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Design and Development of an Iot-Based Intelligent Incubator

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ABSTRACT: The intelligent egg incubator is designed to improve existing egg incubators to transform the traditional breeding method into a modern and advanced breeding method. To reduce the chore that traditional breeding methods can cause, the use of an automatic incubator is therefore recommended to ensure the best possible hatching rate. Automatic incubators also allow you to control heat and humidity levels to reproduce ideal brooding conditions. The main objective of this work is to design an egg incubation system that performs better than manual incubation. The proposed system is an innovation that makes it possible to monitor the temperature, humidity and movement of the egg inside the incubator thanks to a data acquisition system taking into account the physiological conditions of the eggs. The proposed system is equipped with a Wi-Fi module via the ESP32, allowing the system to be manipulated remotely.

KEYWORDS: IoT, egg incubator, temperature, humidity, egg rotation, alveolus.

1. INTRODUCTION

A hen lays on average one egg per day depending on the season. To hatch, the latter must be incubated for 21 days [1] However, in a traditional incubator system, there is no guarantee that this will be respected. Indeed, some hens prefer to explore in search of food rather than brooding, which reduces the hatching success rate. The automatic incubator will therefore ensure good monitoring of breeding. However, the air inside the incubator should not be too dry or too humid. To keep a stable humidity level, it is necessary to add water approximately every 2 days and during the incubation process, the eggs must be turned half a turn twice a day, i.e. a complete turn in 24 hours with a manual incubator [2].This manipulation is essential for the proper development of the embryo and prevents the embryo from sticking to the shell. To reduce the chore that this handling can cause, the use of an automatic incubator is therefore recommended to ensure the best possible hatching rate. Automatic incubators also allow you to control heat and humidity levels to reproduce ideal brooding conditions. Sensing temperature and humidity automatically is a technique that can be used in a variety of applications, including agriculture, monitoring and healthcare. This technique is essential in the implementation of an automatic egg incubator for good management of the air inside it. This project focuses on the development of temperature and humidity monitoring systems on egg incubation machines, particularly those that require continuous monitoring. The intelligent egg incubator is designed to improve existing egg incubators to transform the traditional breeding method into a modern and advanced breeding method. Nowadays, agriculture and livestock are important fields that continue to develop thanks to the evolution of technologies.

2. LITERATURE REVIEW

In this section, we present work done on egg incubation systems.

In [3], the authors were interested in how to hatch chicken eggs automatically. The objective of this study is to design and build an “intelligent egg incubator”. The problem in this work is that in the absence of electricity, there is no egg incubator. In [4], the authors were interested in how to slide egg shelves while supporting the heaviest possible load in an egg incubator. This research has helped reduce electrical energy consumption, but there is no control and this is a big problem.

Authors [5] are interested in how to ensure the best possible temperature for the incubation system. The researcher found the best type of bulb as a heating source, however, there is no control. In [6], the authors were interested in how to rotate a large number of eggs using the DC motor and the DS1307 real-time clock and the SHT11 sensor. The objective is to spin a large number of eggs automatically. However, the system does not take into account the monitoring and status of the incubator. In [7], the authors were interested in how to use renewable energies for example solar energy as a source of energy instead of traditional energy. The new system is easy to use, inexpensive and easy to maintain, but there is no monitoring of incubation status.

In this study [8], the authors developed a system for incubating eggs with the aim of managing temperature. The system is equipped with a LoRa wireless system to communicate with the incubator remotely so that the temperature can be managed remotely. This system does not take into account the rotation of the eggs in its operation at the incubator level.

This research [9] offers a remote incubator monitoring and control system, capable of making the incubator temperature stable and uniform using genetic algorithms. This system also attempts to reduce unnecessary energy consumption. This system does not take into account the rotation of the eggs in its operation at the level of the incubator which plays an essential role in the hatching percentage. In this study [10], the authors designed an egg incubator capable of hatching eggs automatically using a temperature, heating and cooling control system inside the incubator. This system allows you to know if an egg is moving, however, it does not manage the rotation of the eggs in the hatching percentage. In [11], the authors set up a temperature control system through the use of a light bulb and a fan for an egg incubator. In this work [12], the authors designed an egg incubation system that takes into account temperature sensors, humidity, ventilation and an egg turning system using inexpensive materials. The developed system works with a solar panel, a water pump and a humidifier and an MCU node to control the system from the internet. In this study [13], the authors were interested in the design and construction of a smart solar incubator based on GSM and IoT technologies in order to limit human contact during the incubation cycle with a view to reducing chick mortality and the cost of exploitation.

In [14], the authors proposed an egg incubation system with the objective of optimizing the management of the temperature of the incubator through the use of the fuzzy inference system and the Internet of Things. This system can be controlled and monitored remotely via the internet. In [15], the authors developed a smart incubator for quail eggs using an Arduino microcontroller-based system to control the temperature, humidity and egg rotation of the system. The system integrates a Python module and VNC software capable of monitoring the incubator remotely. In [16], the authors also developed an intelligent quail egg incubation system that can be controlled remotely, and capable of controlling the temperature, heating source, humidity regulation, operation of the egg rack using to IoT sensors to optimize quail production. This study [17], made it possible to design an IoT-based remote monitoring system in a duck egg incubator based on temperature and humidity sensors.

3. RESEARCH METHODS

The main objective of this research is to design an egg incubation system that performs better than manual incubation. In this project, microcontroller software is used to control the temperature. This microprocessor is connected to the relay circuit so that it can control the bulbs and fans automatically. If the temperature is above 37°C-38°C and it can be detected by temperature sensor circuit, the relay circuit will turn off the bulb and turn on the fan to reduce the temperature inside the room. 'incubator. If the temperature is below 37°C, the bulb turns on and the fan turns off. The project requires a temperature of around 37°C to 38°C to ensure that the incubation of the eggs is more regular so that the result obtained is of better quality.

3.1. Architecture of the incubation system

The incubation system is based on IoT components.

The diagram in Figure 1 integrates several components and functionalities such as:

i. Built-in sensors: The incubator is equipped with specialized sensors such as temperature, humidity, egg rotation, and possibly gas levels. These sensors collect data crucial for the healthy development of embryos.

ii. Connecting to a Network: The incubator has connectivity capabilities. This allows the incubator to exchange information with other devices connected or an online platform.

iii. Automated settings: The connected incubator can automate certain aspects of the incubation process by automatically adjusting parameters such as temperature and humidity according to the specific needs of each phase of the incubation cycle.

iv. Candling system: the connected incubator is equipped with a specific lighting system designed for candling. These may include LEDs or other light sources suitable for illuminating the egg in a way that makes the air chamber and the developing embryo inside visible.

v. Remote activation: Thanks to the connectivity of the incubator, the candling system can be activated remotely by the user via the app. This helps minimize disruption during the incubation process while providing full control over the timing of candling.

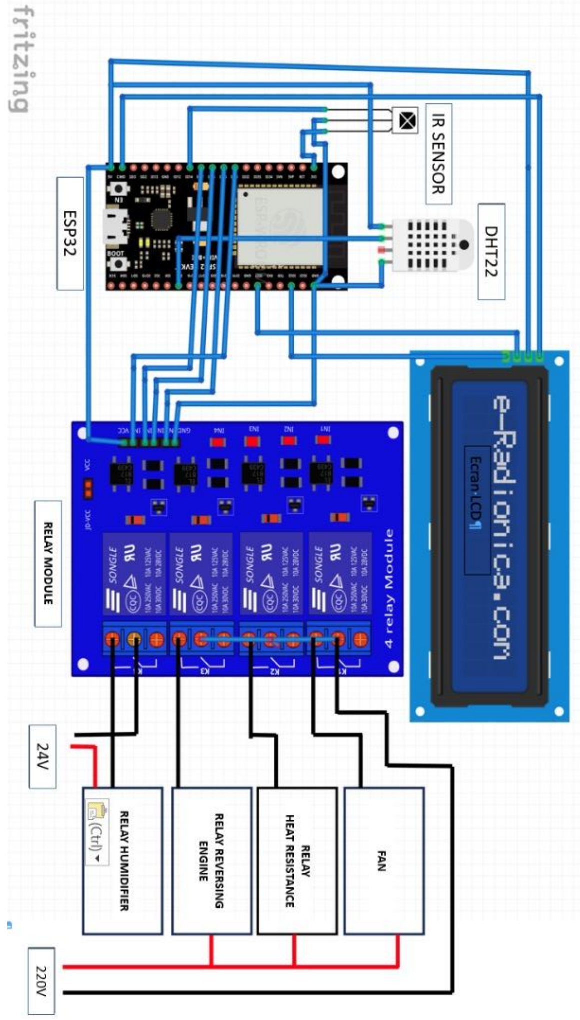


Figure 1: diagram of the incubation system

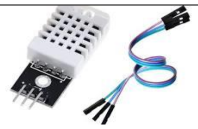
An overview of the components used to create our system is presented in Figure 2 below.

Figure 2: system components

3.2. Description of system components

The system components are shown in Table 1 below.

Table 1: system components

Name	Description
 TFT LCD	A TFT (Thin-Film Transistor) type liquid crystal LCD screen. Allows you to display real-time information on the status of the incubator and sensor data.
 ESP32	A Wi-Fi and Bluetooth microcontroller. Control of the incubator system, connection to the Wi-Fi network, management of sensors and actuators.
 DHT22	Digital humidity and temperature sensor. Measurement of humidity and temperature inside the incubator for environmental control.
 IR sensor	Infrared sensor to detect infrared signals emitted by a remote control. Controls the system via an infrared remote control.
 4 relay module	Expansion card with four relays for switching electrical loads. Control of fan, heating element, egg turning, humidifier.
 Cell with motor	Structure or compartment with a motor intended for the automatic turning of eggs in an incubator on a periodic basis.
 Power supply unit	Electrical power source to provide stable voltage to the system. Powers all incubator components
 Humidifier	Device that adds moisture to the air. Maintains a specific humidity level inside the brooder
 Fan	Ventilation device that can be activated to regulate the temperature. It allows you to cool the incubator by activating the fan when the temperature exceeds a threshold.
 Heating resistor	A heating element that produces heat when supplied with electricity. It maintains a constant temperature in the incubator by activating the heating resistance when necessary.

4. RESULTS AND DISCUSSION

4.1. System assembly

To make the system operational after validation of the architecture, comes the assembly phase which consists of connecting all the components so that they communicate with each other in order to carry out the tasks assigned to them. Figure 3 shows the assembly of the system components.

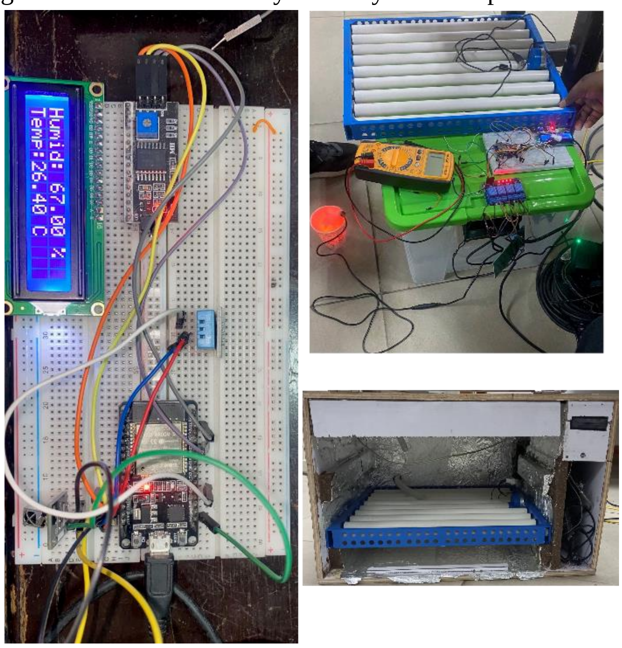


Figure 3: Assembling the system components

4.2. System operation

In this section we describe the operating principle of the incubation system which was designed as part of this project. Figure 4 illustrates how the system works.

When the system is turned on, temperature, humidity and cell data are collected. Concerning the temperature, after this collection phase, the system checks whether the temperature is below normal or not. If the temperature is below normal, the heating resistance turns on until the normal temperature is reached (37.5°C) otherwise the heating resistance is turned off. The temperature is monitored in this manner until the system is turned off.

Concerning humidity management, after the collection phase, the system checks the humidity level of the incubator. If this rate is normal, that is to say between 45% and 60%, the humidifier is turned off, otherwise the humidifier turns on until the normal rate is reached.

Concerning the cell, after the system is started, there must be an inactivity time of 72 hours and after these 72 hours, the cell rotates for one minute, allowing the eggs to rotate, then stops for 8 hours. After 8 hours of stopping, the cell starts to rotate for another minute then stops for 8 hours. The cell operates like this for 18 days and stops until the incubator system is powered on again.

Figure 5 shows the schematic of the complete system where the incubation system is connected to a database system via a wireless network. The image of the incubator is shown in Figure 6.

Figure 4: the incubator in pictures

The system that has been set up interacts with a database system via a web and mobile platform in order to analyze the data collected as illustrated in Figure 7.

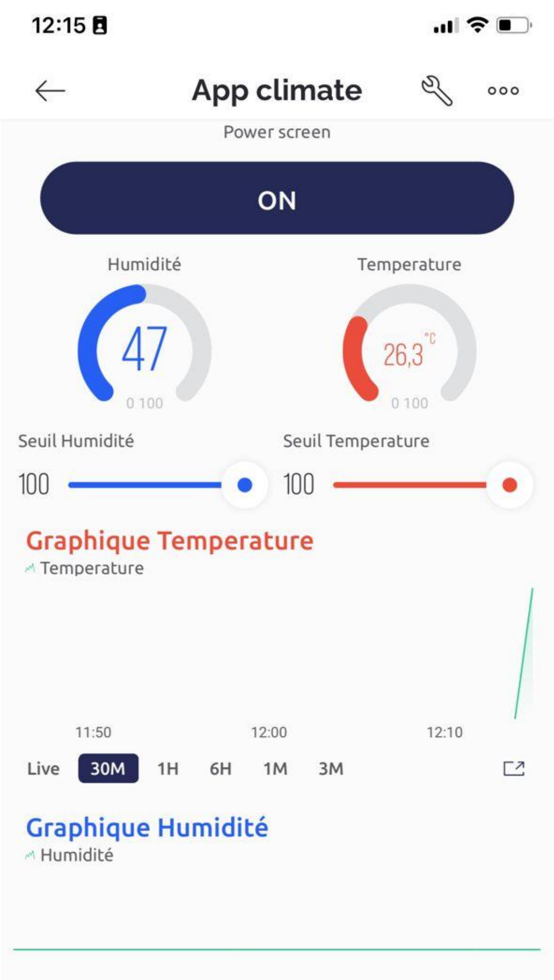


Figure 7: Temperature and humidity resul

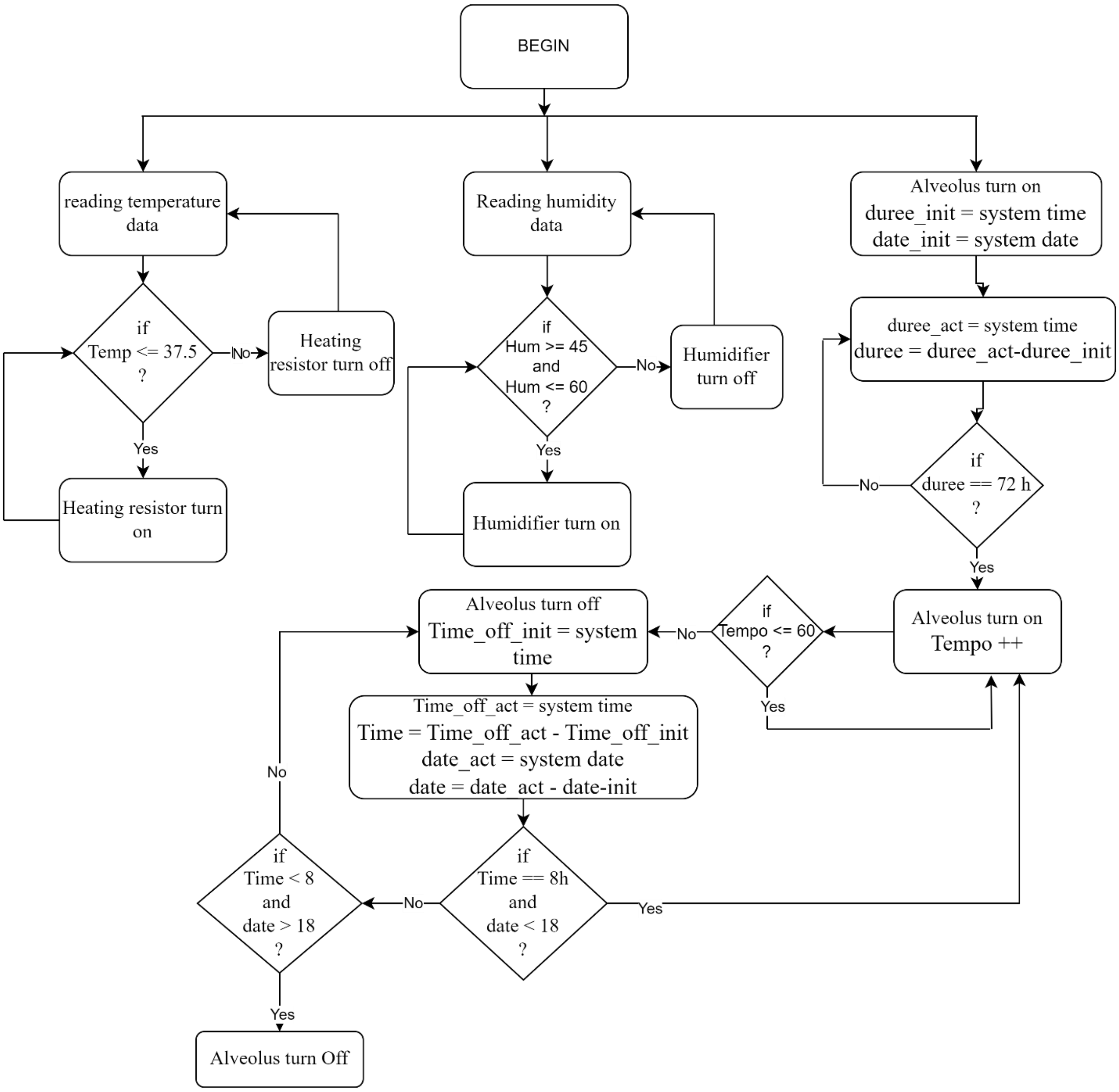


Figure 5: system operating flowchart

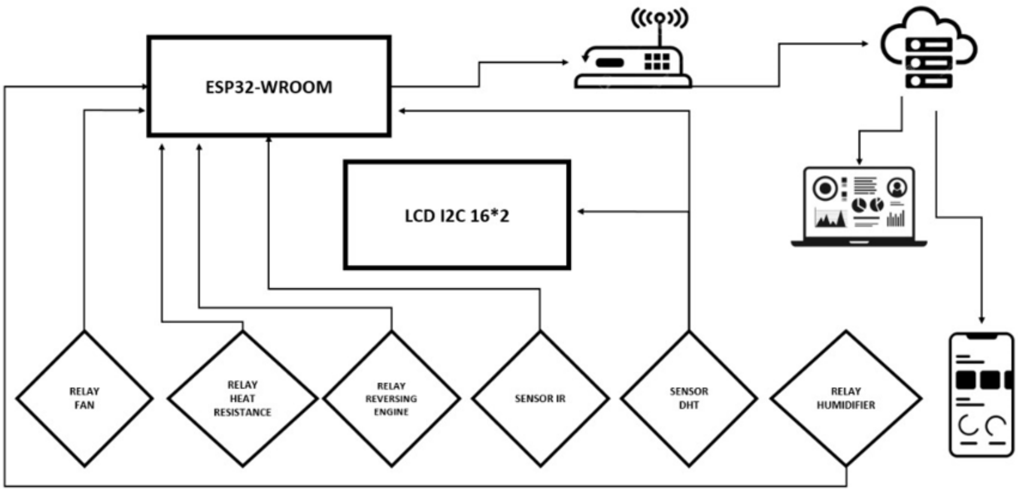


Figure 6: diagram of the complete system

5. CONCLUSIONS

We have designed an intelligent incubator using electronic components from the IoT. We proposed an architecture of the incubator which made it possible to set up a functional prototype. The system that has been put in place makes it possible to automatically and autonomously control the temperature, humidity of the incubator as well as the rotation of the eggs using the automatic cell. All this promotes increased egg hatching compared to a manual incubator. In future work, we will integrate a solar system to power the incubator, which will reduce the cost of energy use and allow the incubator to still be operational in the event of a power outage.

REFERENCES

1. EB Sonaiya and SEJ Swan,*Family poultry production: a technical manual*. Rome: Food and Agriculture Organization of the United Nations, 2004.
2. B. MORIN, “The use of an incubator to ensure good monitoring of your breeding. », Tips for using incubators. Accessed: January 8, 2024. [Online]. Available at: https://www.agrialpro.fr/blog/post/conseils-utilization-couveuses
3. KB Azahar, EE Sekudan, and AM Azhar, “Intelligent Egg Incubator”,*International Journal of Recent Technology and Applied Science (IJORTAS)*, flight. 2, no. 2, Art. No. 2, Sept. 2020, doi: 10.36079/lamintang.ijortas-0202.129.
4. J. Iskandar, S. Alrasyid, E. Nurhaqiqi, F. Andria, and ET Tosida, “Optimization of electronics and mechanics system of automatic egg incubator machine,”*IOP Conf. Ser.: Mater. Sci. Eng.*, flight. 621, no. 1, p. 012004, Oct. 2019, doi: 10.1088/1757-899X/621/1/012004.
5. A. Che Amran*et al.*, “Analysis of Light Bulb Temperature Control for Egg Incubator Design”, IJIE, vol. 11, no. 4, Sept. 2019, doi: 10.30880/ijie.2019.11.04.031.
6. NRD Raja Mohd, NS Mohd, YMZ Mohamad, and HK Abdul, “the development of automatic forced air egg incubator - Google Search,” vol. 8,nº1, p. 101-108, May 2019.
7. LO Thet, H. Hla, and MO Aye, “CONSTRUCTION OF HEN EGG INCUBATOR CONTROLLED CIRCUIT USING PIC16F877A,” vol. XVII, no.º2A, p. 461-482, August 2019.
8. MA Afandi, FK Purnomo, RA Rochmanto, and SI Purnama, “Monitoring and Controlling Temperature Egg Incubator Prototype Based LoRa Communication,”*ELINVO*, flight. 7, no. 2, p. 119-126, Jan. 2023, doi: 10.21831/elinvo.v7i2.53664.
9. F. Alif Fiolana, D. Arie WK, and RA Ansori, “Egg Incubator Design Using Artificial Intelligent,”*prosidingseminar*, p. 9, Nov. 2019, doi: 10.32503/prosidingseminar.v0i0.2.
10. KB Azahar, EE Sekudan, and AM Azhar, “Intelligent Egg Incubator”,*ijortas*, flight. 2, no. 2, p. 91-102, Sept. 2020, doi: 10.36079/lamintang.ijortas-0202.129.
11. E. Mujčić and U. Drakulić, “Design and implementation of fuzzy control system for egg incubator based on IoT technology”, in*IOP Conference Series: Materials Science and Engineering*, IOP Publishing, 2021, p. 012038. Accessed: October 17, 2023. [Online]. Available at: https://iopscience.iop.org/article/10.1088/1757-899X/1208/1/012038/meta
12. L. Niranjan, C. Venkatesan, AR Suhas, S. Satheeskumaran, and SA Nawaz, “Design and implementation of chicken egg incubator for hatching using IoT,”*IJCSE*, flight. 24, no. 4, p. 363, 2021, doi: 10.1504/IJCSE.2021.117018.
13. F. Peprah, S. Gyamfi, M. Amo-Boateng, E. Buadi, and M. Obeng, “Design and construction of smart solar powered egg incubator based on GSM/IoT,”*Scientific African*, flight. 17, p. e01326, Sep. 2022, doi: 10.1016/j.sciaf.2022.e01326.
14. R. Rakhmawati, FD Murdianto, A. Luthfi, and AY Rahman, “Thermal optimization on incubator using fuzzy inference system based IoT,” in*2019 International Conference of Artificial Intelligence and Information Technology (ICAIIT)*, IEEE, 2019, p. 464-468. Accessed: October 17, 2023. [Online]. Available at: https://ieeexplore.ieee.org/abstract/document/8834530/
15. WSM Sanjaya*et al.*, “The development of quail eggs smart incubator for hatching system based on microcontroller and Internet of Things (IoT)”, in 2018 International Conference on Information and Communications Technology (ICOIACT), Yogyakarta: IEEE, March 2018, p. 407-411. doi: 10.1109/ICOIACT.2018.8350682.
16. M. Unik, Y. Fatma, and M. Tantaya, “Internet of things and automatics control system on quail egg incubator using human-centered design method,” presented atthe 2nd international conference of science and information technology in smart administration (icsintesa 2021), Balikpapan, Indonesia, 2022, p. 050011. doi:10.1063/5.0105718.
17. Y. Yanti, A. Rohman, S. Maesaroh, A. Mustopa, and RM Febrian, “The Implementation of The Internet of Things in The Duck Egg Incubator Monitoring System,”*THIRD PARTY*, flight. 3, no. 2, p. 84-90, Dec. 2022, doi: 10.38043/tiers.v3i2.3891.