HATCHIT: Gallus Gallus Domesticus (Chicken), Anas Luzonica (Duck), and Coturnix Cotunix (Quail) Egg Automated Incubator Using ATMEGA2560

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ABSTRACT

The use of conventional egg incubators in the poultry husbandry experience multiple factors that affects mostly the hatching rates, and it has become tedious for husbandry workers to regulate the temperature and humidity. Furthermore, former studies were sought to improve and optimize the mechanism of the automated egg incubator which also reduces the human intervention to prevent mediums or outside factors that could possibly affect the eggs in its incubation period. The study aimed to redesign and innovate the existing semi-automatic incubators located at Batasan Campus that will increase the productivity relative to the hatchability of the incubator. This sought to design a system capable of monitoring, controlling, and regulating the inner workings of the incubator, as well as, to construct a device that will be able to incubate chicken, duck, and quail eggs. Overall, the study determined that the system's hardware components functioned properly and met the specified requirements. Multiple tests were conducted for each environment, and the results demonstrated that the temperature and humidity measurements were accurate and met the required specifications for all three species under all circumstances. The results indicate that the system is dependable and suitable for use in poultry husbandry applications. The study demonstrates that the HATCHIT incubator is a highly sophisticated and effective system that provides precise monitoring, control, and regulation of critical parameters for successful egg hatching.

Keywords: Automated Egg Incubator, Hatching Rates, ATmega2560, Parameters Optimization, Urban Poultry

INTRODUCTION

Artificial Egg incubators has long history, dating back centuries. It follows the same parameters. Even then, factors like heat, moisture, and air renewal were already recognized as crucial for successful incubation. Today, incubators provide a controlled environment for developing chicks, enabling them to hatch under optimal conditions [2][7]. To meet the increasing demand for poultry meat, hatcheries must prioritize maximizing production efficiency in a sustainable manner. This involves more than just incubating more fertile eggs - it requires the use of automated incubation systems that can improve the production capacity of poultry chicks. By implementing these systems, hatcheries can ensure that they are meeting demand while also operating in a way that is environmentally and economically responsible [2][7].

The success of hatchability in chicken eggs is influenced by numerous parameters that must be carefully monitored throughout the incubation process. In an operation that consists of two periods, with the first period taking 17 days and the second period from the 18th day to the 21st day, it is crucial to understand the important factors that contribute to hatchability success. The broody hen plays an important role in rotating the eggs and maintaining the correct humidity levels, while the eggs require a controlled heat input to ensure the optimal temperature is maintained for the microscopic embryo to develop [1-9].

Modern incubation system success rate depends mostly on its ability to regulate multiple factors. In the study of [6] and [4] the incubator must maintain an optimum condition in order for the eggs to hatch successfully. With the development of an autonomous system that uses a programmed microcontroller, the user can monitor and maintain optimal conditions for embryonic development in real-time. The effectiveness of such a system has been demonstrated in studies of [1][8-15], which have shown that modifications to incubation systems can counteract negative effects of egg storage and increase hatchability.

METHODOLOGY

This study used the Descriptive Applied Research and considered a prototyping model which intends to evaluate the effectiveness of the design, process, and prototype creation of this study. In line with the user or customer assessment, a prototype will be built, tested, and then modified as required until an acceptable result is attained from which the whole system may be manufactured. To test further the HATCHIT Incubator, the system was deployed in Quezon City University San Bartolome branch and undergoes series of testing with the collaboration of the Center for Urban Agriculture and Innovation (CUAI).

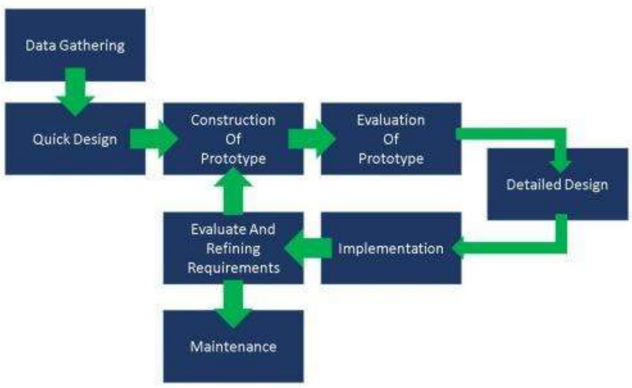

Figure. 1: Prototyping Model of HATCHIT

The researchers conduct data gathering at Quezon City University Batasan Campus on the existing Egg Incubator. Upon data gathering, the research sought the parameters needed for building an egg incubator.

As the research establish the criteria, quick designing comes into play in producing the prototype. Quick design is a step for developing a partial sketch and plan for the incubator. The researchers created a layout design in free hand draw sketch. In addition, the proponents designed a system diagram that will help to understand how the program or system flow.

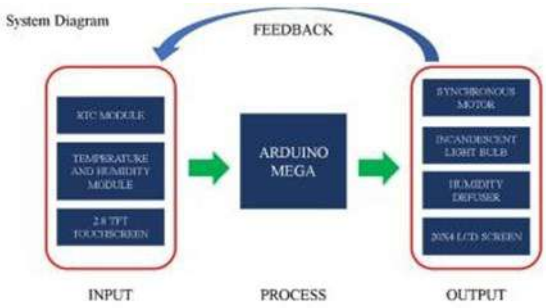

Figure. 2: System Diagram for HATCHIT

The system diagram shows the important electronics components that will help to achieve the desired prototype. The input is a list of sensors that will help determine the required parameters inside the incubator. The process is the one where the program flow takes place. The output is where all the components will do the task command given on the process. The feedback is the one will send the data back into input to determine the parameters value changes.

A. Construction of Prototype

The initial prototype is created using the information obtained during the quick design phase, which will operate on the required system model and serve as a basis to evaluate the construction progress. The prototyping model cycle must repeat simultaneously to develop the prototype in a way of several trial-and-error experimentations. In addition, this prototype will show how the concept of incubator will function as the proponent begin to create the program codes that will command the system in an organized flow.

B. Evaluation of Prototype

The proponents will evaluate the prototype and serve as the first evaluation or experimentation. The prototype will evaluate according to the selected quality model using ISO 25000. As the prototyping model cycle repeats, the proponents must determine the problem before it implemented to designated location or model settings.

C. Detailed Design

In the quick design phase, prototypes will miss some of the expected functionalities, and it required to change and altered in accordance with the desired output. The proponents will first consider whether the recommended adjustments are acceptable or essential for the prototype before integrating such elements from the assessment findings. After everything is described, the new prototype will then integrate the idea of the assessors and users. This phase will also involve developing of recommended idea that will be incorporated. If the initial prototype presentation falls short of consumers' expectations, it will be changed and modified in accordance with their demands. Lastly, this section states all the formula, structure and computation for the in-depth design details.

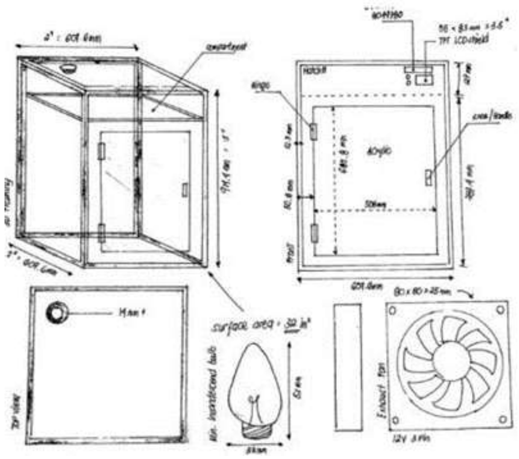

Figure. 3: Layout Sketch for HATCHIT

The layout sketch of the prototype is based on the past incubators deployed at Batasan Campus. The researchers improved the ventilation system and increase the total volume of the incubator to increase the numbers of eggs that will accommodate per batch. Additionally, a candler added to a system to check whether the eggs are fertile or not.

Results and Discussion

The main design of the system is mainly composed of three (3) parts that categories as monitoring, regulation, and controlling.

A. Structure Design of HATCHIT Incubator

1. **Monitoring** – The 20x4 LCD is the monitor display where it shows the value reading on the incubator. The DHT 22 (AM2302) is the one that monitors the temperature and humidity inside the incubator.
2. **Controlling** –The ATMEGA 2560 is the main microchip controller that control and manage the flow of bit codes to enable for the incubator run on specified parameters. This microcontroller is attached in developmental interface board to easily pinout the other components.
3. **Regulating** – The touchscreen is for user- interface where the end user can select the ypes of incubation and calibration setup. The RTC DS3231 regulates the time required for the eggs to hatch by the means of automatic (preset) or manually input.

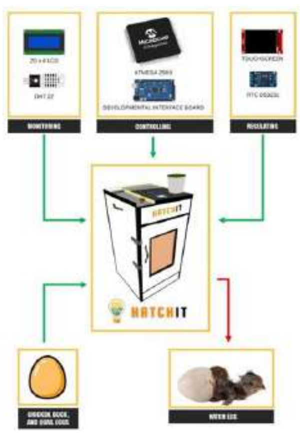

Figure. 4: Structure Design of HATCHIT

B. Layer Coating of HATCHIT Incubator

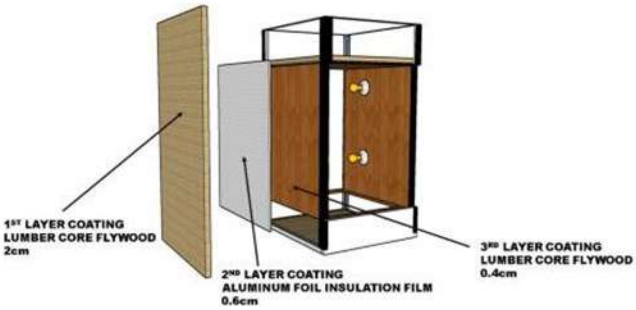

Figure. 5: Layers of HATCHIT

Building an incubator must heat secured from inside and outside the environment. HATCHIT incubator is triple layered coating which will help to protect and accumulate enough heat inside the incubator. The first layer is coated by the lumber core which prevent outside factor that can affect the incubator. The second layer is coated by the aluminum foil insulation which prevent a contact between the heat coming from outside and heat produce inside. The third layer is coated by very thin lumber core which acts as minimal heat absorption. Lastly, incandescent light bulbs are equally separated below and above the incubator to equally distribute a heat and not easily dissipate

C. Redesign of the existing Incubator

The past two incubator used a STC-3028 as their main controller for their incubator. STC-3028 is an electronic device built for incubation and it is program by the manufacturer and cannot be re-program by the user because the devices do not support any an open- source collaboration. On the other hand, HATCHIT incubator used an Arduino Mega Board for main controller and been program and calibrated according to the necessary adjustment for temperature and humidity. The HATCHIT has a three (3) presets program for chicken, duck, and quail that automatically run once it selected while the other two past incubator must need to manually adjust the temperature and humidity by pushing designated buttons. The past two incubator used a SHT 20 that has a ±1% for temperature and ±0.1% for humidity while the HATCHIT used DHT 22 where has a highest accuracy rate at ±0.5% for both temperature and humidity.

Figure. 6: HATCHIT Incubator Prototype CAD (Left) and Actual Prototype (Right)

Moreover, the past two incubator used two incandescent light bulbs with a wattage rating of 25 watts while the HATCHIT used four incandescent light bulbs equally separated inside the incubator. The wattage rating of incandescent light bulb in the HATCHIT incubator is two 45 watts above and two 100 watts below. Lastly, the egg compartment for HATCHIT is greater than the past two incubator.

D. Functionality Testing

The proponents conducted functionality tests to evaluate the functionality of different hardware components contained in the system, including the Temperature and humidity sensor, RTC module timer, Touchscreen LCD, 20x4 LCD, Synchronous motor, and Incandescent light bulb to confirm that the components are functioning as intended.

1. **Primary Components** – The test indicates a “Passed” remarks on all of its Primary System Components. A total of 10 functional requirements as well as 13 test case from sensors to module.
2. **Secondary Components** – The test indicates a “Passed Remarks on all of its Secondary System Components. With a total of 3 for number of functional requirement and 3 for the test case.

The test was conducted altogether with the help of every component on the entire system to determine the problem for ease of troubleshooting.

E. Accuracy Testing

The proponents conducted functionality tests to evaluate the functionality of different hardware components contained in the system, including the Temperature and humidity sensor, RTC module timer, Touchscreen LCD, 20x4 LCD, Synchronous motor, and Incandescent light bulb to confirm that the components are functioning as intended.

1. DHT 22 Accuracy

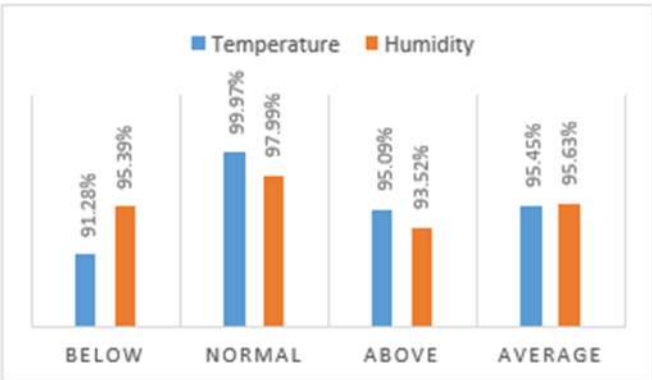

Table. 1: Summary of Accuracy Test for Chicken Temperature and Humidity under Several Condition.

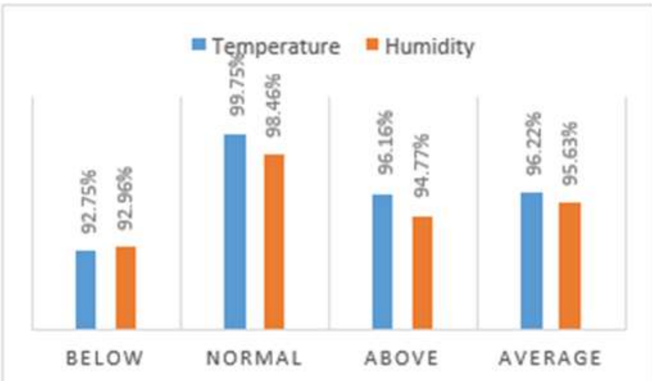

Table. 2: Summary of Accuracy Test for Duck Temperature and Humidity under Several Condition.

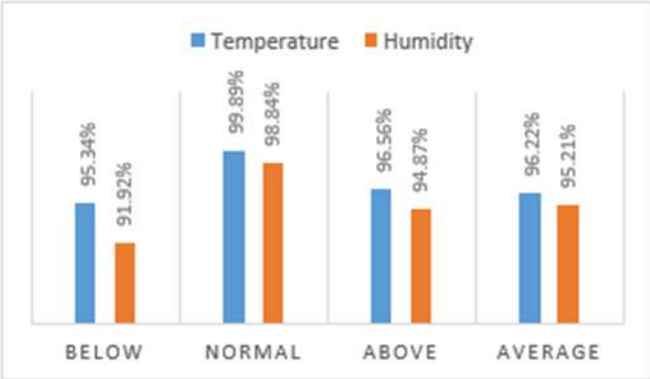

Table. 3: Summary of Accuracy Test for Quail Temperature and Humidity under Several Condition.

This accuracy test has been conducted simultaneously and the time interval for each trial on chicken and duck is two (2) minutes while for the quail is 30 seconds. The trial conducted on an environmentally friendly condition with a normal room temperature and humidity ranging 26°C - 29°C and 30% RH - 50% RH respectively. Overall, the DHT 22 is accurate in reading the temperature and humidity with total average accuracy of 95.54% (Chicken), 95.81% (Duck), and 96.24% (Quail).

2. RTC Synch Accuracy

This accuracy test was carried out continuously within one day, with each five trials, the interval for switching on and off is 10 minutes. The experiment was carried out with a Pacific Standard Time GMT+8. The total accuracy of RTC Synchronization is 96%.

3. Touchscreen LCD Button Accuracy

This accuracy test for touchscreen buttons is simultaneously tested and the total accuracy for clicking input on touchscreen is 90.34%. This touchscreen testing was carried out with a use of only bare hands, the data will change depends on a touch input material been used.

F. Efficiency Testing

The HATCHIT incubator is put through an efficiency test to see if it can successfully hatch a chicken, duck, and quail eggs after a certain amount of incubation period

Type of Egg	Successful Hatches	Premature Dev't	No sign of Dev't	Hatchability Rate
Chicken	0/10	2/10	8/10	10%
Duck	5/7	2/7	0/10	85.71%
Quail	8/10	2/10	0/10	90%

Overall, The HATCHIT incubator has a 61.90% hatchability percentage and categorize as satisfactory based on level of percentage satisfaction. Premature development count as 50% hatched because the eggs is almost hatching. The hatching percentage percentages recorded during the trials and experiments clearly demonstrated the effectiveness of the eggs' hatching rate.

Figure. 7: Hatched Quail

Figure. 8: Hatched Duck

Figure. 9: Hatched Duck

G. Discussion

The HATCIT incubator is the upgraded version of the two previous generation of incubator of Quezon City University. The HATCHIT incubator utilize high- end electronics components and create a program flow in order to incubate a fully automatic method of incubation. It is essential to have a system that provides automatic mechanism as well as alternate method such as manual incubation in order to allow select the appropriate temperature and humidity desire that will able to hatch the egg. The implication of this shows that HATCHIT incubator's versatility and reliability make it a valuable investment for poultry farmers seeking a tool that can effectively incubate various types of eggs. Furthermore, the ability to select the appropriate temperature and humidity through manual incubation provides an alternate method for farmers who prefer a more hands-on approach to egg hatching.

The testing phase of the system was complete done and gives a positive conclusion based on the results. All of components are working properly as on how they intended to function, the overall accuracy testing is about 98.57% for both temperature and humidity with a percent error of only 1.43% and falls under the verbal interpretation of “Excellent” on a Likert scale. This means that the reading on the temperature and humidity sensor on the various condition is very effective. Lastly, the average efficiency percentage rating based on hatchability of eggs using HATCHIT incubator is 61.90% which is categorize as satisfactory. This means HATCHIT incubator is efficient and yet, effective incubation of eggs. This demonstrates that the HATCHIT incubator is an efficient and effective tool for egg incubation.

Like other studies, this prototype has its limitation. In the case of the chicken eggs, all necessary parameters for the incubation were followed yet it still remains unhatched. Factors may possibly come from procuring the eggs from the supplier or the travelling of the procured item. Upon procuring the samples, the research was not able to identify whether the eggs are fertile or not, only after 10 days of incubation period will determine their fertility or not. Increasing the number of samples and procuring it from other suppliers might generate a better result. Adding additional compartment is also a great help to increase the productivity of the system where it may hatch different types of eggs simultaneously without affecting each temperature and humidity boundaries.

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