

Design and Development of a Smart Farm for Broiler Chickens Aged 1 to 10 Days Based on the Internet of Things

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Abstract— Broiler chickens have a lower heat tolerance compared to layer chickens, with a normal temperature range of 30 to 33 degrees Celsius. In Desa Sungai Kuruk III, farmers often use traditional methods like burning charcoal and wood to heat the coop, often without considering the ideal temperature standards for broiler chicks aged 1 to 10 days. This method can result in temperatures that are too high or too low, harming the health and growth of the broilers. This research aims to ensure the ideal temperature in broiler coops using smart farm technology based on the Internet of Things (IoT). Through real-time temperature control and monitoring via the web, the coop temperature can be automatically adjusted to remain optimal. This technology allows for more accurate and efficient temperature regulation compared to traditional methods and facilitates remote monitoring of the coop. This research is expected to help broiler farmers in Desa Sungai Kuruk III improve the productivity and welfare of their livestock through the application of modern technology in farm management.

Keywords: Smart Farm, Broiler Chickens, Temperature, Internet of Things.

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1. Introduction

One of the profitable farming ventures is raising broiler chickens. It takes only 5-6 weeks to harvest broilers. According to data from the Ministry of Agriculture, the predicted demand for chicken meat for household consumption in 2015 was estimated at 4.50 kg/capita/year. From 2016 to 2019, the projected demand for chicken meat for consumption tended to increase by an average of 1.56% per year, reaching 4.69 kg/capita/year. Therefore, the total demand for chicken meat for direct consumption in 2017 was 1.24 million tons, in 2018 it was 1.27 million tons, and in 2019 it reached 1.30 million tons [1].

Broiler chickens have a lower heat tolerance compared to layer chickens. Due to this low heat tolerance, broiler chickens are less able to defend themselves against heat stress. The broiler chickens commonly raised in Indonesia are very sensitive to changes in the microclimate, especially temperature and humidity. If the broiler chicken coop has high temperatures and unfavorable humidity, the chickens will experience heat stress, causing them to drink more and eat less. This can result in liquid feces, which negatively impacts their productivity [2].

Broiler chickens aged 1 to 10 days perform best in a coop with a temperature of 33 degrees Celsius and humidity between 60-80%. For chickens aged 16-23 days, the ideal coop temperature is 29.44 degrees Celsius. After 31 days, chickens no longer require temperatures above 26.33 degrees Celsius. In addition to temperature and humidity, regular and timely feeding is crucial. Farmers often make mistakes or delay in managing temperature, humidity, and feeding schedules in chicken coops, possibly due to unawareness of these environmental changes [2].



Figure 2. The 16x2 LCD

2.4 DHT11 Sensor

DHT11 sensor is an air temperature and humidity sensor with a digital output calibrated through a complex sensor. Each DHT11 sensor features highly accurate calibration from a 12- point humidity calibration chamber. The calibration coefficients are stored in the OTP program memory, and the internal sensor detects signals during the process; we must mention the calibration coefficient. The system's single-interface integrated serial cable is fast and easy. It is small in size, low in power, and can transmit signals up to 20 meters, making it suitable for various applications, even the most demanding ones. The product has a single-row 4-pin package bar. Convenient connection; special packages can be provided according to user needs [10]. The physic of DHT11 sensor was shown in Figure 3.

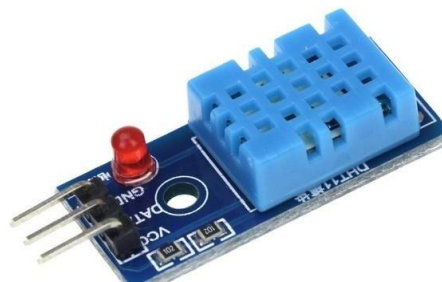


Figure 3. DHT11 sensor

2.5 Servo Motor

Servo motor is a rotary actuator device designed with a closed-loop feedback control system (servo), allowing it to be set up or adjusted to determine and ensure the angular position of the motor output. A servo motor consists of a DC motor, a series of gears, a control circuit, and a potentiometer. The gear train attached to the DC motor shaft slows down the rotation and increases the torque of the servo motor, while the potentiometer, which changes its resistance as the motor rotates, functions as a position limit determinant for the servo motor shaft rotation [11]. The physic of servo motor was shown in Figure 4.



Figure 4. Servo motor

2.6 Dual-Channel Relay

Dual-channel relay is an electromechanical switch that can handle high current in a compact design. It consists of two main parts: an electromagnet (coil) and mechanical contacts (switch contacts). By utilizing the principle of electromagnetism, the switch contacts can be closed or opened

with a small electric current, allowing it to control higher voltage electricity. The relay operates at 5V voltage, requires 5mA current, and is configured as a 1-channel relay for activating low/high signals. The physic of dual-channel was shown in Figure 5.



Figure 5. Dual-channel relay

2.7 Ultrasonic Sensor

Ultrasonic sensor is a device that converts physical quantities (sound) into electrical quantities and vice versa. Its operation is based on the principle of sound wave reflection, making it capable of interpreting the presence (distance) of an object with a specific frequency. It's called an ultrasonic sensor because it uses ultrasonic waves (ultrasonic sound). In an ultrasonic sensor, ultrasonic waves are generated through a device called a piezoelectric transducer with a specific frequency. This piezoelectric transducer produces ultrasonic waves (commonly at a frequency of 40 kHz) when an oscillator is applied to it. Generally, the device emits ultrasonic waves towards an area or target. Once these waves touch the target surface, they are reflected back. The reflected waves are captured by the sensor, which then calculates the difference between the transmission time of the wave and the reception time of the reflected wave [12]. The physic of ultrasonic sensor was shown in Figure 6.



Figure 6. Ultrasonic relay

2.8 Mini Water Pump

Mini water pump can pump up to 240 liters per hour (240 L/h) with an operating voltage range of 3-5 VDC. This mini water pump is highly suitable for aquariums, hydroponic water systems, robotics, microcontroller output devices, and more. The typical of mini water pump was shown in Figure 7.



Figure 7. Typical water pump

2.9 4G WiFi Modem

The 4G WiFi modem is a device that converts 4G signals from a mobile network operator into WiFi signals usable by electronic devices such as smartphones, tablets, laptops, and others for internet connectivity. The typical 4G WiFi modem was shown in Figure 8.



Figure 8. Typical 4G WiFi modem

2.10 Programming Languages

The programming languages used in this research are C++ and HTML. C++ is used to program the device as a whole to ensure it functions according to the research objectives. HTML, on the other hand, is used to create the IoT web interface, serving as a control and monitoring platform.

3. Method

In this research, the experimental method is employed to test whether temperature affects the growth of broiler chickens. The study focuses on the inductive process, with the research object solely centered on controlling the temperature in broiler chicken coops. The aim is to explore or develop insights into this aspect.

The Internet of things-based smart farm device for chicken coops is designed to assist broiler chicken farmers during the critical 1 to 10 day period, a phase where chicks are particularly vulnerable and require careful attention. The research will be conducted at a broiler chicken coop owner's facility in Desa Sungai Kuruk III, Aceh Tamiang. The device's effectiveness in supporting broiler chicken farmers during the growth phase will be tested and evaluated during the study. All steps of research method were shown in Figure 9.

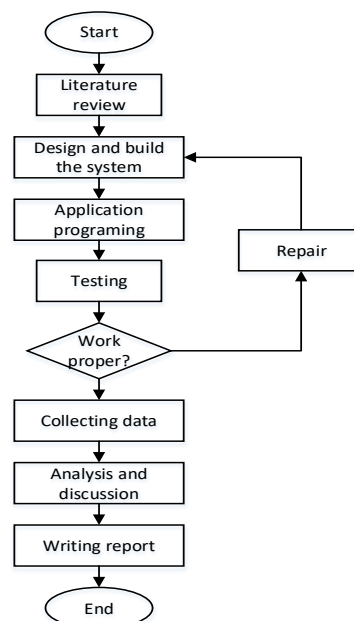


Figure 9. Flowchart of research method

3.1 Electrical Design

Design electronics include several components such as the DHT11 sensor, ultrasonic sensor, LCD 16x2 I2C, and servo motor. The overall operation of the device is as shown in Figure 10.

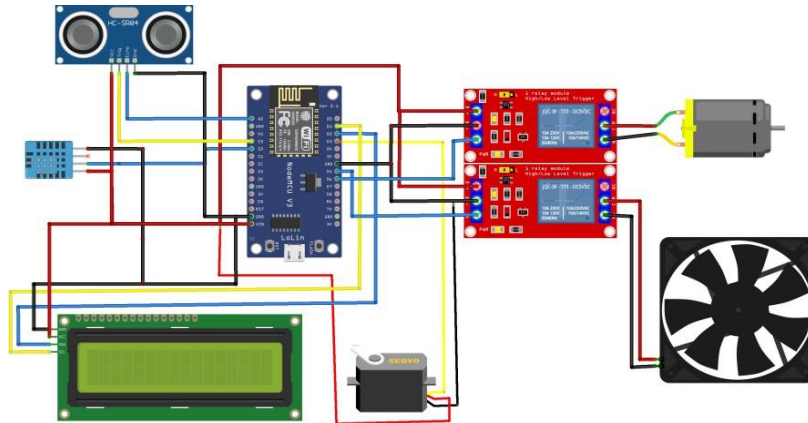


Figure 10. Electrical Design

3.2 Mechanical Design

In the mechanical planning of the Internet of Things-based smart farm device using ESP32 Board, LCD 16x2, 2-channel relay, DHT11 sensor, mini pump, servo motor, and ultrasonic sensor, the components will be integrated properly to ensure successful implementation as a prototype chicken coop. The mechanical design was shown in Figure 11.

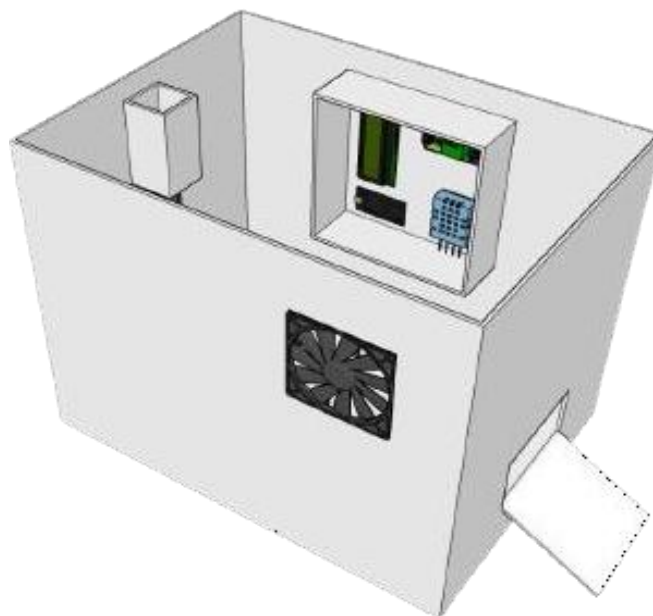


Figure 11. Mechanical Design

4. Result and Discussion

The Control and Monitoring System in a smart farm is designed to regulate and monitor the temperature and humidity within the chicken coop (smart farm). The design outcome of the Control and Monitoring System for the Smart Farm will encompass the results of the electrical design, mechanical design, and their respective testing processes.

4.1 Result of Electrical Design

The result of electrical design included several steps taken to create electronic components that support the overall system functions. This design process involves developing electronic control modules, the DHT11 sensor, ultrasonic sensor, servo motor, LCD 16x2, NodeMCU ESP32, 12V power supply, and 2-channel relay. Figure 12 shows the control box from the electrical design.

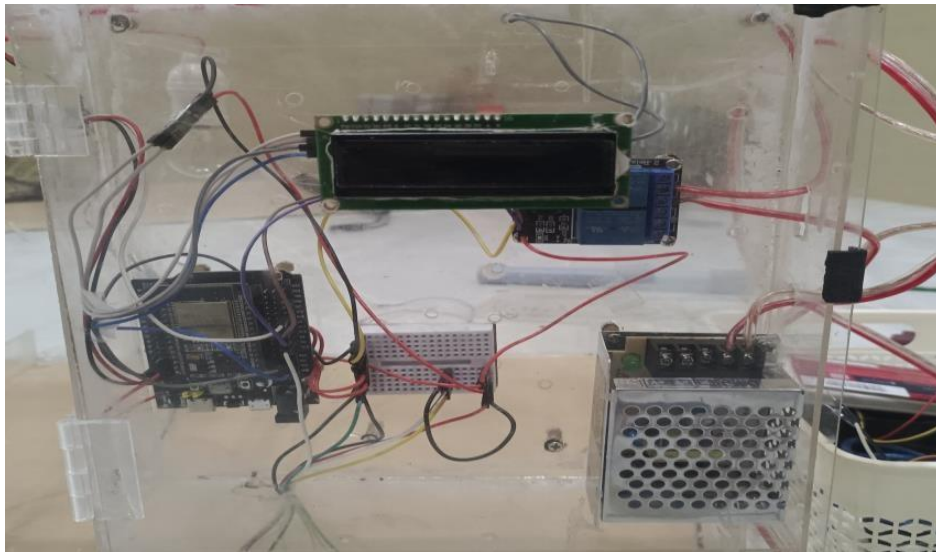


Figure 12. Mechanical Design

4.2 Result of Mechanical Design

The results of the electronic design are specifically tailored to the Smart Farm control and monitoring system, which includes several components. The components used are the DHT11 sensor, ultrasonic sensor, servo motor, LCD 16x2, ESP8266, 2-channel relay, and mini water pump. These components are arranged within a control box used by the researcher, facilitating the research conducted on the Smart Farm by using the control box containing several components like the servo motor, DHT11 sensor, and others. Below is an image of the overall circuit from the electronic design results. The prototype of build system was shown in Figure 13 and Figure 14.

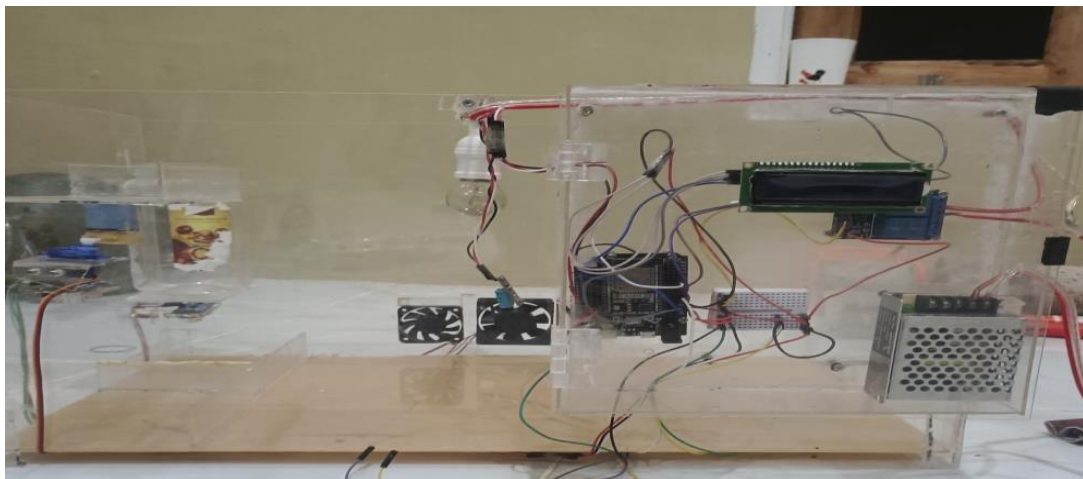


Figure 13. Front view of system prototype

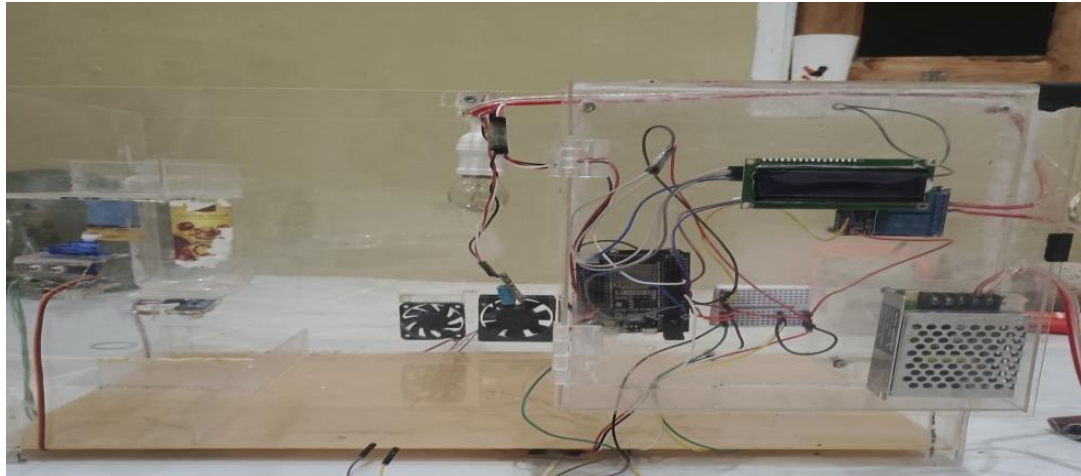


Figure 14. Top view of system prototype

4.3 Result of Testing

The overall testing data results from this research were shown in Table 1.

Table 1. Test results of smart farm for broiler chickens

No.	Day				Night			
	Temperature	Humidity	Lamp	Fan	Temperature	Humidity	Lamp	Fan
1	32,80°C	70%	Off	Off	32,30°C	71%	On	Off
2	32,90°C	70%	Off	Off	31,30°C	75%	On	Off
3	30,20°C	69%	Off	Off	32,80°C	70%	On	Off
4	29,80°C	80%	Off	Off	31,80°C	71%	On	Off
5	31,20°C	70%	Off	Off	29,80°C	72%	On	Off
6	33°C	65%	Off	Off	29,80°C	76%	On	Off
7	29,70°C	75%	Off	Off	30°C	80%	On	Off
8	30,80°C	72%	Off	Off	29,90°C	80%	On	Off
9	31,50°C	71%	Off	Off	28,70°C	79%	On	Off
10	34,20°C	63%	Off	On	30,30°C	76%	On	Off

From the data above, it can be concluded that the temperature in the broiler chicken coop remains stable from day 1 to 9, averaging around 30°C with an average humidity of 72% during the daytime. At night, the average temperature is around 29°C with an average humidity of 70%. The good stability of temperature and humidity in the chicken coop contributes to the health of broiler chickens, preventing stress and mortality. Throughout days 1 to 10, there were no deaths or illnesses observed among the broiler chickens, indicating favorable environmental conditions in the coop that promote their growth.

4.4 Result of Testing for Monitoring and Controlling via Internet of Things

Feeding and controlling the DC fan in the broiler chicken coop can be managed through the web interface of internet of things (IoT). The IoT web interface includes buttons for controlling feeding and lowering the temperature in the chicken coop. Below is an image showing the menu section of the IoT web interface for controlling feeding and reducing the temperature in the broiler chicken coop.

As shown in the above Figure 15, the servo motor control position at 45 degrees. In this position, the servo motor will open and dispense chicken feed stored in the container. In the above image, the servo motor is open to dispense chicken feed stored above it, and within a few seconds, it can be closed again to prevent excess feed from spilling out below in Figure 16.



Figure 15. Controlling the servo angle for feeding

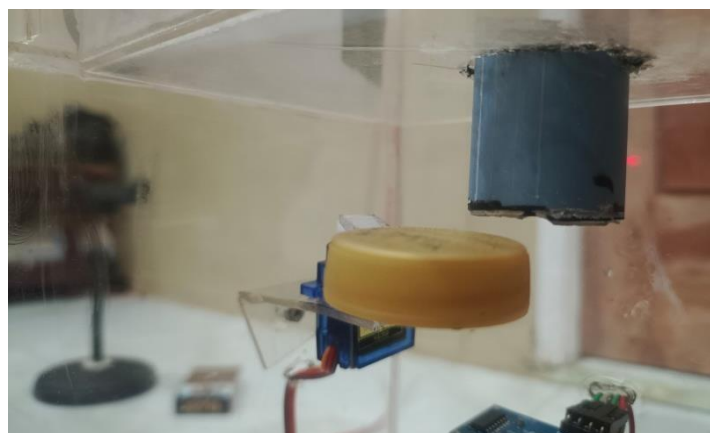


Figure 16. Motor servo position at 45°

Figure 17 shows the display of the internet of things web interface for the light button and DC fan button in the on position, and below is the image of the DC fan in the on position. Figure 18 shows a picture of the light in the chicken coop in the switched-on condition, synchronized with the Internet of Things web interface. Feeding and controlling the DC fan in the broiler chicken coop can be managed through the web interface of Internet of Things (IoT). The IoT web interface includes buttons for controlling feeding and lowering the temperature in the chicken coop. Figure 19 shows the menu section of the IoT web interface for controlling temperature reduction in the broiler chicken coop.



Figure 17. Control buttons for lights and DC fan



Figure 18. Condition of the light when the light button is ON

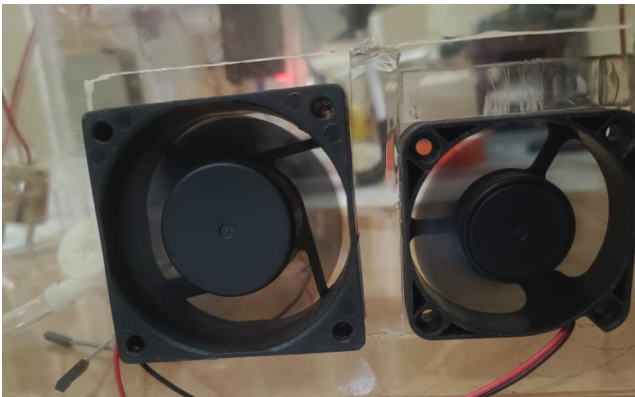


Figure 19. Fan Condition when fan button is ON

5. Conclusion

This research has designed and implemented the smart farm for broiler chickens aged 1 to 10 days based on internet of things. The application of Internet of Things (IoT) in smart farming for broiler chickens aged 1 to 10 days enables automatic and real-time monitoring and management of environmental conditions such as temperature, humidity, and lighting, crucial for optimal growth. Internet of things technology helps improve farm operational efficiency by providing accurate data and analytics for better decision-making and responsive actions to changing conditions. Continuously

monitoring and web-based IoT monitoring help reduce the risk of mortality and diseases in broiler chickens, thereby enhancing survival rates and livestock health. Implementation of IoT-based smart farming allows farmers to optimize manual feeding and watering through the IoT web interface, contributing to improved growth and weight gain of broiler chickens during the 1 to 10 days period. IoT integration in smart farming simplifies and enhances farm management efficiency, with IoT web access enabling farmers to monitor and control farm conditions remotely via internet-connected devices.

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