Flood Monitoring and Early Warning Systems – An IoT Based Perspective

Abstract:

One of the most frequently occurring calamities around the world is a flood. For flood prone areas or countries, an essential part of their governance is flood management. The necessity to continuously review and analyze the adverse or ambient environmental conditions in real-time demands developing a monitoring system so that floods could be detected beforehand. This paper discusses different Internet of Things (IoT) based techniques and applications implemented for efficient flood monitoring and an early warning system and it is observed that in the future, the combination of IoT and synthetic aperture radar (SAR) data may be helpful to develop robust and secure flood monitoring and early warning system that provides effective and efficient mapping during natural disasters. The emerging technology in the discipline of computing is IoT, an embedded system that enables devices to gather real-time data to further store it in computational devices using wireless sensor networks (WSN) for further processing. The IoT-based projects that can help collect data from sensors are an added advantage for researchers to explore in providing better services to people. These systems can be integrated with cloud computing and analyzing platforms. Researchers recently have focussed on mathematical modelling-based flood prediction schemes rather than physical parametric-based flood prediction. The new methodologies explore the algorithmic approaches. There have been many systems proposed based on analog technology to web-based and now using mobile applications. Further, alert systems have been designed using web-based applications that gather processed data by Arduino Uno Microcontroller which is received from ultrasonic and rain sensors. Additionally, the machine learning (ML) based embedded systems can measure different atmospheric conditions such as temperature, moisture, and rains to forecast floods by analyzing varying trends in climatic changes. Keywords: IoT, Wireless Sensor Networks, Sentinel Image, Flood Monitoring, Early Warning System.

1. Introduction

The impact of global warming prompt decision making authorities to enhance flood-risk management processes to address issues related to the causes of floods. Risk mitigation can be done simultaneously with multiple factors . Floods occur when water levels of rivers exceed and there is sea rise during heavy rains. A very common natural disaster that affects the lives of people, and private and public properties are floods, especially in inhabited areas but in urban and rural areas, this could jam road networks disrupting commuters from reaching their destinations. Although the flood rescue teams from the local government units provide support to the people using

different communication channels, the dissemination of flood related information needs to be conveyed quickly. Humans have been trying for a long, but not always have been fully successful in controlling and foiling the destructive consequences of floods. Synthetic flood banks have been made and river courses have been straightened. Further, the riverbed is deeply dredged. These methods are effective but likely to have adverse effects on the river

2. IOT-based Flood Monitoring Techniques

There are different models from some of the existing research that is based on different flood predicting methods which highlight the importance of implementing different approaches in tackling floods. These models use WSNs to build energy efficient monitoring and early alert systems. These models can support in designing of an efficient system to predict and prevent damages caused by floods.

2.1. Monitoring of Air Quality using Smart Sensors

A smart sensors network for monitoring indoor and outdoor air quality was designed by Postolache et al. in 2009 [7]. They installed nodes of some of the sensors inside rooms which consisted of sensors such as tin dioxide connected to the central unit through hardwires or wirelessly [8]. For the accuracy of the result, the concentration of gas in the temperature and humidity is measured. In order to compensate for the influence of the above measurements, they applied MISO neural network (NN) which is based on multiple inputs single output. IEEE 802.11 (Wi-Fi) technology was used for communication

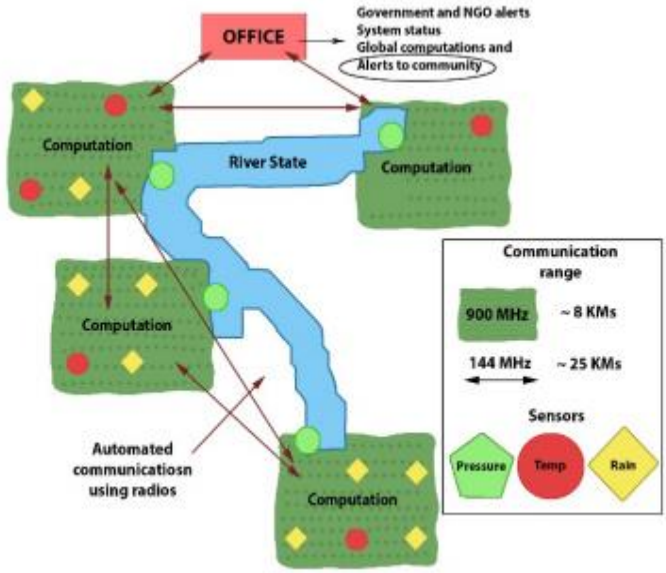
2.2. Monitoring Environment using Controller Area Network

Controller Area Network (CAN) based environmental monitoring system was proposed by Rao et al. in 2012 [9]. The CAN and ZigBee technology was utilized for effective communication among the sensors [10]. The sensors are connected to the microcontroller, ATMEL-89S52 through an interface of CAN to further share this data to the server using ZigBee Communication. This is used since the CAN protocol provides a higher data rate. For any specific area, the benefit of this system is that it uses a precise and

dependable method for data broadcast. Communication is inexpensive and there is no loss in terms of data.

2.3. Flood Forecasting

A flood forecasting model that uses Wireless Sensor Networks was created by Seal et al. [11]. This design used simple and fast calculations using multiple variable robust linear regression methods for flood forecasting. Its implementation is very cost-effective and also simple and easy to understand. It used very low-cost hardware resources. It has all the features desired by any real-world



2.4. Early Flood Warning

Flood Detection using WSN: An early detection of flood system was implemented by Basha et al. [12] by means of a short description of sensor networks in Hondurasi meant for the people who are at risk of getting affected by the flood [12]. It included the analysis detailing the significance of sensor networks, available operational applications, and their lower cost in developing countries. The issues pertaining to the detection of floods and cautioning people in the events of disasters were discussed since it can turn into a complex situation. After in-depth analysis, a solution was proposed that uses WSNs. This solution contains four different categories such as flood prediction, notification to the authorities, alerting the

community, and evacuation of people. The proposed solution was validated by conducting various experiments. The tests were carried out for different communication ranges such as 144 MHz radio usability. The testing activity requires US antenna towers with line-of-sight for reliable communication in the air available between sensors at those ranges. According to them, sensor network technology could be the best way to prevent damage by detecting floods in developing countries.

An early flood warning system described the architecture and deployment strategy to meet the requirements. It permits enhancing the forecasting capability of the system using model-driven control. The design was created in Honduras with its utilization to detect and analyze the flood forecast. An integrated form of the forecasting technique that includes network design and testing of the attached components was utilized by the developer of this system. By deploying the system on the banks of the river in Massachusetts, they achieved a successful outcome in the field examinations. According to the framework, a very unique heterogeneous communication system was utilized by setting sensors over the river basin. These sensors could read real-time data and auto-monitor to adjust their readings if required. These readings help in estimation techniques to address disasters such as floods.

The proposed model as shown in Fig. 1 has an innovative procedure to forecast floods and which utilizes information received from installed sensors that are spatially distributed in nature. A productive Sacramento Soil Moisture Accounting (SACSMA) model has been utilized for detecting floods effectively. Nonetheless, in the case of flood detections in developing countries, SACSMA is an expensive strategy for deployment. Their methodology has easier calculations in comparison to the traditional method to handle floods, using continuous data from sensor hubs. It has an advantage over the SACSMA model. An early warning system is shown in Figure 1.

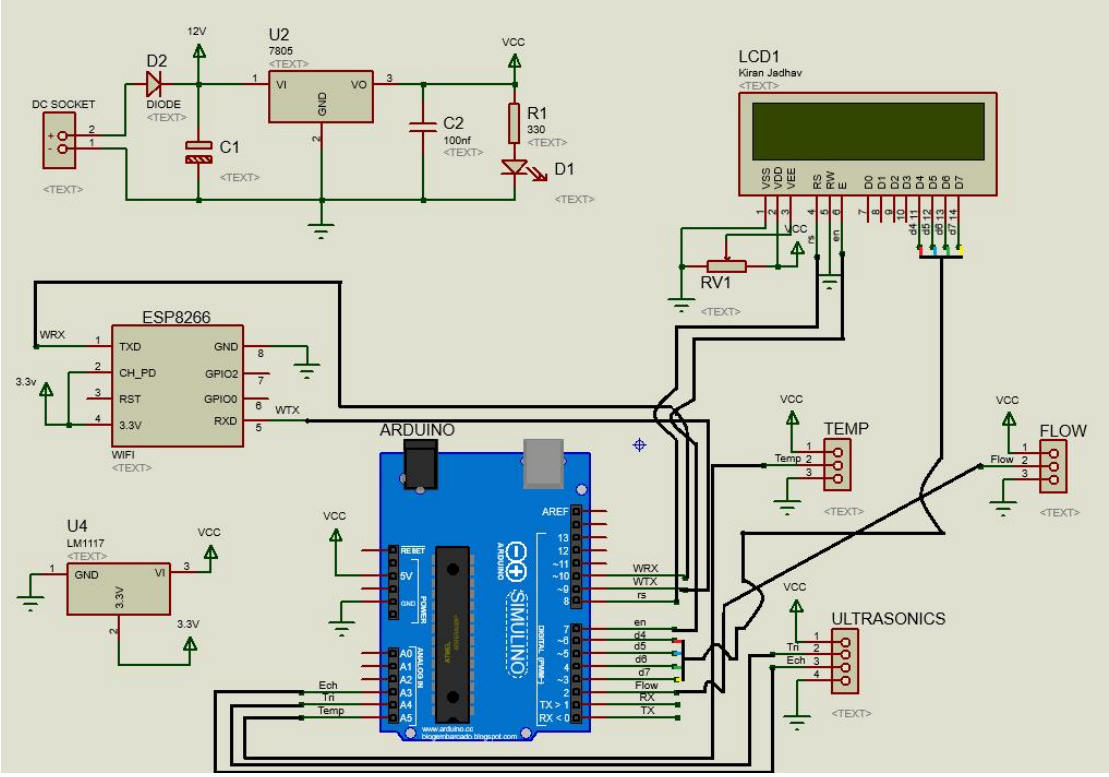
Figure 1. Early Flood Warning Model [12]

By alluding to the model executed as a reference, certainly, developing and underdeveloped nations are greatly influenced by floods on an annual basis. A low-cost and efficient flood detection mechanism can be created and effectively deployed using currently accessible

technologies such as WiFi and ZigBee. Additionally, planning and securely documenting the identified information for further flood prediction. The IoT and cloud computing efficiently store and helps in analyzing the sensor data.

2.5. Applications of Machine Learning Techniques in the Environmental Field

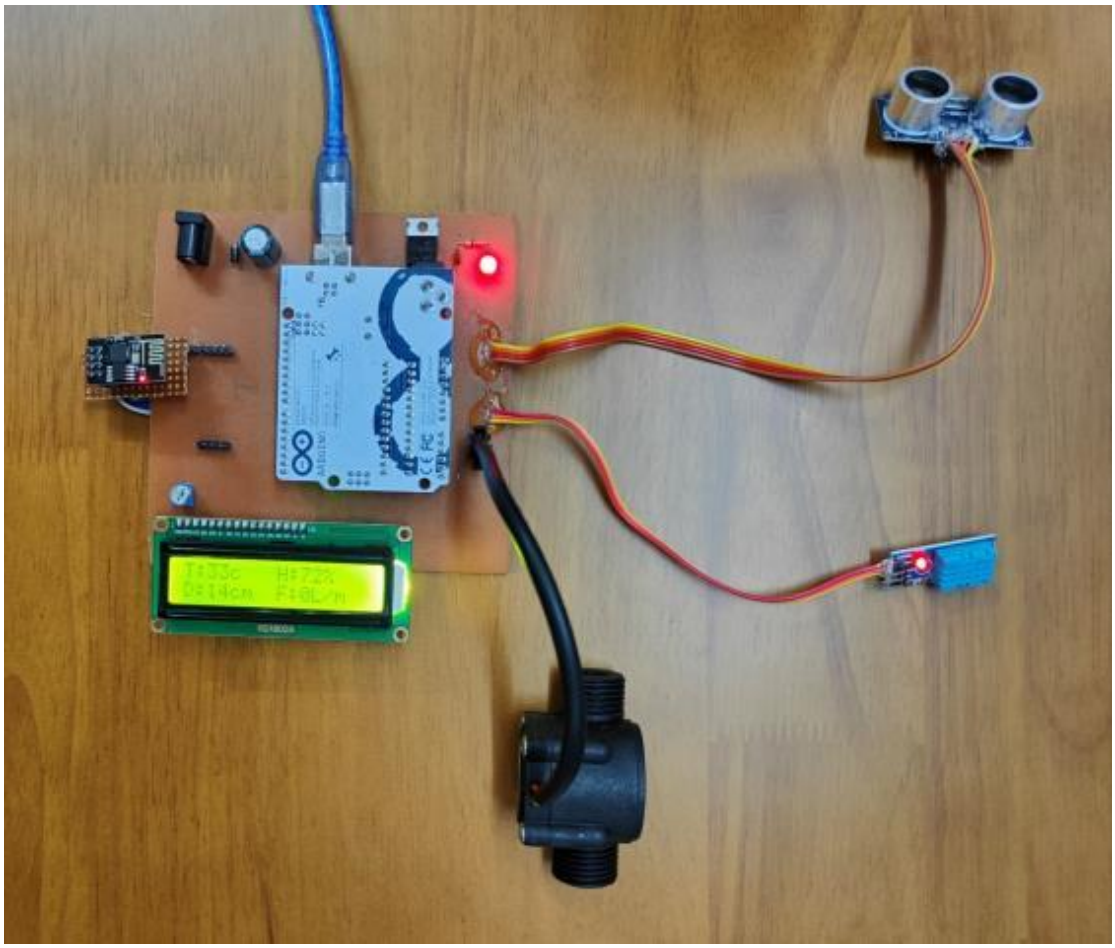
The deep learning (DL) variant of the artificial neural network (ANN) can be used to detect flood-prone regions which can elucidate complex methods such as classification and regression. Traditional hand-crafted methods have been used to automate inundation detection from satellite images. However, these methods do not produce the accuracy required for precise flood detection. To address this limitation, Pallavi et al. [13] proposed a model that combines the water index feature with the generalizable features based on deep convolutional neural

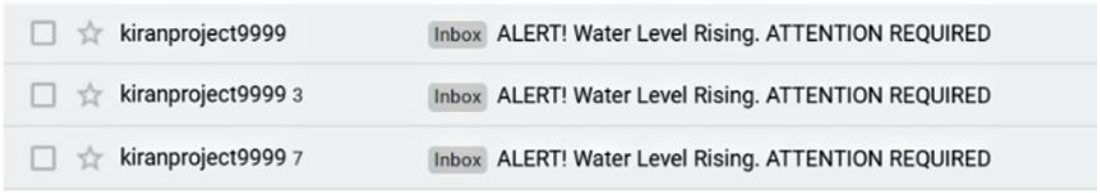


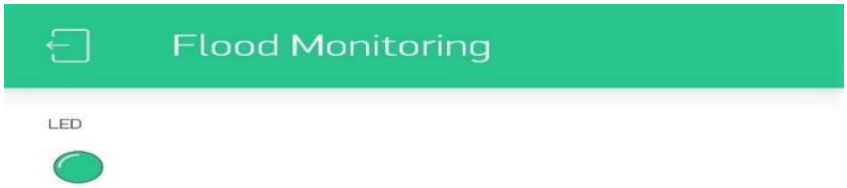
IV.
RESULTS AND DISCUSSION

We have successfully created the Flood Monitoring and Alerting System using Arduino UNO, ESP 8266 Wi-Fi

module, DHT11 (Temperature and Humidity Sensor), HC-SR04 (Ultrasonic Sensor), Flow Sensor, LCD display.
We have also implemented Email Alerts and Real-time readings on the BLYNK App which allows us for Remote







V. CONCLUSION

In this paper, a real-time-based Flood Monitoring and Alerting System has been developed in Arduino UNO┐
enabled environments using rigorous mathematical models. Internet of Things (IoT) is an emerging platform
and broadly used worldwide, this system will display the data of the water level measured on an LCD display.
This device can save lives and properties and reduce hazards to a great extent. The future scope of the
proposed design is to predict the risk analysis of the effect over the low-lying areas and adverse effect analysis
over that condition. It is cost- effective and flexible making it easier to implement.