Journal of Engineering Technology Vol. 10(1): 167-171, 2022
ISSN 2231-8798© 2013 UniKL BMI

Development of Flash Flood Mitigation Problem with Sustainable Auto-Drainage System

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Abstract: Floods are natural phenomena that occur every year in Malaysia during the monsoon season which runs from November to January. Despite the fact that various steps have been taken, it appears to have remained unsolved. Here, the auto-drainage system to mitigate flash flood is proposed to improve the drainage system as it is one of the major reasons that caused the flood. This project is the first phase of the flash flood mitigation system where it provides crucial information such as water level in the drainage system, the plan and the preparation to the public as well as the local authorities. Auto-drainage system offers continuous monitoring on the water level in drainage system and allows water to divert into alternative drainage during critical times. There are 3 different levels of warning; low, medium and high. During low level, the water pump is in idle mode or in a safe zone. When the water reaches medium, the pump will start to divert the water into an alternative drainage system. At high level, the pump will continue to divert the water the notification to evacuate the area is despatched. The test run gives a positive result and fulfills all the objectives in effort to mitigate the flash flood.

Keywords: sustainable energy, sustainability, flash flood, environmental sustainability, auto drainage system

1.0 INTRODUCTION

Natural events are beyond the human ability to control. One of the most prevalent and destructive weather-related is flash flooding. Many factors can cause this event to happen but the most common reason is due to the prolonged heavy rainfalls. [1] The amount of rain falls overwhelms the soil's natural absorption capacity and the inadequate drainage system also contribute to the cause of flooding. According to a research, flood is one of the natural phenomena that caused the most death in the world [2].

The coast of peninsular Malaysia is the most prone to flooding especially during the northeast monsoon season from October to March [3]. Recently, massive flooding across eight states of Malaysia caused the evacuation of 130,000 people from middle December to early January [4] Clogged drains coupled with excessive rainfall from heavy downpour within a short time contributed to several episodes of flash floods reported nationwide recently [5]. The Environment and Water Ministry claims that the drainage systems being overwhelmed and clogged with rubbish prevent water from rainfall flowing immediately into the nearest river.

The resident of this flood prone area should be alert with this matter. They should be the first one to know about the current status before the scenario gets worse. This issue can reduce the rate of death and destruction due to the flash flood [6].

Therefore, this auto-drainage system is developed to mitigate the flash flood as well as to improve the existing drainage system. This system enables warning alerts to be sent to the authorities so that further inspection can be done at the affected area. In addition, the user will receive a real time warning notification via apps when the flood is rising rapidly.

2.0 METHODOLOGY

This section is outlined into 3 parts, the system block diagram, the system flowchart and flash flood forecasting. The first part, system block diagram presents the general and the detail block diagram of the auto-drainage system. The second part is the system flowchart of the drainage system and the third part is the basic forecasting formulation for the flash flood.

I. SYSTEM BLOCK DIAGRAM

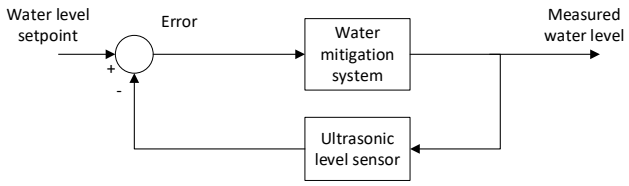

Figure 1: General block diagram for excess water mitigation system

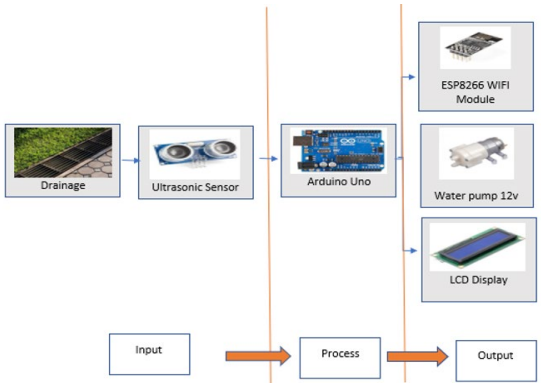

Figure 2: Block diagram for auto-drainage system

Figure 1 is the general block diagram of the mitigation system for excess water in flood situations. The system is set with a desired water level and is measured with ultrasonic level sensor. The desired input and the measured output is compared with a comparator and the system will determine the need for excess water mitigation system. The system will respond only when the error is positive. The excess water is diverted using auto-drainage system. Figure 2 shows the block diagram of auto-drainage system. The block diagram depicts the hardware components. The blocks are divided into three main parts which are input, process and output. The input used for this project is the ultrasonic sensor that is attached in the drainage system to detect the changes of the water level. All of the data recorded by the sensor will be sent to the server to process the data.

The second block is the process block. The main part of the project is programmed using the microprocessor. The microprocessor applied for this project is Arduino Uno. Arduino functions as a server or processing device that is used to receive data from the input components to process the data. Once the data is processed, it will be delivered to the output components. There are 3 output components displayed in Figure 1; the WIFI module, the water pump and the LCD display. The WIFI module is required as the medium to send the data to the control device. The water pump is the output when the water level reaches medium. This is the crucial part where before the water becomes overflow, it will detour to an alternative route or path to avoid flooding. This is the first phase of the flash flood mitigation system. The success of the project prototype is the motivation to proceed to the second phase of the project. This paper focuses on the first phase of the project. The block diagram is Figure 1 is translated in detailed flowchart as shown in Figure 2.

II. SYSTEM FLOWCHART

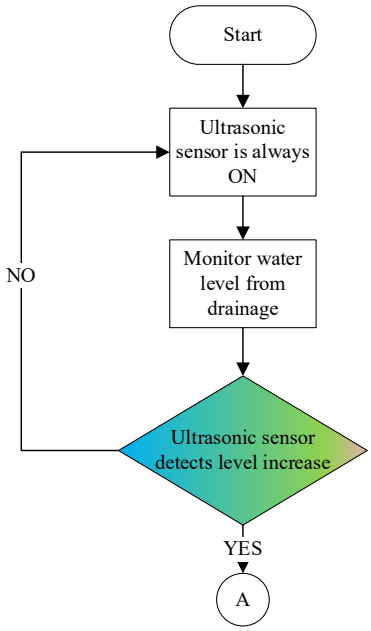

Figure 3(a): Flowchart of auto-drainage system

Figure 3(a), 3(b) show the flowchart of the auto-drainage system. The flowchart shows the movements of the system to understand how the project operates. It starts with the ultrasonic sensor where it is always in active mode in order to record and detect any changes in the water level. If the water level increases, the data recorded by the sensor will be sent directly to the microcontroller (Arduino). Arduino will start to process the data received and pass it to the ESP 8266 WIFI Module to keep all the data and share the data to the users and authorities.

The project is designed in 3 scenarios, the first one is where the water is in the low level. The components that will react during this level is the LED monitoring lights. The green LED will light up to show that the water is in low level, also described as the safe condition.

The second scenario is where the water increases to medium level. Medium level is indicated with yellow LED. The yellow LED will light up and the water pump will start to divert the water into an alternative path or an alternative drainage system. The notification is sent to users alarming that the situation requires to prepare for evacuation. At this level, the water pump starts to divert the excessive water to

an alternative line. The warning is sent through an application called BLYNK.

The third scenario is when the water reaches a high level. The level is shown by the red LED. It will light up to display the water has reached the warning level. The water pump will continuously divert the water into an alternative drainage system until the water level goes back to safe.

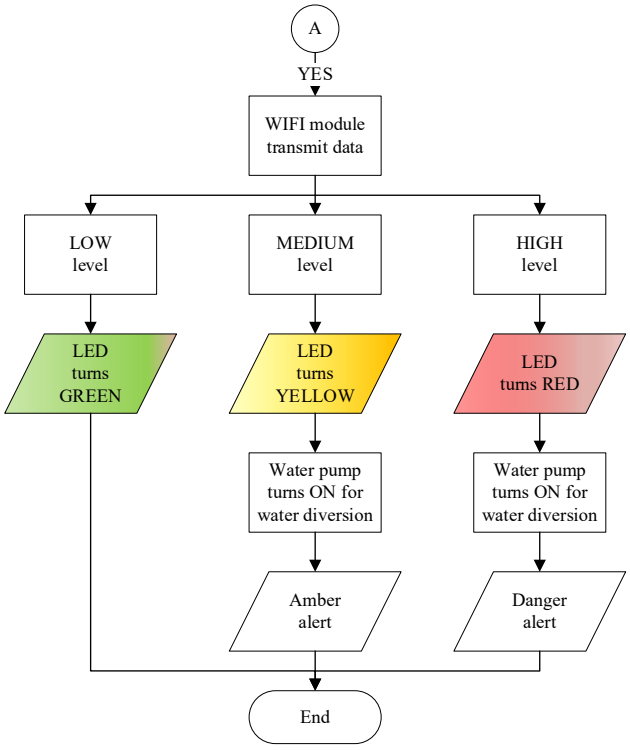

Figure 3(b): Flowchart of auto-drainage system

III. FLASH FLOOD FORECASTING

Flash flood forecasting methods are published in [7], [8]. For instance, the general formulation for known water stream is given by,

$$f = V \times D \times W$$

Where f is the stream discharge, V is the length of travel per unit, D is the depth of the water and W is the width of the water stream. The flash flood can be estimated by taking into account the rainfall rate calculation for a selected area. The rate differs based on the location of the area of interest.

3.0 RESULTS

The prototype of the project is built in a small scale system. It was done by software and hardware. Figure 3 shows the schematic diagram of the development of auto-drainage system. The diagram shows the connection of all components which are Arduino Uno, Ultrasonic Sensor, Battery 12V, Water Pump, Relay, ESP8266 Wifi Module, Buzzer, LED Monitoring Lights and the LCD Display. The diagram was drawn using the Proteus Software.

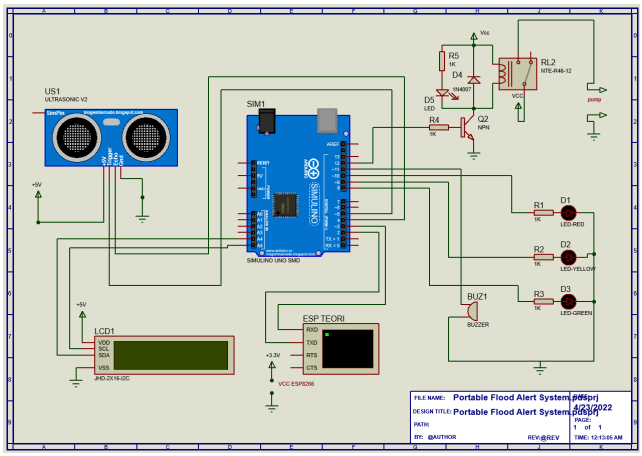

Figure 3: Schematic Diagram

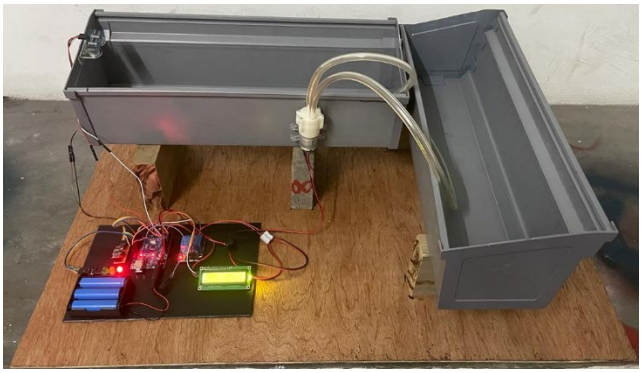

Figure 4: Prototype of the auto-drainage system

Figure 4 shows the prototype of the project. The prototype was assembled and tested successfully. The water pump managed to divert the excessive water to the alternative line. This supports the software development of the system is successful as well.

The testing was conducted to gather all the results and data to identify whether the project fulfilled all the objectives. Figure 5 shows the output date from the serial plotter for the auto-drainage system. The x-axis represents the distance between the water and the ultrasonic sensor. The higher the reading, the further the distance between the water and the sensor.

Table 1 above shows that users will receive notification via the apps to evacuate the area as the water has reached the warning level.

The green LED was lit up to show that the water in the drainage is at a low level. The reading of the water level is high due to the distance between the ultrasonic sensor and

the water far away from one another. The water pump is still in idling mode and the users will not receive any notification via the apps.

When the water reached medium, the LED monitoring light turned from green to yellow. The water level reading went down from 13.163 to 7.346 as the water rose and the distance between the sensor and the water became shorter. The water pump started to divert the water into alternative drainage and the user received notification via the apps. Figure 10 below shows the notification received by the users.

When the water reached high, the LED monitoring light turned from yellow to red. The water level reading also went down from 7.346 to 4.036 as the water increased and the distance between the sensor and the water became shorter. The water pump will continue to divert the water into alternative drainage and will eventually stop when the water level goes back to low.

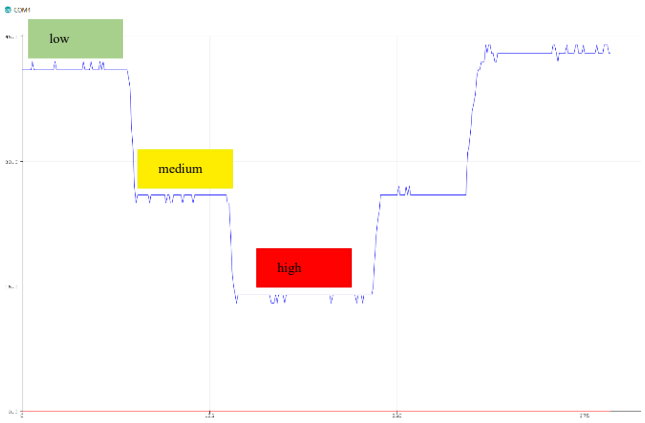

Figure 5: Output data for auto-drainage system

TABLE I. RESULTS

Level	Water Pump	Monitoring Lights	Blynk Application
Low	OFF	Green	No notification
Medium	ON	Yellow	WARNING!!! GET READY TO EVACUATE!!!
High	ON	Red	IMMEDIATELY EVACUATE!!!

4.0 DISCUSSIONS

The project was initiated to mitigate the flash flood problem in the urban area in Malaysia. It is proposed with 3 phases of project development. This project is the first phase of the project. It is developed to mitigate the flash flood problem by designing a system that has the capability to actively detour the water from overflowing in a limited space by diverting it to an alternative line using ultrasonic level sensors. It also has the notification setup to send an alert to the users and the authorities. Based on the results, the project shows it successfully achieved all objectives and goals. All of the components are fully functional and interconnected to produce a quality project that can help to reduce the issue. This project is very important as our drainage system can be well maintained as the device helps in monitoring the water level and the authorities can take part in inspecting the affected area during critical times. With the aid of this device, we can all take part in sustaining our drainage system and avoid littering as it is the major reason why water cannot flow smoothly during heavy rainfalls.

5.0 CONCLUSION

The first phase of development of auto-drainage system to mitigate flash flood problem has been developed and well-functioning. The mitigation process diverts the water stream excess to an alternative route using the water pump. The water level indication is detected by ultrasonic level sensors and is programmed on 3 different levels. The system can be monitored using an IoT application called BLYNK apps. It is convenient to use the apps as we are moving towards high technology era. The second phase of the project will focus on the self-heating elements of the drainage system and the application of the sustainable energy will be the main motivation of the project. As a result, users should not be worried about flash flood as this device can help to notify them of the current status so that they can be well prepared.

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