FLOOD MONITROING AND EARLY WARNING SYSTEM

PHASE 4 : Development part 2

INTRODUCTION :

- There is an obligation on the part of national and international environmental organizations with an important role in controlling floods and protecting public and private properties. Moreover, the situation has further deteriorated due to the increase in the number of flash floods. Most of these organizations have blamed global warming where the melting of ice glaciers and heavy snow results in rising inundation levels rapidly causing ‘flash floods’

- It is common these days to hear major floods making news due to the impact they inflict upon human lives and property. Further, the satellite-based flood assessment to detect the severity of the damage can be crucial in decision making and addressing mitigation plans by the respective risk management authorities. The remote sensing data with diverse areas acquired from satellites such as the Sentinel-1 series can be used effectively in tackling severe real-time flood levels and mapping them more appropriately. This has been analysed by researchers by using various mapping and monitoring techniques on large remote sensing datasets of floods

- The Sentinel images (i.e., C-band SAR images) could be used for regular flood monitoring. Further, classifying and evaluating the data in flood-prone regions over a particular duration can pave the way for detecting and evaluating the changes using time-series analysis

- The SAR satellite sources have been increasing and have enhanced their provisions in flood extent mapping. The sensor features for the predictive modelling techniques to analyze the flood dynamics need to be developed for complete SAR imagebased information extraction. The process of flood mitigation can be achieved through various hybrid machine learning (ML) techniques such as support vector machine (SVM) combining it with metaheuristic optimization procedures. Some of these procedures are the imperialist competitive algorithm, grey wolf optimization (GWO), and differential evolution

DEVELOPMENT PART 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

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- **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. 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 between sensors.

- **Monitoring Environment using Controller Area Network** :

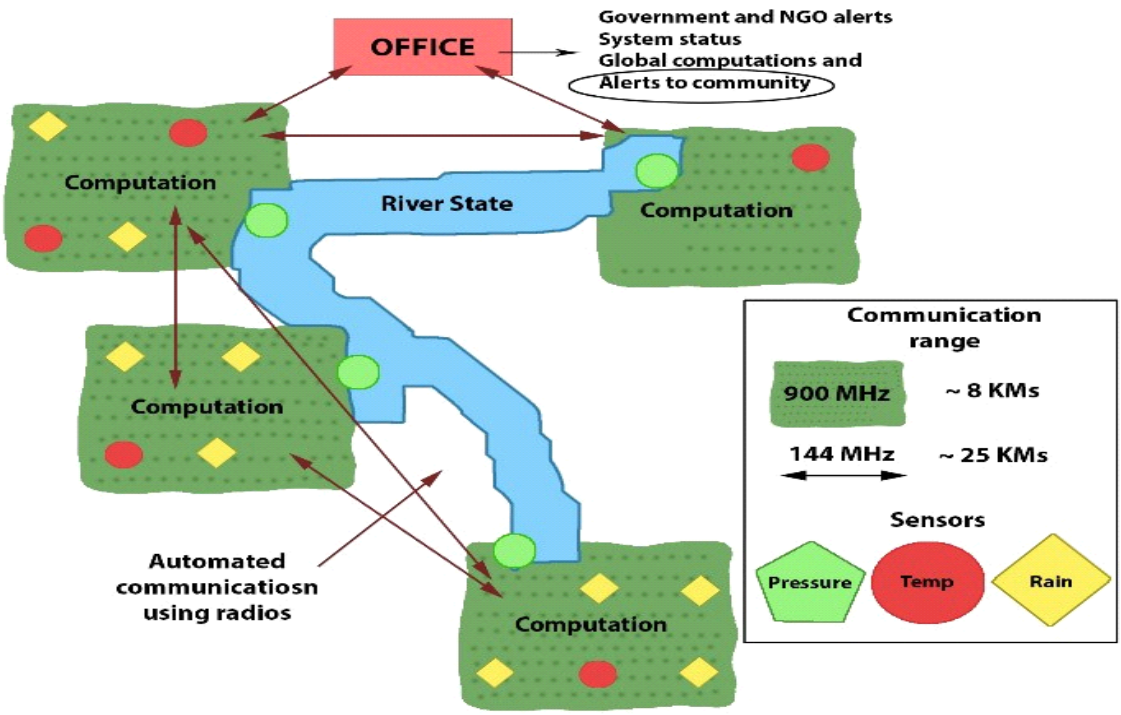
Controller Area Network (CAN) based environmental monitoring system was proposed by Rao et al. in 2012 . The CAN and ZigBee technology was utilized for effective communication among the sensors. The sensors are connected to the microcontroller, ATMEL-89S52 through an interface of CAN to further share 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.

- **Flood Forecasting :**

A flood forecasting model that uses Wireless Sensor Networks was created by Seal . 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 algorithm such as real-time predictions and reliable accuracy. This model does not specify the number of parameters required which means that any kind of parameter can be added or removed. A polynomial represented the rise in water level based on which flood warning level can be determined easily. In order to identify the time interval between each successive reading, a time multiplier function was added. The design strategy does not prevent floods or damage caused by them. It can only predict the occurrence of floods and send a warning to people by methods such as ringing an alarm bell. it is observed that the Wireless Sensor Network is effective when flood warnings are to be communicated. Nevertheless, it is necessary to collect and analyze the sensor data since the calamity alerts could be given to the public at risk with sufficient time to respond during relief operations.

- **Early Flood Warning** :

Flood Detection using WSN: An early detection of flood system was implemented by Basha et al. 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 . 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.



Early Flood Warning Model

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.

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 networks (DCNN). This combination technique and the DCNN model use Sentinel-2 images for training and testing. This model was implemented on the blend of green/SWIR and blue/NIR water indices. The outcomes depict that the VGG16 model-based trained proposed model outperformed when compared with the NDWI, MNDWI, AWEI, Mishra & Prasad's Satellite images and observations of hydrology are important sources of information for early warning systems regarding flash floods. This information is supported by DL models such as UNET, a convolutional neural network (CNN) approach in the segmentation process with higher performance. A combination of the particle swarm optimization algorithm (PSO) and the UNET model known as particle swarm intelligence optimized UNET deep learning (PSO-UNET) was proposed which strives for the maximum layers with parameters over the PSO architecture [16]. By comparing the UNET model, the Dice coefficient value was found to be 79.75% which was approximately 8.59% higher. The dataset used for the implementation from the year 2019 comprised 984 Sentinel-2 images acquired from the national project. The result obtained was found to be based on the best hyperparameters providing higher accuracy.

Existing IOT-based Flood Monitoring and Alert Systems

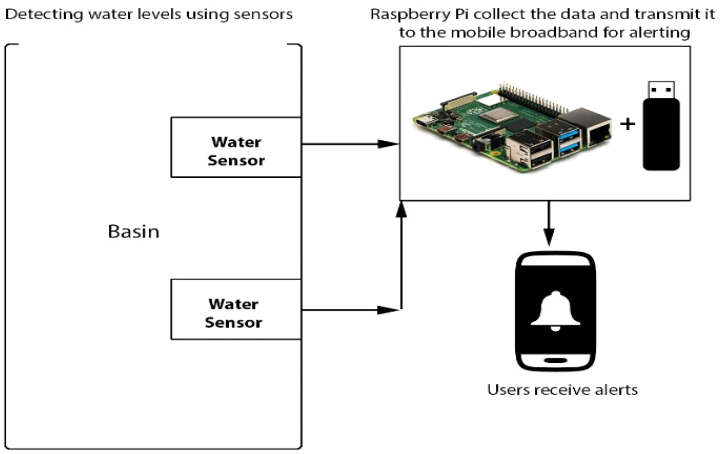
The Implementation of an IoT-Based Flood Alert System

A system to detect inundation stages by measuring the upsurge in water levels and alerting local residents was proposed by Shah et al. [20]. The waterfall model as a methodology with Raspberry Pi was used to gather information from deployed sensors which transmitted it to the Global System for Mobile communication (GSM) module. The system further would alert the resident by sending an SMS as an outcome. As quoted by the author, researchers have estimated that if the sea level rises by 4 inches by 2030, it could be a reason for dangerous flooding that could be affecting many parts of the world. There is an emphasis on the usage of the GSM module since there is an increment trend in the usage of mobile users have been positive.

This makes it easier for the system to alert authorized people when in an emergency. This system followed a waterfall model and discusses the use of different technologies as mentioned below. The authors used a water sensor, SEN113104 model, and USB 3G modem Huawei mobile broadband E173. This was set up along with a resistor 10K, and a jumper cable to connect with Raspberry Pi. The sensors were placed at different heights and the water height increased; they triggered data to the Raspberry Pi. This data is added to GSM Module for additional processing. This system calculates the time and speed with which the water level rises. IoT-based flood alters system.

The performance testing shows that the performance is evaluated using delay in time. The first type of test was carried out with 30 series of data captured manually and automatically using the system. The results verify the system has been accurate in fetching the

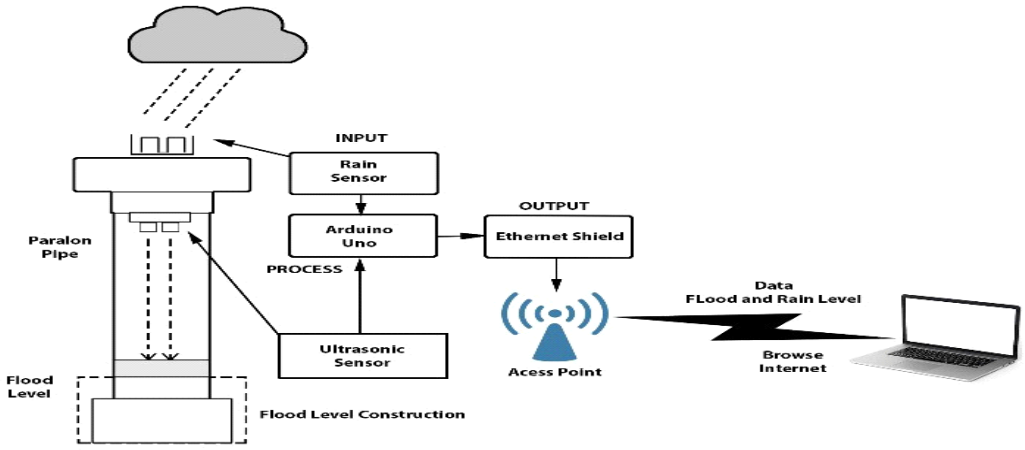
data using sensors. The second test was to identify the delay time in sending SMS to alert authorities in case of emergency and the third test was to identify the range of water increment which summarized the findings. The system highlights the importance of using sensors that can help gather relevant data helping authorities in Malaysia to take necessary measures.



An IoT-Based Flood Alert

IoT- Based Flood Information Monitoring System :

Another system was designed for monitoring information related to floods. This was based on IoT which helps users to identify flood activity by reviewing weather conditions and inundation levels. The ultrasonic sensor HC-SR04 and another type of rain sensor were used to gather information related to flood altitude. It uses an Arduino Uno microcontroller to generate web-based data. The wireless router, TL-MR3020 is connected to the controller and linked with the gathered data and is shared with the users. This system was developed to address the situation of floods in Indonesia. The Ultrasonic and rain sensors are part of the input section whereas, the Arduino Uno Microcontroller is part of the process.



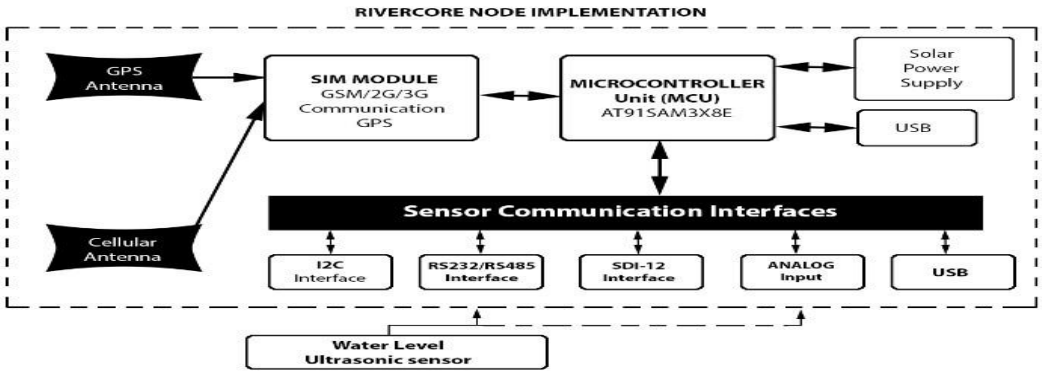
Design of an IoT-Based Flood Information Monitoring System

sensors are placed upper side of the system with a cork float inside which will reflect an echo signal which sensor acknowledges through its trigger. The rain sensors will detect rain conditions and the water height is checked in the pipe. The Arduino Uno Microcontroller receives the data from sensors that are saved in the web server. The early warning system is a web-based system that users can access which includes web flood information.

RiverCore: IoT Device for River Water

Level Monitoring Over Cellular Communications :

The Development of the IoT system “RiverCore” is intended to monitor the river for flooding through data acquisition and data processing. This was implemented for a particular area of the Colima state of Mexico. The data was retrieved using a 3G cellular network and used Message Queuing Telemetry Transport (MQTT) protocol. The system uses a database with data being secured using encryption. A graphical representation displays flood analysis and prediction. Floods are a significant threat in many countries, and it is increasing due to climate change which is confirmed by United Nations Office for Disaster Risk Reduction (UNISDR). The monitoring of floods is based on IoT technology that uses ML and artificial intelligence supports improving data acquisition methods .An ultrasonic sensor with cellular transmission is installed by using telemetry methods to reduce the load of input data.



IoT Device for River Water Level Monitoring

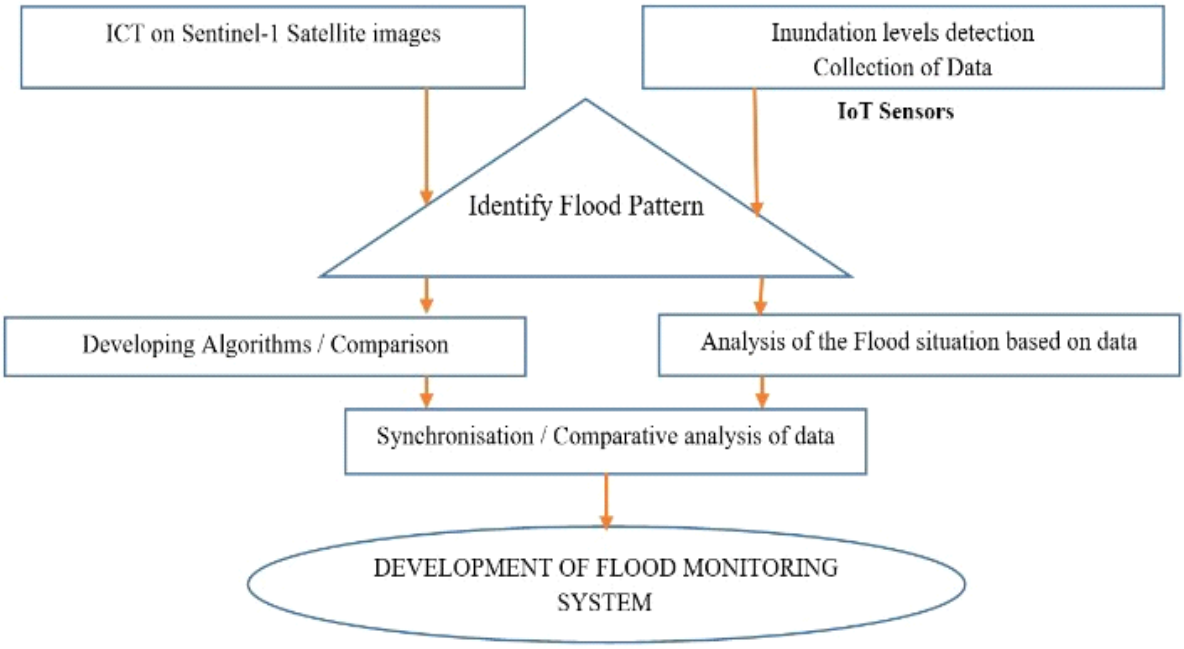
Computer Vision and IoT-Based

Sensors in Flood Monitoring and Mapping :

Computer vision techniques with the use of IoT sensors can be used to implement the Otsu method in predicting inundation levels by analyzing previous and current frames of images of flood-prone areas [25]. The Gaussian and averaging filter could also be utilized by comparing thresholds identified in different identified locations to fetch accurate data. This study concludes that computer vision focuses on a single point in the field of view whereas IoT sensors provide more accurate real-time data to identify inundation levels.

IoT, big data, and HPC based smart flood management framework :

An IoT-based smart flood monitoring and alert system through a combination of HPC and Big-Data were proposed by Sood et al. [26]. To implement this system, a number of IoT devices were installed in classified geographical regions. In this framework, the flood related data consisting of attributes that are gathered by these IoT devices are processed by using High Performance Computing (HPC) and Big-Data. The attribute reduction is carried out by using singular value decomposition, the flood situation is identified using K-mean clustering algorithms (K-Means unsupervised classification technique) and the predictions for the future are done using Holt-Winter's method.



Flood Monitoring and Early Warning System

Conclusion :

IoT sensors-based flood monitoring systems tend to be lower cost, consistent and portable. However, when there are large areas, these systems are not recommended due to the fact that every sensor is generally invigorated by a vitality restricted battery. This paper reviewed and clarified different ecological and flood monitoring systems and various communication technologies that support enhancing the detection of viable floods and identifying cautioning issues. Further, these systems that are having highly reliable sensors with powerful IoT cloud platforms can be fundamentally utilized for large-scale environmental monitoring, and flood prediction and prevent damage caused by it. Even though the methodology of utilizing IoT in flood monitoring is not extensively explored at this point, we will see a colossal utilization of IoT and some new advancements in the near future. For example, AI and 5G techniques meet up for the prediction of floods as well as other natural calamities. The use of satellite images could be very helpful in flood monitoring as they help to keep an eye on the water bodies and the change in their behaviour from above. Some researchers have utilized data based on Google Maps to build a detection model. GSM modules also have been used in different ways similarly. Close consultation with hydrologists and learning machine-learning algorithms can further support building efficient monitoring and alert system. In the future, the usage of SAR data from the Sentinal-1 satellite is an added advantage in handling rescue operations and damage assessments based on data before and after floods. The wireless sensors can help in gathering flood related data by creating a database for further analysis. As a recommendation, there is a tremendous opportunity to explore the combination of IoT systems and SAR data to classify the images from floodprone areas and develop robust and secure Flood monitoring and early warning system.