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Arduino Based Egg Incubator for Anas Luzonica

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INTRODUCTION

A wide range of incubation habits is observed among birds. Incubation is the process of hatching (eggs), as by sitting upon them or by artificial heat.

In most warm-blooded species, such as the duck, the body heat of the brooding parent provides constant temperature to the eggs. Beginners and some home-based poultry producers typically become interested in the thought of artificial incubation of their own chicks (Smith, 2004). The success of the hatching of the eggs depends on proper care and incubation.

Egg incubators are apparatuses in which eggs are hatched artificially. This removes the need for the broody hen to sit on the eggs. These incubators need to have a constant regulated temperature to ensure the successful hatching of eggs.

In 1991, the United States produced about 5.7 billion dozen eggs. Thus, the poultry industry is a large business. An excess of 20 billion dollars was generated in 1991 alone. On the other hand, as of July 2015, the duck population in the

Philippines increased about 3.65 percent from the previous year's inventory. From the first half of 2015, the total duck volume production increased 2.51 percent compared to the 2014 level. Additionally, the volume of production for duck eggs grew by 2.24 percent to this year's 21.23 thousand metric tons from last year's 20.76 thousand metric tons (Philippine Statistics Authority, 2015).

Egg incubation is the most common way to artificially induce heat to an egg to support the hatching process. However, problems occur during different weather conditions that affect the ambient temperature within the incubator which disturbs the cultivation process. Also, deficiency of a device that can smartly control and adjust the incubating temperature in contrast with its surrounding is needed.

The current method of incubation cannot assure all incubated egg hatches to its full development. Existing incubation methods cannot adapt with its surroundings causing the internal temperature to vary with changing weather conditions. In contrast, ordinary incubators have a controlled heat source which provides the temperature gradient where the peak is located at the center though unevenly distributes the temperature through all the eggs.

The project sought to demonstrate a prototype that can maintain a certain temperature within a specified atmospheric condition at a certain time of year. Thus, promoting proper incubation and ideal development within the egg resulting in higher hatching percentage.

From the months of January to March, the prototype must be able to maintain the incubator temperature at 37 to 39 degrees Celsius during operation. Once the temperature detected by the DHT11 Sensor exceeds 38 degrees Celsius, an SMS Message will be sent to a number assigned by the owner to notify the changes. Also, an SMS Message will also be sent once one incubation day is finished. Lastly, the incubator must be able to successfully hatch not lower than 80% of the total number of eggs.

The device is an automated egg incubator. The parameters that will be automated includes: the temperature regulation and the egg rack rotation. Both the ambient temperature and humidity will be monitored by a DHT-11 Temperature and Humidity Sensor. Two racks with a capacity of thirty-five eggs each will be attached to the egg turner. This will be powered by a Direct Current (DC) Motor. The current ambient temperature and humidity will be displayed in a Liquid Crystal Display (LCD) screen as well as through text using a Global System for Mobile Communications (GSM) Module via Short Message Service (SMS).

The project's automation are limited to the following: Egg Turning, and Temperature Level Adjustment. Ambient humidity will be manually regulated using a tub of water inside the incubator. Candling procedure will also be manually conducted.

REVIEW OF RELATED LITERATURE AND STUDIES

A) POULTRY

Proper housing is an important factor for the health and survival of the poultry. It should protect the birds from the elements, predators, and theft. Adequate space for the birds' movement and exercise are needed to avoid stressed social behaviour, that increases disease vulnerability and cannibalism and leaving weaker birds deprived of feed or perch space (Sonaiya, Swan; 2004). A small pond may be provided for the ducks to immerse and keep themselves clean and therefore healthier. One method of poultry farming is the Intensive Poultry Farming Method, wherein the ducks are kept enclosed permanently, either in a covered shelter (indoor system) or with a run in the open where they are easy to monitor. Free range ducks tend to be less productive than ducks kept in closed systems (Meulen, Dikken; 2004). Although, intensive poultry farming method is preferred over free range farming, this result in major environmental degradation. Where an overwhelming amount of animal waste or manure is produced. Excretory fumes from the nitrogen in decomposing excretions affect both humans and birds exposing them to diseases seldom found on the environment (Morris, 1991). The produced manure can also be used as fertilizer both for soil and fish ponds (Meulen, 2004).

B) EGGS

A type of egg, the Omega-3 egg which is produced from hens fed with omega-3 supplements like flaxseeds, chia seed, fish oil, or marine algae (Ayerza, Coates; 2000) are being commercially distributed. These eggs had 5 times as much Omega-3 as the conventional eggs. Omega-3 fatty acid consumption has been linked with fetal development, cardiovascular function, and Alzheimer's disease although it may have a few side effects (Swanson, Block, Mousa; 2012). On average a duck egg will provide about 30 percent more cholesterol than that provided by a chicken egg (Jalaludeen, Churchil; 2006). Eggs can also be classified as fertilized and unfertilized. An unfertilized egg is when the egg only contains the hen's genetic material, and a fertilized egg is produced when a rooster and hen mate, resulting in the eggs to contain the genetic material necessary to create an embryo inside the egg. Fertilized eggs can be easily maintained in humidified incubators and during early stages where you must store and incubate them carefully for a successful bunch. The success of hatching can come down to certain factors such as environmental conditions, handling, sanitation, and record keeping (Archer, Cartwright; 2012). For the case of duck eggs, the incubation period is about 28 days before hatching (Abbot, Emerita, Ernst, Bradley; 2000).

C) TRADITIONAL METHOD OF HATCHING

The oldest method known for artificial breeding was an invention of the ancient Egyptians thousands of years ago, the only heat used were from smoldering straw mixed with cow or dromedary dung where there was no method of determining the temperature (Corti, Vogelaar, 2012). Presently, traditional methods are still being used compared to using modern technology. These methods include sand-based incubators (Rahman, 2011), and clay-based incubators (Kanoute, 2012). Despite these different approaches, caring and monitoring the eggs as they develop are similar. Candling is a way to determine an eggs freshness and fertility by holding it to a light source (Rahman, 2011). An egg Candler or a small torch may be used to see the inside of the egg without opening it. Traditional poultry flocks produce a high fraction of dirty or stained eggs because they were laid in filthy nests or on the floor and may have come in contact with droppings. If not properly washed or sanitized, these eggs can be a health hazard (Sok, Scheideler; 2007).

D) GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)

Short Message Service (SMS) technology has been used extensively today in the wireless world. Originally designed for person-to-person messaging service, SMS has been used widely in the wireless world since its invention. With the help of computer technology, many information such as news, financial information alert notification, etc. have been sent with SMS (Ueng, Tsai, Chang; 2007). This transmission of information was achieved mainly with the use of GSM. GSM wireless modems allow us to use the computer to control the modem to send the alert messages directly. The GSM modem has become a versatile device with a variety of uses. Home security system is needed for convenience and safety resulting in the implementation of a GSM based wireless home security system

(Parab, Joglekar; 2015). Hazards where a GSM notification system is not only limited to intruders, A simple automatic fire alarm system for buildings based on wireless sensor networks is designed and can be implemented as well. This system can remotely alert the property owner or the fire department about incidents of fire and smoke quickly by sending short message via GSM network (Ashwitha, Arjun, Prashanth; 2016). The biomedical field has also conformed with the latest trends in GSM Technology. A system that is able to provide real time remote monitoring of the heartbeat has recently been developed (Ufoaroh, Oranugo, Uchechukwu; 2015). A vehicle's location (Ramani, Valarmathy, SuthanthiraVanitha, Selvaraju, Thiruppathi, Thangam; 2013) for theft incidents, and fuel levels (Aher, Kokate; 2012) can be monitored by vehicle fleet owners as well

CONCEPTUAL FRAMEWORK

The study focuses on developing an automated egg incubator machine wherein the temperature provided by the incubator will be maintained at a desirable level, egg turning to prevent the egg yolks from settling, humidity level monitoring and real time SMS notifications.

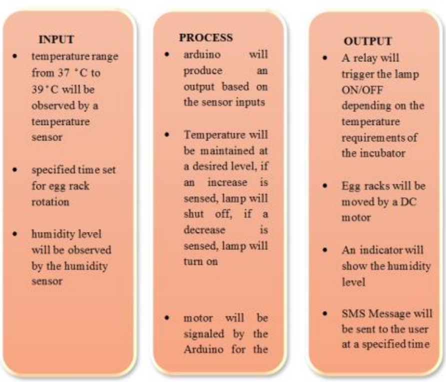


Figure 1: Paradigm of the study

THEORETICAL FRAMEWORK

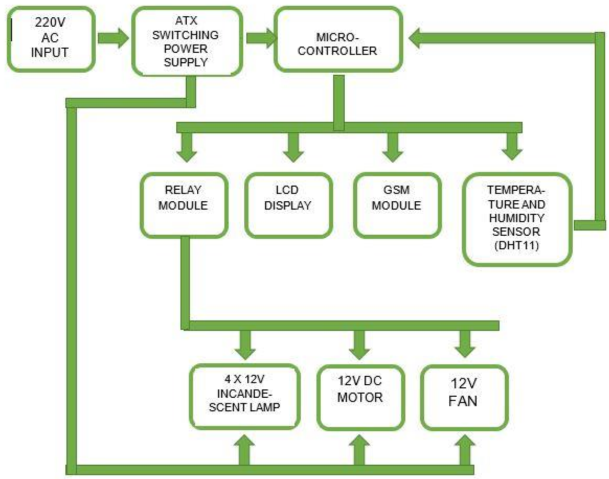


Figure 2: Block Diagram of the Project

The 220V AC input supplies the ATX (Advanced Technology Extended) Switching Power Supply which then in turn supplies the Lamp, Motor, Fan and Microprocessor. The Microprocessor is programmed to control the entire process from switching the relay modules (ON/OFF state), controlling the LCD Module's Output to acquiring calculated data from the DHT11. The DHT11 calculates the Humidity and Temperature inside the incubator and sends the data to the Microprocessor. The Relay module serves as switches to the Lamp, Motor and Fan. Whenever a condition that is programmed within the Microprocessor occurs, like the turning-off of the Lamp whenever the Temperature drops from 37.5 degrees Celsius, the Relay Module responds by switching On or Off. An SMS Message will be sent to the user at a specified time.

PROJECT DESCRIPTION AND RESEARCH DESIGN

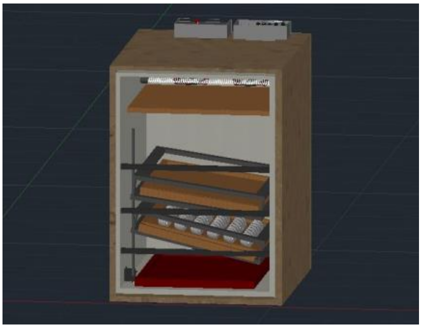


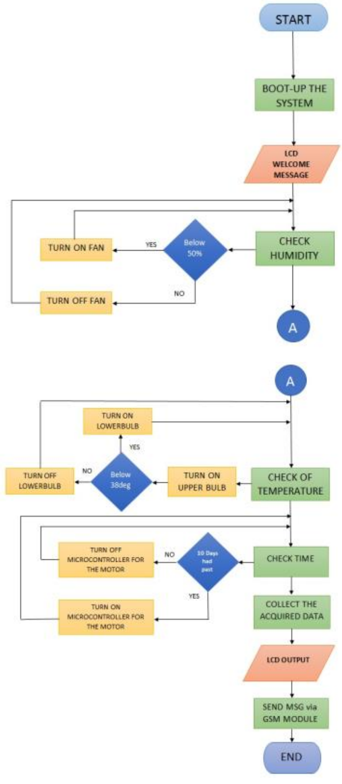
Figure 3: Illustration of project prototype.

Project Description

The prototype's dimensions (L, W, H) are 20", 18", and 24". The frame was constructed by connecting 1'inch angular aluminum bars with each other. The side panels used was made up of MDF Boards. The prototype has a door that can be opened when access to the eggs are needed. To monitor the eggs without opening the door, a glass window was placed on the door. Inside the incubator are two racks that can contain up to thirty-five eggs each. The heat source of the incubator is four 12Vdc Lamps. As well, two 12Vdc fans are placed on the top part in order to circulate the air inside. Lastly, a small tub of water is placed inside to maintain the ambient humidity.

Initially the system will boot-up displaying the Welcome Message. A series of checking will occur after the boot-up such as the preliminary checking of the DHT-11 to compute for the Humidity and Incubating Temperature, checking of the Microcontroller for the time elapsed and collecting for the acquired data to be displayed by the LCD and sent by the GSM Module via SMS. The DHT -11's readings in Temperature and Humidity will determine if whether the Fan will turn ON/OFF or if the lower bulbs will turn ON/OFF. In relation with this, the Time Elapsed will be the controlling variable on whether the motor will run or not to move the egg racks.

Flow Chart



Medium Density Fibre Board

The Medium Density Fiber Board was used in the side panels of the incubator chassis. This type of board was preferred over ordinary softwood ply boards. Its Isotropic properties as well as its consistency and strength give it no tendency to split and break. The light construction and insulation ability of the board made it ideal for usage in an incubator.

Gizduino+ V3.0

The Gizduino is a board based on the ATmega328 and ATmega168. It has an external power input of 8 Vdc to 12 Vdc and a USB input voltage of 5Vdc. Its physical dimensions are 2.7” x 2.1”. A program was compiled in the GIZDUINO+ V3.0 wherein it sends signals to the relays and ports for the temperature control, motor control, GSM module, and the LCD Module. The pin connections are as follows.

Digital Pins

Pin 0-1	-	No Connections
Pin 2	-	DHT 11
Pin 3	-	Relay module of DC fan
Pin 4	-	Lamp
Pin 5	-	Motor Control
Pin 6-8	-	No connections
Pin 9	-	Transmitter pin of GSM Module
Pin 10	-	Receiver Pin of GSM Module

Analog Pins

Pin 14-23	-	No Connections
Pin 24	-	SCL – LCD Module
Pin 25	-	SDA - LCD Module
Pin 26-31	-	No Connections

Power Pins

+5V Pin	-	Power Supply
GND Pin	-	Ground

e-Gizmo SIM800L Shield v1.0

The SIM800L Shield is a configurable quad-band GSM/GPRS module with a full support modem serial port. The Gizduino+ V3.0 was responsible for operating the GSM module. The transmitter and receiver pins of the GSM module were connected to pins 9 and 10 of the Gizduino+, respectively. This module will send an SMS regarding the current temperature and humidity of the incubator. This will be triggered by an SMS from the user.

ATX Power Supply

An ATX Power Supply whose input voltage is 115/230 Vac was used as the main power supply of the prototype. It provides output voltages ranging from +3.2 Vdc up to +12 Vdc. This was selected in place of constructing a multiple output power supply because of its high output current that is needed to power the circuits of the prototype.

Liquid Crystal Display (LCD)

LCD (liquid crystal display) with Serial to I2C Converter allows to display the current status of the system and lessen the configuration pins for the Arduino interfacing. This device will help the user or operator to monitor the temperature, humidity and the remaining days left for a certain batch of eggs before hatching by displaying the reading in LCD. It is powered at 5V dc and is connected to which will be the source of display. The size of the display is 2x16.

Relay Module

The relay module is an electrically operated switch that allows you to turn on or off a circuit using voltage and/or current much higher than it could handle. The relay module is a separate hardware device used for remote device switching. With it you can remotely control devices. The first relay module that we used is connected with the 18W incandescent lamp. The second relay is connected to the 12V fans and the third is connected to the 24VDC motor.

Motor Speed Control Circuit

The speed control circuit allows you to control the speed of the motor inside the incubator. It generates a series of pulses to fire and control a thyristor. By using the UJT as a phase control triggering circuit in conjunction with an SCR or Triac, we can adjust the speed of a universal AC or DC motor. The turning of eggs uses a 24VDV motor connected to the motor speed control circuit powered by a 12VDC supply from the ATX and at the same time connected to the relay module that will control the number of rotation programed in the microcontroller.

METHODS

In developing the project, a variety of approaches of research and data gathering were conducted. These instruments led to further development of the said project.

Descriptive Method

The research procedures in this method can either be qualitative or quantitative. The Qualitative method was used in this study by conducting interviews. These interviews with members of the duck hatchers and raisers community of Visal San Pablo, Bahay Pare, Candaba, Pampanga were utilized in order to gain their personal experiences related to the study. The quantitative method on the other hand, gathers numerical data that can be measured and analyzed. This was employed to determine the working condition and effectiveness of the prototype.

Experimental Method

This method involves conducting an investigation in which a hypothesis is scientifically tested. Here, the constructed prototype was subjected to three tests that were used to determine the effectiveness of the design. The tests are: Incubator Insulating Ability Test, where the number of times the bulb is operated in a span of time is recorded, and Embryo Development Through Candling, where the egg's development was observed from the outside using a light source.

Internet Method

This method was applied during collection of data and information via internet was conducted. Existing related research methodologies related to duck raising, hatching, and poultry were found online and were reassessed and revised for the development of the project.

Instruments

Interviews were used in gathering data. This specific instrument was selected in order to obtain information from first-hand observations of the respondents. Questions with a number of important points in relation to duck raising, hatching and egg incubation were raised in order to help supplement the required data for the study.

Data Gathering

In gathering the needed data for the study, observations, online research, and interviews were used. The information obtained was vital to the prospect of the study.

Observation

Observation was used as supplementary source of data to the interview. The inference drawn from the conducted interviews were observed and evaluated. Existing egg incubators owned by Mr. Peter Buco of Visal San Pablo, Bahay Pare, Candaba, Pampanga were observed whilst conducting the interview with the said person. The inferences drawn were used for the development of the project.

Online Research

Articles about egg incubation, poultry raising, and hatching processes were gathered from the internet. The gathered articles were used to prove and support the study.

Interview

Interview is the verbal conversation between two people with the objective of collecting relevant information for the purpose of research.

The people involved in the conducted interviews are members of duck hatchers and raisers community of Visal San Pablo, Bahay Pare, Candaba, Pampanga. The respondents shared their personal experiences and knowledge about the topics discussed.

Respondents of the Study

A majority of duck hatcheries are based in Visal San Pablo, Bahay Pare, Candaba Pampanga. A series of interviews were conducted among the members of the community concerned with the duck poultry. Their statements and recommendations were used to the development of the project.

METHODS IN DEVELOPING THE SYSTEM

Planning Phase

Plans regarding the procedures in the construction of the incubator, its structure, appearance, and performance were prepared. A schedule in the form of a Gantt chart for brainstorming, collaboration of ideas, and researching related literatures was organized and followed in order to come up with a feasible proposal for the study. Each of these plans were allotted a corresponding amount of time where it was to be completed. These include canvassing and checking the availability of the components and resources needed, conceptualization of the prototype, and projecting the budget allocation in order to achieve the desired output and meet the objectives of this study.

Design Phase

In order to develop a viable and achievable design for the study, consultations from University Professors, Electronics Engineers, Webpages, Articles, and members of the Visal San Pablo Duck Raisers and Hatchers community were utilized. A

Gizduino AT mega 164/164P Version was used to control the variables in this project.

Development Phase

Once the project planning and conceptualization were finished, the actual project was built. This includes building a chassis that will support the planned number of eggs to be incubated, providing a heat source that will maintain the ambient temperature within the incubator, and affixing a motor that will control the egg rack's rotation. Various circuits and modules were built and used to control the aforementioned features.

Testing Phase

The proposed design was subjected to multiple tests to establish the effectiveness operational ability of the prototype. Existing related project's tests were used as reference for the actual assessments that will be conducted on the prototype. Multiple tests were conducted on the device. These include start-up duration testing, motor accuracy testing, insulating ability testing, and burn or endurance testing. Burn testing is the act of subjecting the prototype to operate for extended periods of time.

PRESENTATION AND ANALYSIS OF DATA

Table 1: Temperature of Incubator

Temperature from DHT11 Sensor	Temperature from Wet Bulb Thermometer
36 Degrees Celsius	36.4
37 Degrees Celsius	37.5
38 Degrees Celsius	38.4

The temperature readings from the DHT11 Sensor and the outdoor thermometer were compared through a series of tests. As seen from the table, the actual temperature reading from the outdoor thermometer is up to 0.5 degrees higher. The gathered results show percentage errors ranging from 1.05% to 1.35%.

Table 2: Insulation ability of Incubator

Time Duration	No. of times of switching	
	Trial 1	Trial 2
12:00 AM to 1:00 AM	27	26
8:00 AM to 9:00 AM	21	20
12:00 PM to 1:00 PM	20	20
8:00 PM to 9:00 PM	24	24

In order to determine the efficiency of the insulation of the incubator, a test to determine the number of switching was conducted. It was shown that the frequency of the switching was 24.52% higher during night-time when the ambient temperature is lower. This was conducted during the months of January to March.

Table 3: Result of Candling

Day	Good Eggs	Bad Eggs
10	65	5 (Unfertilized)
18	64	1
21	62	2
28 (Day of Hatching)		

Table 4: Result of Incubation Process

Total number of eggs	**Number of Hatched eggs**	**Success Rate**
70	**60**	**85.71%**

Total number of eggs = 70
Fertilized eggs = 65

As of Day-21 of the incubation period, 88.57% of the eggs have developed from the total number of 70 eggs. However, from the total of 70 eggs, only 65 or 92.86% are fertilized. This brings the development success rate up to 95.38 %. O only 3.08 percent of the fertilized eggs was lost due to underdevelopment.

As of Day-29 of the incubation period, 60 eggs have successfully hatched from the total number of 70 eggs. From Day-1, there are a total of 10 eggs that are undeveloped. This brings the overall development success rate of 85.71%. Only 14.29% of the total number of eggs was lost due to unfertilized eggs.

CONCLUSION

A fairly large amount of gross domestic product goes to the poultry industry for its eggs, meat and feathers. This trade relies much on the quality of its output and for the amount produced yearly. Proper incubation is needed to achieve high quality development and production. Hence, attaining suitable incubation methods will increase the success of good quality goods. In our project, we have incubated 70 eggs for 28 days before the hatching period. The eggs were supplied by a lamp that produces 37 degrees for the egg's temperature requirement. On the 10th day of incubation, we have candled the eggs. 5 eggs were considered undeveloped. On the 18th day of incubation, candling process again has occurred. 1 egg was considered undeveloped. And lastly on the 21th day, 2 eggs were undeveloped. So, after 21 days CONCLU8 eggs were undeveloped and we were expecting 62 eggs to be hatched. With the results that we have gathered, we can say that egg incubation is dependable with temperature and humidity. Temperature must be stable at 37 degrees and must be evenly distributed to all phases of the egg.

RECOMMENDATIONS

By enlarging the incubator chassis, the egg capacity can be increased to cater more eggs. The candling process cannot be automated. However, it can be conducted without removing the eggs from the incubator. This can be achieved by placing the eggs in a rack where holes are cut-out at the bottom and the lamp be placed under it. Also, to be able to determine the fertility of the eggs at day one, similar candling procedures can be done. To avoid the interruption of the incubation process, an Uninterruptable Power Supply can be added to switch to DC power if power outages occur. Lastly, a counting circuit that will be able to monitor the number of time the motor turns can also be added. This circuit will be an application of learning from Logic Circuits and Switching Theory.

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