IOP Conf. Series: Materials Science and Engineering **308** (2018) 012031 doi:10.1088/1757-899X/308/1/012031

Design of river height and speed monitoring system by using Arduino

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Abstract. River is one part of the hydrologic cycle. Water in rivers is generally collected from precipitation, such as rain, dew, springs, underground runoff, and in certain countries also comes from melt ice/snow. The height and speed of water in a river is always changing. Changes in altitude and speed of water can affect the surrounding environment. In this paper, we will design a system to measure the altitude and speed of the river. In this work we use Arduino Uno, ultrasonic sensors and flow rate sensors. Ultrasonic sensor HC-SR04 is used as a river height meter. Based on the test results, this sensor has an accuracy of 96.6%.

1. Introduction

Monitoring technology increasing along the development of information technology especially in the field of IoT [1-2]. Monitoring technology has been widely used in various fields. Direct monitoring helps us to conclude a problem or make decisions. It is also supported by advances in remote communications technology for control and monitoring [3-4]. In disaster management, this is very petrified. Therefore, in this research we develop a river monitoring technology.

River is a part of the hydrologic cycle. The height of the river surface is a condition that must be considered especially in the rainy season. If the river is not able to accommodate the water volume, the water will inundate the land and this condition is called the flood. The impact of flooding can be reduced by monitoring the altitude and the speed of the river flow so it could be an early warning before the flood happened.

There were several studies done before on monitoring technology especially for disaster management. Some researchers have designed monitoring technology to monitor air pollution [5-6]. In addition, telecommunication monitoring has been carried out to monitor water quality [7-8]. Research on river water monitoring has also been conducted primarily for monitoring the water quality of the river [9].

Different from previous studies, in this study we will conduct the design of speed monitoring technology and the water level in detects flooding. The design is done by using Arduino as the control center. Arduino commonly used for the design of monitoring technology [10].

2. Materials and Methods

2.1 System Requirements

In this system design, it uses Arduino Uno, G3 / 4 water velocity sensor and HC-SR04ultrasonic sensors. Arduino UNO is a microcontroller board based on ATmega328 [11]. The Arduino UNO has 14 digital

input / output pins, 6 analogue inputs, a 16 MHz Crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

The HC-SR04 ultrasonic sensor is an ultrasonic wave-based distortion sensor. This sensor working principle is similar with the ultrasonic radar [12]. The ultrasonic wave is transmitted and then received back by the ultrasonic receiver. The distance between transmit time and receive time is a representation of the distance of the object. This sensor is suitable for electronic applications that require distance detection [13]. It can be seen in figure 1.

Figure 1. HC-SR04 Ultrasonic Sensor

The G3 / 4 Water Velocity Sensor consists of a plastic body, rotor and hall-effect sensor [14]. When water flows through the rotor, the rotor spins. The rotation speed of the rotor changes along the speed of the water flow. The output hall sensor is a pulse signal. It can be seen in figure 2.

Figure 2. G3/4 Water Velocity Sensor

2.2 Design of Water Height Measurement

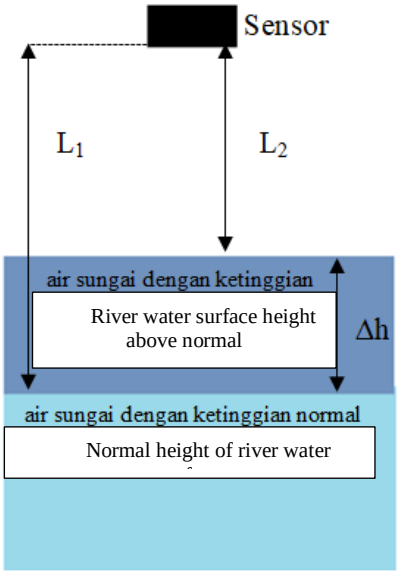

Figure 3. Ultrasonic Sensor Design Formula

Ultrasonic sensors are generally used as a distance meter. In a flood early warning system, ultrasonic sensors are used as a measure of river water level. The ultrasonic sensor is placed on top of the river water facing downward as shown in figure 3.

To calculate the height of river water then the formula used is:

$$\Delta h = L_1 - L_2$$

While:

Δh : Changes of water level

L_1 : Distance between the sensor with normal height river surface.

L_2 : Distance between the sensor with the river above the normal surface.

2.3 Hardware Design

In the phase of hardware design, the system is built for flood-prone river settlement areas. This system consists of several sensors, microcontroller and Arduino. The sensors used in this system are ultrasonic sensors and water velocity sensors. Ultrasonic sensor is used to measure the height of river water while the water velocity sensor serves the measurement of the river water speed. The sensors measurement data will be processed by Arduino microcontroller. The schematic circuit can be seen in figure 4.

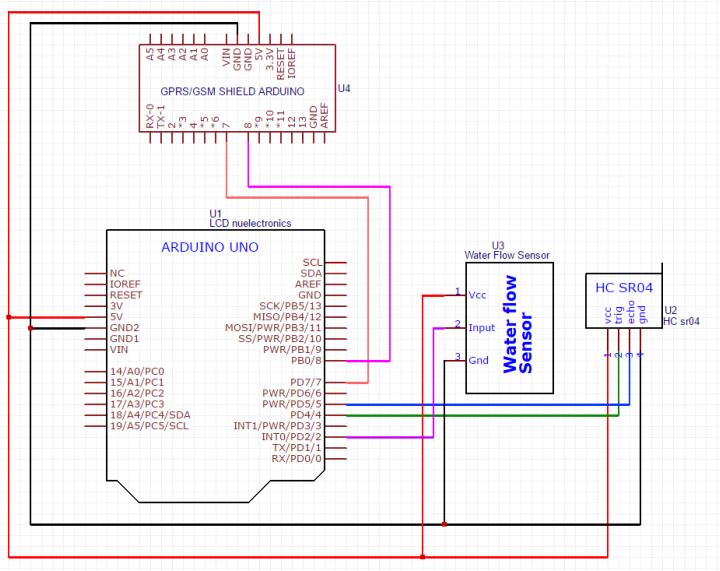

Figure 4. The schematic circuit of system

Here is an explanation of the schematic circuit drawing system:

1. Arduino Uno serves as a mainboard that controls all the components in the system. Arduino Uno uses a 11.1 volt Li-Po battery as its power supply.
2. The water velocity sensor has three pins namely vcc, signal and gnd. The signal pin is connected to the 2nd pin of the Arduino because the Arduino Uno reads numbers of pulse signals from the water velocity sensor using its interrupt function. Arduino has two pins that also have interrupt function which are 2nd and 3rd pins.
3. HC-SR04 Ultrasonic Sensor has four pins namely vcc, triger, echo and gnd. Triger pin is used to emit ultrasonic waves while the echo pin serves to receive ultrasonic waves. Triger pin on ultrasonic sensor is placed to 4th pin in Arduino and echo pin connected to 5th pin of Arduino.

3. Result and Discussion

3.1 Ultrasonic Sensor as Water Height Measurement Tool Test and Analysis

The test of ultrasonic sensor performed in a 50cm tub. The ultrasonic sensor is placed on top of the tub and connected to the Arduino. While the Arduino is connected to the laptop via a USB cable to see the

results of sensor measurements in the serial monitor. Then the tub is filled with water until the water level reaches a predetermined height. The sensor measurement results will be compared with the measurement manually (measuring the distance of the sensor to the water surface by using the meter). In this test, the distance between the ultrasonic sensor and the water surface is 136 cm.

Ultrasonic sensor test results as a height meter can be seen in table 1. From the table can be seen that the difference between the measurement of the sensor with manually measurement results. Water surface at an altitude of 0.08 m to 0.27 m has a measurement difference of 4 cm while the water level at an altitude of 0.31 m to 0.47 m has a measurement difference of 3 cm. This is because the average accuracy of distance measurements by using ultrasonic sensors at a distance of 0.8 meters to 1.3 meters is 96.6%. Although this sensor has an average accuracy of only 96.6%, it can still be tolerated to be implemented in this system.

Table 1. Testing Results Table

Water level (m)	Measured water height by sensor (m)	Distance from the sensor to water surface (m)	Distance by sensor (m)	Accuracy (%)
0.08	0.12	1.28	1.24	96,87
0.14	0.18	1.22	1.18	96.72
0.19	0.23	1.17	1.13	96.58
0.24	0.28	1.12	1.08	96.42
0.27	0.31	1.09	1.05	96.33
0.31	0.34	1.05	1.02	97.14
0.35	0.38	1.01	0.98	97.02
0.41	0.44	0.96	0.93	96.87
0.47	0.51	0.89	0.85	95.50

3.2 Waterflow Sensor Testing

During this section, the water velocity sensor testing has been done. This test was carried out by placing the water velocity sensor in the stream and monitor the measurement results in the monitor series. Sensor measurement results can be seen in figure 5.

Figure 5. Waterflow Sensor Testing Result

3.3 Implementation on River Flow

System testing is done by combining the entire system device and a pre-designed testing program. The test was performed on March 1, 2017 where the test duration was approximately 27 minutes. This test is done in the Juanda River Deli. In this test, the distance of the ultrasonic sensor to the surface of the river at normal altitude is 1.65 m.

Figure 6. Assembling Devices Constructions Results

During this test, the first thing to do is the installation of hardware consisting of mainboard & sensor to its construction as shown in figure 6. Then the construction is placed at the edge of the river whose position has been determined before. The position of the apparatus shall be fixed so that the distance of the ultrasonic sensor to the normal surface of the river water remains unchanged. Then the tool is turned on to start sensor readings and perform data monitoring. Implementation of the system can be seen in figure 7.

Figure 7. Implemented Tools

River water level data graph can be seen in figure 8. In figure 8 can be seen that at 09:31 until 09:55 show the level of river water surface decreased from 65 cm to 60 cm. At 09:39, the water level of the river is 62 cm above the normal surface while at 09:42 the water level rises again to 64 cm above the normal surface. This indicates there was an error reading of the ultrasonic sensor that may be caused by noise. Noise in this case can be the floating objects flowing in the river that reduced the accuracy of sensor measurement.

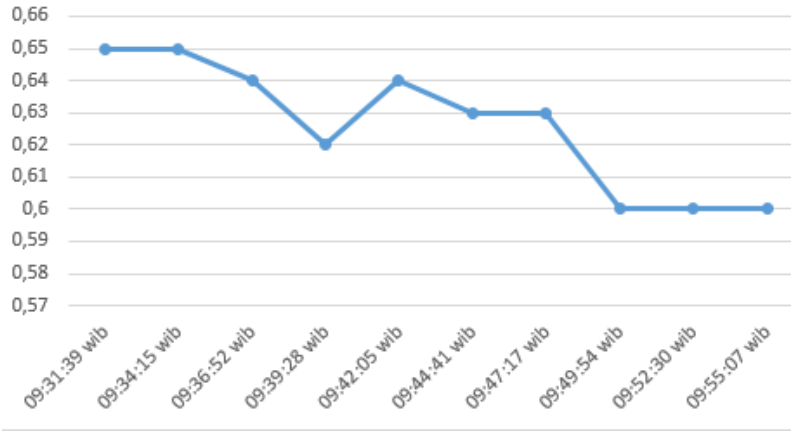

Figure 8. River Water Height Graph

4. Conclusion

From the test results above can be seen that the system can be realized in the river flow to monitor the height of river water and water velocity. From testing the water level is known that HC-SR04 sensor has an average accuracy about 96.6%. While implemented in the river flow there are several water level errors due to the floating objects flowing in the river through the ultrasonic sensor.

5. Future Works

For further research, this system will be developed by sending river water level data and stream flow rate data into the database server. Furthermore, web pages can be created to monitor the data remotely. The system is also can be applied to perform early detection of floods.

Acknowledgments

The authors gratefully acknowledge that the present research is supported by Ministry of Research and Technology and Higher Education Republic of Indonesia. We thank the Vice Rector for Research, Service, and Cooperation University of Sumatera Utara that have supported this research activity. All the faculty, staff members and lab technicians of Electrical Engineering Department, whose services turned my research a success. My Wife, Erna Kurnia and children, Zafran Ahmad Nasution and Zaura Aisya Nasution, family members and friends, without whom I was nothing; they not only assisted me financially but also extended their support morally and emotionally.

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