P-ISSN: 2723-8202
E-ISSN: 2503-1171
Volume 6, No 3, Des 2021, Page: **205-212**

JURNAL TIKA
Fakultas Ilmu Komputer Universitas Almuslim
http://www.journal.umuslim.ac.id/index.php/tika/index
https://doi.org/10.51179/tika.v6i03.661

DESIGNING ARDUINO-BASED SLUICE CONTROL SYSTEM WITH SELF-CHECK SENSOR FEATURE

Balqis Yafis[1], Rahmat[2]
[1,2] Fakultas Ilmu Komputer dan Multimedia, Universitas Islam Kebangsaan Indonesia
Email: [1]balqisyafis@gmail.com,[2]rahmat.mtk88@gmail.com

Abstract

[Designing Arduino-Based Sluice Control System with Self-Check Sensor Feature] The use of Arduino-Based floodgates aims to address the issue of flooding. The goal of this research was to create a system that could monitor water levels and control floodgatesUltrasonic sensor was used to measure water level, as the water level becomes the indicator to open and close the floodgates. The ultrasonic sensor is mounted on the dam and measures the distance between the water's surface and the sensor transmitter. The results of the measurement of the water level are used to control the floodgates. Sensor measurement results are not always valid, given the age of the sensor and the terrain around the dam is quite challenging. The self-check sensor feature is introduced in this study as a way to overcome detection faults in the system, where ultrasonic sensors can perform self-monitoring by relying solely on their neighbours. In general, the process is carried out in four stages, starting from the stage of reading the sensor, the stage transmitting and receiving data from the Arduino, the stage of detecting sensor's value, the stage of displaying the sensor values. At the stage of displaying the sensor value, there are four water level conditions, normal, waspada, siaga and bahaya. According to the test results, incorporating self-check sensors into the system enables for more efficient Arduino-based sluice control systems, as well as the possibility of detecting malfunctions caused by sensor damage.

Keywords: Prototye, Automation, Internet of Things.

Abstrak

Penggunaan pintu air berbasis Arduino merupakan salah satu upaya untuk mengatasi masalah luapan air atau banjir. Penelitian ini merancang sebuah sistem yang mampu mendeteksi ketinggian air dan mengontrol pintu air. Sensor yang digunakan adalah sensor ultrasonik, sebagai indikator yang digunakan untuk mengukur ketinggian air. Sensor ultrasonik diletakkan di atas bendungan, kemudian sensor tersebut akan mengukur jarak permukaan air dengan transmitter sensor. Hasil pengukuran ketinggian air tersebut dievaluasi oleh fitur *self-check sensor*. Hasil pengukuran sensor tidak selamanya valid, mengingat usia sensor dan medan di sekitar bendungan yang cukup menantang. Penelitian ini memperkenalkan fitur self-check sensor sebagai solusi untuk mengatasi kesalahan deteksi pada sistem. Dimana sensor dapat melakukan swa-monitoring dengan hanya mengandalkan sensor ultrasonik di sekitarnya. Secara umum, proses yang dilakukan ada empat tahap, dimulai dari tahapan pembacaan sensor, tahap pengiriman dan penerimaan data dari Arduino melalui transmitter, tahap tampilan nilai sensor dan tahap buka tutup pintu air. Pada tahap menampilkan nilai sensor terdapat tiga kondisi ketinggian air, normal, waspada, awas dan bahaya. Menurut hasil pengujian, menggabungkan *self-check sensor* ke dalam sistem memungkinkan sistem monitoring pintu air berbasis Arduino yang lebih efisien, serta kemungkinan mendeteksi malfungsi yang disebabkan oleh kerusakan sensor.

Kata Kunci: prototype, otomasi, Internet of Things.

1. Introduction

Flooding is a form of natural phenomenon that occurs due to high rainfall intensity where there is excess water that is not accommodated by the system. Based on BNPB data, at the beginning of 2020, at least 207 incidents were recorded and dominated by floods. Therefore, it is necessary to organize flood disaster management by monitoring the environment regularly to predict climate change and deal with natural disasters such as hurricanes, floods, droughts, etc. As a developing country, Indonesia should implement a system that is cheap and easy to maintain (Miazi et al., 2016).

The use of floodgates is one of the efforts to overcome the problem of overflowing water or flooding. The door is basically made of a certain sized iron plate, placed at the junction of the primary to secondary or secondary to tertiary channels with an open-close and waterproof system. The distribution of water depends on the flow of water in the main channel, when there is a lot of water, the time to open each channel door can be longer. Meanwhile, when the water discharge decreases, the setting of the opening and closing of the sluice gate is also adjusted (Laumal et al., 2017). The indicator used to open and close the floodgate is the water level (Anday yani et al., n.d. 2016), (Ahmad & Mahpuz, 2018).

The rapid development of telecommunications technology has created a variety of internet-based innovations, the better reliability of the internet network has encouraged people to use the internet for various purposes (Ahmad, 2018). Internet of Things (IoT) as a new field that allows all devices to talk through sensors and actuators provides new opportunities for various aspects that require automation systems. As the founder of the Indonesian IoT forum, Teguh Prasetya said that the IoT market is expected to grow to Rp 444 trillion in 2022 with the need for sensor devices reaching 400 million pieces (Sahid, 2018). The provision of information about the condition of the water level in the dam is very necessary for the preparation of the surrounding area and to increase awareness of the occurrence of flooding, by utilizing ultrasonic sensors to detect changes in the water level of the dam (Hero & Cochran, 2011).

Ultrasonic sensors are sensors that function to change physical quantities (sound) into electrical quantities and vice versa which are converted into distances. The basic concept of this sensor is to utilize the principle of sound wave tuning which can be applied to calculate the distance of objects with a specified frequency according to the suber oscillator. It is called an ultrasonic sensor because this sensor applies ultrasonic waves as its transducer.

The ultrasonic sensor HC-SR04 uses sonar to determine the distance to an object, just as a bat or dolphin would. This sensor has a fairly good accuracy and reading. Its operation is not affected by sunlight or dark colored materials, but is affected by acoustic materials. This sensor has a range specification of 2 cm – 500 cm with a resolution of 0.3 cm, and an angle range of less than 15 degrees.

2. Hardware and Software Component

Table 1. Hardware Component

No	Hardware and Software Component	Function
1	Arduino Uno R3 	Arduino UNO is a microcontroller board based on the ATmega328 microcontroller. Arduino UNO has 14 digital input and output pins, of which 6 input pins can be used as PWM outputs and 6 analog input pins, 16 MHZ crystal oscillator, USB connection, power jack, ICSP header, and reset button.
2	Sensor Ultrasonik HC SR04 	The ultrasonic sensor HC-SR04 serves to measure the distance of an object with a specification range of 2 cm – 500 cm with a resolution of 0.3 cm, and an angle range of less than 15 degrees. Its operation is not affected by sunlight or dark colored materials, but is affected by acoustic materials.
3	LCD 16x2 	LCD (Liquid Crystal Display) is an electronic component that functions as a display of data, whether characters, letters or graphics.

4	Arduino IDE	The Arduino IDE software is used to write and upload programs to an Arduino compatible board. The source code for the IDE is written under the GNU General Public License version 2.

3. Proposed Method

In this study, the research method used is the experimental method. The following is the design of a sluice control system with a self-check feature on the sensor. The prototype circuit of this system consists of three main parts, namely the input block, the process block and the output block. The input block is the data obtained from the ultrasonic sensor which is then entered in the process block. This process is useful for processing data from the sensor which is then sent through the transmitter and will be received by the receiver.

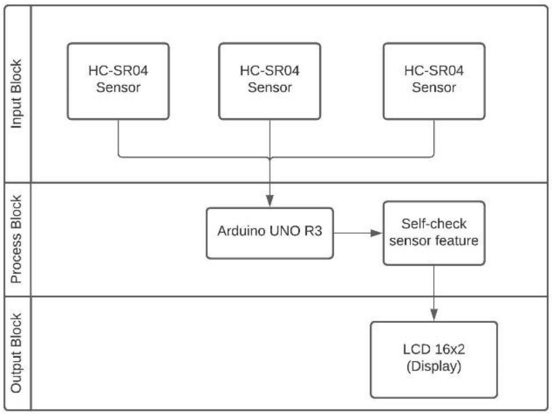

Figure 1. Block Diagram

4. Proposed Method

The data used in this study is data generated by ultrasonic sensors in the form of water level distances. Every 10 seconds the ultrasonic sensor turns on to check the water level. The design proposed in this study is an Arduino-based sluice control system with a self-check-sensor feature. This additional feature complements previous studies with the addition of a self-check-sensor feature as sensor management. The following is a flow chart on the sluice control system in previous studies and a flow chart of how the self-check-sensor feature works.

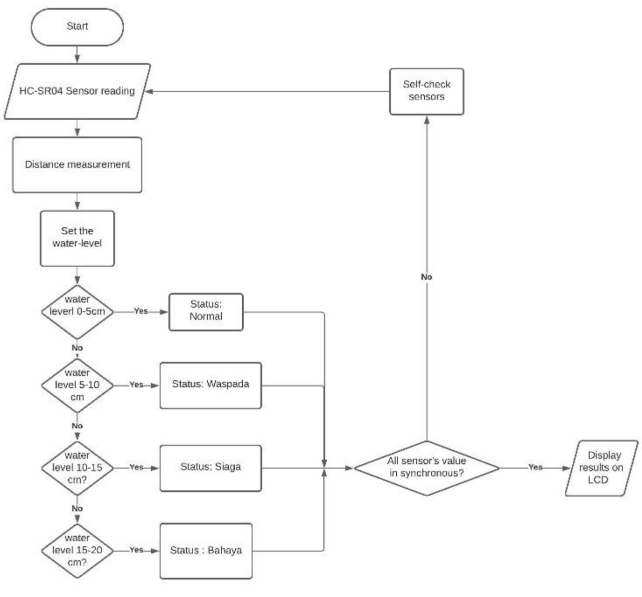

Figure 2. Workflow Diagram

Figure 2 below is a flowchart of how the system works where the sensor performance will be controlled by the Arduino Uno R3 Microcontroller and will activate the ultrasonic sensor. To begin detecting the water level on the prototype, the sensor detection results will be sent to the microcontroller in the form of electrical signal data which is then converted into a digital signal, and will be displayed on the LCD. Sensor values will be classified into 4 groups, Normal, Waspada, Siaga and Bahaya. The water level is different with sensor distance, if the sensor distance is 15 cm, that is means the water level is 5 cm. as detailed in the following table:

Table 2 Alert Status

No	Status	Water level (cm)	Sensor's distance (cm)
1	Normal	0 - 5	15-20
2	Waspada	5-10	10-15
3	Siaga	10-15	5-10
4	Bahaya	15-20	0-5

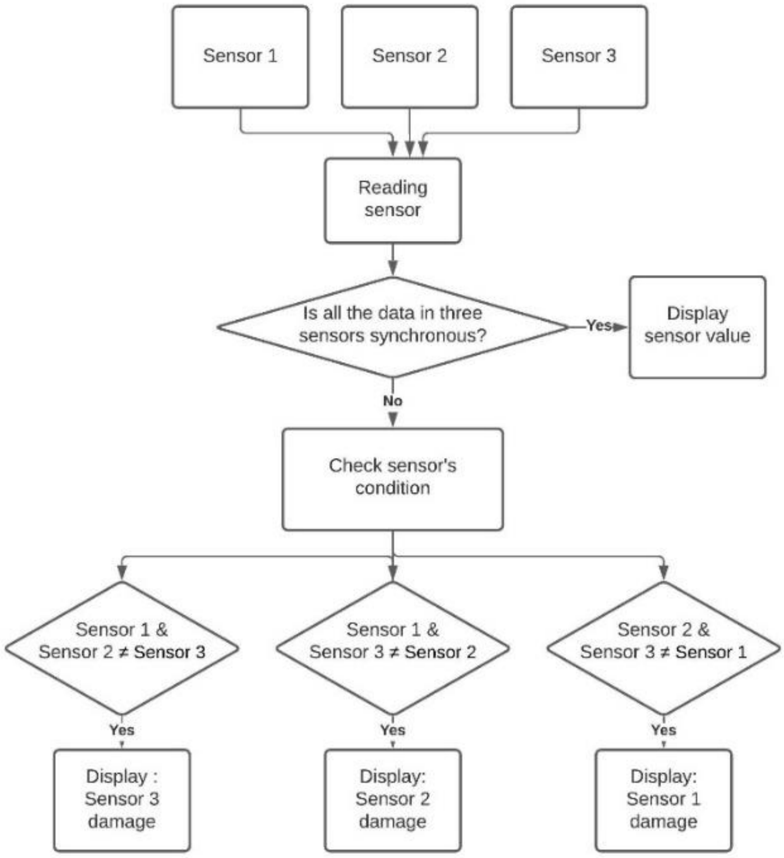

Figure 3. Self-check sensor feature workflow

The system proposed in figure 3 is following the workflow below. The system used three sensors to check water level in the dam, and the data from those three sensors will be compared. By doing this, we can make sure that the sensors always show the correct data. If the data from the three sensors are the same, then system will the result on the screen. And in case that one of the sensors show a different data, then we know that something is wrong in the system and maintenance is needed.

When one of the sensors shows a different data, then the probability of that sensors is damage is high, but the person doing the maintenance need to make sure of this when replacing the sensor. This workflow will help the system to maintain itself to a certain degree and have higher resistance to errors.

Furthermore, in designing this system, a circuit schematic design is carried out to connect the microcontroller with components related to the circuit on each device. The circuit schematic is designed as shown in Figure 4 below.

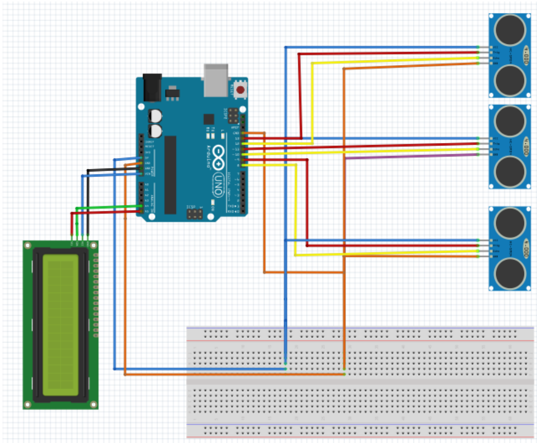
Figure 4. Prototype schematic

Based on the schematic above, the configuration of each pin used in the circuit schematic is shown in the table below.

Table 3 Pin configuration

Pin Sensor	Sensor	Pin Arduino
VCC	Ultrasonic Sensor 1	+5V
Trig 1		8
Echo 1		9
GND		GND
VCC	Ultrasonic Sensor 2	+5V
Trig 2		10
Echo 2		11
GND		GND
VCC	Ultrasonic Sensor 3	Vin
Trig 3		12
Echo 3		13
GND		GND
SCL	LCD	A5
SDA		A4
VCC		5V
GND		GND

5. Testing and Analysis

A. Ultrasonic Sensor (HC-SR04) Testing

Before we apply the ultrasonic sensors (HC-SR04) into the system, we need to clarify the performance of sensor first. We test each sensor one by one as shown in the following figure 5.

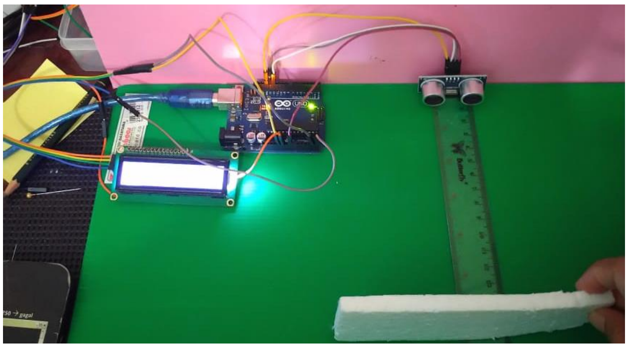

Figure 5 HC-SR04 Sensor's testing

The testing of this research tool includes testing ultrasonic sensor 1, ultrasonic sensor 2, and ultrasonic sensor 3. After testing the tool, then an analysis of the test results is carried out. The error value (%) is calculated according to equation 1 (Shodikin et al., 2021).

$$Error\ rate = \frac{|Sensor\ value - measurement\ value|}{measurement\ value} x100$$

Testing of each ultrasonic sensor is carried out by measuring the water level directly on a miniature sluice gate. The results are then compared with the results of measurements with measuring instruments, in this case a ruler with centimetres (cm). This test is carried out with the aim of knowing the accuracy of ultrasonic sensor measurements. The test results can be seen in Table 3 below.

Table 4 HC-SR04 Sensor compare to the measuring instrument

Value	Measuring instrument (ruler)	Ultrasonic sensor pulse (1)	Ultrasonic Sensor Pulse (2)	Ultrasonic Sensor Pulse (3)
MIN	0 cm	0	0	0
MAX	12 cm	65	64.5	60

Using a scaling technique, an equation is obtained to convert the pulse value to a distance value in units (cm) where to travel a distance of 1 cm the ultrasonic sensor takes 58 s, 29 transmit and 29 s receive.

Table 5 HC-SR04 Sensor test results

No	Pengujian sensor ultrasonik 1			Pengujian sensor ultrasonik 2			Pengujian sensor ultrasonik 3		
	Alat ukur	Sensor	Error (%)	Alat ukur	Sensor	Error (%)	Alat ukur	Sensor	Error (%)
1	1.5	2	33.33	1.5	2	33.33	1.5	2	33.33
2	5.2	5.5	5.77	5.2	5	3.85	5.2	5	3.85
3	6.62	6.5	1.81	6.62	7	5.74	6.62	6.5	1.81
4	7.1	7	1.41	7.1	7	1.41	7.1	7	1.41
5	10.3	10.5	1.94	10.3	10	2.91	10.3	10	2.91
6	12.4	12.5	0.81	12.4	12.5	0.81	12.4	12.5	0.81
7	17.3	17.5	1.16	17.3	17.5	1.16	17.3	17	1.73
8	20.2	20.5	1.49	20.2	20	0.99	20.2	20	0.99
9	22.3	22.5	0.90	22.3	22.5	0.90	22.3	22	1.35
10	30	30	0.00	30	30	0.00	30	30	0.00
	Error rate (%)		4.861			5.11			4.82

From the test results, it is found that the distance of the test results on manual measurement (ruler) is not the same as the distance of the calculation results with an error percentage of about 5%, which is around 4.82 to 5.11%. The HC-SR04 can compute with a distance range of 2 – 400 cm based on the ultrasonic sensor's properties, which means that the sensor can only work with a distance of at least 2 cm and a maximum of 400 cm. In general, the farther the distance measured, the smaller the error. The difference in the distance between the test results and the actual distance can be caused by noise. The ultrasonic sensor can read distances in increments of 0.5 cm.

B. Prototype Design Results

The implementation of a water level monitoring prototype using the self-check sensor feature can be seen in Figure 6 below.

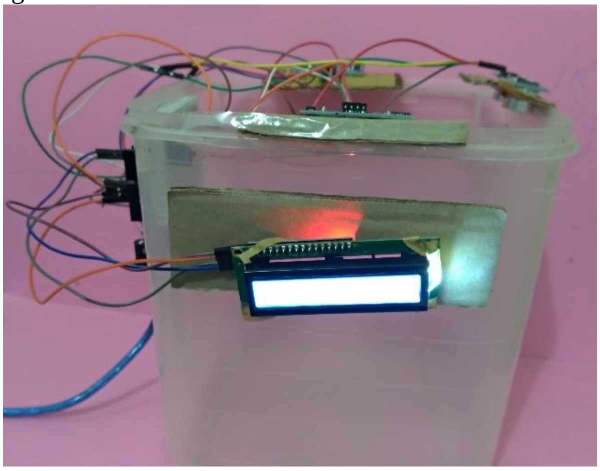

Figure 6 Prototype front view

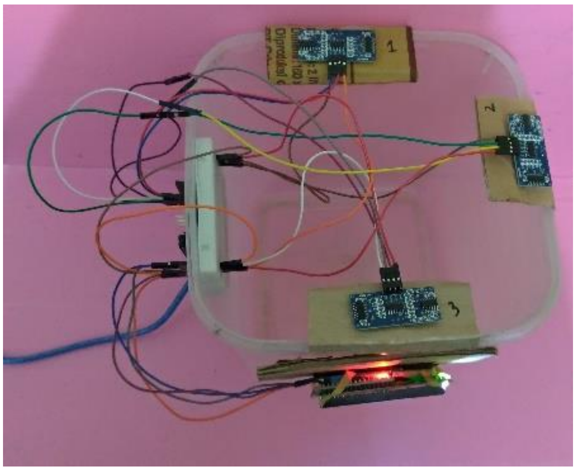

Figure 7 Sensor's setup prototype

Meanwhile the LCD show the distance of each sensor each as seen in the following figure 8.

Figure 8 Sensor's value display

In this section, we simulate sensor's data gathering by displaying it into LCD. The result shows that those three sensors are in a good condition. In other hand, as each 10 seconds the sensor value vary depends on water level, we simulate the condition if one of the sensors give contrasting results compared with the majority sensors as we can see below.

Figure 9 Sensor's value case display

Figure 10 Sensor's damage alert

6. Conclusions

In this paper, we introduce self-check sensor feature for sensor management in designing Arduino-based sluice control system. Based on the research that has been done as well as system performance testing, we can infer that the system works well under 5% of sensor's error rate. In addition, the system can also quickly respond to changes that have been determined for flood management or overflow of the water level in the dam.

To sum up, designing Arduino-based sluice control system with self-check feature is generally applicable but requires a lot of improvement, particularly in terms of scalability and durability under varied conditions.

Reference

Ahmad, R., & Mahpuz, M. (2018). Perancangan Prototipe Sistem Kontrol Pintu Air Irigasi Berbasis Android dan Jaringan Nirkabel. *Infotek: Jurnal Informatika Dan Teknologi*, *1*(2), 115–121.

Andayyani, F. T., Rismawan, T., & others. (n.d.). PROTOTYPE SISTEM KONTROL PINTU AIR OTOMATIS PADA SALURAN IRIGASI LAHAN PERTANIAN PADI DAERAH ALIRAN SUNGAI (DAS) AIR ASIN. *Coding Jurnal Komputer Dan Aplikasi*, *4*(2).

Hero, A. O., & Cochran, D. (2011). Sensor management: Past, present, and future. *IEEE Sensors Journal*, *11*(12), 3064–3075.

Laumal, F. E., Hattu, E. P., & Nope, K. B. N. (2017). Pengembangan pintu air irigasi pintar berbasis arduino untuk Daerah Irigasi Manikin. *Jurnal Rekayasa Elektrika*, *13*(3), 139–144.

Miazi, M. N. S., Erasmus, Z., Razzaque, M. A., Zennaro, M., & Bagula, A. (2016). Enabling the Internet of Things in developing countries: Opportunities and challenges. *2016 5th International Conference on Informatics, Electronics and Vision (ICIEV)*, 564–569.

Sahid, D. (2018). *Fenomena Internet of Things (IoT) dan Urgensi Regulasinya* (Issue 55417110031) [Universitas Mercu Buana, Jakarta]. https://www.academia.edu/37130219/Fenomena_Internet_of_Things_IoT_dan_Urgensi_Regulasinya

Shodikin, M., Stefanie, A., & Bangsa, I. (2021). PERANCANGAN SISTEM INSTRUMENTASI PADA VERTICAL AEROPONIC (VERO) BERBASIS MIKROKONTROLER ATMEGA 2560. *Jurnal Elektro Dan Telekomunikasi Terapan (e-Journal)*, *7*(2), 866–876. https://doi.org/10.25124/jett.v7i2.3255