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Monitoring and temperature control system for fish farming in an IOT-based bucket using an android application

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Abstract: This study seeks to create and implement an Internet of Things (IoT)-based system for monitoring and controlling temperature in fish farming within a bucket (Budikdamber) using temperature sensors. The main focus is to set the optimal temperature range for catfish farming in the Budikdamber, ensuring environmental conditions that suit the needs of catfish. Automatic controls are integrated to keep the water temperature in the bucket within the desired range. The system is also capable of automatically activating or deactivating devices such as the Peltier, lights, filling pump, and draining pump to achieve the appropriate temperature. In the test using a 50-litre bucket, a thorough evaluation and testing showed that the DS18B20 temperature sensor had an error rate of 0.8826%, while the Ultrasonic sensor had an error rate of 0.737%. Nonetheless, the other components in the device operate optimally with performance levels reaching 100%, according to their functions. Testing of the Android App on this device achieved an accuracy rate of 100%, indicating that this device can be effectively monitored and controlled remotely through the Android App. The conclusion of this research provides insight into the performance of temperature sensors, system optimization, and the effectiveness of remote control using Android Apps in the context of fish farming.

Keywords: Android App, Automatic Control, Budikdamber, Internet of Things

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Introduction

In the face of rapid growth in the development sector, there are land restraints that hamper activities including gardening and fish farming [1]. However, the need for both animal and plant protein continues to increase [2]. People living in urban areas, cannot fulfill this protein demand by keeping fish in lakes, ponds, rivers, or other bodies of water in the same way as people in rural areas. Limited land for fish farming in urban areas is increasingly becoming a constraint due to the ongoing development process. In contrast, the demand for animal protein continues to increase [3]. As a solution to deal with these conditions, the concept of Bucket Fish Farming or Budikdamber emerged, which can be a potential alternative solution for raising fish and gardening on limited land by using water appropriately. Bucket fish farming allows people to do fish farming at home at an affordable cost, thus meeting the nutritional needs of the community [4].

The Budikdamber method is a technique that can be utilized to cultivate various freshwater fish species, including snapper, catfish, shrimp, and tilapia. Additionally, it can be employed to grow water spinach. The choice of these crops in this context was selected based on several advantages, such as ease of cultivation, affordable prices, and short harvesting periods [5]. In Budikdamber, vegetables, and fish are treated with polyculture in the same bucket or container. Compared to complex aquaponic systems that require pumps, filters, large areas of land, and high investment, Budikdamber is a simpler method. The Budikdamber method has several advantages, including low water consumption, low waste production, simple maintenance, and no need for harmful chemicals.

By adopting the concept of Bucket Fish Farming, community groups can use limited areas efficiently and sustainably. Therefore, there is a need for a form of Bucket Fish Farming System that can be monitored and controlled even without the user being present at the location.

Research conducted by Nursandi in his journal entitled Fish Cultivation in a Bucket "Budikdamber" with Aquaponics in Narrow Land explained that the temperature needed for catfish in Budikdamber is between 25.0 to 31.5 ° C. The ideal water temperature can enhance fish appetite and speed up growth rates. However, temperature changes can occur within the Budikdamber system as it is influenced by ambient temperature, be it rainfall or intense sunlight. A significant increase in temperature can cause a reduction in the dissolved oxygen content in the water, which can cause stress to the fish. Therefore, it is important to keep the water temperature within an appropriate range for the catfish to grow well.

In a previous study entitled Turbidity and Water Level Monitoring System for Fish Cultivation in a Bucket (Budikdamber) Based on the Internet of Things conducted by Septian, in this study the tool has a feature of monitoring water levels and water turbidity levels and also controlling water levels, the application used is Blynk [6]. Research conducted by Faris Nidaul Haq with the title Designing an Automatic Feeding System for Fish Cultivation in a Bucket (Budikdamber) Based on Arduino Uno ATMega 328, in this study the tool only focuses on automatic feeding using RTC and Push Button without any mobile application [7]. However, these two studies did not consider other factors such as automatic control of water level and temperature and the use of an android platform for monitoring and control. A comparison of the author's research with previous research is described in Table 1 below.

Table 1. Research comparison

Fitur	Author's Research	Septian's research	Faris' research
Water Level	Control & Monitoring	Monitoring	Control
Water Temperature	Control & Monitoring	-	-
Water Turbidity	-	Monitoring	-
Fish feed	-	-	Feed Automation
Application Platform	Android Apps	Blynk	-
User Interface	LCD 16x2	-	-
Microcontroller	ESP32	ESP8266	Arduino Uno

Thus this research was developed to provide an alternative to maintaining the temperature condition of Budikdamber. By combining monitoring and control devices, Budikdamber owners can monitor water temperature, measure water level, and control existing actuator devices with ease. In addition, the system ensures that the water temperature in the bucket stays within the optimal range. If the temperature rises above the upper limit or falls below the specified lower limit, the system takes automatic action by activating or deactivating devices such as the peltier, lights, filling pump, and drain pump to regulate the temperature back into the desired range. The purpose of this Final Project research also involves providing remote access through a user interface that uses an LCD attached to the Budikdamber device and an Android application on a Smartphone. This allows the user of the Budikdamber system to get immediate notifications about detecting inappropriate water conditions and control the device remotely. Thus, the control and supervision of Budikdamber can be done easily even when the owner is not nearby.

Methodology

DS18B20 Sensor Testing and Water Temperature Monitoring

In this series of research, an evaluation of the DS18B20 sensor and water temperature monitoring through the Android Application was carried out. This sensor test involved a comparison in the form of a digital temperature thermometer, the experiment was run 30 times. The purpose of this experiment is to verify the performance and accuracy of the DS18B20 sensor and to observe real-time water temperature monitoring through the Android application on a smartphone. The distance between the two sensors is less than 5 cm.

Calculation of the error in testing the DS18B20 Sensor with a Digital Thermometer is done using the following Equation 1.

$$Error = \left|\frac{Thermometer - DS18B20}{Thermometer}\right| x\ 100 \quad (1)$$

Remarks:
1. A thermometer refers to a standard or reference thermometer used to accurately measure temperature.
2. DS18B20 refers to the DS18B20 digital temperature sensor that is being compared to the reference thermometer.

Ultrasonic Sensor Testing and Water Level Monitoring

In this research, an evaluation of the Ultrasonic sensor and water level monitoring via the Android App was conducted. The sensor test involved a ruler for comparison, and the experiment was run 30 times. The purpose of this experiment is to verify the performance and accuracy of the Ultrasonic sensor and to observe real-time water level monitoring through the Android application on a smartphone.

Error calculation in testing the Ultrasonic Sensor with a Ruler is done using the following Equation 2.

$$Error = \left|\frac{ruler - ultrasonic}{Ruler}\right| x\ 100 \quad (2)$$

4 Channel Relay Testing

In this research, an evaluation of the 4 Channel Relay was conducted. The experiment was conducted 30 times. The purpose of this experiment is to verify the performance and accuracy of the Relay. Calculation of success in Relay testing is done using Equation 3 as follows:

$$Result = \left|\frac{Many\ Data\ Successful}{Total\ Data}\right| x\ 100\ \% \quad (3)$$

Testing the Water Temperature Condition of the Peltier

In this research, the water temperature condition of the peltier was evaluated. The experiment was conducted 15 times. The purpose of this experiment is to verify the performance and accuracy of the water temperature of the Peltier. Calculation of success in testing is done using Equation 3.

Testing the Water Temperature Condition of the Lamp

In this research, the water temperature condition of the lamp was evaluated. The experiment was conducted 15 times. The purpose of this experiment is to verify the performance and accuracy of the water temperature of the lamp. Calculation of success in testing is done using Equation 3.

Overall System Testing

In this research, an evaluation of the entire system, which is a combination of sensors, components, and Android applications, was conducted 30 times. The purpose of this experiment is to verify the performance and accuracy of the system. Calculation of success in testing is done using Equation 3.

Budikdamber

Budikdamber, or bucket fish farming, is a system model that offers several prominent advantages. Known for its affordable cost, ease of application, and simplicity of execution, this system has attracted the interest of many. In bucket culture, fish are cultivated in a bucket or similar container, which allows the owner to manage the pond efficiently and effectively. The affordable cost advantage makes the system attractive to many fish farmers, while the ease of application allows new users to quickly adopt the technique.

ESP32

The ESP32, a microcontroller developed by Espressif System, comes as an evolution of the ESP8266, its predecessor. One of the prominent features of the ESP32 is the WiFi module incorporated into the chip. This provides significant support in the development of Internet of Things (IoT) devices [8]. The ESP32 provides several benefits, including high-frequency capability, affordability, integrated sensors (such as temperature and Hall effect sensors), and Wi-Fi and Bluetooth connectivity. The device includes speeds of up to 150 Mbps, a 10-pin ADC, a power management module, a receiver with a low noise amplifier, security features, filtering, and is easy to install [9].

DS18B20 Temperature Sensor

The DS18B20 sensor is one example of a sensor that is often used to measure temperature with water resistance. The sensor is equipped with an aluminum tube cover that protects water, allowing its use in situations where there is the potential for immersion in liquid [10]. In the DS18B20 sensor, the red cable is used to connect to the voltage source (VCC), the black cable is used to connect to the ground (GND), and the yellow cable acts as a data connection line. The width of the cable used is about 4 mm, and the total length of the cable reaches 90 cm [11].

HC-SR04 Ultrasonic Sensor

Ultrasonic sensors are devices that work by using reflected sound waves to detect the position of an object in the vicinity [12]. The HCSR04 sensor is designed specifically to measure the distance to an object. With its reliable capabilities, this sensor can detect distances within a range of between 2 to 450 cm. In other words, this sensor provides considerable flexibility in measuring distance, making it suitable for a wide range of applications, from DIY (Do It Yourself) projects to more complex industrial uses [13].

Push Button

A push button is a straightforward mechanical or electrical switch that operates when pressed [14]. Its presence inside the electrical box provides ease of access and use in controlling various connected electrical devices, while outside the electrical box, this device is often used as an additional switch to easily turn electronic devices on or off.

Relay

A relay is an electrical device that serves as a switch controlled by electrical signals. Comprising two primary components a coil of electromagnet and a set of mechanical switch contacts the relay operates by using the electromagnet to move the switch contacts [15]. Relays are used in a variety of applications due to their ease, longevity, and proven reliability. Their functions include monitoring, regulating, and controlling power [16].

Liquid Crystal Display 16x2 I2C

A Liquid Crystal Display, also known as a 16x2 LCD, is a type of visual display that utilizes liquid crystal materials and is executed using a dot matrix structure. In a 16x2 configuration, this LCD can display a total of 32 characters divided into two bars, with each bar representing up to 16 characters. In addition, 16x2 LCDs can communicate via the I2C protocol [17].

Blynk

Blynk is a platform designed to manage components such as ESP32, ESP8266, Arduino, Raspberry Pi, and so on. It may be connected via an internet connection, and it can be accessed through the iOS and Android operating systems [18].

Kodular

Kodular is an online platform that provides users with tools to create Android apps without having in-depth programming knowledge. The platform uses a block-based programming method, similar to the concepts found in MIT App Inventor [19].

System Block Diagram

The following is a block diagram of the designed device:

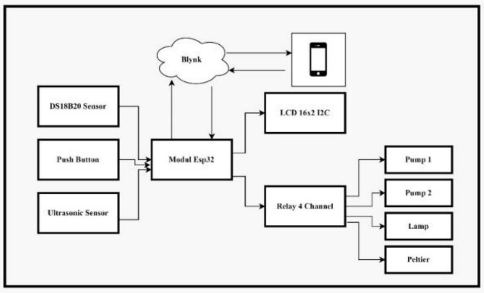

Figure 1. System block diagram

With reference to the block diagram in Figure 1, the system consists of several components. The operational way of this device or block diagram can be explained as follows The DS18B20 sensor is an input component that functions as a water temperature detector. An ultrasonic sensor is an input component that functions to measure the distance of the water surface. The ESP32 microcontroller is a module for controlling various sensors and actuators, the alternating arrows indicate communication between the ESP32 and Blynk and the user's smartphone. The 16x2 I2C LCD serves as a presenter of temperature value information from the DS18B20 sensor and water surface distance value data from the Ultrasonic sensor. Relay Module 4 Channel is used to control several functions in the water bucket management system.

Schematic Design

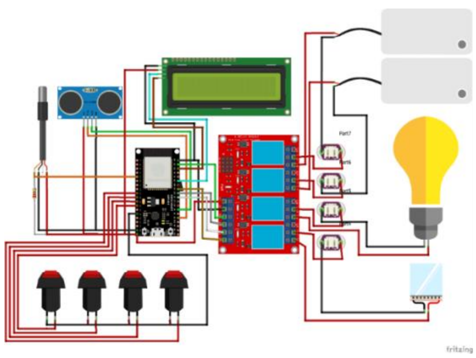

Figure 2. Schematic design

Based on the schematic circuit illustration in Figure 2, this Wiring Management Note describes the cable connections required to integrate the various components in this project using the ESP32 microcontroller. This project aims to control and monitor various sensors and devices through the ESP32 using the wiring connection.

System Flowchart

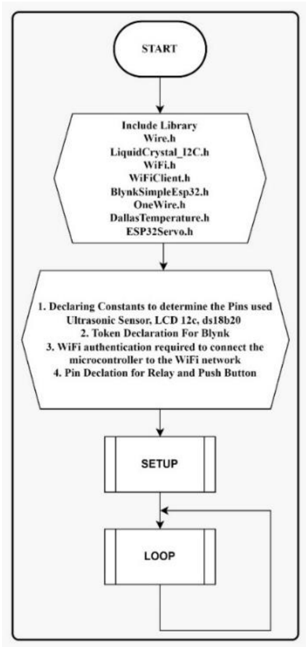

Figure 3. System flowchart

Based on Figure 3, the program starts by importing the library used and then continues with the declaration of the variables used. Next, the program has two main parts, namely Function Setup and Function Loop.

Automatic Control Plan

In this research, an IoT-based monitoring and temperature control system for fish farming in buckets is controlled using several controls that are designed in detail. The main control plan involves setting the temperature and volume of water in the bucket. The following is a detailed control plan for each aspect:

1. Temperature Control

a. High Temperature (More than 30°C)

Based on Figure 4, if the temperature exceeds 30°C, the drain pump is activated. The drain pump remains active until the water level reaches 30cm. After reaching a water level of 30 cm, the dewatering pump is switched off. Subsequently, the charging pump and Peltier were activated. The water level is increased until the water level reaches 10 cm. After reaching 10cm water height, the charging pump and Peltier were switched off. Repeat until ideal temperature. The system highlights the connection between temperature and water level, detailing how variations in water level contribute to effective temperature regulation and the maintenance of fish health.

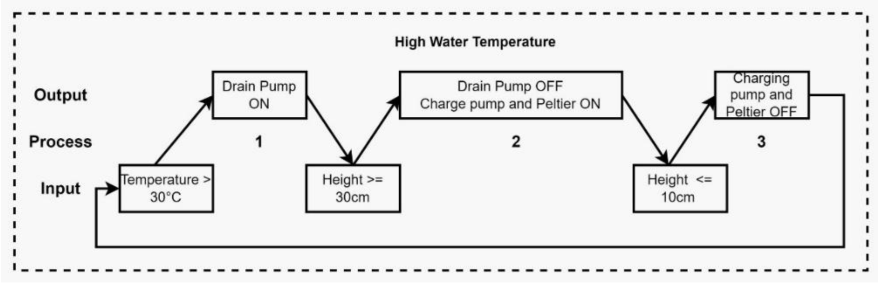

Figure 4. High water temperature

b. Ideal Temperature (25°C - 30°C)

Based on Figure 5, If the temperature is within the range of 25°C to 30°C, then all devices, including the drain pump, charge pump, Peltier, and lights, are turned off.

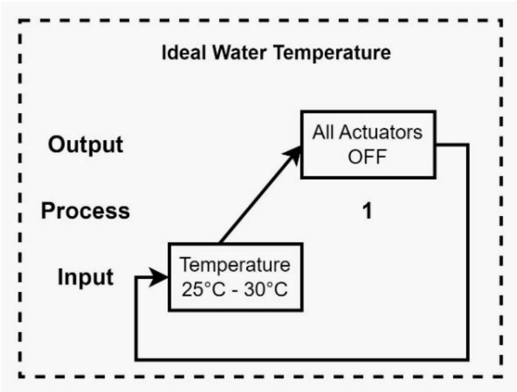

Figure 5. Ideal Temperature

c. Low Temperature (Less than 25°C)

Based on Figure 6, If the temperature drops below 25°C, the lamp is activated. The light is switched off when the temperature reaches or exceeds 25°C. The system emphasizes the relationship between water temperature and the use of heat lamps, explaining how heat lamps help maintain water temperature within the optimal range for fish health.

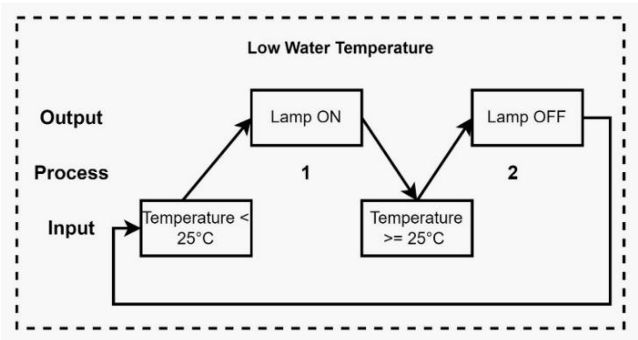

Figure 6. Low temperature

2. Water Volume Control

a. Low Water Volume (Lower than 20 cm)

Based on Figure 7, If the Ultrasonic Sensor detects water lower than 20 cm, the filling pump is activated. The filling pump is switched off if the Ultrasonic Sensor detects water already at or higher than 10 cm.

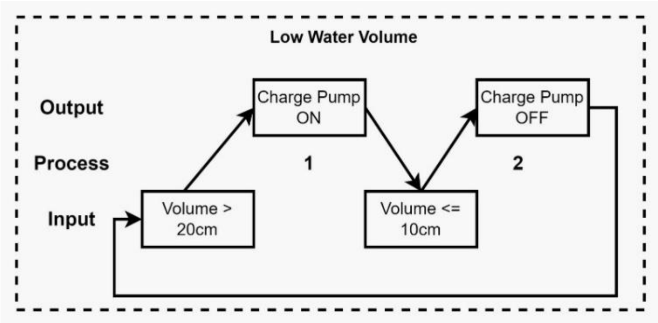

Figure 7. Low water volume

b. High Water Volume (Higher than 10 cm)

Based on Figure 8, If the Ultrasonic Sensor detects higher than 10cm, the drain pump is activated. The drain pump is switched off if the Ultrasonic Sensor detects lower or equal to 10cm.

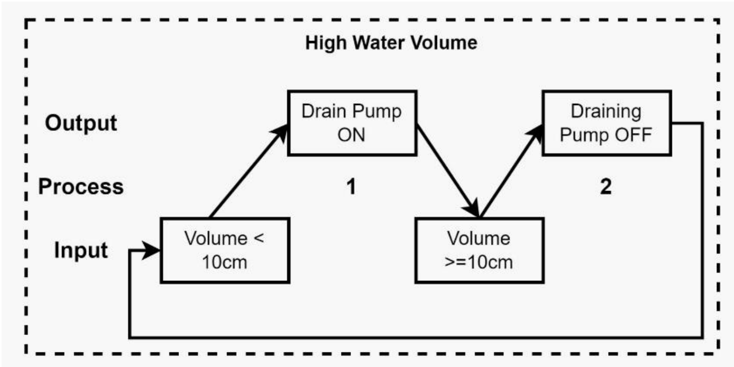

Figure 8. High water volume

Results and Discussions

Results

Table 2. DS18B20 sensor testing results

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Error (Percent)	Monitoring on Smartphone
1	26	25.9	0.387%	Data Displayed
2	26	25.7	1.553%	Data Displayed
3	27	27.0	0.370%	Data Displayed
4	27	27.1	0.370%	Data Displayed
5	27	27.4	0.733%	Data Displayed
6	27	27.4	1.48%	Data Displayed
7	27	27.6	1.449%	Data Displayed
8	27	27.7	1.446%	Data Displayed
9	28	28.1	0.357%	Data Displayed
10	28	28.2	0.355%	Data Displayed
11	28	28.1	0.357%	Data Displayed
12	28	28.3	0.354%	Data Displayed
13	29	29.5	1.695%	Data Displayed
14	29	29.6	1.351%	Data Displayed
15	29	29.4	0.680%	Data Displayed
16	28	28.7	0.69%	Data Displayed
17	28	28.7	0.69%	Data Displayed

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Error (Percent)	Monitoring on Smartphone
18	28	28.6	0.35%	Data Displayed
19	29	29.1	0.34%	Data Displayed
20	29	29.3	0.34%	Data Displayed
21	29	29.2	0.34%	Data Displayed
22	29	29.1	0.34%	Data Displayed
23	29	29.2	0.34%	Data Displayed
24	30	29.9	0.30%	Data Displayed
25	30	29.9	0.30%	Data Displayed
26	30	30.1	0.30%	Data Displayed
27	30	30.2	0.33%	Data Displayed
28	30	30.1	0.30%	Data Displayed
29	30	29.9	0.30%	Data Displayed
30	30	30.1	0.30%	Data Displayed
	Average Error		0.3958%	

Table 3. Ultrasonic sensor testing results

Test To	Sensor Ultrasonic (CM)	Ruler Value (CM)	Error (Percent)	Monitoring on Smartphone
1	19	19.2	1.04%	Data Displayed
2	19	19.1	0.526%	Data Displayed
3	23	23.3	1.29%	Data Displayed
4	23	23.2	0.435%	Data Displayed
5	25	25.1	0.396%	Data Displayed
6	25	25.1	0.396%	Data Displayed
7	24.4	24.5	0.408%	Data Displayed
8	24.2	24.4	0.819%	Data Displayed
9	24.0	24.0	0%	Data Displayed
10	23.5	23.5	0%	Data Displayed
11	23.3	23.4	0.429%	Data Displayed
12	22.8	23.0	0.870%	Data Displayed
13	22.6	22.8	0.877%	Data Displayed
14	22.5	22.4	0.446%	Data Displayed
15	22.4	22.3	0.448%	Data Displayed
16	22.4	22.3	0.446%	Data Displayed
17	22.4	22.3	0.446%	Data Displayed
18	22.3	22.2	0.448%	Data Displayed
19	22.3	22.2	0.448%	Data Displayed
20	22.3	22.2	0.448%	Data Displayed
21	22.3	22.2	0.448%	Data Displayed
22	22.6	22.5	0.446%	Data Displayed
23	22.6	22.5	0.446%	Data Displayed
24	22.7	22.7	0%	Data Displayed
25	22.7	22.6	0.446%	Data Displayed
26	23.0	23.1	0.435%	Data Displayed
27	23.0	23.1	0.435%	Data Displayed
28	23.0	23.1	0.435%	Data Displayed
29	23.2	23.2	0%	Data Displayed
30	23.2	23.1	0.435%	Data Displayed
	Average Error		0.3683%	

Table 4. Relay testing results

Test To	Control Status				Conditions
	Relay 1 Lights	Relay 2 Peltier	Relay 3 Pump 1	Relay 4 Pump 2	
1	On	On	On	On	On
2	Off	Off	Off	Off	Off
3	On	On	On	On	On
4	Off	Off	Off	Off	Off
5	On	On	On	On	On
6	Off	Off	Off	Off	Off
7	On	On	On	On	On
8	Off	Off	Off	Off	Off
9	On	On	On	On	On
10	Off	Off	Off	Off	Off
11	On	On	On	On	On
12	Off	Off	Off	Off	Off
13	On	On	On	On	On
14	Off	Off	Off	Off	Off
15	On	On	On	On	On
16	Off	Off	Off	Off	Off
17	On	On	On	On	On
18	Off	Off	Off	Off	Off
19	On	On	On	On	On
20	Off	Off	Off	Off	Off
21	On	On	On	On	On
22	Off	Off	Off	Off	Off
23	On	On	On	On	On
24	Off	Off	Off	Off	Off
25	On	On	On	On	On
26	Off	Off	Off	Off	Off
27	On	On	On	On	On
28	Off	Off	Off	Off	Off
29	On	On	On	On	On
30	Off	Off	Off	Off	Off

Table 5. Water temperature testing results of Peltier

Test To	Duration of Ignition	Initial Temperature (Celcius)	Final Temperature (Celcius)
1	1 Minute	30.1	29.9
2	1 Minute 30 Seconds	29.9	29.6
3	4 Minute	29.6	29.1
4	8 Minute	29.1	29.0
5	8 Minute 44 Seconds	29.0	28.9
6	1 Minute	32.2	31.9
7	3 Minutes 20 Seconds	31.9	31.5
8	5 Minute	31.6	31.4
9	7 Minute	31.4	31.2
10	10 Minute	31.2	30.9
11	1 Minute	30	29.8
12	2 Minute 30 Seconds	29.9	29.5
13	5 Minute	29.6	29.0
14	9 Minute	29.1	28.9

Test To	Duration of Ignition	Initial Temperature (Celcius)	Final Temperature (Celcius)
15	10 Minute 30 Seconds	29.0	28.8

Table 6. Water temperature testing results of lamp

Test To	Duration of Ignition	Initial Temperature (Celcius)	Final Temperature (Celcius)
1	10 Minute	28.0	28.3
2	10 Minute	29.2	29.4
3	10 Minute	30.4	30.5
4	10 Minute	27.1	27.2
5	10 Minute	27.2	27.4
6	10 Minute	27.2	29.4
7	10 Minute	25.6	25.7
8	10 Minute	32.1	32.2
9	10 Minute	25.1	25.2
10	10 Minute	25.2	25.3
11	10 Minute	25.4	25.6
12	10 Minute	27.1	27.1
13	10 Minute	28.2	28.3
14	10 Minute	28.3	28.4
15	10 Minute	28.4	28.5

Table 7. Overall test results of the monitoring system

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Sensor Ultrasonic (CM)	Ruler Value (CM)	Monitoring on LCD	Monitoring on Smartphone
1	29	29.5	15.6	15.5	Data appears	Data appears
2	29	29.3	16.2	16.1	Data appears	Data appears
3	28	29.0	16.1	16.0	Data appears	Data appears
4	28	28.7	15.9	16.0	Data appears	Data appears
5	28	28.4	16.0	15.9	Data appears	Data appears
6	26	26.2	19.2	19.3	Data appears	Data appears
7	26	26.1	19.3	19.3	Data appears	Data appears
8	26	26.0	19.7	19.9	Data appears	Data appears
9	26	26.3	20.1	20.2	Data appears	Data appears
10	25	25.1	20.1	20.2	Data appears	Data appears
11	25	25.1	20.4	20.4	Data appears	Data appears
12	27	27.0	20.5	20.6	Data appears	Data appears
13	27	27.2	21.0	21.2	Data appears	Data appears
14	30	30.3	21.1	21.2	Data appears	Data appears
15	30	30.2	21.7	21.9	Data appears	Data appears
16	30	30.2	21.0	21.2	Data appears	Data appears
17	30	30.1	21.0	21.2	Data appears	Data appears
18	29	29.3	21.7	21.9	Data appears	Data appears
19	29	29.2	21.7	21.9	Data appears	Data appears
20	29	29.3	21.7	21.9	Data appears	Data appears
21	29	29.2	20.5	20.6	Data appears	Data appears
22	29	29.2	20.5	20.6	Data appears	Data appears
23	28	28.0	20.5	20.7	Data appears	Data appears
24	28	28.1	20.5	20.6	Data appears	Data appears

Test To	Sensor DS18B20 (Celcius)	Digital Thermometer Value (Celcius)	Sensor Ultrasonic (CM)	Ruler Value (CM)	Monitoring on LCD	Monitoring on Smartphone
25	28	28.0	20.5	20.5	Data appears	Data appears
26	28	28.1	20.5	20.6	Data appears	Data appears
27	28	28.0	19.7	19.8	Data appears	Data appears
28	28	28.2	19.7	19.7	Data appears	Data appears
29	29	29.2	19.7	19.7	Data appears	Data appears
30	29	29.2	19.7	19.7	Data appears	Data appears

Table 8. Overall testing results of the manual control system

Test To	Control Status				Control Condition via Push Button	Control Conditions via Android App
	Relay 1 Lamp	Relay 2 Peltier	Relay 3 Pump 1	Relay 4 Pump 2		
1	On	On	On	On	On	On
2	Off	Off	Off	Off	Off	Off
3	On	On	On	On	On	On
4	Off	Off	Off	Off	Off	Off
5	On	On	On	On	On	On
6	Off	Off	Off	Off	Off	Off
7	On	On	On	On	On	On
8	Off	Off	Off	Off	Off	Off
9	On	On	On	On	On	On
10	Off	Off	Off	Off	Off	Off
11	On	On	On	On	On	On
12	Off	Off	Off	Off	Off	Off
13	On	On	On	On	On	On
14	Off	Off	Off	Off	Off	Off
15	On	On	On	On	On	On
16	Off	Off	Off	Off	Off	Off
17	On	On	On	On	On	On
18	Off	Off	Off	Off	Off	Off
19	On	On	On	On	On	On
20	Off	Off	Off	Off	Off	Off
21	On	On	On	On	On	On
22	Off	Off	Off	Off	Off	Off
23	On	On	On	On	On	On
24	Off	Off	Off	Off	Off	Off
25	On	On	On	On	On	On
26	Off	Off	Off	Off	Off	Off
27	On	On	On	On	On	On
28	Off	Off	Off	Off	Off	Off
29	On	On	On	On	On	On
30	Off	Off	Off	Off	Off	Off

Table 9. Overall testing results of the automatic control system

Test To	Temperature Control			Volume Control		Conditions
	High Temperature	Ideal Temperature	Low Temperature	Low Volume	High Volume	
1	31.4°C	27.0°C	24.1°C	25 cm	9 cm	Retrieved

Test To	Temperature Control			Volume Control		Conditions
	High Temperature	Ideal Temperature	Low Temperature	Low Volume	High Volume	
2	32.1°C	27.2°C	24.5°C	28 cm	7 cm	Retrieved
3	35.7°C	29.7°C	23.8°C	30 cm	5 cm	Retrieved
4	34.0°C	30.2°C	23.7°C	29 cm	6 cm	Retrieved
5	36.4°C	28.9°C	23.9°C	24 cm	7 cm	Retrieved
6	31.5°C	25.5°C	24.5°C	21.5 cm	9.5 cm	Retrieved
7	30.8°C	26.8°C	23.8°C	22.8 cm	8.2 cm	Retrieved
8	32.2°C	27.2°C	22.7°C	23.2 cm	6.8 cm	Retrieved
9	30.5°C	28.1°C	24.2°C	25.1 cm	9.7 cm	Retrieved
10	31.7°C	25.9°C	23.1°C	20.7 cm	7.6 cm	Retrieved
11	33.0°C	26.4°C	22.9°C	26.4 cm	5.3 cm	Retrieved
12	30.3°C	29.0°C	24.0°C	24.8 cm	8.9 cm	Retrieved
13	32.8°C	27.8°C	23.5°C	22.3 cm	6.4 cm	Retrieved
14	31.2°C	25.7°C	22.4°C	21.9 cm	9.2 cm	Retrieved
15	30.9°C	28.5°C	24.3°C	23.7 cm	7.9 cm	Retrieved
16	32.5°C	26.2°C	23.7°C	27.0 cm	5.8 cm	Retrieved
17	31.1°C	29.5°C	22.8°C	25.6 cm	8.5 cm	Retrieved
18	33.5°C	25.3°C	24.1°C	20.5 cm	6.1 cm	Retrieved
19	30.6°C	27.0°C	23.2°C	26.1 cm	9.4 cm	Retrieved
20	32.1°C	28.7°C	22.5°C	24.3 cm	7.1 cm	Retrieved
21	31.4°C	25.8°C	24.4°C	22.9 cm	5.6 cm	Retrieved
22	33.2°C	29.2°C	23.9°C	28.2 cm	8.7 cm	Retrieved
23	30.2°C	26.9°C	22.2°C	29.7 cm	6.9 cm	Retrieved
24	32.7°C	27.5°C	24.7°C	27.5 cm	9.1 cm	Retrieved
25	31.9°C	28.3°C	23.3°C	21.2 cm	7.4 cm	Retrieved
26	33.8°C	25.2°C	22.6°C	28.9 cm	5.9 cm	Retrieved
27	30.4°C	26.7°C	24.6°C	25.3 cm	8.3 cm	Retrieved
28	31.6°C	29.7°C	23.6°C	29.1 cm	6.6 cm	Retrieved
29	33.1°C	27.3°C	22.3°C	23.5 cm	9.8 cm	Retrieved
30	30.1°C	25.6°C	24.9°C	20.3 cm	7.3 cm	Retrieved

Discussions

Table 2 records the experimental results using the DS18B20 sensor. After 30 tests, the DS18B20 sensor showed an average error of 0.3958% when compared to a digital thermometer, indicating a high level of accuracy. This minor discrepancy could be attributed to factors such as calibration differences, sensor precision, or environmental conditions during testing. Despite this small error, the sensor's performance is deemed highly reliable for practical use in monitoring fish farming environments, where precise temperature control is crucial for maintaining optimal conditions.

Table 3 records the experimental results using the Ultrasonic sensor. After 30 tests, the test results show that there is an average error of 0.3683%. This means, that in each measurement, the average difference between the value measured by the Ultrasonic sensor and the value of the Ruler is about 0.3683%. The test results fall into the Very Good category.

Table 4 includes the experimental results of the Relay. The test results show that the success obtained from the Relay test is 100%. This means that the Relay can work properly.

Table 5 includes the experimental results of the water temperature released by the peltier. The test results show that the success obtained from testing the water temperature of the peltier is 100%, which means that the peltier can reduce the water temperature properly.

Table 6 includes the experimental results of the water temperature released by the lamp. The test results show that the success obtained from testing the water temperature of the lamp is 100%, which means that the lamp can increase the water temperature properly.

Table 7 includes the experimental results of the entire monitoring system. The test results show that the success obtained from the test is 100%. Table 8 includes the experimental results of the entire manual control system. The test results show that the success obtained from the test is 100%. Table 9 includes the experimental results of the entire automatic control system. The test results show that the success obtained from the test is 100%.

Prototype and Android App Documentation

Figure 9a. Prototype

Figure 9b. Android App

Figure 9a displays the prototype consists of a 50-liter bucket equipped with an ESP32 microcontroller, an HCSR04 ultrasonic sensor, a DS18B20 temperature sensor, and a 16x2 I2C LCD. The bucket lid can be opened halfway for easy access. A push-on button is located on the side of the bucket. The entire system is housed in a project box attached to the bucket.

Figure 9b illustrates the android application interface includes several screens: the first page, which is the main screen to access the login and sign-up menus; the login menu, which allows users to log in with their email and password; the sign-up menu, where users can create a new account by filling in their email and password; the main menu, which provides access to various features, including monitoring and control options; the monitoring menu, which displays real-time data from the sensors, including water temperature and water level distance; and the controlling menu, which contains controls for the system, allowing users to manage and adjust the fish farming environment.

Conclusion

Based on a thorough evaluation and testing along with data comparisons, several conclusions were drawn that need to be considered: (1) The DS18B20 temperature sensor is not capable of reading data to decimal values with an average error rate of 0.3958%, for the Ultrasonic sensor it has an average error rate of 0.3683%. The temperature and ultrasonic sensors can measure the temperature and volume of water and transmit the data in real time to the IoT platform. (2) Based on literature study and practical experience, the optimal temperature range for catfish farming in Budikdamber is found to range from 25 Celsius to 30.1 Celsius. (3) The automatic control of this system can ensure that the water temperature remains within the desired range. Peltier, lamp, filling pump, and draining pump are integrated to achieve this goal. (4) The Android App testing of the device achieved 100% accuracy, indicating that the device can be effectively monitored and controlled remotely through the Android App.

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