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Development of Hardware for Smart Flood Warning System

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Abstract

Flooding is a common natural disaster that can cause significant damage to property, infrastructure, and human life. In flood-prone areas, it is critical to have an effective flood warning system that can provide real-time data on the water levels, rainfall intensity, and water flow rates to predict potential floods accurately. Existing flood warning systems often suffer from limitations such as delayed warnings, insufficient data accuracy, and limited coverage. These shortcomings result in inadequate response times, hindering effective evacuation, infrastructure protection, and resource allocation. This research aims to develop a hardware for flood monitoring system which automatically collects and processes the real time data of flood monitoring. Beside that, to obtain the information from sensors through calibrations and comparing to the actual manual measurement.

1. Introduction

In recent times, communities worldwide have faced a heightened frequency of flood events, brought significant threats, and necessitated robust flood management strategies. Floods, recurring and destructive natural disasters, have caused substantial damage to property, posed infrastructure challenges, and, critically, endangered human lives [1]. The escalating frequency of these events, often intensified by climate change, underscores the pressing need for effective global flood management and early warning systems. Nowadays the Internet of Thing (IoT) is broadly used worldwide [2].

This project aims to develop hardware for flood monitoring systems which automatically collects and processes the real time data of flood monitoring. The system will obtain the information from sensors through calibration and comparing to the actual manual measurement.

1.1 Problem Statement

This project aims to address the shortcomings of existing flood warning systems in flood-prone areas. Recognizing the common occurrence of flooding as a natural disaster. The current system suffers from delayed warnings, inaccurate data, and limited coverage. These deficiencies contribute to insufficient response times, hindering effective evacuation, infrastructure protection, and resource allocation. Traditional flood warning systems, relying on manual data collection, lack the capacity for real-time updates, resulting in delays in alert dissemination and potentially jeopardizing public safety. To address these issues, this project seeks to develop an innovative hardware solution for monitoring floods. The proposed system is designed to automatically collect and process real-time data, utilizing calibrated sensors to enhance accuracy.

Progress in Engineering Application and Technology Vol. 5 No. 1 (2024) p. 140-147

1.2 Objective

There are two main objectives for this research which are:

i. To develop hardware for flood monitoring system which automatically collects and processes the real time data for flood monitoring.

ii. To obtain the information from sensor through calibration and comparing to the actual manual measurement.

2. Materials and Methods

Describe the method used to create the Development of Hardware for Smart Flood Warning System in greater detail. The description will include all hardware details, a system flowchart with an explanation, and a system block diagram with explanation.

2.1 Materials

Table 1 *Hardware Details*

No	Part Name	Qty	Function	Cost (RM)
1	NodeMCU ESP32	1	Used as microcontroller board for collect data from sensors	32.50
2	Ultrasonic Sensor	1	To detect the distance using sound wave	3.30
3	Flowrate Sensor	1	To detect the water flow rate	15.00
4	Rainfall Sensor	1	To detect the rainfall intensity	3.60
5	Solar Power Bank	1	Power source of the circuit	40.00
6	Jumper Wire Set	1	Connects components on a circuit board	3.60

2.2 System Block Diagram

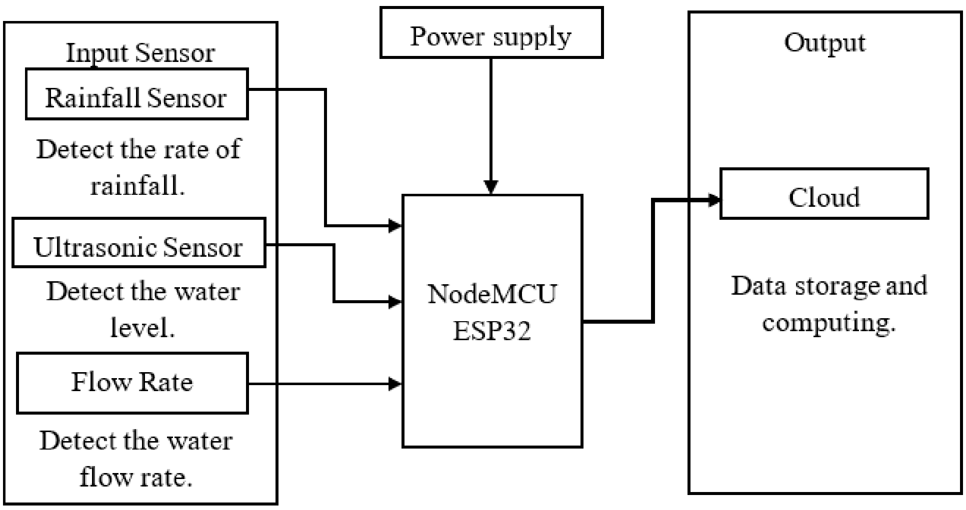

Fig. 1 *Block Diagram of the project*

Figure 1 shows details of the system block diagram. The system block diagram made up of several parts that cooperate to monitor the real-time data. The NodeMCU ESP32 is the main component in the system that is connected to all the components [3]. The NodeMCU ESP32 offers Wi-Fi, Bluetooth, Ethernet, SPI, UART and CAN modules [4]. Data from various sensors, including a rainfall sensor, ultrasonic sensor and water flow rate sensor are collected by the EPS32. The rainfall sensor used in this project is to detect the amount of rainfall for flood prediction. The ultrasonic sensor worked as the main sensor to detect the water rising rate and water level of river while the flow rate sensor to monitoring the water flow rate. The Blynk app gives simple dashboard to monitors system parameters and make necessary modifications which user friendly for visualizing the data from the sensors [5]. The combinations of rainfall sensor, ultrasonic sensor, water flow rate sensor, power supply, NodeMCU ESP32 and cloud (Blynk) are shown at Figure 1.

2.3 System Flowchart

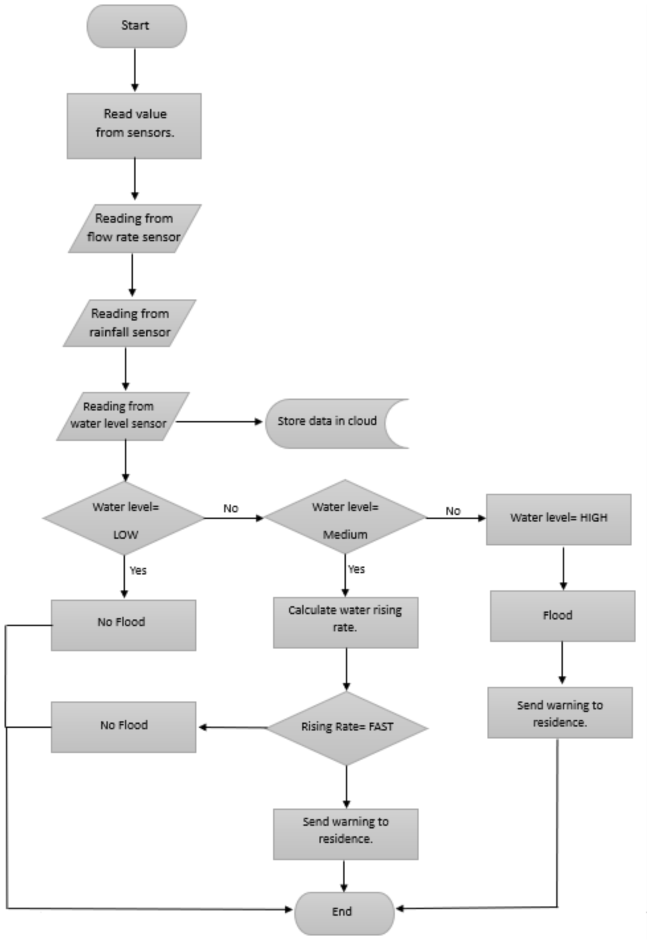

Fig. 2 *System Flowchart*

For Figure 2, the rounded box at the top of the flowchart represents the system initial. Initializing the system in the system is the first step, which ensures all required parts are installed and prepared well for use. The ESP32 will read the values of various sensors. The flow rate sensor, rainfall sensor and ultrasonic sensor will collect the real-time data at the deployment point. After collecting the data, the data will be stored in the cloud. The programming on Arduino IDE will allow the ESP32 to store data in cloud [6]. When water level is low, that is not flood happening. If the water level at medium stage, the system will calculate the water rising rate. When the water rising rate is fast, system will indicate warning while rising rate is slow that is no flood happening. When the water level is high, flood happening. The warning will send to the residence. The water level is collected by sensors and sensed data is transferred through computational node [7]. The collected data from the sensor are gathered and will be forwarded to microcontroller and data will be displayed at web server. Then, data will be analysed and compared [8].

3. Result and Discussion

The implementation and operation of the Development of Hardware for Smart Flood Warning System will be described in this chapter. In this section, the actual results of monitoring will be presented in more detail.

3.1 Results

Figure 3 illustrates the interface of the Blynk app displaying the water flow rate, the water level and rainfall intensity in real time. The various sensor reading will displayed in the Blynk app's visually appealing and user friend display.

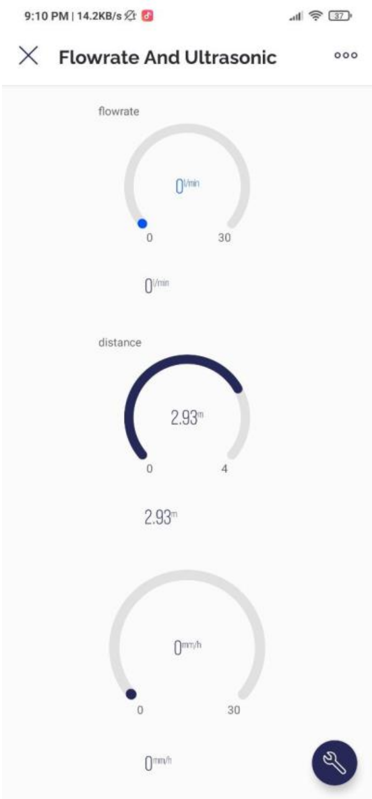

Fig. 3 *The dashboard of water level, water flow rate and rainfall intensity*

Figure 4 shows the location of deployment of hardware at Sungai Muar (Panchor).

Fig. 4 *The location of deployment of hardware*

3.2 Data Analysis

Table 2 *Data Analysis for Rainfall Sensor*

No	Condition	Outcome	Reading
1	Little water on the surface of sensor	Rainfall intensity is light	Sensor voltage: 4.70 V Mapped rain sensor value: 5 Rainfall: 0.50 mm/h Rainfall intensity: Light
2	More water on the surface of sensor	Rainfall intensity is moderate	Sensor voltage: 2.66 V Mapped rain sensor value: 46 Rainfall: 4.60 mm/h Rainfall intensity: Moderate
3	Large water on the surface of sensor	Rainfall intensity is heavy	Sensor voltage: 1.23 V Mapped rain sensor value: 75 Rainfall: 7.50 mm/h Rainfall intensity: Heavy

Table 2 shows the data analysis carried out on the rainfall sensor. When we sprinkle little water on the surface of the sensor, this simulates the light rain is happening., the mapped sensor values show the reading of 5. The sensor voltage drops from 5.00V to 4.70V. In this calibration of rainfall sensor, the rainfall is 0.50mm/h. When we sprinkle more water on the surface of the sensor, this simulates the moderate rain is happening. The mapped sensor values show the reading of 46. The sensor voltage drops from 5.00V to 2.66V. In this calibration of rainfall sensor, the rainfall is 4.60mm/h. When we sprinkle large water amount on the surface of the sensor, this simulates the heavy rain is happening., the mapped sensor values show the reading of 75. The sensor voltage drops from 5.00V to 1.23V. In this calibration of rainfall sensor, the rainfall is 7.50mm/h.

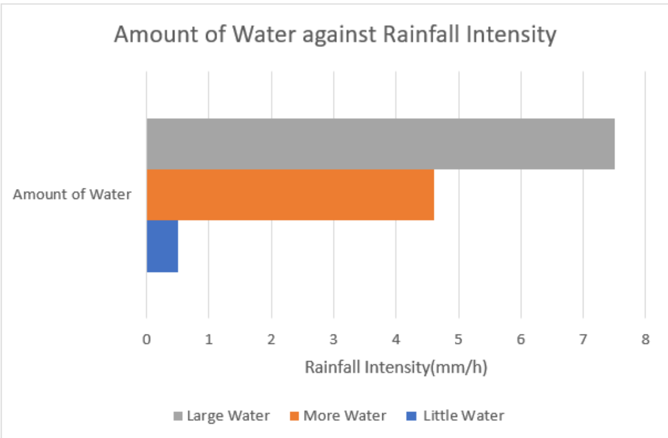

Fig. 5 *Graph of Amount of Water against Rainfall Intensity*

Figure 5 shows the comparison between different amounts of water corresponding to the rainfall intensity.

Table 3 *Data Analysis on Ultrasonic Sensor*

No	Condition	Outcome	Reading
1	Add the water until 4cm of the jar	The serial monitor show 0.04m	Distance: 0.04 m, Rising Rate: 0.00 m/second
2	Add the water until 10cm of the jar	The serial monitor show 0.10m	Distance: 0.04 m, Rising Rate: 0.01 m/second Distance: 0.05 m, Rising Rate: 0.02 m/second Distance: 0.07 m, Rising Rate: 0.01 m/second Distance: 0.06 m, Rising Rate: -0.01 m/second Distance: 0.08 m, Rising Rate: 0.01 m/second Distance: 0.10 m, Rising Rate: 0.02 m/second Distance: 0.10 m, Rising Rate: 0.00 m/second
3	Add the water until 15cm of the jar	The serial monitor show 0.15m	Distance: 0.10 m, Rising Rate: -0.00 m/second Distance: 0.11 m, Rising Rate: 0.01 m/second Distance: 0.11 m, Rising Rate: 0.00 m/second Distance: 0.11 m, Rising Rate: 0.00 m/second Distance: 0.13 m, Rising Rate: 0.02 m/second Distance: 0.15 m, Rising Rate: 0.02 m/second

Table 3 shows the data analysis on Ultrasonic Sensor. When the ultrasonic sensor is placed on the top of the jar, the serial monitors show the distance which is the water level is 0.04m. The rising rate is 0.00m/second because that is no added water. When the ultrasonic sensor is placed on the top of the jar, the serial monitors show the distance which is the water level is 0.10m. The rising rate is 0.04m increase to 0.05m with 0.01m/second and 0.05m increase to 0.07m with rising rate 0.02m/second and the drop to 0.06 with -0.01m/second due to the surface of water. After 0.06m the water level increases to 0.08m and maintains at 0.10m. When the ultrasonic sensor is placed on the top of the jar, the serial monitors show the distance which is the water level is 0.15m. The rising rate is 0.10m increase to 0.11m with the 0.01m/second and 0.11m increase to 0.13m with the rising rate 0.02m/second and then increase to 0.15m at the rising rate 0.02m/second. After 0.15m, the water level was maintained.

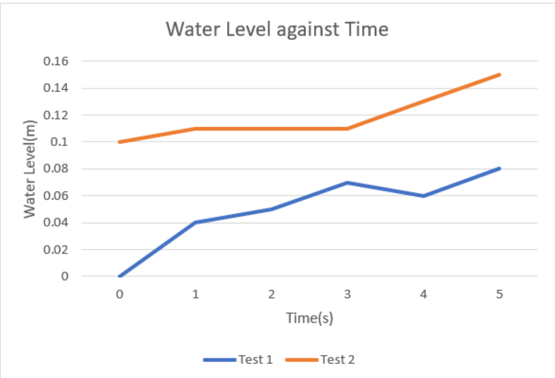

Fig. 6 *Graph of Water Level against Time*

Figure 6 shows the comparison between 2 tests on the water level against the time. The graph shows the 2 different tests on the water level using the ultrasonic sensor.

Table 4 *Data Analysis on Water Flow Rate Sensor*

No	Condition	Outcome	Reading
1	Minimum water pressure of water	The water flow rate sensor shows 0.6-0.7L/min	Flow rate: 0.6L/min Current Liquid Flowing: 11mL/Sec Flow rate: 0.6L/min Current Liquid Flowing: 11mL/Sec Flow rate: 0.6L/min Current Liquid Flowing: 11mL/Sec Flow rate: 0.7L/min Current Liquid Flowing: 13mL/Sec Flow rate: 0.7L/min Current Liquid Flowing: 13mL/Sec Flow rate: 0.6L/min Current Liquid Flowing: 11mL/Sec Flow rate: 0.6L/min Current Liquid Flowing: 11mL/Sec
2	Maximum water pressure of water	The water flow rate sensor shows 10.3-10.5L/min	Flow rate: 10.3L/min Current Liquid Flowing: 172mL/Sec Flow rate: 10.2L/min Current Liquid Flowing: 170mL/Sec Flow rate: 10.5L/min Current Liquid Flowing: 176mL/Sec Flow rate: 10.5L/min Current Liquid Flowing: 175mL/Sec

Table 4 shows data analysis on water flow rate sensor. The water flow adjusted to simulate the minimum water flow through the water flow rate sensor. The serial monitor on Arduino IDE shows the constant flow rate about 0.6L/min to 0.7L/min. The water flow adjusted to simulate the maximum water flow through the water flow rate sensor. The serial monitor on Arduino IDE shows the constant flow rate about 10.2L/min to 10.5L/min.

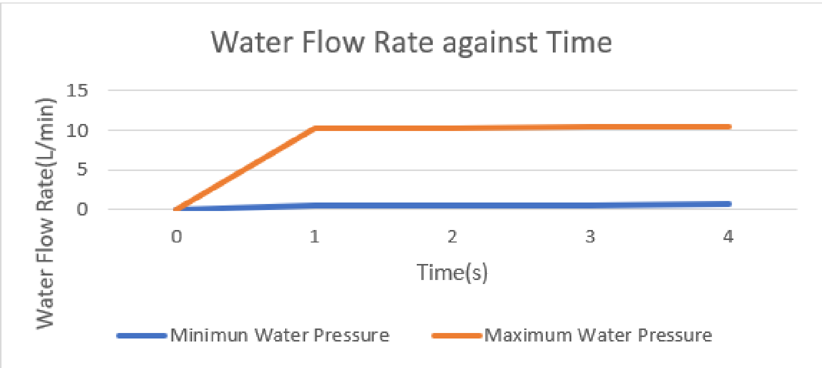

Fig. 7 *Graph of Water Flow Rate against Time*

Figure 7 shows the comparison from the data simulated by minimum water pressure and maximum water pressure. The graph gives a clear comparison between minimum water pressure and maximum water pressure.

3.3 Discussion

In conclusion, the prototype has produced the expected outcome based on the analysis of the data obtained through the Arduino IDE and calibration of sensor. The prototype connected to the Blynk app successfully to enable the monitoring and display of water flow rate, water level and the rainfall intensity. The prototype successfully receives and processes the data because all the hardware components are linked. The data of ESP32 and sensor are effectively shown on the Blynk app.

Overall, the analysis of the many scenarios demonstrates the effectiveness of sensors and ESP32 are in good condition to deployment of hardware. These observations on the data show the importance of calibration of mapped sensor value to ensure the data is accurate.

4. Conclusion

In conclusion, the project Development of Hardware for Smart Flood Warning System using ESP32, and several sensors has succeeded in achieving its goal of creating a complete real time monitoring system. The project has made real-time data collecting from the water flow rate sensor, ultrasonic sensor, and rainfall sensor by utilizing the capabilities of the ESP32 microcontroller. Various steps ware made throughout the project, such as configuring the hardware, creating wireless connectivity, and calibrating the sensors to obtain the accurate data.

The project's outcomes show that a develop an automatic IoT device in real-time data collection and analysis of critical parameters has been successfully implemented. Overall, the project has demonstrated the calibration process and perform comparisons between sensor measurements provide the sensors to obtain accurate reading.

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