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IoT Multiple Temperature Control Quail Egg Hatcher

Full Paper

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Abstract

This study developed an automatic quail egg hatcher with multiple temperature controls that was designed for small scale hobbyist or user. This system works by using the temperature and humidity profile in the hatcher as input parameters to control the temperature and humidity in the quail egg hatching process. At the same time, the system will send an information message to the user through Telegram application. The data obtained from the temperature and humidity sensor (DHT11) and sent to process by the Arduino Nano controller which has the advantage of small size and is integrated with ESP8266 module as a transmitter to send the information via the internet to the user's telegram phone (using C++ codes). The data taken from DHT11 will give an information provided about the current temperature and humidity in the hatcher. As temperature and humidity profile control for this system, the heating element component that works to increase the temperature when its needed, the DC motor as the exhaust fan that will reduce the temperature and humidity if there is excessive temperature and humidity and the air humidifier component from the water tank supplied to increase the humidity level. There are three (3) levels of temperature that have been set according to the setting which will change according to the time period that has been set, which is during the hatching period of 18 days. The size of the system product is suitable for user mobility in order to setup and installation and the numbers of twelve (12) eggs can be set for hatching in one time suitable for hobbyists as a targeted user. Temperature, humidity and movement data from the system were successfully sent via wi-fi connection into Telegram application, and the eggs has been hatched in obtained period, temperature and humidity.

Keywords: - Temperature and humidity profile, telegram application, user mobility

1. Introduction

The issue of the food supply crisis is becoming a global problem that is getting worse if no action taken immediately from now. For this reason, the agricultural industry plays a very important role and from that, this industry becomes increasing rapidly and developed to increase the production of food resources in global. This issue was promoting the United Nation's Sustainable Development Goals (SDGs 2016) number 2: "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture" (United Nation 2016). The process of keeping the fertilized eggs warm during hatching process enables the embryo to develop into a bird as intended. It could be man-made or natural. The bird sits on the relatively few eggs she lays periodically as they incubate naturally, creating the ideal environment for the eggs to develop in an open area. Egg hatchability is often increased using artificial incubators, which improves and increases the production of chicks and eggs for human consumption and the commercial market (Jeffrey et al., 1996). Egg hatching percentage is one of the important aspects in the egg hatching process. This is because a high hatching percentage causes egg wastage to decrease while increasing yield. This product is specially designed for people who are interested in making this egg hatching activity their hobby. Since the size is not too big, this product is suitable to be placed in the bedroom, living room

or kitchen. There are also other egg incubators available in the market, but most of them require manual setting, i.e., the user has to set the temperature himself according to the hatching phase. This project aims to design an automatic temperature control quail egg hatcher that can control various temperature profiles with the product can be mobile easily. In addition, this research also aims to develop a circuit and source code for an automatic temperature control that been used in the system with any information or parameter that could be senses will be send via telegram application in additional IoT technology feature. A telegram chatbot is a part of technology on an Internet of Things (IoT) system device and may take commands from people or microcontroller (Findawati et al., 2020). This is because there are some incubator products that have been produced before, have not yet used some of IoT technology, i.e. any data or parameter changes will be sent to the user as an early warning or information required by the user. While all this information or initial changes are urgently needed for users to make any decisions, this has been recommended (Shittu et al. 2017) in order to be able to inclusive of a communication module to notify the user of present condition and give an alarm for any emergencies that require attention. As for fundamental of study in number of days in entire hatching process for quail eggs, it will take about 15 to 18 days until all the eggs are hatching (Redzwan et al., 2018). The device was designed to function within the 37°C to 39°C temperature range, which was determined to be sufficient for the development of embryos and the maintenance of 45–70% relative humidity (Fredrick et al., 2021).

Recent development on this incubator or an automatic hatching system was the size of the finished product was built in big size and quite impossible to bring or change places as for mobility. This kind of product suitability is limited for users who need the production of birds (Kyeremeh. et al., 2017). Some innovation existing product was not including with movement sensor such as passive infrared (PIR) sensor (Mariani et al., 2021). Furthermore, Szolga & Bondric (2020) had developed a smart incubator based on Arduino for quail eggs by using global system for mobile (GSM) module as for IoT technology. The results show the system has successfully hatched a quail egg normally between targeted period and the information can be send to the user via GSM module.

2. Methodology

The project development was divided into three main parts. There are mechanical design, electronic design and software design that has combined together in its process. The micro-controller is essential part which manages almost all of the incubator's sensors and devices and sets the ideal temperature and timing for quail egg incubation. The physical nature of the system and its economical material consumption are designed. The incubator chamber was heated by an incandescent bulb that was controlled by a micro-controller. The forced convective air flow, which was facilitated by installed centrifugal fans, evenly dispersed the heat throughout the chamber. Throughout the whole incubation time of the quail eggs, the micro-controller regulated the temperature and relative humidity of the air inside the incubator chamber. In this research the chosen of Arduino Nano is the best choice that selected. For both novice and seasoned developers, its small size, simplicity of usage, adaptability, and cost make it a great option, Ismailov & Jo'Rayev (2022). ESP8266 Module was suited to use together with Arduino Nano as a part of data transmitted through wifi connection. The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability, Azahar et al. (2020). PIR sensors are electronic sensors that detect motion and are used in motion-activated lighting and security systems. They detect infrared light-emitting items inside their range of vision. Heat energy is released by the body that has a temperature higher than zero and takes the form of radiation. This motion sensor to be used to detect any movement from baby quail inside the product whenever the eggs to be hatch. Thus, this movement information to be send to the user. The main sensor component on this project is DHT 11. The function of this sensor is to measure humidity and temperature. This sensor uses only 3 pins, namely Vcc, GND and 1 data pin to communicate with the Arduino. The DHT sensor has several variations namely DHT 21 and DHT 22. DHT 11 was chosen due to its price (Sonawane et al., 2019). Although the accuracy and temperature and humidity range of DHT 11 is lower than that of DHT 22, DHT 11 is seen to be more suitable in this project because the temperature and humidity range to be measured is not very large – around 50% –80% humidity and 25 ℃ - 40 ℃. As for air humidifier which to control the humidity in the chamber, the suitable component was selected which are water atomization modules. These compact modules turn liquid water into a tiny mist. Usually, these modules use ultrasonic technology, in which the water's surface is broken up into tiny droplets by high-frequency vibrations. They are used in cooling systems, humidifiers, air purifiers, and scent diffusers. Fig. 1 shows the block diagram of the system. As for software design, a source code was written in C++ language by using Arduino IDE platform.

In Fig. 2, it shows the schematic diagram of the system by using Fritzing online freeware. Fritzing is an open-source software tool designed to make electronics accessible to everyone, it can show in various views for easily to design such as breadboard view where it can virtually assemble components on a digital breadboard, just like a real one. Schematic view for more formal representation of the circuit, showing components and connections in a clear diagram and PCB view. Fritzing can generate PCB layouts, which can then be sent to manufacturing. Instead using the 20X4 LCD with I2C, the 7-segment display used here is 16X2 without I2C module. This schematic is essential in order to simulate the prototype before developing the hardware version of it.

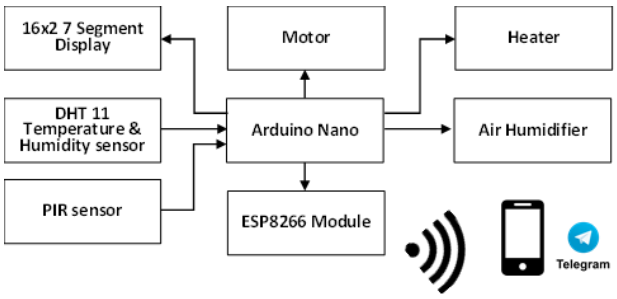


Fig. 1. Block diagram of the system

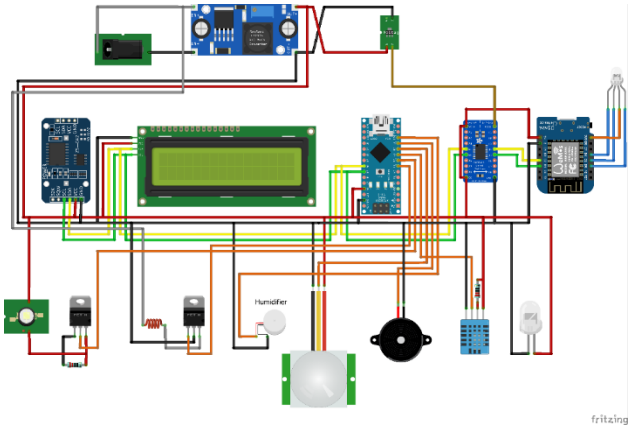


Fig. 2. Schematic diagram of the system

Fig. 3 shows the flowchart for this system. Overall, this system works to control the temperature and humidity at a set value. This value can change over time the day since this egg hatching process started. On the first to seventh day of the hatching process, the temperature is maintained around 38.14 and on the eighth day until the eggs hatch the temperature is raised slightly to 38.75 ℃. In terms of humidity, the temperature humidity is maintained from 50% to 55% from the first day until the 13th day and the next day the humidity is increased slightly from 60% to 65%.

As for mechanical design, the product material for this project by using plastic acrylic perspex. Perspex is a suitable material to be used as a door because of its light and transparent material in further the temperature grade for this material can be up to 90 ℃ (Foist, 2020). The design for this quail egg hatcher project is entirely inspired by the design of an oven. The design of this oven is considered the most suitable because of its simple design and easy to make. This tool is designed to be easy to carry anywhere and is suitable for small-scale egg hatching projects. Fig. 4 shows the mechanical outlook of the product.

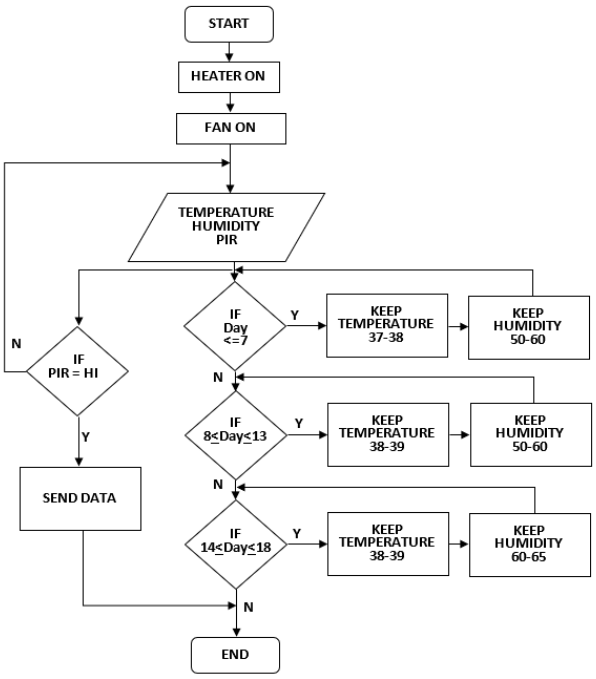
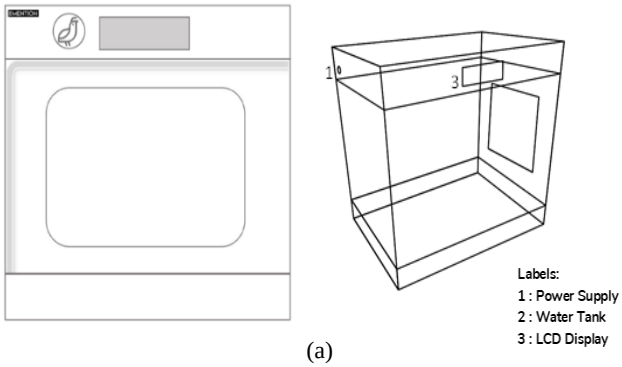
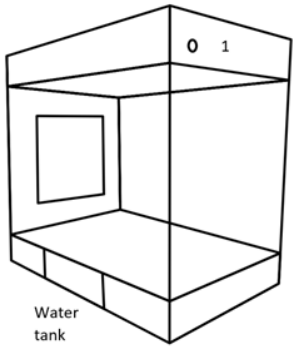


Fig. 3. Flowchart of the system



(a)



(b)

Fig. 4. (a) Front view (b) back view

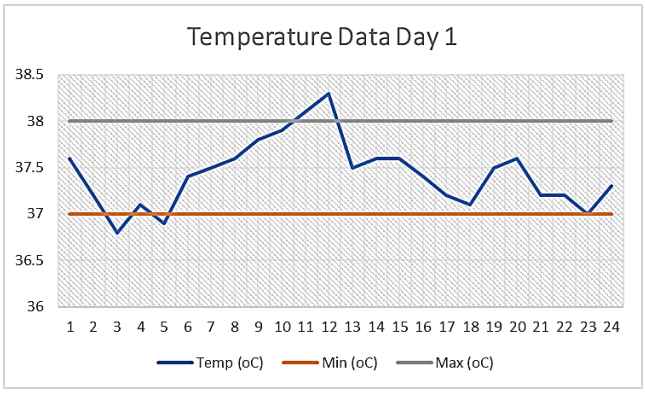
3. Result

Several series of tests and observations were carried out to obtain research results. All the results obtained have shown positive results and the development of this research has successfully achieved the objective target. In Table 1, a series of tests on the temperature and humidity accuracy of the developed system were carried out. In this testing, the sensor used to monitor both temperature and humidity within the incubator is DHT11 yang located in the product chamber. These temperature and humidity data were taken in ten (10) attempts in various levels. The data was compared with the reading from hygrometer that located inside the chamber. As the result, accuracies of the system were acceptable with for temperature was 99.43% and humidity was 98.8%.

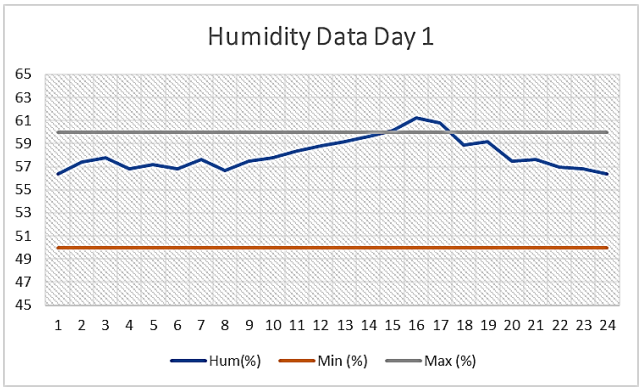
Second evaluation is to check the validation of the temperature and humidity during incubating period. The data was taken on day 1, day 10 and day 14 with 24-hour monitoring for in hour time intervals. The monitoring was made to these days by referring of period in three phase changes as sets. Fig. 5 shows temperature and humidity data for day 1. Likewise, as shown in Fig. 6 for day 10 and Fig. 7 as for day 14.

Table 1. System temperature and humidity accuracy testing

			Attempts(n)										
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Temperature	**System Data**	**°C**	33.0	34.0	35.0	36.0	36.0	37.0	37.0	38.0	38.0	39.0	Average
	Hygrometer Reading	**°C**	34.0	34.5	35.0	35.5	36.0	36.6	37.0	38.0	38.5	40.0	Accuracy (%)
	Accuracy	**%**	97.06	98.55	100.00	101.41	100.00	101.09	100.00	100.00	98.70	97.50	**99.43**
Humidity	**System Data**	**%**	49.0	53.0	54.0	58.0	60.0	64.0	65.0	68.0	69.0	72.0	Average
	Hygrometer Reading	**%**	48.0	52.0	55.0	58.0	61.0	63.0	65.0	67.0	69.0	71.0	Accuracy (%)
	Accuracy	**%**	97.92	98.08	98.18	100.00	98.36	98.41	100.00	98.51	100.00	98.59	**98.80**

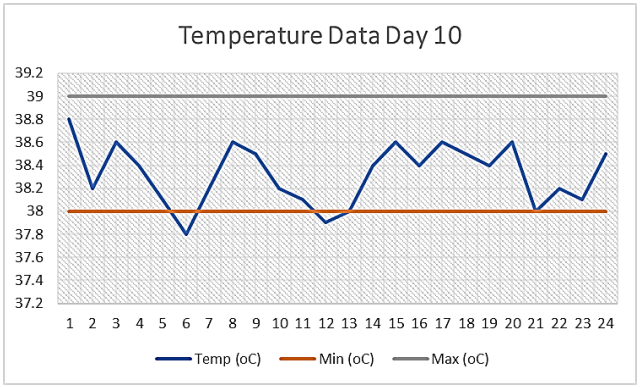


(a)

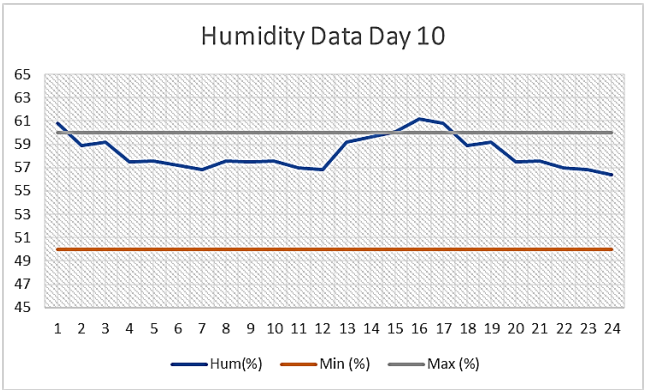


(b)

Fig. 5. Temperature (a) and humidity (b) monitoring data for day 1

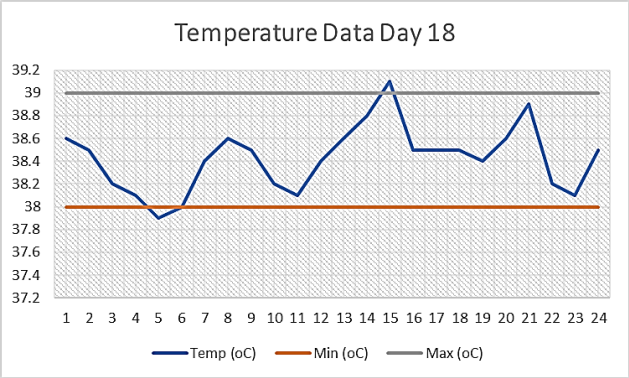


(a)

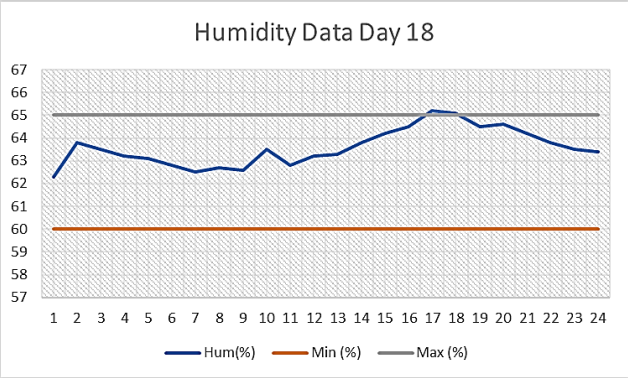


(b)

Fig. 6. Temperature (a) and humidity (b) monitoring data for day 10



(a)



(b)

Fig. 7. Temperature (a) and humidity (b) monitoring data for day 18

Even though there are some data was out of range, however the condition still acceptable due to the system was re-aligned to get the data in the range back with a short while.

The evaluation was continued by conducting a functionality of data transmitted to telegram application. Fig. 8 shows the system able to send data of temperature and humidity to user's phone on telegram application via wi-fi connection. While Fig. 9 shows the message was sent through telegram application for alerting a movement in the chamber in existing a baby quail start hatched.

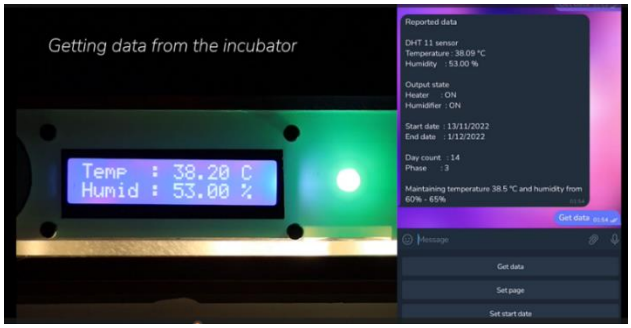


Fig. 8. Temperature and humidity data sent to telegram application

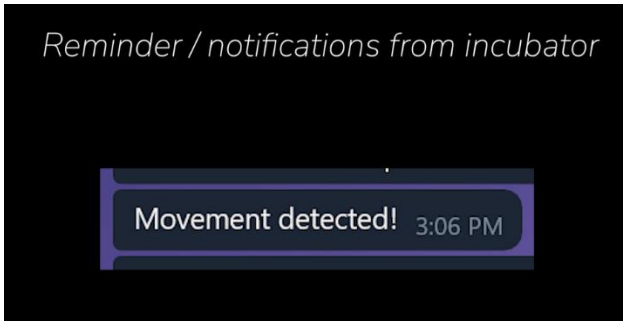


Fig. 9. Message was sent through telegram application for movement detected

The result obtained from this product that the specimens of quail eggs was successfully hatched in tested period 18 days. Even though out of eight (8) quail eggs from twelve (12) has succeed to hatch, it shows the product has a good potential and functioning well and successful. Fig. 10 shows the picture of the eggs successfully hatched on day 18.

Fig. 10. The quail eggs successfully hatched

Fig. 11 shows the full completed product has been used successfully and got a positive response from the community.

Fig. 11. The quail eggs successfully hatched

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