Smart Monitoring System and Early Warning Water Level “SMOORTY” using Raspberry Pi Technology

Edward Arlis Chouwanto¹, Rini Wongso², Violitta Yesmaya³

Computer Science Department, School of Computer Science, Bina Nusantara University, Jakarta Indonesia 11480

Abstract— The river has become an inseparable part of human life, but river water's excessive overflowing can lead to disaster, namely flooding. Floods are quite common globally, but the people are often not ready to deal with it as there is no early warning to the public about the upcoming flood. The development of a smart monitoring city or referred to as SMOORTY in this study was made to provide a warning of the possibility of a flood disaster. SMOORTY application can help as one solution to improve the community's alertness in dealing with floods by providing an early warning notification through WhatsApp. SMOORTY also provides reports to monitor the river water level. SMOORTY uses a Raspberry Pi microcomputer to run the system and is supported by an ultrasonic sensor to measure the distance between SMOORTY and the measured river water. SMOORTY also has a warning system implanted in the device in the form of a buzzer and an LED that will be active when the water level exceeds the threshold limit.

Keywords— Flood, Monitoring, Warning, Raspberry Pi, Water Level Sensor.

I. INTRODUCTION

The river has become an inseparable aspect of people's lives, especially in Indonesia. Rivers are often used by the communities to support daily lives, such as bathing, washing, and cooking [1]. Although river water has provided benefits that humans have widely used, it is not uncommon that river water's excess flow becomes a disaster for the community itself, causing floods [2]. The flood disaster begins with the increasing discharge of river water due to several factors such as high rainfall, slow flow of river water to the sea due to garbage, and others [3], which leads to the rise of river water level above expectations.

The current weather is very erratic, this happens because of changes in the world that are happening. Pollution, global warming, and forest destruction that occur can cause natural disasters, one of which is flooding. In Indonesia itself, especially in Jakarta, floods have become a natural disaster that occurs every year and impacts at least ten sub-districts, as reported by Detik.com [4].

Although flood frequently occurs in Jakarta, not all people are ready to face it, as there is no early warning. Flood leads to loss of property and many casualties; hence it must be minimalized [5].

II. LITERATURE REVIEW

Based on research that discusses the flood disaster in Asia [6] regarding the impact that occurred before and after the flood disaster occurred. And research that informs about the solutions offered in dealing with flood disasters in Indonesia [7]. Many research attempts to create a monitoring system for the water level in recent years [8]. Develops the prototype for monitoring water level height using a microcontroller, ATmega 8535, LED, buzzer, and motor [9]. Some research uses an ultrasonic sensor to measure the water level and then display it in a small LED embedded in the microcontroller. The system they built also sounds a buzzer when the water has reached a certain height. While in 2018, [10] use ultrasonic sensors to measure water level in a tank. In this research, the author uses Arduino as a microcontroller with a single task to monitor the altitude and display it on the provided LED. [11] also use Arduino to make the tool, and they assess that ultrasonic sensor have high accuracy in measuring the distance between the device and the water. An alarm is connected to the microcontroller and will sound when the water reaches a certain height [12].

This research proposed a system to monitor the water level and send early warning might be a solution for the community to prepare for flood disaster, namely SMOORTY. Based on the literature that has inspired, this research is used to detect flood disasters with an indication of water levels by giving warnings using WhatsApp. The use of WhatsApp is useful for getting a wide reach to many users in real time. WhatsApp also has advantages such as security aspects, and low costs compared to conventional models such as SMS [13]. SMOORTY will run on the internet, using Raspberry Pi technology as it is low-cost [14].

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SMOORTY will use WhatsApp for notification because it is the most widely used instant messaging platform in Indonesia, with up to 143 million users [15], or 83% of total internet users in Indonesia [16]. The government can also reduce costs (time and money) for sending flood disaster early warnings to the public because there is no additional cost for using WhatsApp. By using WhatsApp as an early warning system, early warning dissemination is also more economical because WhatsApp is an instant messaging application that is free and fast in time [17].

The early warning system works by sending short messages via WhatsApp to the community if something abnormal happens in river water, such as when a device detects that river water has reached a certain height, which requires the public to be more alert that a flood will occur. The government and the community can also monitor the level of river water around them with this system that will run automatically.

SMOORTY can be implemented as one of the Smart City Framework in Jakarta to increase public services and welfare through technology, especially in public [18].

III. METHOD

We conduct surveys of 200 respondents living in Jakarta area to find out more about their concerns towards the river water level and how they would like to be supported. According to the result, they are not well informed regarding the water level near the area they lived in, as the water overflows not only due to the rain, but often overflows from Bogor, a city well-known as the “Rainy City” in Indonesia due to the high rainfall. As they do not aware of the water level, they are not well prepared for floods as sometimes the water overflows from the river while they are asleep.

According to the result of the surveys, 95% of the respondents need information regarding the water river level near the area they live in so that they will be able to evacuate their valuable properties to a higher place, and they can evacuate on time. They also prefer to be informed through instant messaging, such as WhatsApp, as all the respondents have WhatsApp installed on their phone and use it for daily communication. Hence, SMOORTY will have an early warning notification feature sent through WhatsApp.

SMOORTY will be built on a Raspberry PI, connected with an ultrasonic sensor, a LED light indicator, and a buzzer.

SMOORTY uses Raspberry PI as it is quite practical in terms of size, and it is low in cost. In the beginning, we will have to set the water level threshold for the system to send an automatic notification to the community. We might adjust the threshold for each river according to the depth of the river. The WhatsApp number must also be registered in the database to support the automatic notification explained above. The Raspberry Pi will be equipped with an ultrasonic sensor to monitor the water level. The sensor will be set by default via the Raspberry Pi code to retrieve data every 30 seconds, then the Raspberry Pi will return to idle state to wait. Distance calculation via ultrasonic sensor required speed and time. Velocity indicates how fast the object is moving, and time is the interval between 2 events [19]. In this study using an ultrasonic sensor, the speed following the speed of sound is 343 m/s or the equivalent of 34300 cm/s, while time is the time from the start of the sound wave to the end of the sound wave. The system will then check whether the data obtained exceeds the predetermined water level threshold. We measure water level data using an ultrasonic sensor by measuring the length of the sound wave reflection produced with the following formula:

$$\text{Altitude} = \text{Depth} - (\text{Wave Duration} * (34300 \text{ cm/s}) / 2)$$

SMOORTY system uses Python and Golang, which will measure river water level data and send the data obtained online for processing and make it accessible to anyone and anywhere. This system can also send messages via WhatsApp to the community if the water level has reached a certain point so that the community can be prepared to face potential flood conditions.

Golang is used to send WhatsApp messages to numbers recorded in the database [20]. Python is used to connect with GPIO pins or pins in the Raspberry Pi [21], while Golang is used to process the data that has been obtained and handle triggers to the SMOORTY system.

SMOORTY also uses Cron jobs technology that allows devices to execute commands or scripts automatically within a predetermined period [22]. Cron jobs will run binaries from Golang and read files created by the Python system (a system that aims at ultrasonic sensors).

SMOORTY also uses NSQ for message queueing as it promotes distributed and decentralized topologies, enabling fault tolerance and high availability coupled with a reliable message delivery guarantee. Therefore, if the system experiences a problem, the existing monitoring data will not be lost.

The hardware design of SMOORTY begins with an ultrasonic sensor installation plan with four cables of TRIG, ECHO, GND, and POWER, as described in Figure 1. The figure also shows that the ultrasonic sensor interruption must also install 1K ohm and 2K ohm resistors. HR-SR04 ultrasonic sensor will measure distances between 2 cm to 400 cm and emit 40kHz with eight waves. The TRIG and ECHO must be attached to a pin that can accept input or output on the Raspberry Pi. Breadboard, a circuit builder to create connections on electronic devices, makes it possible to build electronic devices without using solder, using jumper cables to connect device components [23]. The breadboard is one of the components chosen to connect the Raspberry Pi with the sensor used [24]. Then, POWER is attached to the Raspberry Pi pin, which can output 5V of power, while GND is attached to the Raspberry Pi pin integrated with the ground.

Figure 1. Ultrasonic Sensor Installation Plan

The LED installation plan can be seen in Figure 2, where one of the LED branches is connected to a Raspberry Pi pin that can receive input and output, then the other pin is connected to a larger resistor equal to 330 ohms before being connected to the Raspberry Pi pin which is integrated with the ground. In theory calculations, we need a resistor with a resistance of 80 ohms. However, the 80-ohm resistor is not a standard size resistor, so in this case, a 330-ohm resistor is used with the tradeoff that the lamp can be a little dim.

Figure 2. LED Installation Plan

After that, we install a buzzer, a device that can make a sound (warning) when given a voltage. Two types of buzzers can be connected to Raspberry Pi. The first is an active buzzer, and the second is a passive buzzer. An active buzzer is a buzzer that can make a sound immediately when given a voltage, while a passive buzzer requires an oscillator (additional circuit to regulate waves) to be able to sound [25]. The buzzer installation plan uses an active buzzer, as shown in Figure 3, connected to a pin that allows input and output, while the other connection is connected to a ground-integrated Raspberry Pi pin.

Figure 3. Buzzer Installation Plan

The system will initialize the pins on the raspberry pi to determine the pins for input and output for each sensor that has been installed on the raspberry pi. Next it will call the predefined processes, namely GetDistance and ValidateAndAlert.

Figure 4. Flowchart SMOORTY System

Figure 4 describes the GetDistance function which shows how SMOORTY has the capability to get water level figures. The system will activate the trigger sensor to emit ultrasonic waves and then will continue to loop until the echo sensor receives back the sound waves previously issued by the trigger. After that, the distance calculation will be carried out using the physics formula for calculating distance, using the constant speed of sound.

IV. RESULT AND DISCUSSION

SMOORTY is developed on Raspberry Pi 3 using Raspbian 4.19, with 1 Gb RAM, equipped with Micro SD 32 GB, an ultrasonic sensor, an LED, a buzzer, jumper cables (M to F), resistors, and a breadboard. Figure 5 describes SMOORTY prototype (hardware).

When the system detects that the water level exceeds the limit, it will trigger the LED and buzzer, as shown in Figure 6, and then send the early warning notification to communities through WhatsApp.

FIGURE 5. SMOORTY Prototype

Figure 6. LED and buzzer in SMOORTY are turned-on as warning (left) then WhatsApp message are sent (right)

SMOORTY will have a web-based system to view water level for the rivers that have been connected to the prototype, as can be seen in the following Figure 7.

Figure 7. SMOORTY web application

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The result of conduct testing with the SMOORTY prototype using four test cases and two different types of containers to determine whether SMOORTY runs well as shown in Table 1 and 2.

TABLE 1.
SMOORTY TESTING RESULTS FOR BEAM-SHAPED JAR CONTAINERS
WITH A BASE OF 10CMX12CM

Test Case Distance	Expected Result	Actual Result
Min Distance: 10cm, Get Distance:16cm	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent
Min Distance: 10cm, Get Distance:8cm	Lamp : ON Buzzer : ON Whatsapp : Sent	Lamp : ON Buzzer : ON Whatsapp : Sent
Min Distance: 10cm, Get Distance:1cm (Out of range condition)	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent
Min Distance: 10cm, Get Distance:500cm (Outside container)	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent

TABLE 2.
SMOORTY TESTING RESULTS FOR TUBULAR JAR CONTAINERS WITH A
BASE OF 17CM IN DIAMETER

Test Case Distance	Expected Result	Actual Result
Min Distance: 10cm, Get Distance:13cm	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent
Min Distance: 10cm, Get Distance:5cm	Lamp : ON Buzzer : ON Whatsapp : Sent	Lamp : ON Buzzer : ON Whatsapp : Sent
Min Distance: 10cm, Get Distance:1cm (Out of range condition)	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent
Min Distance: 10cm, Get Distance:450cm (Out of range condition, not inside container)	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent	Lamp : OFF Buzzer : OFF Whatsapp : Not Sent

V. CONCLUSION AND RECOMMENDATION

According to the survey conducted while interviewing 50 respondents who have tested SMOORTY system, we concluded that users are satisfied with the notification they received as it can serve as early warning and have more time to be prepared for the flood. The respondents suggested that it will be better to receive the notification with information according to a certain threshold level, just like the terms Jakarta's Government use, i.e., "Siaga 4", "Siaga 3", "Siaga 2", "Siaga 1". They feel that it will also be more helpful to check other river water levels for family safety, as sometimes they live apart from their beloved families.

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