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Research paper

The concept of Arduino based on Wireless communications for flood warning system

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Abstract

Wireless communication for flood monitoring is developed to observe the status of flooding which could alert people who were in the area when it happens. Flood is a very common problem that Malaysian faced every year caused by the change of climate and also due to urbanization. These floods can cause a lot of damages and can even endanger to human lives. The flooding can be caused by the over-flowing of rivers or drains in the affected area. Problems in rural areas near the river bank, not all equipped with flood warning system. Flood warning system is usually found in the main streets with limited warning distance. Therefore, it is necessary to put a wireless communication system that can detect the rising water levels during flooding and also gives warn the local residents especially those who live along the river banks. This system can be used as flood monitoring tool as well as for evacuation during save and rescue operation. The purpose of this paper is to propose a wireless communication based on Arduino system that can help the local residents by detecting the water levels and give an early warning when a flood occurs. Basically, there are two part of the system which are the sensor node and the base station that can generate warning signal during flooding to the affected area.

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Keywords: *Wireless communication, Arduino, flood*

1. Introduction

One of the unexpected natural phenomenon that occurs around the world is a sudden heavy rainfall which are caused by the change in climate and an increasing in urbanization [1-2]. This sudden heavy rainfall can cause floods which is one of the frequent problems that Malaysian people faced especially during the monsoon season. The damages caused by these floods are huge where people need to be evacuated, properties are lost, schools are closed and endanger the human lives. This research uses the wireless communication consisting of sensor node network and a bluetooth. Here, a bluetooth acts as a communicate medium between the sensor node and the base station. The wireless communication network consisting of a sensor node connecting with the ultrasonic sensor detects the current water level and transmit it to the base station via bluetooth. Micro-sensor networks is one of the most important technologies for the 21st century and it can be used for environmental applications such as flood detection [3]. Research on flash flood based on the concept of warning system consisting of a system that uses SCADA, PLC and wireless level sensor [4]. An early flood warning system using a GSM modem that can transmit data via SMS was created [5].

It can be customized so that it is easier to set this system at various spots or areas prone to flooding with various alert levels. The benefit of the GSM modem was that the user can received the warning message wherever but only if the area is covered with GSM signal. Flood is a phenomenon where there is an overflow of water that submerges lands that are usually dry. It can be an overflow of water from a lake, river or drain that is caused by sudden heavy rainfall. The change in climate can also cause flood and this is because climate change increases the probability of some types of weather like heavy rainfall. Climate change means there is an increase in warm air and warmer air holds more moisture than normal air. Another factor of flooding is an in increasing of urbanization when people migrate from rural to urban areas [1-2]. Urbanization happens due to inappropriate construction of drainage system in the area. Floods can cause a lot of damage and have a devastating effect on the environment, economy and people. The water can be contaminated with hazardous substance which can cause diseases that can affect human health. The aim of this research is to design and construct a wireless communication flood warning system based on Arduino and Bluetooth in order to warn the local residents in the affected area during flooding.

2. Experimental Work

The project focuses on an early flood warning system to help the citizens when a flood occurs. The operator only needs to observe the base station box to know the distance of the water from the sensor node and act accordingly when the water reaches a dangerous level. The process must be determined first in order to have a more understanding on how this system works. Figure 1 shows the block diagram for the sensor node (master) and Figure 2 shows the block diagram for the base station (slave). The sensor node uses the ultrasonic sensor as its input. Just like sonars and radars, the ultrasonic sensor emits ultrasonic wave and the wave is then converted to electrical signals. The method used by this sensor is by transmitting a high frequency short duration ultrasonic pulse into the system. Since the sensor is an electronic component, it must avoid direct contact with the water as the water can damage the component. The time taken for the echo signal to return from the surface of the water indicates the depth of the water [6].

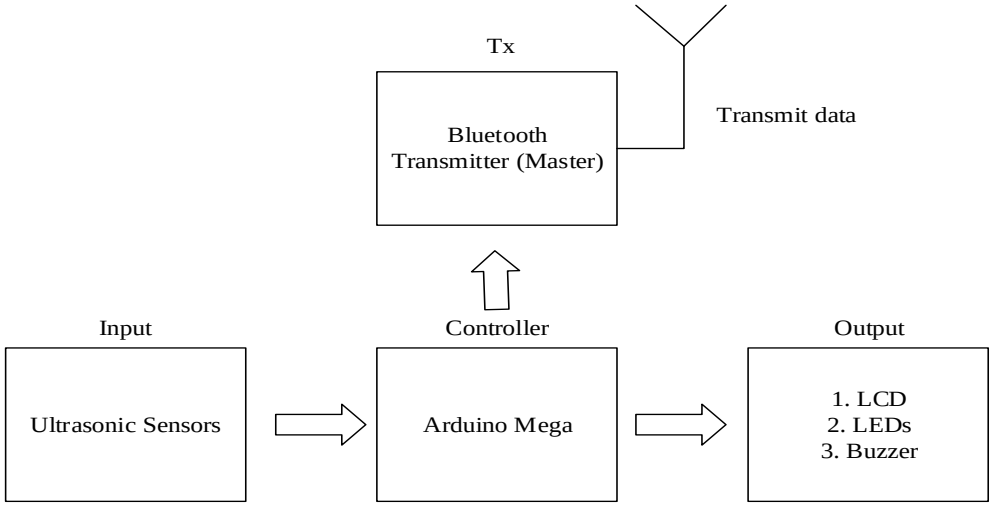

Figure 1: Block diagram of sensor node

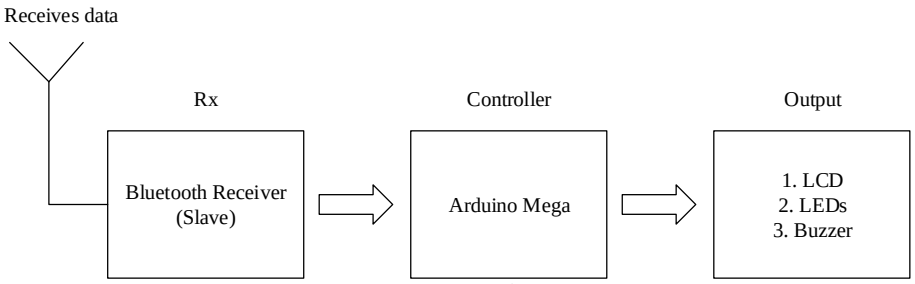

Figure 2: Block diagram of sensor node

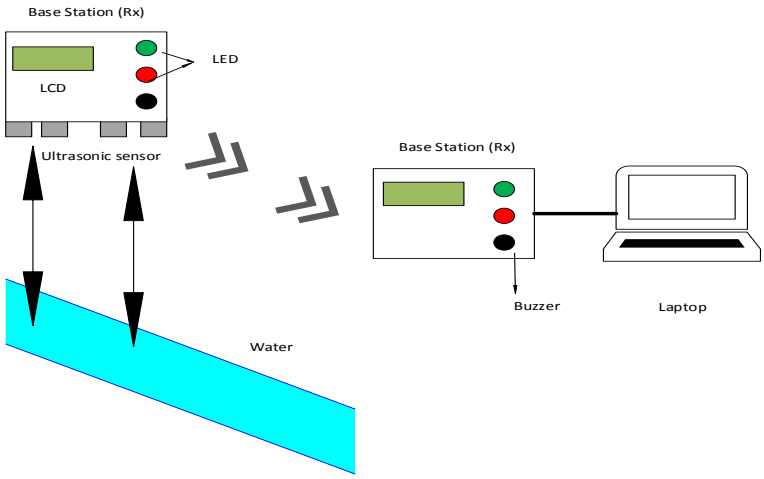

Figure 3: Flood monitoring system setup

The shorter the time taken for the signal to return, the higher the level of water. This system will determine whether the level is dangerous or not. If the level is higher than the set level, the output which is the alarm will turn on. The values will be displayed at both the transmitter (Tx) and receiver (Rx) side for easy monitoring.

Two boxes are used in this work, one is for the sensor node and the other is for the base station. The sensor node has two sensors, one Bluetooth, one LCD, two LEDs and one buzzer. While the base station has one Bluetooth, one LCD, two LEDs and one buzzer. By using a box shape for the sensor node, the sensors can be aligning properly. When the sensors are at the same level, the readings from both of them will be the same and this will make the readings more accurate. As for the base station, the design is the same as the sensor node but without the sensors. This design needs to be simple so that the operator can easily understand how to use the device. Figure 3 shows the design for the flood warning system setup diagram.

2.1 Controller

He controller for this project is an Arduino Mega 2560. It is a microcontroller based on the ATmega2560 with 54 digital input and output pins, 16 analog pins and 4 UARTs or hardware serial ports. A 16MHz crystal oscillator, a reset button, an ICSP header, a USB connection and a power jack are also included on this board. The recommended input voltage for this is between 7V and 12V. It has DC current of 20mA for each of the input/output pins with a flash memory of 256KB.

2.2 Input

The sensor node uses the ultrasonic sensor as its input. Just like sonars and radars, the ultrasonic sensor emits ultrasonic wave and

the wave is then converted to electrical signals. The method used by this sensor is by transmitting a high frequency short duration ultrasonic pulse into the system [4]. Since the sensor is an electronic component, it must avoid direct contact with the water as the water can damage the component. The time taken for the echo signal to return from the surface of the water indicates the depth of the water [4]. The shorter the time taken for the signal to return, the higher the level of water. The HY-SRF05 ultrasonic sensor uses sonar to determine distance from the sensor to an object. It provides the distance from an object regardless of sunlight or colour of the object.

The range for the sensor to detect is between 2cm to 500cm and it has a resolution of 2mm compared to HC-SR04 which is only 3mm. The device sends a pulse for 10us to the Trigger pin and the ultrasonic sensor will automatically send eight 40 kHz square waves. When the signal is reflected back, the Echo pin will output a high level and the duration is the time taken for the launched ultrasonic to return. Speed of sound = 340m/s = 29.41us per centimeter where: distance (cm) = (Time x Speed of Sound) / 2 / 100 0r distance (cm) = Time (in us) / 2 / 29 [6].

2.3 Bluetooth Transceiver

Bluetooth is a short range wireless communication that uses radio waves to exchange data between devices which operates at a frequency between 2.4GHz to 2.485GHz [5]. The Bluetooth HC-05 is used to communicate between the sensor node and the base station. The range is approximately 10m and can operate at 5V. For this project, the Bluetooth at the sensor needed to be set as a Master and the Bluetooth at the base station as a Slave through the AT mode. This will enable the data to be transferred from Master to Slave.

2.4 Output

The outputs for both the sensor node and the base station are LCD for displaying the distance, LED and buzzer for the alarm.

2.5 Input Output Assignments

Before designing the schematic diagram, the placements and ports used by the inputs, and outputs must be decided first to avoid any malfunctions or hardware problems. Table 1 shows the inputs and outputs assignments for the sensor node.

Table 1: The input output assignments of Arduino

Inputa and outputs	Arduino ports
Ultrasonic sensor 1	A0,A1
Ultrasonic sensor 2	A14, A15
LCD	12,11,7,6,5,4
LED1	26
LED2	32
Buzzer	42
Bluetooth	0,1

3. Results and Discussion

Two types of experiment were conducted which are indoor test and outdoor test to test the functioning of the wireless communication system based on Arduino and Bluetooth. The first experiment was conducted in the Laboratory of Robotic, Faculty of Electrical Engineering, UiTM Shah Alam, Selangor. This indoor test acts as a test pilot where the sensors were placed at the top of the bucket. For the outdoor test, the sensor node was placed 64cm above the drainage system of UiTM Shah Alam where flooding always happened at Jalan Ilmu 1/1 near the Office of International affairs. Figure 4 shows the set up for the indoor test while Figure 5 shows the set up for the outdoor test.

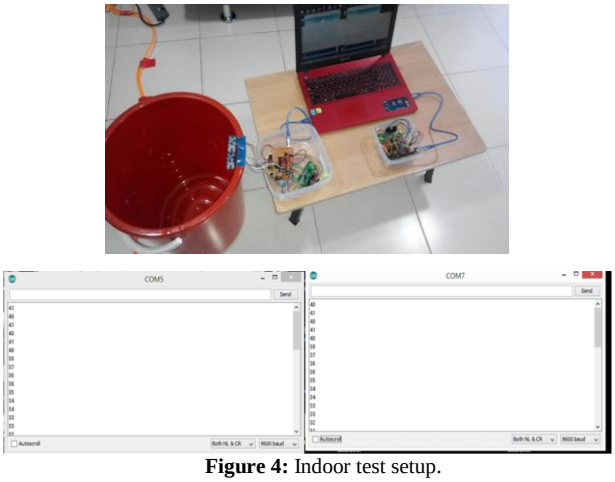

Figure 4: Indoor test setup.

Figure 5: Outdoor test setup

The maximum distance of the ultrasonic sensor to the bottom of the bucket is 41cm. Water is then filled into the bucket and the data transmitted from the sensor node to the base station was recorded. In this research, three outputs are used as a monitoring flood system which consist of LCD, LED and buzzer. The system has been programmed to display these three outputs when their conditions are met according to the set point. Table 2 shows their respective conditions and the outputs.

Table 2: System outputs

Water level (%)	Outputs			
	LED1	LED2	Buzzer	LCD
0-64	On			Safe
65-79	On	On		Warning
80-100	Blink	Blink	On	Danger

Table 3 shows the recorded data. The average distance for the first test is 165cm, for the second test is 168cm and the last test is 167cm. The distance increases on the second test when compared to the first test and on the third test it decreases when comparing to the second test.

Table 3: Statistical analysis of water absorption of after exposure to different relative humidity, compared between different densities

Time (s)	Sensor Node (Tx) (cm)	Base station (Rx) (cm)
2	41	41
4	40	40
6	41	41
8	40	40
10	41	41
12	40	40
14	38	38
16	37	37

18	36	36
20	36	36
22	35	35
24	34	34
26	34	34
28	33	33
30	33	33
32	32	32
34	31	31
36	32	32
38	31	31
40	31	31

4. Conclusion

As a conclusion, this research shows that the wireless communication system based on Arduino controller and Bluetooth can detect the water level and gives warning automatically as an early warning when there is a flood happened in the respective area. In addition, this research used a low-cost component such as Arduino, ultrasonic sensor, LCD, LED, buzzer and also Bluetooth module. The design of this wireless communication system is very simple and affordable. Therefore, this wireless communication system can help the local residents reducing the damages caused by floods. The important part of this system is that the ultrasonic sensor will detecting the water level while the Bluetooth sending the data from the sensor node to the base station. The base station must be within the range of the sensor node so that it is able to function properly.

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