

Development of Advanced Flood Detection System with IoT

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Abstract: Advanced flood detection system gives early warning to residents near bodies of water especially river that is impacted when dams release its water. This will save lives and valuable properties as the warning system alert the user, thus giving time for evacuation. Advanced flood detector consists of a sensor module, microprocessor, and output module. The output module is installed inside resident's houses. It consists of an ultrasonic sensor to detect water level and features IOT and the data is directed at the microprocessor. The microprocessor will collect the data, process it and selected output will be sent to the output module. The feature that differentiates from other flood detectors is the application of IoT systems. Output module consists of alerts which is an app alert from the IoT feature. Users will first receive an alert from the app in case there is a water level rise, or an alert is given by a nearby dam via IoT. If the dam opened the water gates, the siren and the user will get an app alert. This project will help a lot of people due to the rapid climate change that is experienced in Malaysia due to global warming.

Keywords: Level, Water, IoT, Monitoring, Arduino, Ultrasonic Sensor

1.0 INTRODUCTION

An old flood detection system is outdated and is inefficient such as the manual water reading from the water surface. It needs continuous observation and maintenance. Thus, it is not relevant anymore. More complex flood detector uses GSM as their way of transmission. However, this is still irrelevant because many devices use the same frequency, the main drawback of GSM. The communication can be messed with by appropriate users [1].

If any error occurs such as data misinterpretation, the device will spam continuously SMS which will cause a lot of money. Next, the existing product is very expensive and difficult to install compared to the latest version. The GSM module requires a sim card which may cause certain hardware problems. Lastly, old flood detector is not safe and sanitary because most of them use a float that touches the water and is constantly needed to be clean.

2.0 LITERATURE REVIEW

Following is the literature review for the above research of flood detection systems. Many researchers have been done to monitor a flood using several techniques. The main mains are to inform the people which stay nearly to river or sea.

2.1 A River Flood Monitoring Technique based on Image Splitting Algorithms.

This paper emphasizes the monitoring of river floods using image processing methods for sub-blocks. With this system, it can estimate the occurrence of floods accurately and quickly by using a system that is Environmental Risk Control (CORA). The proposed method is to use pattern recognition, segmentation, and separation, warning detection, high memory, existing cameras that do not require high resolution. With this equipment, the estimation for floods detection in the river can be done accurately and quickly to users [2].

2.2 Global Flood Mapping Services from JPSS

This paper has described the data collection from the Joint Polar Satellite System (JPSS) by using the Visible Infrared Imaging Radiometer (VIIRS) sensor. With the system developed, it can detect floods around the world. For example in the United States, when bad weather events can cause floods and claim many human lives, the property is destroyed with an estimated billion of money lost or destroyed due to floods. This is exacerbated by floods in remote areas that are slow to receive information when the crisis occurs. With the satellite image that was built earlier, it can detect the area earlier than the flood so that all property, lives, and other things can be saved earlier. The

device built earlier is called VIIRS which can detect a radius of 3000km with a resolution of 375m. While its polar orbit will determine the area accurately. With the high technology, the VIIRS device is sent to the JPSS-1 spacecraft in conjunction with the Suomi NPP spacecraft to send the observed data more frequently to the control room. With this method, action from the control room is important so that information can be sent to the monitored area and even to any country that will be affected by the flood disaster. Therefore, the safety of the community can be maintained through the JPSS flood system for many years to come [3].

2.3 Rapid Flood Detection Using Remote Sensing Images

The main purpose of this paper is to describe the detection and prediction of impending floods. When this system is in place then the results of the forecast and the actual occurrence of floods will be sent to the community. The developed system uses high computation and data processing at a low cost. The system uses the Graphics Processing (GPU) method whose implementation can be done using very high computations that are directly related to the CPU. The cost for its construction is cheap with the help of computers. The process for recognizing flood levels is complex and requires robust work. It can also be assisted and observed via satellite systems. The entire development of this system needs to create an algorithm that is run by the CPU and GPU so that the performance of the system can be evaluated in terms of speed in producing an accurate decision [4].

2.4 Flooding Level Classification by Gait Analysis of Smartphone Sensor Data.

Urban floods are one of the problems we hear where in any country during bad weather can cause various properties and lives to be lost, the effects of the floods involve billions of money that have been lost as a result of the floods earlier. With this, if the location of the flood is known early then the initial response to the emergency can be taken quickly. With the available information, all the available data can be used for the development of emergency waterways to remove water from the area into the sea. In this paper, a new technique proposed to detect flood levels is introduced without the use of additional sophisticated tools. It is done using a smartphone which is then used to classify the level of flooding in an area. In the development of this system, a support vector machine namely Synthetic Aperture Radar (SAR) was introduced with an accuracy of 99.45%. Sensors from a smartphone will detect a person's body style during a flood. Next, these sensors can be installed on various vehicles to detect the level of flooding earlier [5].

2.5 Early Detection Of Flood Monitoring And Alerting System To Save Human Lives.

The change of natural climate factors such as temperature, humidity, rainfall, severe haze, and others can cause sudden climate change. Other factors such as continuous forest exploration until the forest and mountains become gondolas then the presence of heavy rain cannot accommodate excess water that can cause water to continue to overflow in large quantities to low-lying areas resulting in flash floods occur anywhere. This situation is exacerbated by poor or non-existent drainage systems and needs to be taken seriously to prevent flooding. Therefore this paper will discuss the proactive measures that need to be taken from the problem of floods so that early prevention can be given to the common people. Initially, the current weather needs to be updated especially about rainfall levels, and information collected from microcontroller systems, ESP32, GSM, and IoT (Blynk Applications) will be developed for the purpose as stated. An ESP32 tool is a tool that acts to connect with the various application technologies presented in this model. This system will be placed in any strategic location so that flood warnings will be communicated to the community to help people get out or evacuate from the area [6].

2.6 Fuzzy Logic-Based Flood Detection System Using Lora Technology

This paper has explained the monitoring of floods that occur in any area. Flood conditions are caused by many factors such as prolonged rainfall, geographical locations that have water absorption, and poor flow into the ground or discharged to the sewer system. The system developed has taken into account many of the parameters used and even some ambiguity of the information is considered. Therefore, the Fuzzy Logic System (FLS) is used so that it can apply human behavior through a combination of linguistics and the level of human membership.

Also, in this study, a flood detection system based on Fuzzy Logic is used so that the factors of water humidity, water volume, and water flow during the rainy season are also taken into account in the development of this system. Next, the Semtech SX1278 LoRa chip is used for the preparation of low-power wireless communication with a sensor point distance in an area at risk of flood events under consideration. The system that has been developed earlier will be placed in a location that has a high risk of flood and can also be placed above the floodwater level. Next, the UI is developed so that users can see the flood parameters with a smartphone. The developed system was placed at the sensor point and can last for a long period of four months by using a 2000mAh battery. In this development, it is found that there are two important parts. First, the branch node is used to evaluate and send data for the measurement of soil moisture and water flow above the soil surface to the main controller. The main controller will

also receive a signal from the LoRa from the Branch Node and subsequently processed through the FLS whose output is from the flood clearance. Second, this section is to presents the decision on flood risk in the form of percentage by display via smartphone. This system will work and continue non-stop to release information to the public about floods as long as the battery life does not expire [7].

3.0 MATERIALS AND METHODS

The development of advanced flood detection systems with IoT is divided into two systems which are hardware and software. The hardware required in this project is being discussed in this section. The software that is being used for this project is Proteus ISIS 7 and the Blynk Application. The following Sections 2.1 and 2.2 will explain the materials and methods are used.

3.1 Materials

a) *Arduino UNO*

Arduino UNO in Figure 1 is the main part to read the voltage output from the voltage sensor as shown in Figure 1 and all the output are shown on the Blynk app to avoid leakage through the display module. This Arduino Uno contains a single-board microcontroller based on 8-bit ATmega328p. It consists of other components, such as a crystal oscillator, serial contact, and the microcontroller's voltage regulator. Arduino Uno has fourteen optical input/output pines (6 for PWM output), six analog entry pins, a USB connection, a power barrel port, an ICSP header, and a reset button [8].



Figure 1: Arduino UNO

b) *Ultrasonic Sensor*

The operating voltage for the ultrasonic sensor as shown in Figure 2 is 3 – 5 volts. This ultrasonic offers very short to long-range detection with low power consumption which is 75milliwatt. The sensor detects objects from 2cm up to 400-metres [9].



Figure 2: Ultrasonic HC-SR04

c) *Voltage Sensor*

A voltage sensor as shown in Figure 3 is used for the voltage calculation and monitoring of an object. AC voltage or DC voltage levels can be determined by voltage sensors. The input of this sensor may be the stimulus when the output is an analog signal, an audible signal, etc.[10].

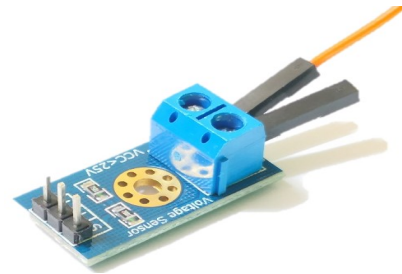


Figure 3: Voltage Sensor

d) *WiFi Serial Transceiver Module (ESP8266)*

ESP8266 as shown in Figure 4 is a highly integrated chip designed for the needs of a new connected world. ESP8266 is a Wi-Fi-enabled system on chip (SoC) module and is mostly used for the development of IoT (Internet of Things) embedded applications. ESP8266 has many capabilities such as 2.4GHz Wi-fi, Inter-Integrated Circuit (I2C) serial communication protocol, analog-digital conversion (10-bit ADC), pulse-width modulation, and many more [11].

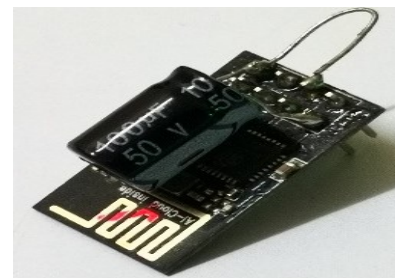


Figure 4: ESP8266 module

e) Blynk Application for mobile

Blynk is an Arduino, Raspberry Pi control interface, and the like over the Web with Android and IOS device platform. The user will drag and drop controls to create the graphical interface for his project. It is a digital dashboard. It is also known as the IOP platform designed to make smart devices rapid and easy to design and easy to use. It can be used for remote reading, storage, and visualization of sensor data and hardware. The logo for the Blynk Application is shown in Figure 5.



Figure 5: Blynk Application Logo

3.2 Methods

The comprehensive methodology is used in the development of an advanced flood detection system with IoT as shown in Figures 6 and 7.

a) Block Diagram

The block diagram of an advanced flood detection system with IoT is shown in Figure 6. The ultrasonic sensor and voltage sensor will be the input of the device by converting the physical signal to an electrical signal to be sent to the Arduino. Then Arduino will give a command to the output which is the Wi-Fi module and the buzzer. Blynk app will show the water level of the river and battery capacity. When the water level is high, Arduino will compute an alert message and it is sent via a Wi-Fi module. The buzzer will trigger to give the signal for a high-level alarm. The Blynk app will also receive a notification if the battery level is low.

b) Flowchart

Figure 7 shows the whole process of communication between sensor, Arduino, and Wifi.

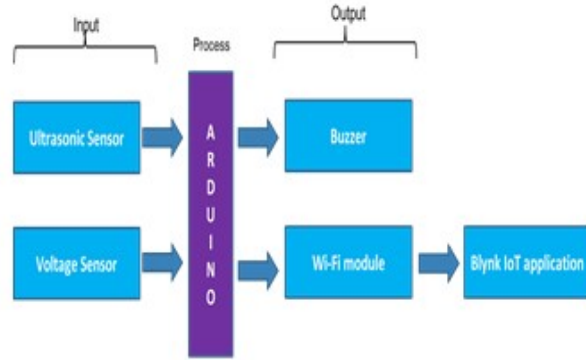


Figure 6: Block Diagram

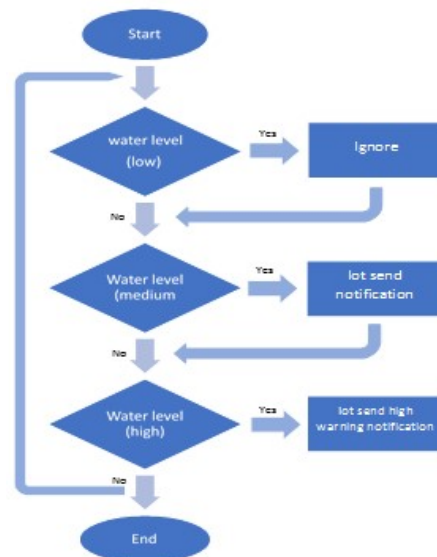


Figure 7: Flowchart of the System

c) Schematic Diagram

The software involved was Arduino IDE and Proteus. The process has begun with the assembly of the hardware. The pin assignments for Arduino UNO were as shown in Figure 8. The voltage sensor output is connected to the analog input of Arduino because the voltage is the only input in analog form. This whole circuit was powered by a 12V battery. The electronic components that are powered by 5V get power directly from the Arduino 5V output. Next, the micro-hydro generator will be directly connected to the battery. The ultrasonic sensor will be connected to pin analog (0) and analog (1). The transmitter and receiver pins of the Wi-Fi module are connected to the pin second and third of the Arduino. The simulation is unable to simulate esp8266 and voltage sensors because there is no library for those components.

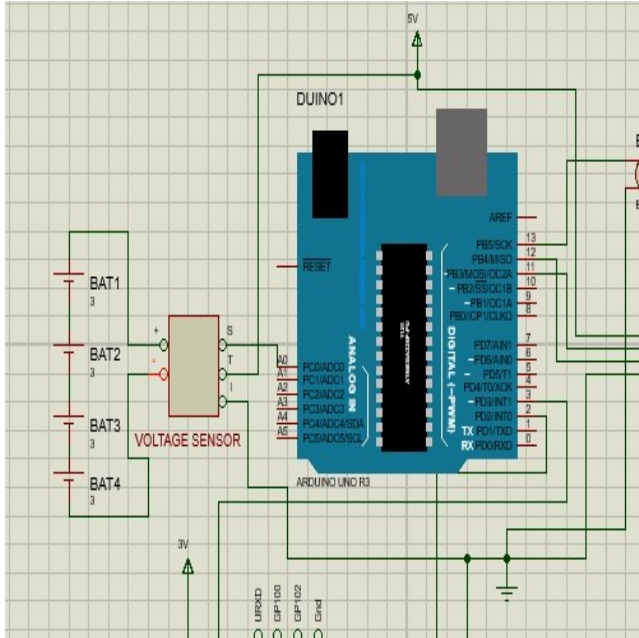


Figure 8: Circuit Diagram of the project

d) Device placement

The unit will consist of the main circuit (Outdoor) and Blynk Application (Indoor). Indoor is the unit that includes Blynk App. to receive a notification. The outdoor unit is where all the circuitry of the product is placed. It is suggested that the outdoor unit is placed at the edge of the water such as the riverbank or lakeside. The maximum height from the ultrasonic sensor is roughly 5 meters because if exceeded the device will get a delayed alert and may cause harm to the residents. Figure 9 shows the arrangement of device placement to detect flood.

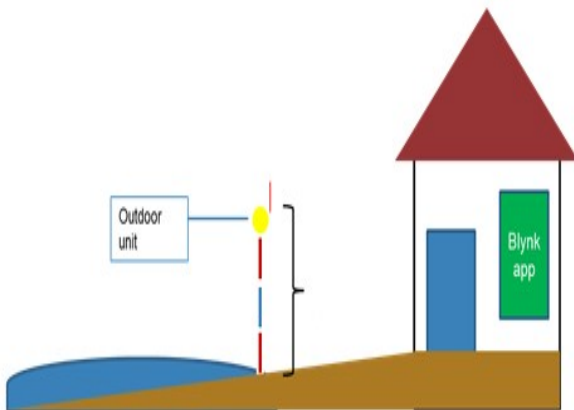


Figure 9: Device placement

4.0 RESULTS AND DISCUSSION

This section will describe the result and discussion from the experimental works.

4.1 Results

Table 1 shows the results of the sensor's ultrasonic distance measurement with the water level. There are three categories in measuring water level with sensors namely low, medium and high. This means that if the distance between the water surface and the sensor is small it means the water level in the river is high. If the distance between the water surface and the sensor is large it means the water level in the river is low.

In general, if there is a lot of overflowing rainwater then the river water will rise continuously and result in the distance of the river water surface with the sensor becomes smaller and at the same time, the system will function to send early warning signals to the users.

Table 1: Result For The Water Level Vs Notification

No.	Distance Ultrasonic Sensor With Water Level of River (Meter)	Water Level of River Condition	Notification Status Received by Smart Phone
1	4-5	Low Water Level	No Alert
2	3-4	Low Water Level	No Alert
3	2-3	Medium Water Level	No Alert
4	1-2	Medium Water Level	Medium Priority Alert
5	0-1	High Water Level	High Priority Alert

Figure 10 shows the process of testing for the ultrasonic sensor using a measuring tape to observe the behavior of the system and its accuracy.

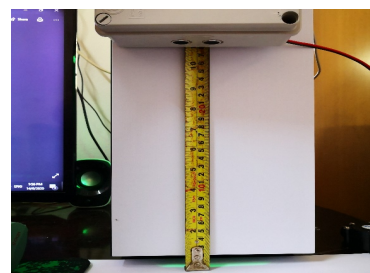







Figure 10: Measuring Distance between Ultrasonic Sensor and Water Level for the Calibration

Table 2 shows the results of the comparisons between measurements and Blynk Application for flood detection.

Table 2: Result For Comparisons Between Tape And Sensor

No.	Measured Value Using Tape (Meter)	Measured Value Using Sensor and Blynk Application (Meter)	Percentage of Error (%)
1	1.0		1.4
2	1.5		0.6
3	2.0		9.5
4	2.5		1.2
5	3.0		0.8

4.2 Prototype

The final prototype of flood detection level is located at the river as shown in Figure 11.



Figure 11: Prototype of Flood Detection with IoT is Located at River

4.3 Discussion

The average error in detecting flood water levels was 2.7%. This percentage of error is small and still acceptable. The system shows that the system can send an early warning signal to the user about the impending flood. Therefore, people can leave the area that will be hit by floods sooner. In addition, it was also found that the system casing was entered by rainwater which caused the system equipment to be damaged and not functioning. Therefore, the system casing must be tightly closed.

5.0 CONCLUSION

The experiments that have been conducted, show that when the river water surface rises, therefore the water level will be closer to the system and simultaneously provide a flood warning signal to the users. The distance between the rising water surfaces with the system was detected by an ultrasonic sensor through Blynk Application with an accuracy of 97.3%. This system is also a mobile system that can be placed in any area at risk of flooding.

6.0 RECOMMENDATION

Following are the recommendations for the improvements.

1. This device is suitable to be installed in rural areas but the internet access in this area is quite weak. Therefore, this internet performance can be improved by using a pole high enough to capture the internet connection.
2. The casing of this system should be made from waterproof materials so that it can protect all

system devices from getting wet by water during heavy rain or other things.

Ultrasonic Proximity Sensor: Custom. [Online]. Available: <https://maker.pro/custom/tutorial/hc-sr04-ultrasonic-proximity-sensor-datasheet-highlights>.

REFERENCES

- [1] My Boost Phone Doesn't Have a SIM Card. (2019, May). [Online]. Available: <https://www.techwalla.com/articles/my-boost-phone-doesnt-have-a-sim-card>
- [2] Roberta Avanzato, Francesco Beritellingelo, Cavallaro Massimiliano, and Cuccia Tiziana Lombardo, “ A River Flood Monitoring Technique based on Image Splitting Algorithms ”, The 10th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, 18-21 September 2019.
- [3] Bill Sjoberg, Sanmei. Li, and DonglianSun, “Global Flood Mapping Services from JPSS”, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 2018.
- [4] Suchitra Patil, Ujwala Bhangale, Asha Khatri, and Shruti Gudkha, “ Rapid Flood Detection Using Remote Sensing Images ”, International Conference on Advances in Computing, Communication and Control (ICAC3), IEEE, 2019.
- [5] Ujjawal K. Panchal, Hardik Ajmani, and Saad Y. Sait, “Flooding Level Classification by Gait Analysis of Smartphone Sensor Data”, IEEE Access, vol. 7, Publisher: IEEE, 2019.
- [6] Shivashankar, Mahaveer Penna, Jijesh J J, Sruthi P V, Dileep Reddy BollaAlla, and Gowthami, “ Early Detection Of Flood Monitoring And Alerting System To Save Human Lives ”, 5th International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT-2020), 12 – 13 November, 2020.
- [7] Choo Kam Khuen, and Alreza Zourmand, “FuzzyLogic-Based Flood Detection System Using Lora Technology”, 16th IEEE International Colloquium on Signal Processing & its Applications (CSPA 2020), 28-29 Feb. 2020.
- [8] Arduino Uno Pin Diagram, Specifications, Pin Configuration & Programming. (2018, February). [Online]. Available: <https://components101.com/microcontrollers/arduino-uno>.
- [9] Hertz, D. (2019, May). HC-SR04 Datasheet: Ultrasonic Proximity Sensor: Custom. [Online]. Available: <https://maker.pro/custom/tutorial/hc-sr04-ultrasonic-proximity-sensor-datasheet-highlights>.
- [10] Electrical4U. (2020, May). Voltage Sensor: Working Principle, Types & Circuit Diagram. [Online]. Available: <https://www.electrical4u.com/voltage-sensor/#:~:text=A voltage sensor is a voltage or DC voltage level. & text=Sensors are a device, electrical or some optical signals.>
- [11] ESP8266 WiFi Module: Sensors & Modules. (2020, July). [Online]. Available: <https://www.electronicwings.com/sensors-modules/esp8266-wifi-module>