHT 11, echo sensor and turbidity sensor. DHT 11 measures the temperature and humidity of the environment, echo sensor measures the water level and turbidity sensor measures the water quality. LCD and monitor is used to display the sensor values and its graphical representation respectively. Finally a buzzer is used to alert the public.

Messaging application called Telegram is used. GUI is created using JSON scripting. It is a framework used to transmit data between server and web applications. User can login to the application by giving the valid username and password. User can get the live weather data as well as past weather data by clicking on various buttons that appear on the screen. Admin can get the graphical representation that helps in weather prediction.

VII. RESULT

Flood is the most devastating natural disasters in the world. It causes great damages to agricultural lands, residential areas, property, human and animal life. Thus it leads to social and economic losses in the flood affected areas. Human beings cannot totally avoid floods. The only thing humans can do is they can develop suitable systems to predict the flood occurrence and alert the people.

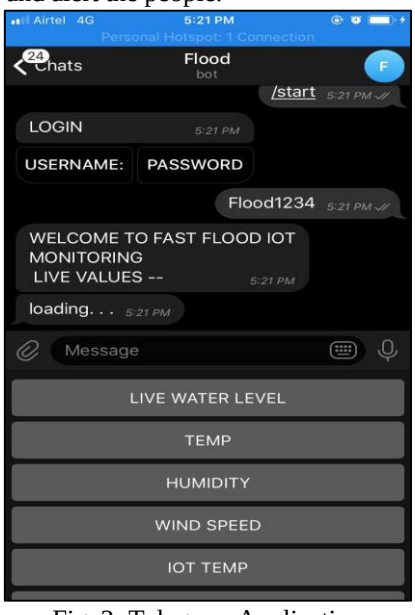

Fig. 2: Telegram Application

Here an IoT framework with artificial neural networks has been rendered for the development of flood

monitoring and prediction system. The system consists of sensors that sense the surrounding environment, a microcontroller which processes the sensed data, a Wi-Fi based communication infrastructure, a cloud server, and data analytics algorithm that would finally help to predict the flood disaster situations. Users can get the flood and weather details through the telegram application installed in their mobile phones. The flood and weather data along with the date and time is stored as a log file that the users can obtain through the application. Weather prediction is also possible from the sensor readings. Sensor readings as well as its graphical representations are displayed through LCD and monitor respectively that are placed at public locations so that they can be aware of the climatic conditions of their area in real time.

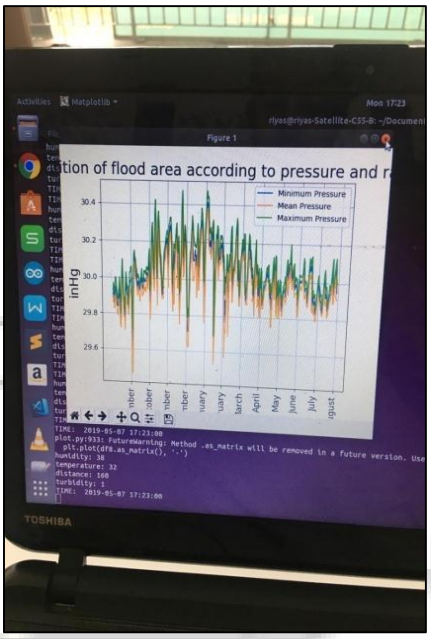

Fig. 3: Flood Prediction According to Pressure and Rain

The integrated approach combines the scalability of IoT and reliability of artificial neural networks to handle data provided by a sensor network and by effective communication between these two components, an early prediction of flood is done. Early detection will help to relocate the people from current location to safer places. It will help to speedup the rescue process. The flood data will be stored which can be used for flood prediction in future. The proposed model is a protective and reliable model which helps in alerting civilians during floods.

VIII. Conclusion

Flood is a phenomenon by which the living and non-living entities that belong to the environment suffers various losses. Human beings cannot totally avoid floods but the only thing humans can do is they can develop suitable systems to predict and take subsequent measures to alert the people about its occurrence. There are many technologies available to predict and prevent flood which will help to reduce the effects of the disaster. Thus the smart flood prediction system is relevant in terms of actual deployment and reliability with real time monitoring and updating of environmental parameters and prediction of flood as compared to existing approaches.

The IoT and neural network enabled flood prediction system makes early flood and weather prediction possible. It helps the people to know the current climatic conditions in real time. Early detection helps to relocate the people from current location to safer places. It speeds up the rescue process. This low cost and low powered system can be applied in real time and it has greater efficiency. The proposed model is a protective and reliable model which helps in alerting civilians during floods.

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