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Development a prototype of river water level monitoring system using ESP32 based on internet of things for flood mitigation

N A Pramono*, B A Purwandani, O Ghaisyani, F P P Mallisa, and F I Sofyan
Department of Physics, Universitas Negeri Malang, Indonesia

*Email : nugroho.adi.fmipa@um.ac.id

Abstract. Flood is one of the disasters which often strike Indonesia. It is one of the disaster which can cause plenty of losses for the community that are not limited to material losses only, but casualties too. Along with the development of science and technology, flood mitigation can also be performed through the latest technologies which are more effective. One of the technologies which can be applied to help monitoring flood is river level monitoring system that is based on the Internet of Things. The purpose of this study is to create a river level monitoring system by using ESP32 based on the Internet of Things for flood mitigation. This system uses Ultrasonic Sensor and the monitoring results will be displayed on Blynk and Thingspeak which are connected to the ESP32. The result is a prototype of a river level monitoring system, which es expected to be used for flood mitigation.

1. Introduction

Flood disasters are one of the most common types of disasters in Indonesia. This is due to the fact that Indonesia has a tropical climate with just two seasons, the rainy season and the dry season Floods are caused by a variety of events, including waste dumped in rivers and severe rainfall. According to the Meteorology Climatology and Geophysics Agency's (BMKG in Indonesia) rainfall analysis in September 2021, as much as 78.99 percent of the observation points in Indonesia experienced above-normal rain characteristics, and as many as 10.5 percent of the observation points experienced continuous rain with very heavy intensity [1]. Every year, Indonesia receives an average of 1600 millimeters of rainfall [2]. Furthermore, flooding is a disaster in Indonesia that ranks first as the disaster with the highest number of events for a complete year, with 1,065 events [3].

Floods is one of the calamities that produces a lot of losses in a community; the impact of flooding is not just material losses, but also casualties. This damage can be reduced if the community in the watershed takes disaster mitigation measures. Catastrophic mitigation is an effort to lower the risk of disaster events through development, public awareness, and capacity building to deal with disaster threats [4]. Flood disaster mitigation is currently being carried out in the form of monitoring through CCTV or referred to as EWS (Early Warning System) which is installed at several points in the watershed, where this point is the point - a point where flooding occurs quite frequently, according to information from Mr. Rahmat Hartawan, the Head of the Malang City Regional Disaster Management Agency Program Preparation (BPPD). The operator performs this monitoring manually for 24 hours.

This research is about structural mitigation, which is a type of disaster mitigation that focuses on reducing disasters by constructing technology-based physical infrastructure. One strategy to use technology to alleviate flood disasters is to transmit real-time information on river water levels to the public, particularly to people who live distant from the emergency information center. The Internet of Things, or IoT, is used to disseminate this information. Where IoT refers to objects that may send and receive data via the internet [5][6]. Because IoT allows information to move fast and be accessed from anywhere, it is more effective and efficient. The water level of the river will be measured using an ESP32 microcontroller in this experiment. The ESP32 is a Wi-Fi and Bluetooth-connected Smart on Chip with a simple design [7]. ESP32 is a NodeMCU with Xtensa DualCore type 32 bit LX6 and 600 DMIPS, ESP32 is also an integrated System on Chip with 36 GPIO pins, and it is superior to other microcontrollers since it can be connected to Wi-Fi and Bluetooth. This means that the ESP32 can be used as a microcontroller in applications that require a large number of components [8]. The ultrasonic sensor in this study's river water level monitoring device reads data from the river to be measured. The ESP32 will take data from the ultrasonic sensor and send it to the LED as a manual output. The data will also be received by the Blynk app for Android or iOS cellphones [9], and it will be posted on the Thingspeak website in real time. This system will be more effective if it uses the Internet of Things because data can be retrieved in real time using a smartphone or laptop.

As a result, the goal of this research is to develop a river water level monitoring system based on the Internet of Things using ESP32, to learn how to use ESP32 and ultrasonic sensors in a river water level monitoring system, and to use technology to reduce flood disasters early. It is intended that this research will serve the community by making flood management easier so that it may be handled more promptly, precisely, and effectively. As a result, it will be able to lessen the impact or losses caused by the flood disaster.

2. Method

This research technique is a study path or sequence that is followed when utilizing ESP32 to monitor river water levels. The research and development (R&D) approach is used in this work. The Research and Development approach is thought to be very useful and appropriate for use in planned research.The ESP32, Ultrasonic Sensor with type HC-SR04, and LED as a height indication are used in the design of the river water level monitoring system in this study. The output will eventually be displayed in real time on the Thingspeak website and on the Blynk application that has been installed on the smartphone.

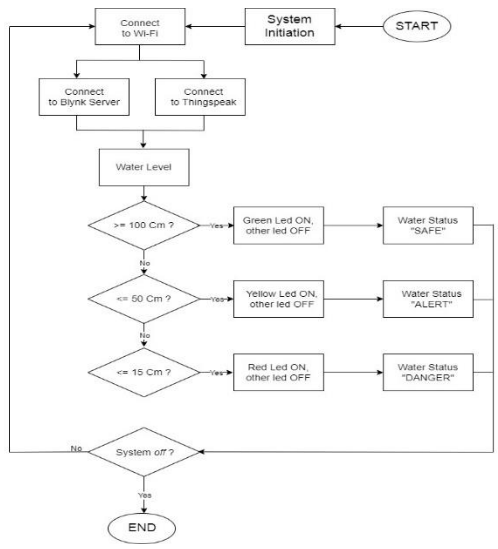

Figure 1. Flowchart

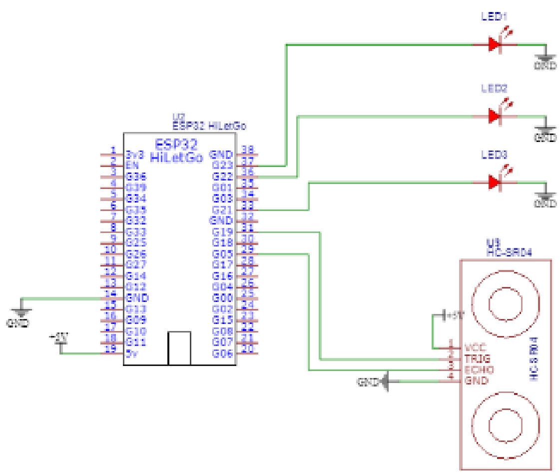

Figure 2. Schematic Circuit

The water level is measured from the ultrasonic sensor to the river water level to determine the water level, as indicated in the system flowchart in the figure above. The hardware design is carried out using Fritzing software, as indicated in the following picture based on the flowchart in Figure 1. Following the creation of the hardware circuit diagram in figure 2, the appropriate electronic components must be assembled After the system has been assembled, the following step is to program the ESP32 microcontroller with the program code supplied in the attachment to this article using the Arduino IDE software. When the application is free of problems and the system is functioning properly, the author will test the tool.

3. Results and Discussion

3.1. Ultrasonic Sensor HC-SR04 Standard Deviation Measurement

The standard deviation must be calculated to determine the accuracy of data from a sample when compared to the average of the data obtained. The accuracy or precision of the ultrasonic sensor HC-SR04 was determined in this investigation using distance measurements from the ruler and ultrasonic sensor. The table below shows the results of both measurements.

Table 1. Comparison of distance data from ruler and ultrasonic sensor HC-SR04

Ruler (mm)	Ultrasonic Sensor (mm)
51	50
52	50
53	50
54	50
55	50
56	50
57	50
58	50
59	50
60	60

The standard deviation value was calculated using the data in the table above and then plotted using Microsoft Excel. The values of y = 0.5455x + 20,727 and R2 = 0.2727 are derived from the data processing findings. The figure below depicts a graph of the processing results.

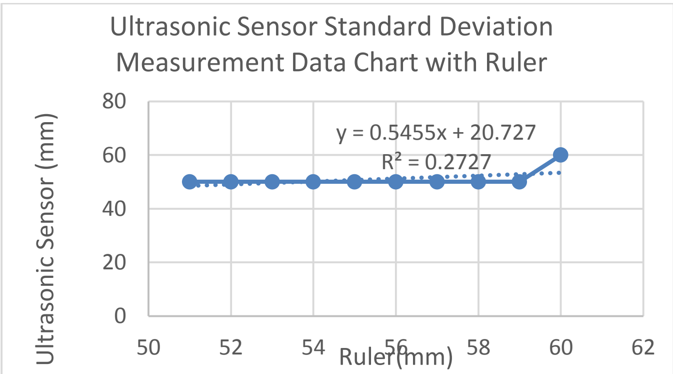

Figure 3. Ultrasonic Sensor HC-SR04 Standard Deviation Data Chart with Ruler

3.2. Wi-Fi Range Measurement

Wi-Fi coverage measurements were taken to see how Android responded or communicated with the ESP32 via the internet network, particularly on the Blynk application and the Thingspeak website. Wi-Fi range is also measured to establish the maximum or farthest distance that the system can receive in order for it to function effectively. The internet network employed in this investigation is a smartphone hotspot. The results of the measurements are shown in the table below.

Table 2. Wi-Fi range test

Range (m)	Connection
0	Connect
5	Connect
10	Connect
15	Connect
20	Connect
25	Connect
30	Disconnect

The Wi-Fi network connection is connected at a distance of 0 to 25 meters, but the Wi-Fi network is disconnected or disconnected at a distance of 30 meters, according to the findings of the Wi-Fi Range Test displayed in Table 1. Several factors effect this, including the amount of buildings that act as a barrier, the Wi-Fi network speed used, network speed, and network disturbances from the center.

3.3. Testing Tool
The tools in this study were put to the test in two separate locations. The first test was conducted in a bathtub, while the second test was conducted on a river behind the Malang State University Polyclinic.

3.3.1. Testing on the Bath The test begins when the tub is empty and slowly fills with water from the faucet, as shown in the image above. The green light or led of the system can be seen in the image, indicating that the water conditions are safe. This is also visible in the Blynk application and on the Thingspeak website.

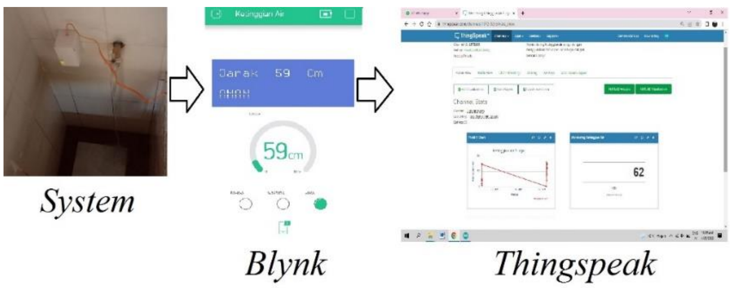

Figure 4. First test results in the bath

The LED light on the system changes color to yellow when the water has filled half of the tub. The water level measured from the sensor to the water surface is 28 cm, according to the findings provided by the Blynk application as well as the results measured on the Thingspeak website.When the Blynk application is set to 'Alert,' the led widget displays 'Alert,' and the application's yellow LED, as well as the system's yellow LED, are both lit. And it still measures 31 cm on Thingspeak, because Thingspeak requires a 15-second delay before displaying the most recent measurement results. This can also be viewed on the Blynk app and on the Thingspeak website, as illustrated in the following image.

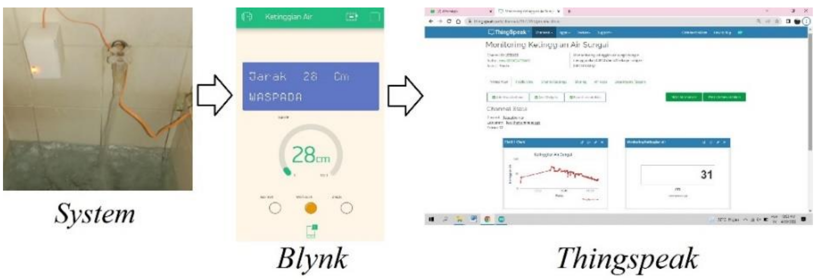

Figure 5. Second test results in the bath

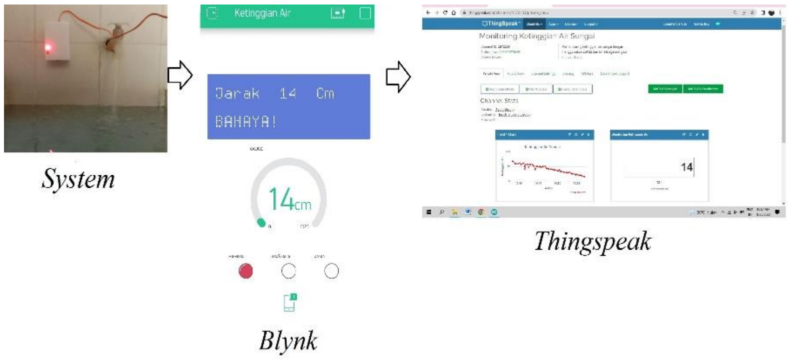

Figure 6. Third test results in the bath

Figure 7. Blynk Notifications

You can see the led light on the system become red when the water in the tub starts to fill up. The water level is 14 cm, based on the results visible in the Blynk application and the Thingspeak measurements as shown in the image above. When the water is full of lights on the Blynk application and the system is red, this indicates the status of the water. 'Danger' is the word that comes to mind. When the water status in the Blynk app is dangerous, a notification will appear that says 'Danger, Beware of Floods!'

3.3.2. Testing on the River This test was conducted on two days, when there was no rain on April 26, 2022 and after rain on April 28, 2022, with each test lasting 60 minutes. According to the results of the tool testing conducted on April 26, 2022, the system's light or led is green, indicating that the water conditions are safe. It may also be observed in the Blynk and Thingspeak programs. When there is no rain, the river's water level ranges from 108 cm to 110 cm from the sensor to the river's surface. The equipment was situated next to the bridge in a river with a pretty quick stream, causing the water level to be unsettled or slightly wavy, resulting in these height variations. The measurement of the river water level did not change considerably for 60 minutes.

Figure 8. First test results in the River

The next test was conducted on April 28, 2022, in conditions following a significant amount of rain. The lights or leds on the system are still green, indicating that the status or condition is in a 'Safe' state, according to the results of tests conducted on various days. These results are also visible in the Blynk and Thingspeak apps, as shown below.

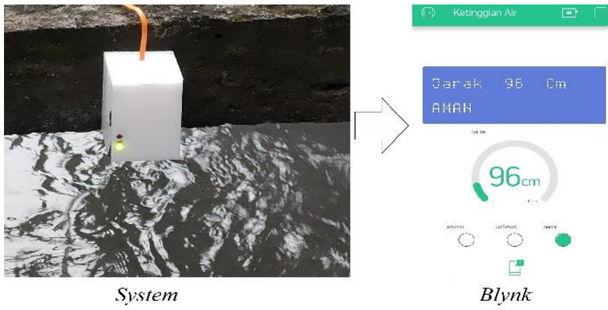

Figure 9. Test results in the River before rain

Figure 10. Test results in the River after rain

The water level of the river on the Blynk app runs from 96 cm to 98 cm, with the water status set to 'Safe,' and the light or led widget on Blynk is green. The same measurement results can also be displayed on the Thingspeak website in the form of graphs and widgets. The river water level had receded after a short period of time, about 45 minutes after the rain. The water level is 101 cm to 102 cm from the sensor to the river surface, as indicated in the image below, according to Blynk and Thingspeak.

4. Conclusion

The system was able to perform well, according to the findings of the tests conducted in this study. This is proven by the sensor's accuracy in measuring the water level while testing the tool using the Arduino IDE at the time of testing. The ESP32 was then used as a microcontroller in this study to process data from Ultrasonic Sensors, where the sensor works on the principle of sound wave reflection to determine the distance to an object at a specific frequency. Based on the findings, this system can be utilized to correctly monitor river water levels and as a flood catastrophe mitigation system.

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