# Implementation of Wireless Sensor Network for Automatic Duck Egg Hatching Machine

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**Abstract.** Due to the development of IoT-based technology, it is easier to exchange data between devices on a massive scale. Its application has expanded to all sectors. One of them is in the field of animal husbandry. In duck egg hatching, seeds are one of the keys to success. Efforts can obtain excellent sources are to using an automatic incubator. In this study, we tried to combine the technology of combining WSN concept and updating the technology of the conventional duck egg hatching process. This study uses a DHT11 sensor, a sound sensor, and a Servo Motor, which can automatically produce a duck egg incubator and be monitored in real time on the website. Based on the results of this study was able to create a hatching process of 87%. We tested this device in the summer and the rainy season. It expects to reduce the risk of failure of the duck egg hatching process.

**Keywords:** WSN, egg duck, production, hatching

## 1 Introduction

The development of internet access has almost become a significant need in the needs of people's lives. The theme of the internet of things has begun to spread to essential applications such as intelligent environments, intelligent buildings, smart cities, and innovative farmers. Massive data collection enabled by IoT technology, Wireless Sensor Networks (WSNs) have become the most commonly used IoT-based platform for data collection [1]. Therefore, WSN is recognized as a fundamental component enabling IoT systems development [2]. In such a network, many sensors are deployed in thousands, collaborating to collect and transfer information to data servers.

The livestock sector plays a role in meeting the needs of animal protein sources. In general, livestock in Indonesia is still operated by small businesses with conventional management. The impact of traditional management is low productivity, the availability of feed depends on the season, and the price of animal protein sources fluctuates [3]. Animal protein provides essential amino acids that are much more complete than vegetable protein. Especially in eggs, there are lots of animal protein, omega-three fatty acids, vitamins, minerals, and antioxidants. Based on this, we suggest a breakthrough in animal husbandry. Hopefully, The breeders can

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run their businesses already inserted with technology. To improve welfare and increase food security in Indonesia.

The conventional duck egg hatching process uses a heat source from the sun with heat storage in the form of husks. Fertile egg production, proper handling, and exact incubation process are critical factors in producing good quality ducks. There are several requirements in the incubation process, such as temperature, humidity, and an actual emission of heat energy. These three factors can reduce the risk of embryo mortality. The application of IoT or WSN-based technology in previous studies was found in smart farmer [4], hatching pada performance of chicks from broiler breeders [5], the implementation of IoT in increasing efficiency in livestock [6], setting the position of eggs to increase hatchability [7]. In this study, we will describe the incorporation of the WSN concept and update the technology for the duck egg hatching process. The testing process is divided into two categories: testing components that can function and trying duck egg hatching.

## 2 Literatur Review

### 2.1 Wireless Sensor Network Concept

A wireless sensor network (WSN) is a multi-hop network or self-organizing network of sensor nodes that read and control natural phenomena occurring in the environment [8]. WSN consists of sensor nodes, the base station (gateway), and clients [9]. Figure 1 shows an outline of the structure of the WSN.

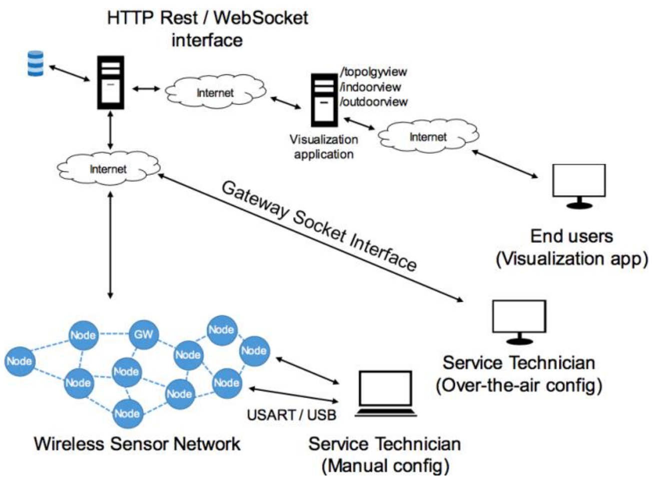


**Fig. 1.** Architecture of Wireless Sensor Network

### 2.2 Duck Egg Hatching Process

The conventional duck egg hatching process uses a heat source from the sun with heat storage in the form of husks. This method has long been known in the community. In addition to placing the eggs in the proper position. The success of the egg hatching process will be achieved if you pay attention to the following treatments [7]:

a. Temperature.

Table 1 shows the ideal temperature for each embryonic development of birds. The embryo in poultry eggs will develop rapidly if the egg temperature is at the right conditions and will stop producing if the temperature is less than required. The temperature needed for hatching eggs for each bird is different.

**Table 1.** The Ideal Temperature for Poultry

| No | Kind of the Poultry | Temperature |
|---|---|---|
| 1 | Chicken egg | $38{,}33^{O}$ - $40{,}55^{O}$ C |
| 2 | Duck egg | $37{,}78^{O}$ - $39{,}45^{O}$ C |
| 3 | Quail Egg | $39{,}5^{O}$ C |
| 4 | Swallow eggs | $32{,}22^{O}$ - $35^{O}$ C |

b. Humidity.

During the hatching process, parameters related to the temperature and humidity of each type of poultry have different values. Especially duck eggs should have moisture of about 70% in the first week and then 60% to 65% in the following week.

c. Ventilation.

Under normal conditions, the embryo needs oxygen ($O_2$) and produce carbon dioxide ($CO_2$) through the pores of the egg. Therefore, ventilation must be provided in the hatchery box to make incubators.

d. Time for hatching.

Duck egg hatching usually takes about 21-23 days.

### 2.3 Previous Research

This section describes this research's significant studies, which consist of analyses of related literature or previous research and systems design. Table 2 shows a comparison of related studies.

Based on the related studies in table 2, we can see the gap between this research and the other studies. Most other studies still do not use the sensors. Research using temperature and water sensors has been used, but for swallow incubators. This study aims to use duck eggs as an object and use temperature, humidity and sound sensors. The results can increase by 37% compared to other studies using the object of a duck egg incubator.

**Table 2.** Relative Research

| No | Ref | Research Title | Kind of the Poultry | Sensor | Persentage |
|---|---|---|---|---|---|
| 1 | [8] | Incubation of free-range chicken eggs in semi-automatic hatching machines with differences in egg storage time | Kampong Chicken | - | 80% |
| 2 | [9] | Automatic Egg Incubator Design Using the Temperature Sensor and Air Sensor | Swallow | Temperature and air | 98% |
| 3 | [10] | Development of Egg Incubator Using Artificial Heat Equalization | Chicken | - | 70% |
| 4 | [11] | Improvement of Itik Livestock Productivity Through The Application of Egg Hatching Machines | Duck | - | 60% |
| 5 | | Implementation of Wireless Sensor Network for Automatic Duck Egg Hatching Machine | Duck | Temperature, Humidity, and Sound | 87% |

## 3 Research Method

This section describes the proposed system design and explains the test scenarios used in this study.

### 3.1 System Design

Figure 2 shows a system flowchart that explains the workflow of the incubator.

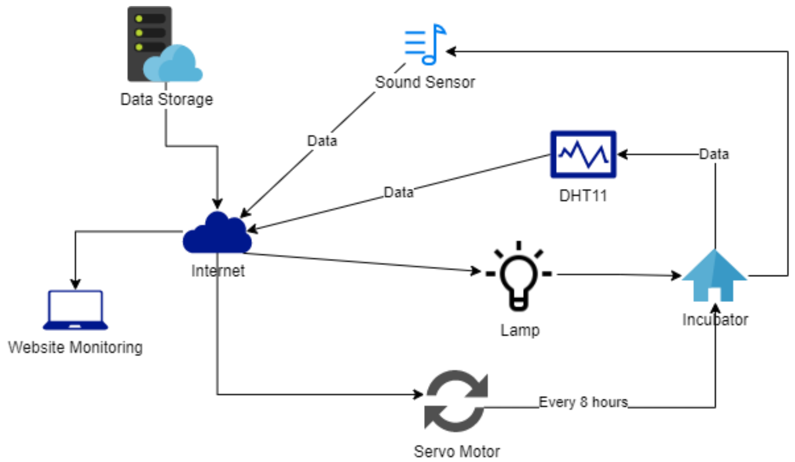


**Fig. 2.** System Design

Figure 2 show the system design of this research. DHT11 sensor taking temperature and humidity data on the engine. If the engine temperature > 40$^o$ C then the light will turn off, and if the temperature < 39$^o$ C then the light will turn on. The following process is sound data retrieval. If the sensor detects a sound that is heard only once, no eggs have hatched and returned to the egg-turning process. If the sound is heard several times, eggs are hatching. The website shows the monitoring of temperature, humidity and log of the reversal egg.

In Figure 3, the design of this device is the design of a series of tools such as Arduino , 16x2 LCD, DHT11, sound sensor, wifi esp8266 01, servo motor, and relay.

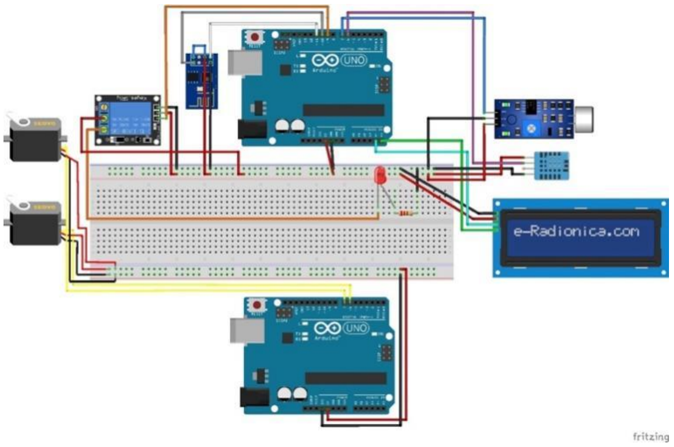


**Fig. 3.** Device Design

### 3.2 Research Method

Based on Table 3 shows the test scenario of the tools used. After all the tools are assembled, we use 40 duck eggs for hatching tests during the rainy and dry seasons.

**Table 3.** Device Testing Scenario

| No | Devices | Success Parameters |
|---|---|---|
| 1 | DHT11 | Can read temperature and humidity values |
| 2 | LCD 16x2 I2C | Can display output of DHT11 sensor |
| 3 | Sound sensor | Can detect sound |
| 4 | Relay | Can supply or cut electricity to the lamps |
| 5 | Wifi ESP8266 01 | Can send data to the server |
| 6 | Servo Motor | Can reverse the position of the egg |

## 4 Result and Discussion

### 4.1 Device Test Result

This chapter explain the output of several experiment based on table 3. Table 4 show the resume of the result.

**Table 1.** Result of the Testing Device

| No | Devices | Status | Result |
|---|---|---|---|
| 1 | DHT11 | Success | Fig.2 |
| 2 | LCD 16x2 I2C | Success | Fig.4 |
| 3 | Sound sensor | Success | Fig.6 |
| 4 | Relay | Success | Fig.8 |
| 5 | Wifi ESP8266 01 | Success | Fig.10 |
| 6 | Servo Motor | Success | Fig.12 |

When testing, the DHT11 sensor can function adequately as shown in figure 4 and 5. When the sensor gets closer to the fire, when you want to increase the temperature—the data reading by the sensor increases, and vice versa. When you want to cool the temperature, the sensor gets closer to ice, the data reading by the sensor decreases, and the humidity level increases.

**Fig. 4.** DHT11 Test Circuit


**Fig. 5.** Result of DHT11 Capture Data

**Fig. 6.** LCD Installation Process


**Fig.7.** LCD Output

Figure 6 shows a series of LCD screen installations. Figure 7 shows the output. At the time of testing, the LCD can function properly. The maximum number of characters on the first line LCD is 16 characters, including spaces, and the second line also has 16 characters, including spaces.

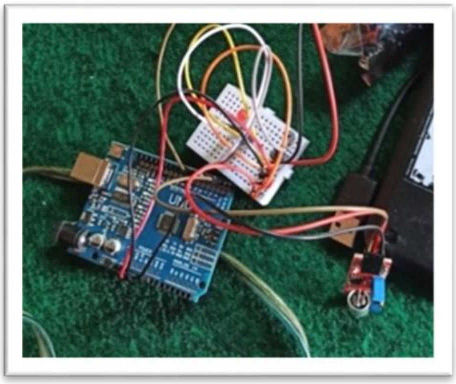

**Fig. 8.** Sound Sensor Circuit

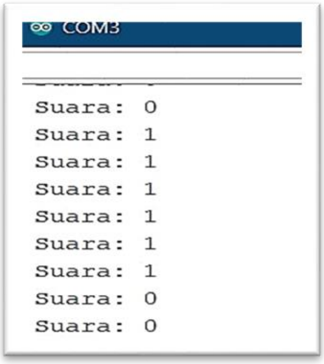


**Fig. 9.** Sound Sensor Output

Figure 8 shows the circuit of the sound sensor. Figure 9 shows the reading output from the excellent sensor. At the time of testing, it can be concluded that the sensitivity level of this tool is low because the sound produced is very close to the sensor, but the sensor is very slow in detecting the sound produced. Sensor readings are 0 and 1. If one means the sensor detects sound, and if 0 means the sensor does not detect sound.

**Fig. 10.** Relay Circuit

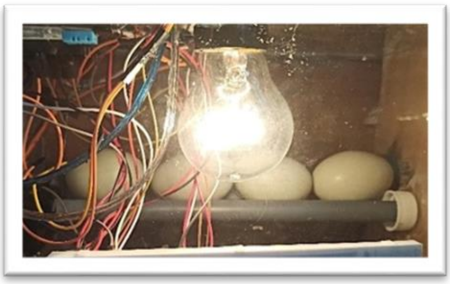

**Fig. 11.** Relay Output

Figure 10 shows the relay circuit. Figure 11 shows the relay's results in transmitting energy to incandescent lamps. The relay can function adequately according to the given program at the testing time. Namely, when the temperature detected by DHT11 is $>40^{o}C$, the relay can disconnect the electric current from the power cable to the lamp. When the detected temperature is $<39^{o}C$, the relay automatically flows electric current to the light.

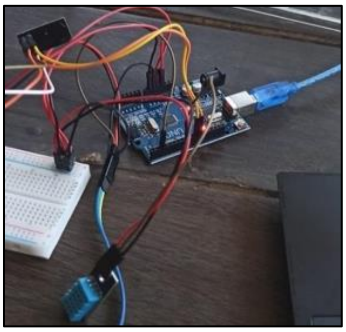

**Fig. 12.** Wifi Circuit

```
Suhu       = 39.00C
Kelembaban = 41.00%

AT+CIPSTART="TCP","192.168.43.71",80
AT+CIPSEND=66
GET /mushab/simpan_suhu.php?data=39.10 HTTP/1.1
Host: ip_host

AT+CIPSTART="TCP","192.168.43.71",80
AT+CIPSEND=69
AT+CIPCLOSE
 Suara: 0
```

**Fig. 13.** Wifi Connection Result

Figure 12 shows the wifi network. While Figure 13 shows the results of the data transfer output. When testing, wifi esp8266 01 sometimes works and sometimes doesn't. This is caused by loose cables, cables whose installation is swapped between tx and RX, then the laptop that is used as a server must be on the same network with wifi so that data can be sent.

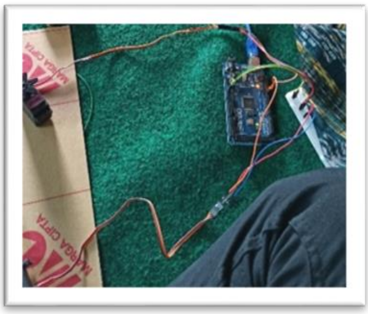

**Fig. 14.** Servo Motor Circuit

**Fig. 15.** Result of Servo Motor Circuit

Figure 14 shows a series of servo motors. Figure 14 shows the test results of the servo motor. In the test results, the servo motor can rotate well, but the maximum rotation of the servo is only 180$^o$, and this is because the manufacturer of the tool can only make a full rotation of 180$^o$ so that when testing is carried out, the cycle is back and forth, which is 180$^o$ rotating once from top to bottom then around turn from bottom to top 180$^o$.

### 4.2 Result of Hatching Process

In the first test, we used 40 duck eggs with the temperature set at 39 - 40$^o$C in summer. For the second test, we use 40 duck eggs with a temperature setting of 39-40$^o$C in the rainy season. The results of the first test are in Table 5. There is a success rate of only 50%. 20 duck eggs can hatch under normal conditions, ten eggs hatch but die, and ten eggs cannot hatch.

**Table 5.** The First Testing in Summer

| No | Status | Condition | | |
|---|---|---|---|---|
| | | Normal | Defective | Die |
| 1 | Hatch | 20 | - | 10 |
| 2 | Can not hatch | 10 | - | - |

**Table 6.** The second Testing in Rainy Season

| No | Status | Condition | | |
|---|---|---|---|---|
| | | Normal | Defective | Die |
| 1 | Hatch | 35 | - | - |
| 2 | Can not hatch | 5 | - | - |

Furthermore, during the rainy season, we try the second test. Table 6 shows the results of the second test. Thirty-five eggs hatched, and five did not hatch. We can see that based on the second test, the success rate has increased to 87%.

During the first and second tests, there were several obstacles encountered, namely the sound sensor that could not be used optimally due to the low level of sensor sensitivity in detecting if there was an audible sound resulting in inaccurate data collection by the sensor. The advantage of this hatching machine is the use of the DHT11 sensor which turns out to be very helpful in maintaining temperature stability in the machine because if there is a change in temperature in the box it will immediately stabilize at a temperature of 39-40ºC.

The monitoring process can help with the visualization. Figure 16 shows the temperature result from the incubator. Figure 17 shows the humidity result.


**Fig. 16.** Visualization of Incubator's Temperature

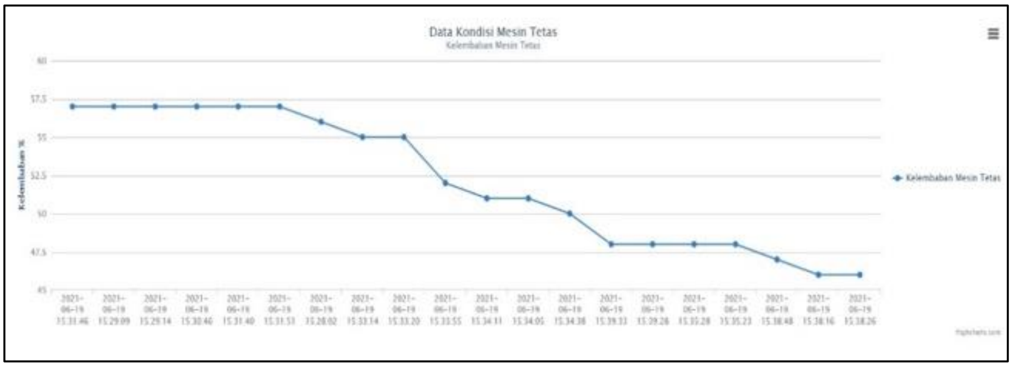


**Fig. 17.** Visualization of Incubator's Humidity

## 5 Conclusion

This study proposes the implementation of the use of a wireless sensor network in duck egg hatching automatically. In the first test, the hatching of eggs was 50%. Twenty eggs from 40 eggs hatched, and in the second test, the percentage of success in hatching eggs was 87%, or as many as 35 eggs from 40. The advantage of this hatching machine is very helpful in maintaining temperature stability in the device because if there is a change in temperature in the box, it will immediately stabilize at a temperature of 39-40$^{o}$C. Based on this research, we can conclude that this WSN-based automatic incubator can help farmers to increase their egg hatching production without being constrained by season.

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