Review Paper on IoT Based Flood Prediction Model

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Abstract — *The importance of environmental monitoring is undoubted in this age. Knowledge of environmental monitoring is important to determine the quality of our environment. Information gathered through environmental monitoring is important to many different decision makers. So it is necessary to develop a system that monitors the environment conditions or the ambient conditions in real-time. The Internet of Things (IoT) is a field of embedded systems and computing where number of devices collectively gathers data in real time and transfers it through a Wireless Sensor Network (WSN) to the computational devices for processing and analysis. IoT generally combines embedded system with cloud computing and analyzing platforms. Of all the natural disasters, floods are the most common of them, and cause significant damage to life, infrastructure, and agriculture. Researchers and scientists have moved on from physical parameter based flood prediction to mathematical modeling based flood prediction schemes, and now the methodologies are focused around algorithmic approaches. In this work, an IoT and machine learning based embedded system is proposed to measure different atmospheric conditions to predict the weather information like temperature, pressure, humidity, wind speed and direction, rainfall etc and predict the upcoming natural disasters like floods after analyzing the trend of climate change. The proposed system uses a mesh network connection over ZigBee for the WSN to collect data, and a Wi-Fi module to send the data over the internet and also consumes low power. The data sets from array of sensors are recorded and monitored using cloud database and processed using an artificial neural network model to forecast the different weather events and predict the upcoming disasters.*

Keywords: IoT; Wi-Fi; Prediction of Floods

1. Introduction

A. Environmental Monitoring

The term environment means the surroundings of an organism. All living and non-living beings surround each other with other hydrological and meteorological components of nature make an environment. In this environment there is an interaction of these components which includes survival of living beings and daily activities of human life. Humans and other living species are surrounded by non-living elements such as land, air, atmosphere, water, and by living elements like plants and animals. The environment also includes other factors such as pollutants, which adversely affect human lives. Environment, therefore, refers to the sum total of all the forces, materials and influences around us at a given point of time and place. Environmental monitoring can be defined as taking samples of water, air, and soil moisture, soil nutrients etc with the help of sensors so that researchers can observe variations in them and study the relationships between various environmental parameters. Monitoring the surrounding environment helps in assessing its impacts on human lives, as well as analyze situations in which human activities carry a risk of harmful effects of the natural environment such as natural disasters. A natural disaster is a situation which results when there is rapid changes in normal processes of the natural environment; examples include floods, storms, volcanoes, earthquakes, tsunamis, and other geological processes.

A natural disaster causes loss of life or damage of property & infrastructure, the severity of which depends on the affected population's ability to recover and also on the relief infrastructure available to them. Of all the natural disasters, floods are the most common natural disasters, and cause significant damage to life, agriculture, infrastructure and economy.

B. Floods

Floods are naturally occurring events in our environment. They mainly happen when the catchment of river receives greater than usual amounts of water (due to either heavy rainfall or melting snow). The river cannot bear this extra water in its streams and causes the water level in the river to rise and flow out of streams leading a flood to take place. This flooding may take place at any point along the river course and not necessarily at the place where the extra water has entered.

Humans have long tried, but not always successful, to control and prevent the damaging effects of flooding rivers. Artificial flood banks are being built, the river course is straightened, or the riverbed is dredged to make it deeper. All of these methods of control can work, although they often have a negative effect on the river as a habitat. The International & National Environment Organizations have a significant role in the control of flooding and the protection of people and their property. Their job is a difficult one as there is an increasing tendency of rivers towards 'flash flooding' - this is where rainfall or melting ice and snow result in a rivers level rising very quickly, often far more quickly than in past years. Major floods make news around the world because of their impact upon human lives. This impact is in terms of loss of life, property and disruption of day-to-day living.

2. Literature Survey

These catastrophic events and uneven environmental keeps on changing and influencing our lives, harming property and the way of life we live in a wide range of ways on the grounds that the greater part of the essential needs of the individuals relies on upon the farming and agribusiness which ultimately relies on upon good weather. It is very difficult to monitor different weather parameters through wired and analog devices in an agriculture zone and localities near river zone during certain hazardous and critical situations. Researches done of the different environment monitoring applications works for different

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parameters like temperature, humidity, wind, solar radiations ,water flow, water level, vibration and light, etc.

A reliable computational model which could prevent the event of flood not completely but partially in developing and poor countries is our main concern. In this survey paper different research works describing to predict and prevent floods generally deployed using wireless sensor network (WSN) are discussed. There are different models, different energy efficiency models, and different networking arrangement of wireless sensor networks. These models motivate us in preparing a most efficient model for predicting and preventing flood.

Octavian A. Postolache, J. M. Dias and P.M.B Silva Girao [3] in 2009 implemented smart sensor network for indoor and outdoor air quality monitoring. In this system sensor nodes are installed in different rooms and it consist of tin dioxide sensors which were hardwired or wirelessly connected to the central unit. It also measured the concentration of temperature and humidity for accuracy. In this research, the concept of multiple input single output (MISO) neural networks was implemented to compensate for the influence of temperature and humidity on the concentration of gas present. IEEE 802.11n (Wi-Fi) technology was used for communication between sensors.

In the year 2012, Dr. Boyina. S. Rao, Deepa. k, Abarna. I, Arthika. S, Hemavathi. G and Mohanapriya. D [4] introduced Controller Area Network (CAN) for environmental monitoring. They used a combination of both CAN and Zigbee technology for effective sensors' communication. In this cost-effective system, sensors were connected to the microcontroller ATMEL 89S52 via CAN Interface and finally gathered data were sent to the PC server using Zigbee Communication. CAN protocol gives higher data rate for communication, hence utilized in this system.

In the implementation of monitoring and measuring systems using the Zigbee radio technology is represented by flexibility in topology, redundancy and robustness of the wireless sensor network [1],[4]. The Zigbee mesh networks having number of sensors in the network can operate over years, without any need of changing the original battery. The Zigbee technology has also been used in many other different types of emergency conditions like fire detection in forest, wirelessly sending internet information to system in disaster areas for medical responses and many more [1]. There are some applications done by researchers on the automation of weather stations in different areas which likely monitors, checks and controls the greenhouse effect [2] and provide weather forecast to central and local organizations [6]. So the work of the automation of weather station is useful in different application areas such as for agriculture, fishing, prevention of life and infrastructure. So in the survey paper we discuss various systems for the automation of weather station in river zone using Zigbee and Wi-fi technologies i.e. IEEE 802.15.4 and IEEE 802.11 respectively. This systems overcome the problem of low transmission speed and the existence of a single point of failure during the communication between Zigbee/IEEE 802.15.4, and also emergency services could not respond to false emergencies so their time can be better utilized to fight or manage real emergencies [7]-[9].

With the advancements in sensor technologies, the size and cost of sensors are drastically reducing enabling applications like flood detection and flood monitoring easily deployable in flood occurring regions. Also wireless communication technologies have rapidly evolved over the past few years with the advent of 3G, 4G, 6LoWPAN and LoRaWAN technologies and easy availability to users. So there came a term coined by Kevin Ashton called "Internet of Things (IoT)" into general use due to these advancements in embedded systems and communication technologies. Here in the next sections we discuss use of these IoT devices for flood detection and early flood warning systems which would enable us to make an effective flood-warning system.

A. Flood Detection

Basha et al. [2] presented a brief description about implementation of the sensor network in Honduras for an early detection of flood and warn the people at risk of their lives. They have analyzed the significance of using low-cost sensor networks in developing countries, sensor networks for flood detection and the available current operational systems for flood detection. This paper discussed about the flood detection problem of warning communities in events of disasters which quickly becomes complex due to its multifaceted nature. They studied the flood detection problem in Honduras and proposed a solution. Using wireless sensor network (WSN), they divided the solution into four tasks (event prediction, authority notification, community alert, and community evacuation). They have conducted different experiments to validate the proposed solution. They checked the usability of the 144 MHz radios for communication. They also tested it with the various communication ranges necessary for the system.

To communicate at these ranges reliably, the radio antennas need line-of-sight high in the air, which requires antenna towers and limits the ability to test this portion of the system in the US. This paper says that wireless sensor network can be a perfect technology to be deployed for fighting with the flood in poor and developing country.

In the research paper [9], Ancona et. al have proposed used of low-cost effective and dense spatial grid of rain gauges over an area of flood detection with an ability to provide samples of data in short time-intervals. Thus when the rain guage sensors show that the rainfall is over the set threshold levels for a particular given area, then an effective alert or warning may be given depending upon the level of risk to the people living in the underlying areas. This warning system requires co-ordination of all the meteorological agencies as well as other organizations in this domain with the most important of them – people who are at the receiving end of this system and also at the huge risks of their lives. In the next section, we discuss of use of IoT in Flood Warning System development.

B. Flood Warning

Seal et al. [7] presented a flood forecasting model designed using Wireless Sensor Networks. This model helps to predict riverine floods using simple and fast calculations with the use of multiple variable robust linear regression method which is easy to understand and simple yet cost

effective in its implementation. It utilizes very low hardware resources and still provides with real time predictions and reliable accuracy, thus having features which are desirable in any real world algorithm.

The model is independent of the number of parameters, i.e. any kind and any number of parameters may be added or removed based on the on-site requirements. The rise in water level is represented by using a polynomial from which the exceeding of the flood line in the near future can be determined. In this paper a time multiplier function is used only to decide the time interval between two successive readings.

The central node is mentioned in this model but it is not taken into account. This model is only predicts the flood situation and warns people about flood by ringing an alarm but it has no role in prevention of the flood event. We see how WSN is being effective for communication of flood warnings. However even with these communication approaches, it is necessary that real-time collection and analysis of sensor data be done so that the disaster warnings may be given to people at risk with effective time to response relief operations.

C. Early Flood Warning System

Basha et al. [2] described architecture of a system and deployment of how to meet the design requirements. It allows model-driven control for optimizing the prediction capability of the system. This architecture is developed in Honduras and is used to observe and analyze the river flood prediction. The authors have used a centralized form of the prediction model, with a network implementation and element testing. Deployed on the banks of river in Massachusetts, they got the effective results of the experiments on-field. In this system very fe number of nodes are deployed across river basin and a unique heterogeneous communication system is used for reading real-time sensing of data, self-monitoring for failure and adaptation of measurement schedules is done to capture disaster events.
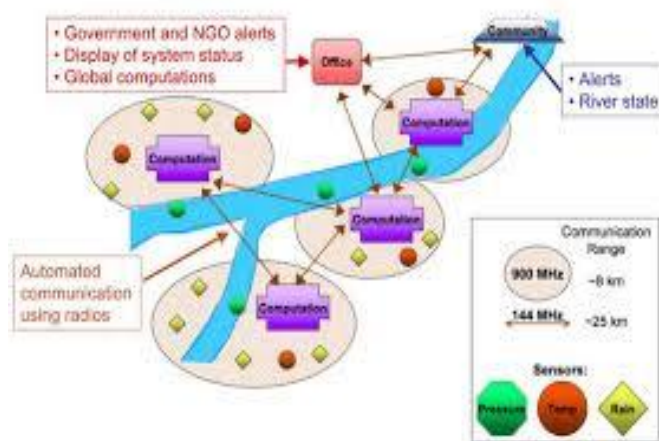

Figure 1: Model proposed by Basha [2]

They proposed a model as shown in Figure 1 [2] and an efficient algorithm for flood prediction that uses data from the nodes of a spatially distributed sensor network. They have used Sacramento Soil Moisture Accounting (SAC-SMA) as in reference which is an efficient model detecting flood very easily. However, SAC-SMA is very costly

method certainly not affordable for a developing country to be deployed for flood detection. This approach is uses simpler computations as compared to the conventional approaches to flood modeling and prediction, utilizing real-time data from multiple sensor nodes. This states the advantage of this model over SAC-SMA model. Considering the model implemented by Basha et. al as a reference, it becomes clear that for developing and poor countries highly affected by flood situations every year, a low-cost flood warning system can be developed and can be easily deployable with recent available technologies of Wi-Fi, ZigBee etc. Moreover, it also becomes necessary to prepare and archive the complete sensed data with proper safety for further prediction of flood situations in coming years. IoT and cloud computing serves the best in this part as a medium to store and analyze the sensors' data effectively.

Ancona et.al in their paper have discussed the need of easy-to-use graphical interfaces and IoT based Platforms for this purpose. Some of the examples include Thinspeak, ThingsWorx, Eclipse, Artik, AWS IOT, Google Cloud, SalesForce, Xively etc.

D. IoT Hardware Resouces

Widely used hardware resources currently by the commercial industries are Arduino, Raspberry Pi, Intel Joule, Beaglebone Blue & Green, DraganBoards, ESP8266, HummingBoard, Intel Galileo boards etc. This IoT hardware will bridge the sensors and the cloud platforms for effectively implementing the flood monitoring, detection and flood warning or alert systems in the following years to come.

3. Conclusion

It has been observed that wireless sensor network based environment monitoring systems are low cost, small size and easily reliable. But these systems cannot be used for large area because each node is usually energized by energy limited battery. This paper performs survey of various environmental and flood disaster detection & monitoring systems and different communication technologies which help to improve upon the effective flood detection and flood warning problem. So in the near future, these systems with highly reliable sensors and effective IoT cloud platforms will critically be used for large scale environment monitoring and disaster prevention. Though the approach of using IoT in flood prevention is in it's infant stage at this juncture, but in the years or even months to come, we see a huge use of IoT and some new technologies such as machine learning and 5G techniques coming together for predicting not only the flood events but also other disaster events. This IoT based flood prediction and prevention systems can also be used in flood disaster monitoring, outdoor living monitoring, water habitat monitoring, and prevention of loss life, infrastructure and economy of the flood-risk regions.

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