A Survey on Flood Prediction Systems

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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 it affects the economy of the involved country. Floods are usually due to monsoon and heavy rains causing flash floods. Many states of India suffer from flood disasters every year regularly due to the absence of proper early warning system that would alert the people in the affected regions. A number of researches have been done in the area of flood disaster management and various flood prediction systems have been developed. This paper highlights the latest methodologies and flood management techniques used by researchers to predict flood occurrences.
Key words: Flood, Early Warning System, Flood Disaster Management, Flood Prediction System

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. So, a survey was done among different proposals and this paper emphasizes different flood prediction systems.

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 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 water may rise rapidly and the people may have only limited time to prepare for their relocation. 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 to provide early warning to public, but most of them are intended for the respective organizations and the system covers only a limited distance. So when flood happens, it will take time to alert the people nearby, and they cannot save their valuable belongings as the water rises quickly. Generally, flooding cannot be stopped, but early flood detection or warning system can be used to reduce the losses faced by the public and the government. The flood observatory system communicates with the monitoring station through GSM modem to send information about flood water level and to 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. The access to the system between the first NodeMCU and second NodeMCU can be made within less or more than 50 meters. In the findings, it is observed that the system works well when the value measured by the ultrasonic sensor is displayed on the Blynk application and both buzzer and LED are functioning. The results obtained shows that the system is capable to handle the flood problem in the affected area.

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 issues associated with each of them. Also proposes an effective flood alert system that overcomes the drawbacks of all the studied systems. 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 is independent of mobile towers for alert notification broadcasting that consumes less power and works well even in the absence of internet and broadcast messages directly to the public so that the delay is

avoided and free from complex calculations is proposed. The reason behind this work is mainly the huge loss Chennai faced in 2015 due to flood. The proposed system consists of level sensor and flow sensor that monitors the level and speed of flow of water respectively. If the level is low, medium or high (exceeds threshold) then microcontroller automatically sends the water level information to server. If the level exceeds from the limit alert messages are broadcasted through Zigbee automatically. The speed of water flow is checked by a flow sensor. Even when there is a small change in the flow of water, the server will be notified. 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.

Nova Ahmed et al. proposed ShonaBondhu: a cloud based system to handle flash flood (2016) [4] that works in three different planes. The first plane consist of server or servers residing in the Cloud and it is responsible for long term data forecasting that impacts the strategic planning and making long term decisions regarding flood and affected areas. The second plane consists of the distributed local servers known as Gradient Servers that use real time decision making and forecasting at local points based on its gradient information which is calculated by local water level, rainfall level, time and expected water level. The third plane is responsible for real time monitoring and it consists of water level sensors placed at various locations. The sensing nodes are distributed all over the country. The servers that collect data from the sensors are spread around various locations. A function of rainfall and current water level that indicates a particular gradient to that sensor is used by the server. The gradient information among sensors are related using the water level and rainfall data over four years from 2008 to 2011. This gradient information is updated and propagated when any type of change is present near the river source. A communication abstraction is created to transmit sensitive information and periodic updates of current status. They have used actual sensors to monitor the water level in the river and have used emulated sensors to mimic the behavior in large distributed system. Their current system works as a proof of a concept system before the actual deployment of this system in collaboration of Water Development Board of Bangladesh.

Victor Seal et al. proposed A Simple Flood Forecasting Scheme using Wireless Sensor Networks (2012) [5] that works by ringing alarm to alert the people before the occurrence of flood using calculations to provide real time results. In this system multiple variable linear regression is used to perform calculations that is easy to use and understand. It is economical and also fast. It helps to reduce the resource utilization and also provides results with greater degree of accuracy. This model does not have any constraints on the number of parameters to be used. Any variety can be used and any number of parameters can be added or deleted depending on the requirements. The water level rise is represented by using a polynomial from which flood occurrence can be detected when the values exceeds the threshold. A time multiplier function is used by the system to decide the time gap between any two successive readings taken. There is a central node mentioned in this model but it is not used anywhere in the working. This model only predicts the flood occurrence and it alerts public through an alarm, but the alarm frequency and the distance it can cover is not clearly mentioned. The efficient energy consumption part is mentioned as a future work.

Basha et al. presented A Model-Based Monitoring for Early Warning Flood Detection (2008) [6]. A model based approach is followed by the proposed system in its design and processing feature. This system is intended for the early prediction of flood in order to avoid losses and damage to the society. A few nodes are deployed across river bank and it uses a unique heterogeneous communication system for fetching and sensing real-time data. This system has a built in self-monitoring feature to detect failures. The inbuilt feature also helps in working by following the measurement schedules that helps to capture events. The advantage of this system is that they have used the multiple linear regression models for the purpose of flood forecasting that provides accurate and fast computation. Rainfall driven flood is the prime consideration of this model. So this model requires knowledge about the measure of rainfall and the soil's time dependent response to the rainfall in order to predict the flood occurrence. This model requires information about the soil composition, topography and land cover, along with weather conditions and soil moisture. There are a lot of parameters that the sensors must work on which indicates that a number of different type of sensors are needed to be employed. This implies the expensiveness and complex computation which is the drawback of this model.

An Intelligent and Adaptable Grid-based Flood Monitoring and Warning System proposed by Danny Hughes et al. (2006) [7] states that damage caused by a flood is directly proportional to the time before its actual occurrence provided a warning is given. The system comprises of both local and remote sensor network. The local sensor network is used to compute and arrive at a conclusion of conformance about a flood event and give alert to the people nearby. Performance is maintained by the use of combined local and remote networks. The wireless sensor network and remote fixed network grids are combined for computationally-intensive flood modelling purposes. This model uses a GridStix sensor platform that comprises of embedded hardware, wireless network (heterogeneous) and next generation grid middleware and it is used for implementation of an adaptable WSN. The local computation can be used to certain environmental conditions like details about flood and power usage are informed for the system to adapt accordingly. Wide range of sensor are supported i.e. image-based flow prediction. A series of images will help to know about parameters like flow rate and the speed of surface water. This technique is less expensive and easier to install than the ultrasonic flow sensors. This is considered as an advantage about this system. The system alerts the public in two ways. One is visual in public websites and second is SMS alerts. A sequence of high-resolution images is used for

image-based flow prediction. The transfer of these large images is an issue by usage of GSM or GPRS technologies. Thereby this image alerts is not feasible and cannot be implemented practically. It is a major disadvantage of this system. The platform mentioned requires a high end embedded hardware. Every computational GridStix node is based on an embedded computing platform named GumStix. It contains a processor (400 MHz) Intel XScale PXA255 CPU, RAM (64Mb) and flash memory (16Mb) and a variety of hardware for I/O mechanisms that provides connections with variety of sensors. This specification mentioned indicates the expensiveness which is a disadvantage. For the working of above system huge units of power is necessary.

Pre-Flood Warning System Based on User Mobility proposed by Fateen et al. (2015) [8] is a conceptual framework that consists of three 3 main stages, monitor water level, alert flood victims on flood danger status and inform them to relocate to the safe zones nearby. This is done by leveraging on the Mobile Telephone Switching Office (MTSO), where alert SMS is broadcasted only to the flood rainfall driven cellular numbers logged at the affected base station. The early flood warning system 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) [9] 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 main aim of this system is to monitor humidity, temperature, pressure, rainfall, river water level and to find their temporal correlative information for flood prediction analysis. The IoT approach is used for data collection from the sensors and communication over Wi-Fi and an ANN approach is used for data analysis in flood prediction. 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. In the developed system, a model is designed in which 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. There is communication between various low power IoT nodes through internet using Wi-Fi module connected to the IoT board. 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. This system uses a single board computer called Raspberry Pi 3, which is widely used in IoT applications also based on Wifi protocol for communication. The programming language used is Python. ANN is used for prediction analysis. ANN is a neural network similar to the biological neural network which computes in parallel. It consists of processing elements called neurons connected together in a particular manner to get the desired outcome. The ANN network works upon the non-linear times series data obtained from the sensors' for the prediction purpose.

Swarup Mandai et al. proposed A Neural Network Based Prediction Model for Flood in a Disaster Management System with Sensor Networks (2005) [10] based on an artificial neural network (ANN) model, namely, Multi-layer perceptron (MLP). They have mentioned the relative importance of different environmental parameters used to predict flood occurrence and it is found that underground water level is the most important parameter for the prediction model. The proposed technique provides a statistically significant forecasting result in the test data set. The input environmental parameters, such as rainfall, temperature, humidity, underground water level and wind speed are obtained through a sensor network. Sensors used are temperature sensors, humidity sensors, airflow sensors, and water level sensors. For predicting the flood occurrences, the data collected from the base sensors are taken as input to the system. The database of past flood and non-flood is used for training the ANN model. This trained network is capable of predicting the occurrence and non occurrence of flood by considering the current climatic data obtained from sensors as input. Alert is given to the public through an alarm.

IV. CONCLUSION

In this paper latest works in the field of flood management were discussed. Many researchers have contributed and are still working on it. There are a number of problems in existing systems that need to be addressed such as internet dependency, information sent to government first and then to common man makes a delay, towers may become inoperable due to power shortage, complex calculation mechanisms and excessive power consumption by the alert system. However some of the problems like internet dependency, power consumption, delay in broadcasting alert messages have already been solved but still have room for improvement. It is concluded that the new innovations in technology such as IoT and Artificial Neural Networks have made it possible to overcome most of the disadvantages of the existing systems and has provided a more reliable and practical solution for flood management.

ACKNOWLEDGMENT

I would like to convey my heartfelt gratitude towards my guide Mrs. Hrudya K P for her constant guidance, encouraging help and inspiring words. I am thankful to the department of computer engineering for their support.

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