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Solar Powered IoT Flood Detector

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Abstract: Flooding has become common in Malaysia. These floods, which have been happening more and more often in a scary way over the past few years, have had a huge effect on the lives of both people and other living things. This disaster happened because there were not enough systems to detect and track floods. The goal of the research is to use the "Internet of Things" (IoT) to make a system that can detect and track floods. Solar panel were utilized as the power source for the system. Ultrasonic sensors were used as inputs when building hardware to find water and keep track of how much water was there. The information can also be shown on an LCD panel. This system relies on LoRa SX1826 transceiver to operate as a wireless connection for data transfer between the system and the sensor despite using two Arduino Uno microcontrollers. To obtain the most recent value of the water level, ESP8266 further serves as a conduit between the sensor and the smartphone. A buzzer has been installed as an alarm to warn users of the hazard when the water level rises to a risky level. A small-scale prototype experiment is used to verify the proposed system's accuracy and simulate real flood condition. The system is expected to provide real time water level measurement utilizing an LCD display and a Blynk smartphone notification. By having an efficient display and alerting system, quick action and precaution may be done to prevent loss of life and minimize flood disaster damages.

Keywords: Flood Detector, Solar Powered, IoT, LoRa, Blynk, LCD

1. Introduction

Natural disasters are well known as a worldwide natural phenomenon occurred all around the world. Various types of natural disasters including floodings, earthquake, hurricanes and tsunami are all classified as natural disasters that has happened to various location before. In the recent flooding in Malaysia a few months ago due to storm and heavy rainfalls in the state of Selangor, loss of lives and property were estimated by the Selangor government at a loss of 1.4 billion ringgit including the 400 million ringgit of infrastructure repairs [1].

Floods occurred most when water from heavy rainfall, from melting ice and snow from the country that having cold weather, or from a combination of these exceeds the carrying capacity of the river

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system lake, or ocean into which it runs. Usually, the combined flow of several water-swollen tributaries causes flooding along riverbanks or shoreline. The geographical location also one of the factors that caused flood occur, where the cyclical monsoons during the local tropical wet season. Due to the floods, many lives and the property are found destroy [2].

Using internet of Things (IoT) components, the management of various electronics appliances in home and businesses would be easy. Additionally, with the use of IoT, the peruse of information from sensors can be obtained easily and displayed to the users without having the need to be physically present with the targeted location. With the combination liquid sensor, information regarding the present of water would be sent and transferred to a cloud database allowing constant monitoring of users with the utilizing Arduino Uno and LoRa technology. With Arduino microcontroller, it would obtain information of the present of water from the water level sensor and enables it to the LoRa transmitter. LoRa is a spread range regulation procedure derived from chirp spread range (CSS) innovation [3]. With the use of LoRa, it is a device and wireless radio frequency that offers wireless radio frequency with long- range and low powered wireless platform suitable for IoT.

1.1 Flood Detector System

Flood detector system would be a combination of hardware and software, and each component would serve a specific purpose. The river's water level would be measured by sensors placed near it. The Arduino water level sensor had been used to monitor various types of water levels. The sensor's signal had been sent to the Arduino Uno once there is a rises or changes on the water level. As a backup power supply, a solar power system is provided. This backup energy was required by the system to ensure that it never runs out of energy and continues to function properly. This system had been wireless because it would use two Arduino boards, one for the transmitter and one for the receiver. The information about the water level would be sent to the user's smartphone in addition to being uploaded to the IoT cloud [4]. With this method, Users' smartphones gained access on flooding information. This simplified the monitoring process, and the process of displaying the water level required some programming.

1.2 Solar Panel

Solar cell or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon [5]. Solar cells are a form of photoelectric cell, also being described as a form of device that also contains electrical characteristics as any other electrical appliances, such as resistance, voltage and current. These characteristics may vary time to time based on the time exposed to light and the intensity of the light. When solar cells were being stack together in a block of building together to form a photovoltaic module, it would be known as a solar panel. Solar cells were also being described as photovoltaic regardless of the source of light were natural sunlight or from artificial lighting. Solar cells were used as a photo detector infrared detector, detecting light or other electromagnetic radiation near the visible range, or measuring light intensity [5]. Solar cell is essentially a diode with a junction in p-n. Solar cell is also considered a type of photoelectric cell, which also described as devices with properties of electrical that exchange when exposed to the sunlight.

1.3 Lora Technology

LoRa stands for long range. LoRa technology is capable of transmitting data over a long distance. According to Machina Research, connected objects would account for more than 25 billion connections by 2025 [6]. With certain extends, LoRa covered over a hundred-kilometer square of area. The long range of the LoRa technology is due to its link budget and the chirp spread spectrum modulation that it employed [7].

There was a total of 4 basic elements were needed to establish a complete LoRa network spectrum:

- LoRa Node or End Points
- Gateway
- Network Server.
- Application Server

1.4 Internet of Things with LoRa Technology

LoRa, a new communication technology that were part of the Low Power Wide Area Network (LPWAN). It emphasizes long-range communication with high receiving sensitivity, allowing it to work effectively under noise interference or noise floor. The range of communication has become a critical component in the majority of IoT systems [8].

With the advent of LoRa technology, further advancements in Internet of Things (IoT) applications are possible. In contrast to Wi-Fi-based systems, which require many access points to increase coverage area, the LoRa network can handle many nodes at multiple locations within the area by using a single receiver [8]. The combination of LoRa and Wi-Fi technology lowers the cost of IoT system deployment.

In recent years, Wi-Fi and Bluetooth were well-known wireless technologies for Local Area Networks (LAN). Wi-Fi, Bluetooth 4.0, and Zigbee were all well- established standards in both. Wireless technology had dominated the IoT market due to its popularity and simple protocol. The transmission range is a disadvantage or challenge with that technology in IoT. Smart positioning systems and smart farming are examples of IoT application domains that required high energy efficient sensor nodes that can communicate over long distances.

Based on indoor experiments [9, 10], Bluetooth had a transmission range of 50 feet (without a range extender) and Wi-Fi has a range of 200 feet. Implementing the solution with Wi-Fi or Bluetooth technology would incur additional costs to build a long-range communication network that would necessitate the use of a range extender. To meet these requirements, many Low- Power Wide Area Networks (LPWAN) technologies, such as LoRa, were being developed.

The modulation technique used in LoRa made it robust to channel noise since the entire allocated bandwidth was used to broadcast a signal (information or data). Furthermore, the security of the LoRa system can be guaranteed as the transmission were spread in a pseudo-random way which presents like a noise; hence the modulation technique had provided the basic security for the LoRa system [11]. Based on this statement alone, LoRa were also the best option for IoT solutions that required long-range data communication while consuming little power. In other words, the LoRa signal's high penetration allowed it to provide adequate coverage in a difficult-to-reach indoor location. When compared to Wi-Fi or Bluetooth-based IoT solutions, which had a limited data communication range. This technology provided maximum efficiency in data communication while keeping development costs low.

1.5 Lora System Architecture

In a star topology, LoRa end devices communicated with the LoRa single channel gateway via LoRa modulation. LoRa end devices communicated with the LoRa single channel gateway via LoRa modulation. Before the communication begin, the spreading factor and bandwidth of the LoRa network would be configured in the coding section. When the LoRa gateway identified the sync word, it forwarded the received packet from the end-devices to the local Matchbreaker through the ESP8266. The ESP8266 is a Wi-Fi module which to be used to provide an internet interface for the LoRa gateway [11].

The LoRa gateway communicated with the ESP8266 via SPI, which is the same as the connection with the Arduino. Message query Telemetry Transport (MQTT) is used for the web interface. On the Internet of IoT, MQTT is a well-known machine- to-machine (M2M) communication protocol (IoT). The LoRa gateway's ESP8266 will publish the data received from those end-devices to the local MQTT broker, while Node-RED would display the receiving packet from the end-devices by subscribing to the same MQTT broker.

1.6 Related Work

Satria et al [12], in their research aimed to build an information system that were able to provide anticipation regarding the flooding hazard, warnings and flood monitoring systems. Typically, in disasters information, phone communication was being regarded as one of the main communications systems in the process of distributing disaster information [12]. Analysis began when the sensor started detecting water rising through the flood detector system. The data received by the flood detector were processed to produce a data format for the purposes of sending data in the form of SMS to the information system server via GSM modem. Altitude data received by the flood location information system were stored in the database server, Flood data was then sent to the flood monitoring officer as appropriate actions can be taken.

Hadi et al [13], in their paper of Flood Detection and Avoidance System, IoT is being used as a foundation for data exchanged between the sensor's components and the mobile application in this research. An ultrasonic sensor converts energy into ultrasound and were utilized in this research to detect and monitor the level of water from time to time. The GPS is being used to pinpoint the flood zone's exact location [13]. A flooding avoidance mechanism were also included in the system, which employed a solenoid valve to manage the excess water going out, allowed the water level to be controlled before flooding occurred.

Research done by Zain & Khalid [14], involved the development of flood detector system which would determine the current water level that is assuming from the voltage from the detector. The data that had been collected would be analyzed in database to make sure the safety purpose been taken if the water reached to warning level [14]. The overall system design of this flood detector system consists of a few of the parts and development design. Hardware included are water level sensor, transmitter module, receiver module and microcontroller module. when water reached and detected by the water level sensor, analogue signal would be sent from the water level sensor and converted to digital signal by the converter to be transmitted to the part of the receiver. After the data were received by the receiver, the data in digital form would be processed at the processing part to produce a match deepness of value that were set inside the system measurement.

Paper written by Utomo et al [15], With the plan of using the combination of image processing and computer vision, more known as digital image processing techniques, with Sobel Canny edge detection (SCED) algorithms to have the accurate detection of water level in real-time [15]. After the water level measured, a flood detection process was carried out based on the specified water level. Two tests were conducted in the study, the first to determine the approach's efficacy in object recognition and the second to determine the accuracy of the system in detecting water level with a warning level. orange ball was placed in a container filled with water adjacent to the water level gauge for the item recognition experiment as a water level indicator. The second is by placing the orange ball indicator on a bounding box filled with water. Water level is divided into three levels, a safe level at 1-10 cm, an alert level at 10-23 cm, and a warning level at a height of 24-27 cm. A water level gauge was used to make the measurement.

Research by Pratama et al [16], focuses on the usage of fuzzy logic to be used in order to determine the conditions and surrounding of the artificial river, the sensors that were chosen in this research included ultrasonic sensors and water flow sensors. Ultrasonic sensor would be tasked on monitoring the levels of water and the water flow sensor to be used in the aim of monitoring the flow of water in the area. The first process is a node connection, which involves the Arduino Uno as a microcontroller and the Xbee as a connector between the nodes. The connection passed through the coordinator node to the gateway that was integrated with the internet network after the nodes were connected. When all connections are made, the sensor read the data and send it to the server for processing [16]. The results of these preparations are displayed on the Web Interface-based GUI. Data from the sensor readings received, and the microcontroller applied Fuzzy Logic to the input water level and water flow from the sensor readings. If the output of the Fuzzy Logic process were less than or equal to 5, it displayed a warning sign. However, if the output were between 5 and less than or equal to 15, a Prone warning would appear, and if the output was greater than 15, the area is safe.

2. Materials and Methods

Figure 1 shows the block diagram of the research. The ultrasonic sensor was constantly measuring the range of water surface to the ultrasonic sensor. When the water level is rising, sensor would send data to the microcontroller and to the LoRa transmitter, signal of the collected data is then sent to the receiver and upload to the IoT cloud.

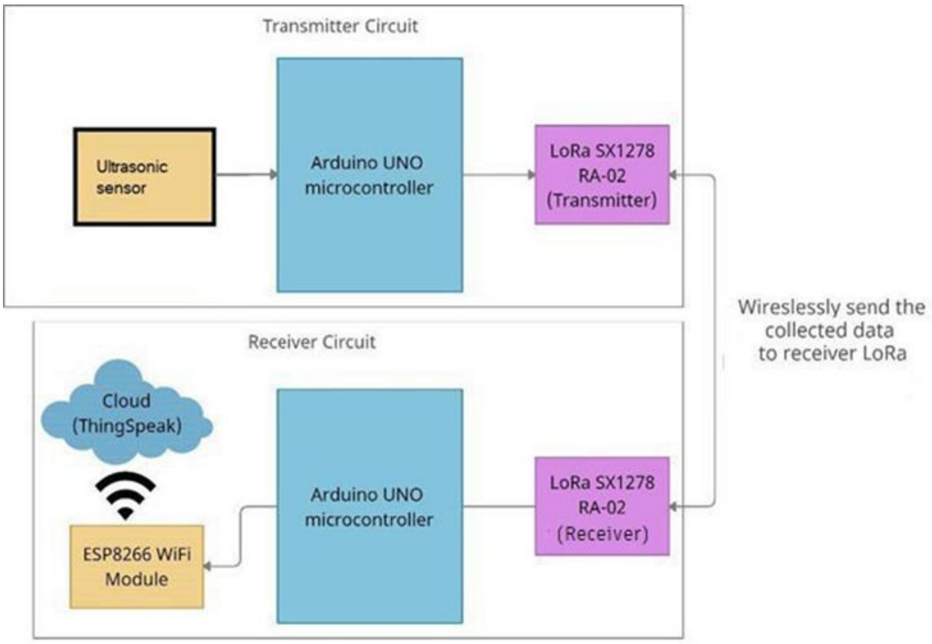

Figure 1: Block Diagram of IoT Flood Detector

This system would contain two Arduino UNO microcontrollers. The first Arduino UNO were use as the main board for the sensor and LoRa SX1278 transmitter. Ultrasonic water sensor was connected to the Arduino microcontroller on the digital pin and the other connected to the ground of the board.

The communications between two Arduino microcontroller and the purpose of IoT in this research is the LoRa iSX1278 iRA-02 and the ESp8266 WiFi module. The LoRa iSX1278 iRA-02 was being used to send the collected data from the sensor at the transmitter circuit to the receiver circuit. LoRa iSX1278 iRA-02 has a high frequency ofi-148dBm with a power output ofi+20 dBm. The LoRa iSX1278 iRA-02 wireless communication module can achieve a distance of 15-20 km communicating range.

2.1 Flowchart

Figure 2 shows the overall flow of the system from the transmitter side all the way to the receiver side of the research. elaborated the flow of system at the transmitter side. First initial setting such as pin assignments must be done. Then the baud rate and frequency must be set according to the requirement of LoRa. Since system uses serial communication, it must be checked for the availability of serial pin. If serial pin were available, collect the data from sensor and broadcast the data and check for the gateway. If available, check for acknowledgement form the gateway. If acknowledgement were received successfully, then it indicated communication successful between the transmitter LoRa and receiver LoRa. Flow chart illustrated elaborates the system at the LoRa receiver. Initially the baud rate and frequency must be set with the data match obtain from the cloud account. Continuously check for the data at the set frequency. If available, get the data and displayed it on the cloud as well as on the Blynk user smartphone application.

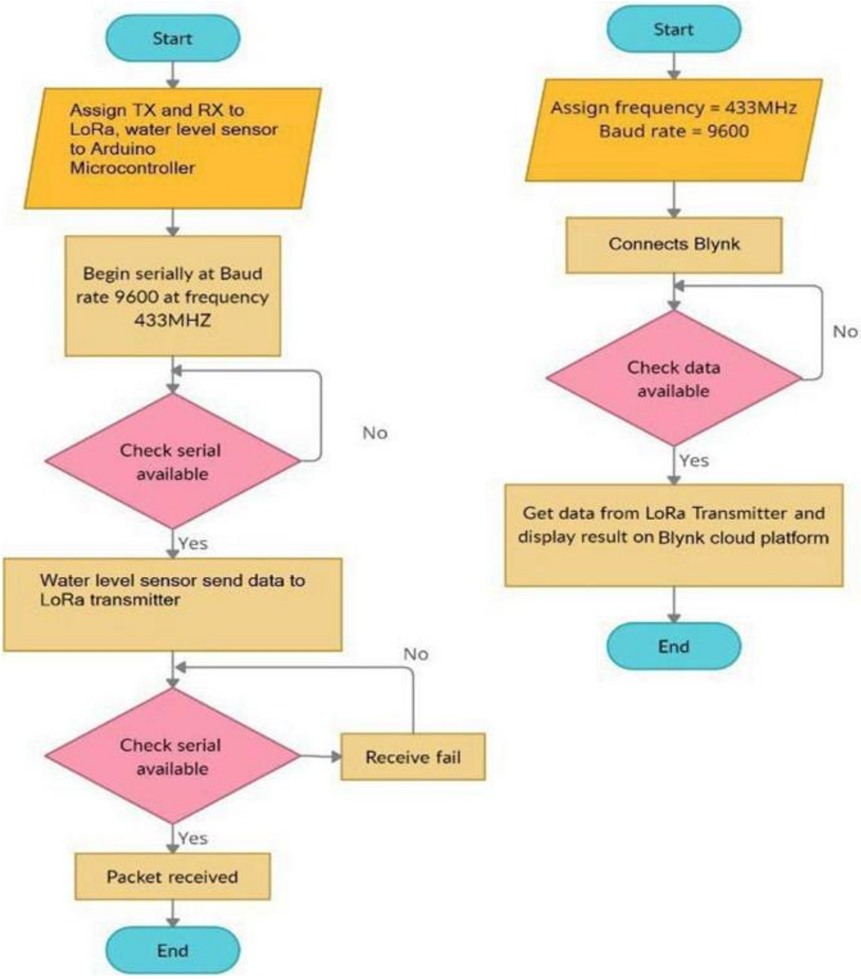

Figure 2: Research Flow Chart

3. Results and Discussion

Figure 3 and 4 shows the circuit diagram of solar powered IoT flood detector with variable resistor acts as the source of object for the ultrasonic sensor. Code was compiled on Arduino IDE and uploaded onto the circuit constructed with proteus software shown in Figure 3. Also shown in Figure 4, the simulated ultrasonic sensor was able to detect objects and giving a distance reading on the virtual terminal.

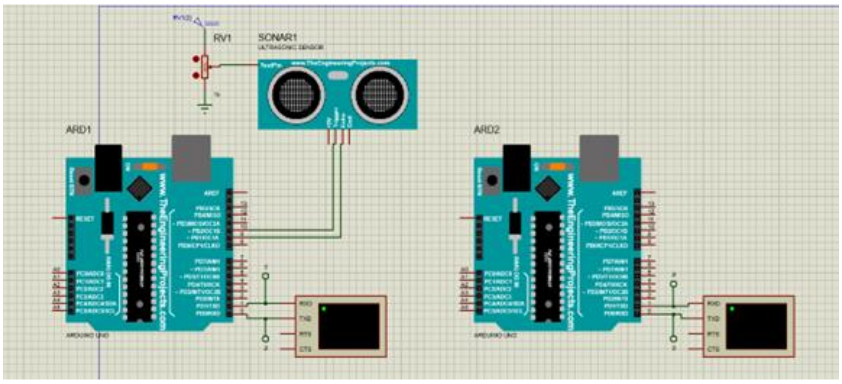

Figure 3: Circuit Diagram of IoT Flood Detector

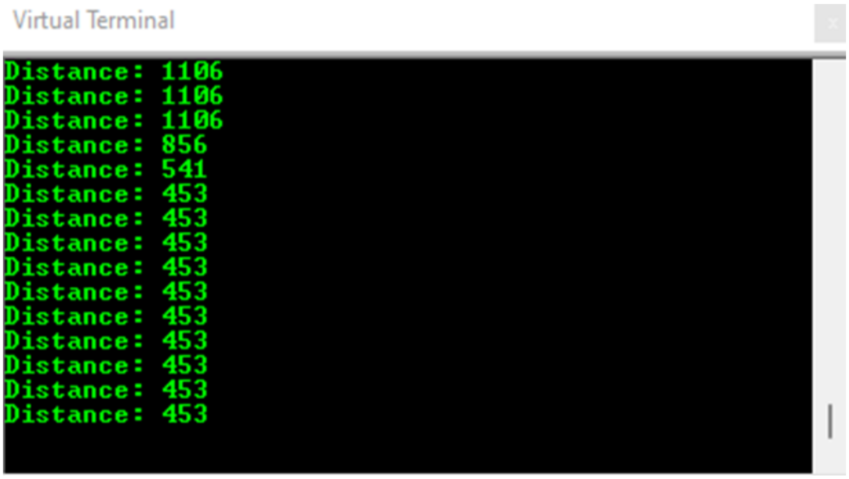

Figure 4: Results on Virtual Terminal

3.1 Readings on LoRa Transceiver

Referring to Figure 5 and 6, the simulation of the hardware on the virtual terminal shows that the LoRa at the transmitter circuit was able to communicate with one other by sending signals to the LoRa receiver. Both LoRa transceiver were using 433-MHz frequency to communicate with each other and were able to send the signal through and fourth wirelessly.

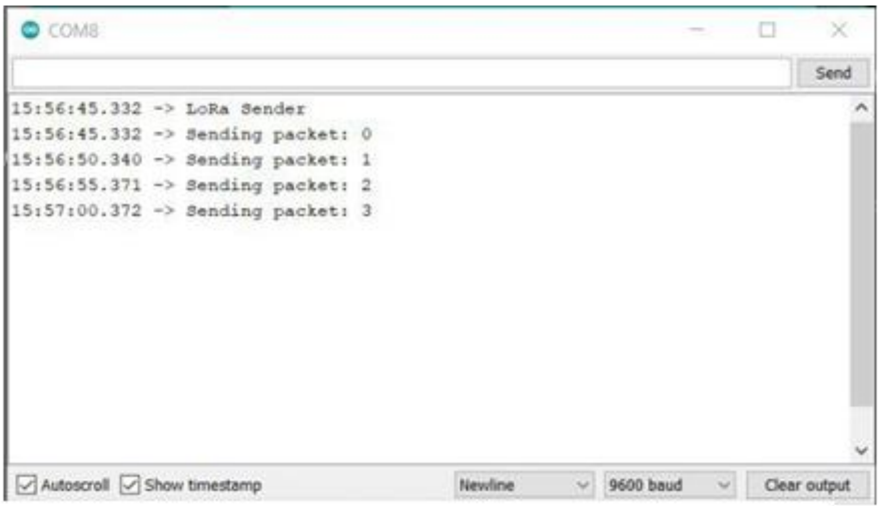

Figure 5: LoRa Transmitter Transmitting Data

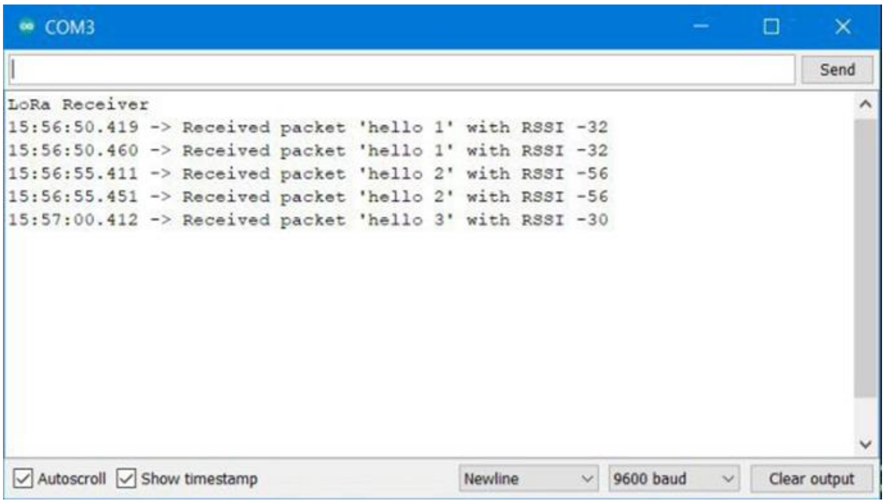

Figure 6: LoRa Receiver Receiving Data

3.2 Flood data

The system was outfitted with three distinct indicators of output devices and peripherals, each of which delivered crucial information in a manner that was both more precise and efficient. LCD display, the Blynk android application, and a buzzer are all examples of output devices that were incorporated. A container with a height of 15 cm was used to hold water, and the water level was raised incrementally by 1 cm at regular intervals.

Figure 7 showed the method used to test the flood detector. The ultrasonic sensor was faced downwards toward the water to measure the distance of water level. While in Figure 8 shows the results to be shown on the LCD and IoT Blynk application on a smart device.

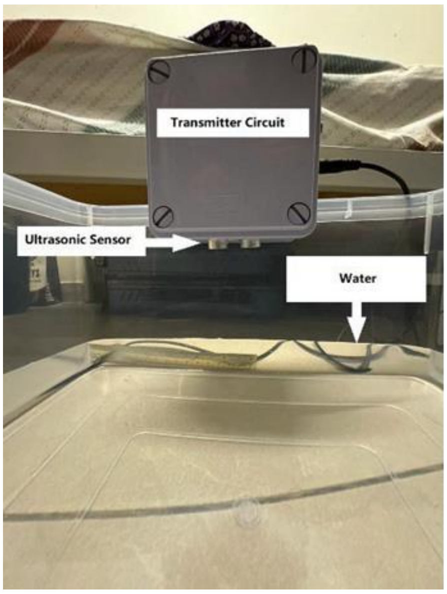

Figure 7: System Hardware Test

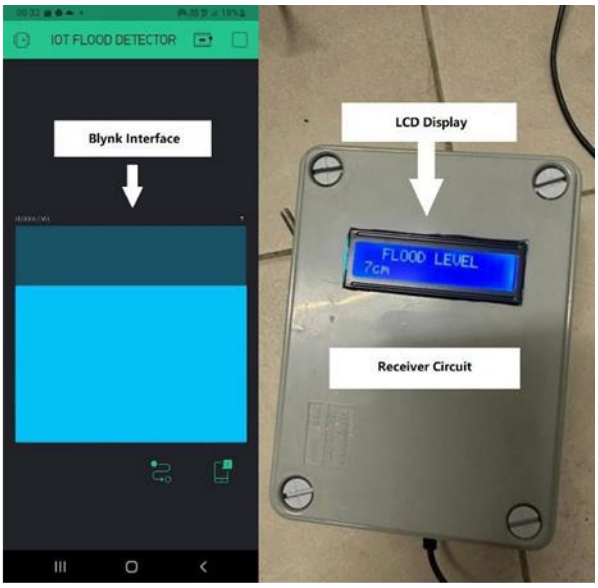

Figure 8: Display Result on Blynk and LCD

Referring to Table 1, it showed that the sensor was able to collect information regarding the changes of water level with the ultrasonic sensor and sends the data to the receiving circuit to be displayed on the LCD. On the side of the buzzer, the buzzer would only be activated whenever the water was 4 cm away from the ultrasonic sensor to be a warning sign indicating that it was on a danger level.

Table 1: Flood Data

Distance of Water	LCD Display	Blynk Display	Buzzer Sound
15 cm	15 cm	15	NO
14 cm	14 cm	14	NO
13 cm	13 cm	13	NO
12 cm	12 cm	12	NO
11 cm	11 cm	11	NO
10 cm	10 cm	10	NO
9 cm	9 cm	9	NO
8 cm	8 cm	8	NO
7 cm	7 cm	7	NO
6 cm	6 cm	6	NO
5 cm	5 cm	5	NO
4 cm	4 cm	4	YES
3 cm	3 cm	3	YES
2 cm	2 cm	2	YES
1 cm	1 cm	1	YES

3.3 Flood Data (Outdoor Simulation)

The sole function of the internet of things (IoT) flood detector was to determine the height of the water level. But if it were to be placed outside on the actual field, there would be a few natural occurrences that would need to be taken into mind, such as the flow of the tides and the waves. In order to recreate this, water was placed inside of a container, and then the container was lightly shaken for a period of 15 seconds to simulate the movement of waves while data was recorded. The water level that was measured for a period of twenty seconds is presented in Table 2.

Table 2: Recorded Water Level

Time (s)	Recorded water level
1s	10 cm
2s	10 cm
3s	9 cm
4s	8 cm
5s	10 cm
6s	10 cm
7s	10 cm
8s	10 cm
9s	10 cm
10s	9 cm
11s	10 cm
12s	10 cm
13s	10 cm
14s	9 cm
15s	10 cm

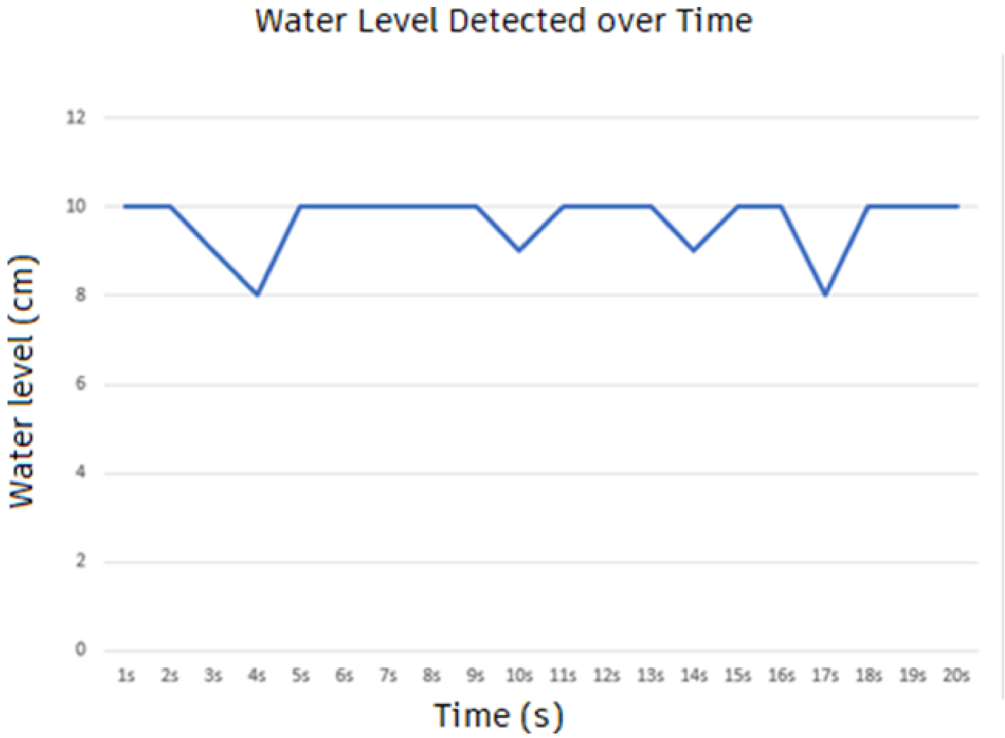

Figure 9: Recorded Graph of Water Level

As shown in Figure 9 with a line graph, the value detected rises and drops between 10 cm to 8 cm as the water waves moves. As the mathematical overall value of the water level was 10 cm, that would be actual value of the water level.

3.4 Battery Life

The transmitter circuit of the system which contains components such as Arduino Uno Microcontroller, LoRa transmitter and an ultrasonic sensor. Whole systems were powered by two batteries and were charged by a solar panel. For the testing of battery life, transmitter circuit was drained of power completely and then recharged with solar panel. A direct exposed of sunlight on the solar panel for 6 hours can power the transmitter circuit for an approximate duration of 3 day

3.5 Transmitter Circuit Module

Hardware of the transmitter circuit is depicted in Figure 10. The transmitter circuit was connected to a 13V 5W output solar panel to provide power to the whole circuit with its components. Both batteries with the overall capacity of 3400 mAh were implemented to store power harvested from the solar panel. Arduino uno microcontroller is used to control the ultrasonic sensor for water level sensing, and a LoRa SX1826 transmitter module was also connected to the Arduino board for the establishment of connection with the receiver circuit for data sending purposes.

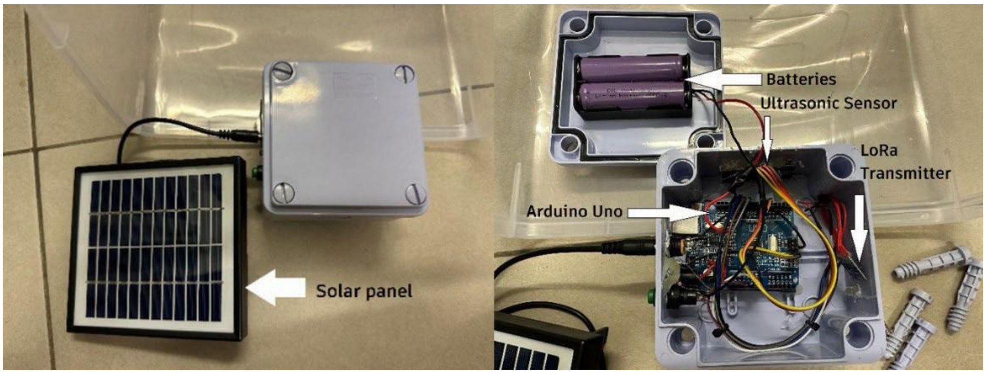

Figure 10: Transmitter Circuit Hardware

Figure 11 depicts the various components that make up the receiver circuit. In order to turn on the circuit and all of its components, the receiver was connected up to a power adaptor with 3 pins and operated at 5 Volts. In order to control the functionality of the sensor and the components, an Arduino Uno board is utilized. LCD display has been incorporated for the purpose of displaying the data that has been gathered, and a Lora receiver has been made use of for the purpose of receiving data that has been transmitted from the transmitter. In order to send data about floods to the IoT cloud and display it on the Blynk smart device application, a NodeMCU8266 wifi module was connected to the board. A buzzer is employed as a warning siren to alert the user in the event that the flood has reached a potentially hazardous level that is less than 4 cm.

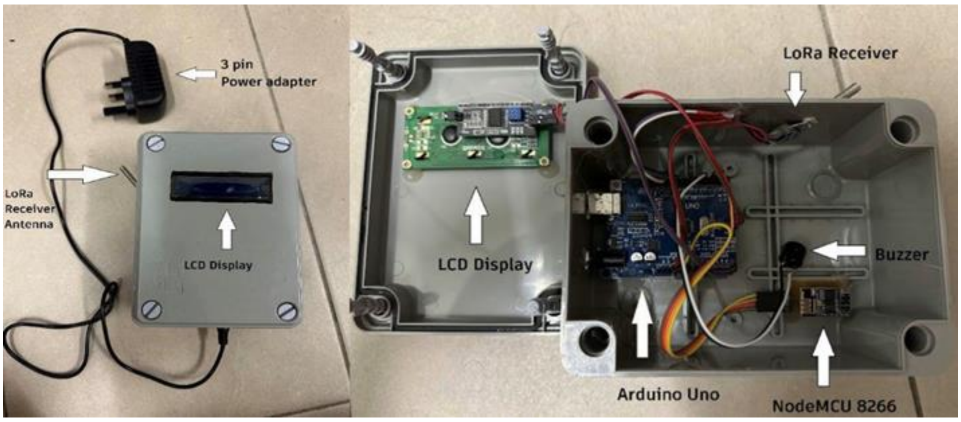

Figure 11: Receiver Circuit Hardware

4. Conclusion

The objective of the Solar Powered IOT based Flood Detector has been successfully achieved partially. Based on the development objectives, the ultrasonic sensor used were able to detect the rises of waer level and stability of water level to be measured simulating water flow during outdoor conditions. The LoRa transceivers were able to communicate with each other by sending the collected data from the sensor at the transmitter circuit to the receiver circuit. On the side of the receiver circuit, after collected the data by the LoRa receiver, the data is able to be processed by the Arduino Uno microcontroller and displaying a clear reading of measurements on the LCD display. However, there was a shortcoming in the site of IoT Blynk application as the server has been shut down on January 2023 and a readings on the Blynk application were interrupted on the later period of developing the project. This causes the users were only able to access the upload data real time via the LCD screen displayed on side of the receiver circuit. This system is a cost efficient and practical implementation.

Solar Powered IoT flood detector will be able to solve flood problem that has been plaguing Malaysia for the longest time. It is also a potential in saving countless lives.

Acknowledgement

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