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DEVELOPMENT OF A WIRELESS MONITORED EGG INCUBATION SYSTEM

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Abstract

The integration of electronics into poultry farming offers farmers an opportunity to enhance their efficiency within the industry. By automating the control of temperature and humidity, this system caters to the specific requirements of various poultry breeds, aiming to optimize their management processes. The incubator system overview highlights its interconnected components, centered around a Raspberry Pi microcontroller. It integrates sensors (temperature, humidity, light, relay), a web camera, and a step motor. The Raspberry Pi processes data from sensors, while the light sensor controls the step motor, web camera, and relay. Data is transmitted to a server via the Internet. The web camera captures real-time images inside the incubator, enabling breeders to remotely monitor conditions via a web service. The Raspberry Pi-controlled step motor rotates the egg shelf for optimal incubation, while the light sensor detects heat from incandescent bulbs. Temperature and humidity sensors maintain the ideal environment, and the relay regulates the incubator's temperature and humidity devices. Data is transmitted via the internet to a server, where a web service application stores it in a database. This system provides breeders with control and monitoring capabilities for their chicken egg incubator. For the system to be improved, it is recommended that: future systems should leverage on machine learning algorithms, to optimize incubation processes for improved hatchability rates; Integrate the wireless monitoring system with a secured cloud platform for data storage, analysis, and collaboration; and a user-friendly interface with intuitive visualizations should be developed for easy navigation and effective utilization by breeders.

Keywords: *Wireless monitored incubator, Remote Monitoring, System development, Incubator Efficiency, Poultry production*

INTRODUCTION

Raising domesticated birds like chickens, ducks, turkeys, and geese for their meat, eggs, and feathers is known as poultry farming. The environments in which these birds are grown range widely, from modest household operations to enormous industrial farms, and everything in between. However, elements like temperature, humidity, and pollution can have an impact on the microclimate in poultry houses. These elements can result in decreased output and higher bird death if not effectively managed. To solve this problem, accurate temperature control and air ventilation are required in both commercial and backyard poultry farming operations to provide the birds with a pleasant environment. [1].

Poultry farming with electronics gives farmers a chance to improve their efficiency in this industry. In order to meet the unique needs of many varieties of poultry, this system automates the management of temperature and humidity. Using this technology will update and automate conventional chicken farms, making them more productive and sophisticated. [2].

With the world's population growing rapidly, there is an increasing demand for protein, particularly in rural areas. Poultry serves as an excellent protein source and is also affordable, making it a viable solution to meet the protein needs of the expanding population [3].

According to the Food and Agriculture Organization of the United Nations (FAO) [4], chickens are the most commonly raised poultry species, accounting for nearly 60% of all poultry production worldwide. They are followed by ducks, geese, turkeys, and other poultry species. In many countries, poultry farming is a major contributor to the agricultural economy and a significant source of protein for human consumption.

There are several different types of poultry farming operations, each with its own set of advantages and disadvantages. The most common type of poultry farming is the intensive method, which involves the confinement of large

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numbers of birds in a small area, such as a barn or a cage. This method is highly efficient and allows for the maximum utilization of space and resources. However, it can also lead to poor living conditions for the birds, which can result in a variety of health problems. Another type of poultry farming is free-range, which allows birds to move freely and access the outdoors. This method is considered more humane than intensive farming, as it allows birds to engage in natural behaviors and reduces the risk of health problems. However, it is generally less efficient and more expensive than intensive farming [5].

LITERATURE REVIEW

Over the years, a multitude of diligent researchers have undertaken numerous studies, each driven by the shared objective of creating an incubator that is distinguished by its exceptional quality and unwavering reliability. Through their collective efforts and unwavering dedication, they have strived to establish a benchmark for excellence in the field of incubator development. The findings and insights gained from these meticulous studies served as the compass that guided the development of our novel system, allowing us to effectively address and overcome the myriad challenges encountered during the comprehensive review of the relevant literature.

According to Olatayo, Mutiu, and Olisaemeka [6], it is recommended to maintain a relative humidity (RH) level of 50-70 percent throughout the entire growth period, including the brooding stage. They noted that dusty conditions in poultry houses are associated with RH levels below 50 percent.

On the other hand, an RH of 70 percent or higher creates an environment conducive to microbial growth in the litter, leading to an increase in the diffusion of ammonia within the house. Extensive research has demonstrated that elevated ammonia levels negatively affect the immune system and result in an increased incidence of respiratory diseases in birds. Hence, it is unfavorable to have an RH level exceeding 70%, and measures should be taken to control it through proper ventilation in buildings [7].

In their work on monitoring environmental parameters in poultry production facilities, Corkery, Ward, Kenny, and Hemmingway [8] observed that when birds are exposed to temperatures outside their comfort zone, they need to expend more energy to maintain their body temperature. This additional energy is obtained from the feed they consume. In colder temperatures, birds consume more feed to sustain their normal body temperature, which reduces the amount of feed available for meat production. Similarly, in excessively warm temperatures, birds waste energy as they try to keep themselves cool. Consequently, there arises a necessity for a temperature and humidity control mechanism. To achieve suitable temperature and humidity control in a poultry system, the implementation of a microcontroller-based system capable of monitoring and regulating these parameters is crucial [9].

Levărdă and Budaciu [9] aimed to develop a temperature control system using the Pic18f4620 microcontroller. The primary objective of their project was to utilize a microcontroller to regulate both the temperature and humidity of the poultry environment (prototype) with the purpose of maintaining a comfortable atmosphere for the poultry birds. They emphasized that the combination of measurement and control can be enhanced by incorporating programmable components, and typically, a microprocessor or microcontroller is employed for monitoring and controlling physical variables [11].

Joshi and More highlighted the effectiveness of implementing microcontrollers for controlling various process variables, such as temperature, humidity, light, and pressure, in both industrial and research-oriented settings. The selection of a controller depends on factors like complexity, size, system hardware requirements, and cost-effectiveness. Numerous intelligent process control systems based on microcontrollers have been developed as a result of advancements in this era [12].

Khairurrijal, Abdullah, Mikrajuddin, and Budimandiscussed the design of a homemade temperature control system based on the PIC 16F877 microcontroller for learning automatic control. The system could employ either the PIC family fuzzy logic microcontroller or Intel's 8751 microcontrollers. In some cases, when dealing with complex parameters, a hybrid approach combining two methods, such as a fuzzy-PID controller, can be utilized [13].

Goswami, Bezboruah, and Sarma presented a study on the design of an embedded system for monitoring and controlling temperature and light. They utilized the AT89S52 microcontroller for this purpose. Additionally, a low-cost automatic control system for temperature and humidity in a silkworm house was developed using the DHT11 sensor and AT89C51 microcontroller [14].

In another study investigating the effect of climate on poultry productivity, an experiment to determine the optimal temperature for hatching was conducted. Equal numbers of eggs were placed in four different incubators with temperatures set at 36.1, 37.2, 38.3, and 39.4°C from the 18th day of incubation until hatching. Hatching time, hatchability rate, and the incidence of embryo mal-position were recorded as percentages of fertile eggs. The highest mean embryonic heat production or eggshell surface temperature was observed in the hatching cabinets operating at 39.9°C, while the lowest was at 36.1°C. Eggs incubated at 37.2 and 38.3°C showed significantly higher hatchability compared to the other treatment groups [10].

OBJECTIVES AND METHODOLOGY

The aim of this project is to develop a wireless monitored egg incubation system which will use a webcam camera in order to make users able to see the condition inside the incubator machine. To achieve this aim, the following objectives were identified:

i. to review the exiting wireless egg incubation system;

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ii. to configure the microcontroller, sensors, relay and the web camera that will be added to the Existing System; and

iii. to Implement the Wireless Monitored egg incubation System using the component in (ii) above.

The research methodology used in this research is based on SDLC (Software Development Life Cycle) method in form of waterfall model. The waterfall model is the most famous model among other approach models in SDLC method. It is a development model which works linearly and in sequence. It is also the first model formed. Every step shall be finished before going to the next step. The figure 1 below shows the structure of the model.

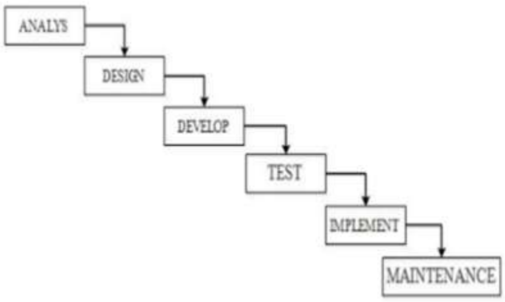

Figure 1: Waterfall Model

In summary, by adopting the waterfall model, the system was developed in the folowing linear steps. Each component was exhausted before the next component is undertaken. The following points summarizes the steps followed:

1. Clearly define the research objective and conduct a literature review to understand existing knowledge and identify research gaps.
2. Design and develop the system, considering the hardware components (sensors, microcontrollers, wireless modules) and software architecture.
3. Collect data by conducting experiments or simulations using the developed system.
4. Analyze the collected data using appropriate statistical or qualitative methods to evaluate system performance.
5. Validate and verify the system by comparing results with established benchmarks or alternative methods.
6. Discuss the findings, draw conclusions, and propose recommendations for future improvements.
7. Document the research process, results, and implications, and communicate them through reports and presentations.
8. Ensure ethical considerations such as obtaining necessary permissions and adhering to animal welfare regulations.

Following this methodology, the system was developed which will enable systematic planning, execution, and evaluation of the Wireless Monitored Egg Incubation System's development, contributing valuable insights to the field.

DESIGN

The proposed system has several features, including the monitoring of temperature, humidity, and light. This feature involves Raspberry Pi collecting data from sensors and sending it to a server for storage and access through a graphical user interface (GUI).

Another feature is the automatic control of temperature and humidity, where Raspberry Pi adjusts the conditions based on received data.

Additionally, the system includes automatic turning of the egg shelf to ensure even temperature distribution and prevent the embryo from sticking to one side of the eggshell.

Furthermore, the system allows for image capture using a USB Web Camera, either through user request or automatically at regular intervals. The captured images are stored in Raspberry Pi's memory and transmitted to the server for storage. This entire process is repeated periodically throughout the incubation process.

The research methodology follows a systematic approach, ensuring the successful development and implementation of the Wireless Monitored Egg Incubation System.

The design is based on the availability of the components for the system realization. The various units were designed and tested separately. The units are listed below:

1. power supply unit;
2. heat and humidity sensing unit; and
3. fan and heater switching circuit.

POWER SUPPLY UNIT

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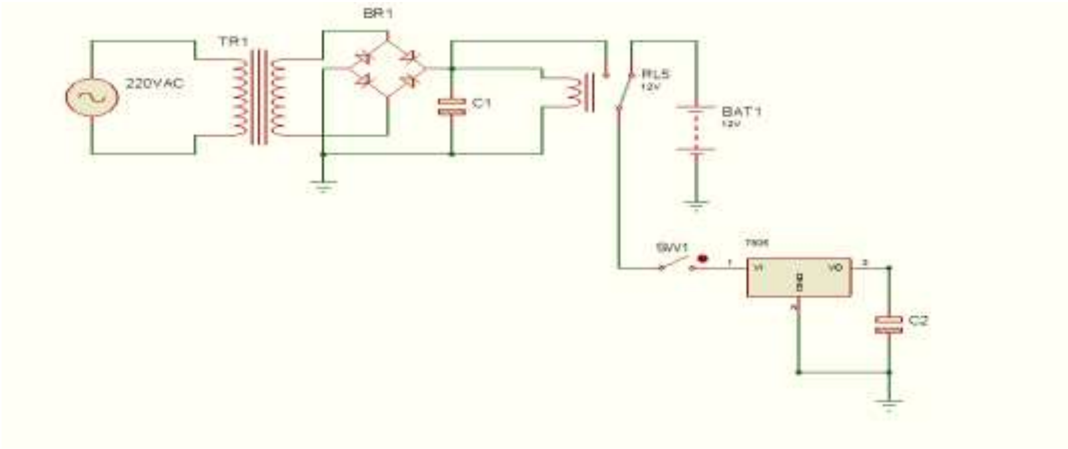

Figure 2: Power Supply Circuit

The power supply circuit comprises of the following components transformer, rectifier, polarized capacitor and regular. To re-filter the circuit against any ripple capacitor C_2 of value 100µf is added.

The power supply is from the 12Vdc battery which is 12Vdc, switch SW1 is to power on the device ON/OFF. Capacitor C1 is 2200µf with main function to filter any ripples, the regulator chosen is 7805 which enable the power supply to regulate at 5V since the PIC16F877A is powered with 5Vdc only. Capacitor C2 is 100µf with the function of filtering any ripple in that unit.

The display contrast is adjusted by the 10KΩ resistor VR1, the common terminal is connected to the VO terminal of the LCD while the other two are connected to ground, the common is adjusted until desire contrast is achieved.

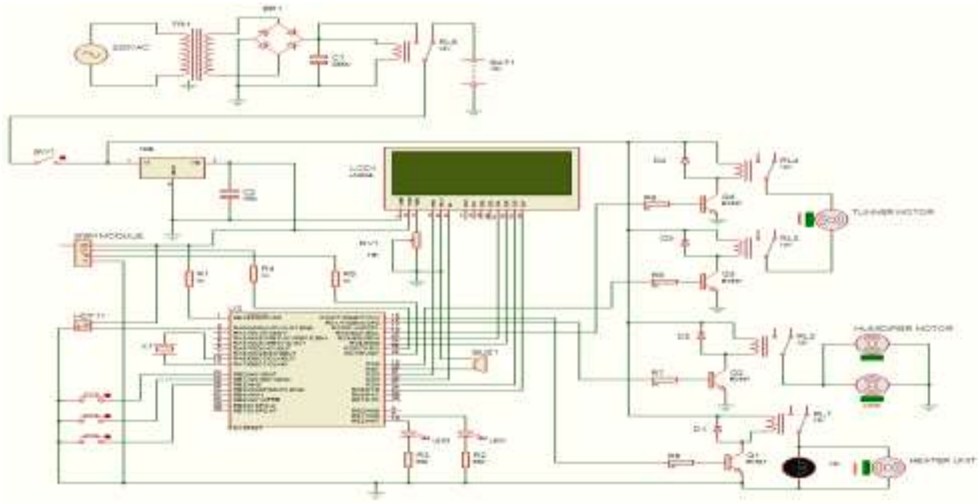

Figure 3: Complete circuit diagram of the project

FLOW CHART

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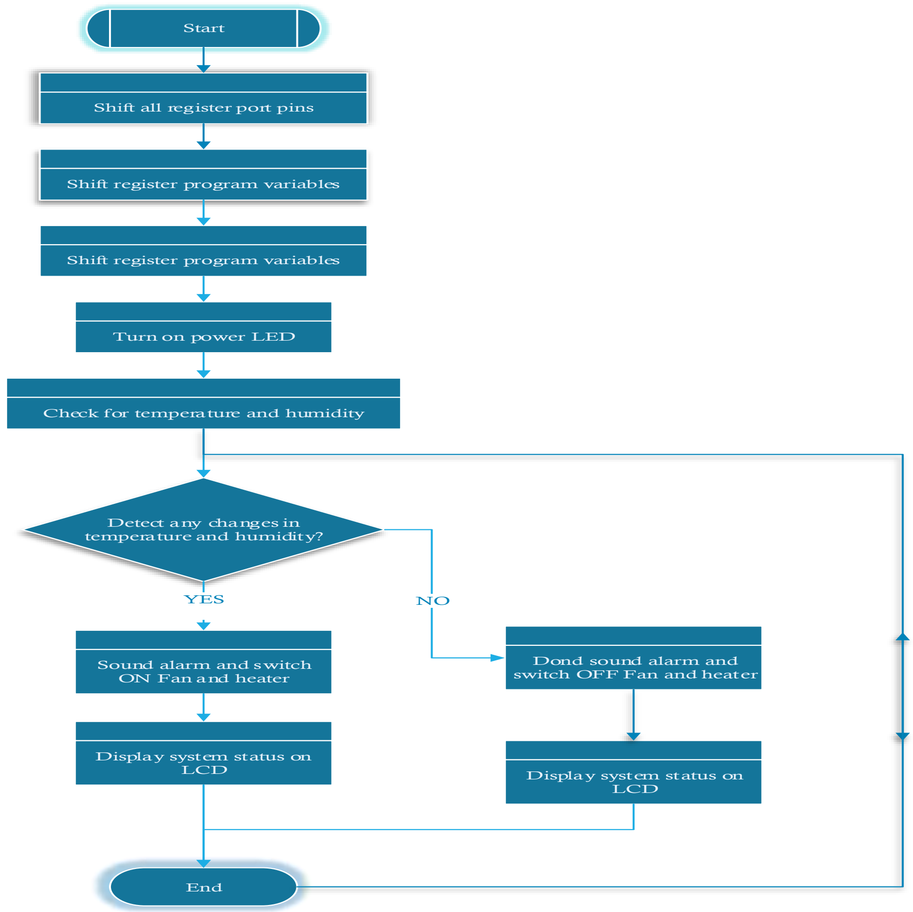

Figure 4:System flow chart of the project

IMPLEMENTATION AND FEATURES OF THE SYSTEM

The developed system has the following features:

I. Monitoring of Temperature, Humidity, and Light

This feature is used to monitor the condition of the temperature, humidity, and light in chicken eggs incubator space. How this feature works is Raspberry Pi gets temperature data through temperature and humidity sensor, and also the light sensor. After those data obtained, then is checking the data condition which is empty or not. If the data obtained is not empty, it continues the encoding data process in form of UTF-8, and then send it to the server and save it in the database. If the data obtained is empty, it has to do retrieve the data. Website application provides a graphical user interface (GUI) to access that data. Sending data to the server is done every 5 minutes until the incubation process finish.

II. Automatic Control of Temperature and Humidity

This feature is used to control temperature and humidity in chicken eggs incubator space to keep it stable at the normal level automatically. How this feature works is Raspberry Pi receives temperature data through temperature and humidity sensor. After the temperature data is received, then check the condition of the temperature itself. If the temperature is 38°C or up to that, it is called high temperature, SET GPIO.LOW process in Raspberry Pi pin that is connected to relay is done, so that the bulb will turn off. Temperature of 37°C or less than that is called low temperature, it means SET GPIO.HIGH process in Raspberry Pi pin that is connected to the relay is done, and the bulb will turn on. The data of humidity is received by checking the condition of the humidity itself. If the humidity is 51-60% is called normal. If it up to 60%, it is called a high humidity, then the SET GPOI. HIGH in Raspberry Pi pin process which is connected to the relay is done, so the water pump and air fan will turn off. If the humidity is only 50% or less than that, it means the humidity is very low, then the SET GPIO.LOW in Raspberry Pi pin process which is connected to the relay is done, so that the water pump and air fan will turn on. Beside that condition mentioned before, it is called abnormal condition, it can be happened because of the error when Raspberry Pi receives the temperature and humidity sensor from DHT11 sensor module.

III. Automatic Turning of Egg Shelf

This feature is used to turn the egg shelf automatically in order to the temperature spread evenly on all sides and also to make the egg embryo not stick to one side of the eggshell. How the feature works is the turning of egg shelf is done every six hours. First position of the egg

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shelf faces to the centre, then Raspberry Pi moves the step motor which is set to the fore with approximately 45°-degree angle, and remains in this position for six hours. After those six hours, the egg shelf will be moved by the step motor facing backward with approximately 45°-degree angle and remains in this position for six hours, and then back to the first position in the center. It happens repeatedly until incubator process stopped.

IV. Taking Images

This feature is used to monitor condition inside the incubator space by taking images using USB Web Camera. By using this feature, the condition inside the incubator space, whether the eggs have already hatched or not, is known by seeing the images that have already taken. Website application provides graphical user interface (GUI) to access this feature. There are two ways in which image can be taken as discussed below.

a. Taking Images through User Request

The way of this feature works is taking and sending the images after user does request process on the website. Raspberry Pi read the request, the bulb will turn on first, and then the USB camera will also turn on and take the images. Those images will be stored in saving memory of Raspberry Pi, then are sent and stored in the server.

b. Taking Images Automatically

The way of this feature works is taking and sending the images every once hour which is done automatically after incubation process is started. First thing to do is checking whether there is an incubation process or not, if there is an incubation process, the bulb turn on first, then the USB camera will also turn on and take the images. Those images will be stored in saving memory of Raspberry Pi, then are sent and stored in the server. This process is done repeatedly every once hour after the incubation process ended.

The overview of the system gives a summary of various components in the system and how are those components connected. The main hardware component in the system is microcontroller Raspberry Pi, various sensors such as temperature sensors and humidity, light sensor, relay, web camera, and step motor. Figure 5below is the actual system developed. Whereas, Figure 6 gives the general overview of the system and how different components of the system are connected.

Figure 6: System Overview

Figure 5: The Constructed System

SUMMARY AND CONCLUSION

The implementation of a control and monitoring system for a chicken eggs incubator machine, utilizing "internet of things" technology and Microcontroller, has been successfully conducted. This system provides a solution for chicken breeders by offering convenience in monitoring and controlling the incubator machine and streamlining the process of hatching chicken eggs, ultimately improving efficiency. With this system, breeders can easily control and monitor their incubator machine from anywhere and at any time. The utilization of a website application as a graphical user interface (GUI) enhances the usability of the system as it can be accessed through internet browsers on various devices such as Smartphone's, tablets, and desktop computers. Looking ahead, there is a vision to further develop the system on a larger scale by incorporating more advanced and sophisticated components along with enhanced techniques.

RECOMMENDATIONS

Based on the system developed, the following recommendations were made:

1. Implement Machine Learning Algorithms: Consider incorporating machine learning algorithms into the system to analyze the collected data and provide intelligent insights. By leveraging machine learning, the system can learn patterns and make accurate predictions related to temperature, humidity, and other environmental variables, thereby optimizing the incubation process and increasing the hatchability rate.
2. Integration with Cloud Platform: Integrate the wireless monitoring incubator system with a cloud-based platform for data storage and analysis. This would enable breeders to securely store and access historical data, track performance trends, and collaborate with other breeders or experts in the field. Additionally, cloud integration can facilitate remote software updates and enable scalability for future expansion.
3. User-Friendly Interface: Focus on developing a user-friendly interface for the monitoring system. This includes designing an intuitive dashboard and implementing visualizations that are easy to understand, even for users with limited technical expertise. Providing clear instructions and documentation will ensure that breeders can easily navigate and utilize the system effectively.

By implementing these recommendations, the wireless monitoring incubator system can be further improved, providing breeders with advanced features, increased convenience, and enhanced control over the incubation process, ultimately leading to improved hatchability rates and productivity in poultry farming.

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