**SMART EGG INCUBATOR: IoT-Based Smart Egg Incubator with Mobile Monitoring**

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1. **INTRODUCTION**
   1. Project Context

An egg incubator is a device that allows the growth of an embryo in a fertilized egg. It’s an innovation that offers activity possibilities, especially for individuals who need to emerge as skilled farmers.

It is an Energy-saving incubator, a multiple-drawer design that minimizes heat loss when opening drawers one at a time and maximizing heat and minimizing power consumption, making it a cost-effective solution for egg-laying. Lawrence San Diego, (2024) These incubators mimic a bird’s natural brooding by growing in the appropriate environment with the right temperature, humidity, and normal egg turning. [1]

An egg incubator's primary goal is to update the work that animals do once they incubate an egg for hatching. Keep the eggs are the usage of synthetic for hatching. Hatching eggs naturally by the hens is considered a big problem for poultry farmers. Hatching the eggs fast by using the technology can produce more chicks. To hatch the eggs by technology, a hatching incubator is implemented by using the Internet of Things (IoT) Jaichandran R et al., (2022). [2]

Despite the development in the egg incubation era, there are still prevailing problems that prevent its premiere use.

Using small-scale hatcheries to hatch native chickens, they always encounter the problem of low incubation capacity because one of the obstacles is power outages during the incubation process Purwanti, S et al., (2021). One primary problem is keeping the environmental situations simply right, which is critical for an excellent hatch price. This may be especially challenging in locations with intense climate situations in which temperature and humidity can exchange loads. [3]

Moreover, many small-scale farmers and poultry enthusiasts lack entry to low cost and reliable incubators. The excessive charge of advanced incubators makes it difficult for them to put money into such an era, limiting their capability to expand their operations and improve productivity. Industrial raising of homestead creatures inside under states of cosmically limited versatility is regularly kenned as processing plant cultivating. It is done as a segment of industrial agribusiness which is a lot of strategies that change as laws and innovation change are kenned as industrial agriculture which is intended to induce the most elevated yield at the least cost, using economies of scale, current hardware, present-day prescription, and ecumenical exchange for financing, buys, and deals. Islam, N et al., (2019, March) [4]

For individuals who want to create an egg incubator and need to hatch a huge sort of egg and need a consistent temperature, humidity, solar panels, and automatic turners to prevent embryos from sticking to the shell properly improvement, Smart egg incubators provide a dependable incubator that continues temperature and humidity. Enable tracking and management through cellular devices for convenience and overall performance. The prototype was found to be more efficient than traditional models, saving manpower, energy, and functionality. Automatic sorting is recommended for quality hatching and

preventing spoilage. Gene Michael M. Manguino, (2022) [4]

A Smart egg incubator is a user-friendly, IoT-primarily based smart egg incubator with cell tracking abilities. Provides a reliable way to hold specific temperature and humidity levels via IoT era. Egg fertilization is one of the main factors to consider in poultry farming. The smart egg incubation system is designed to combine IoT technology with smartphones to make it more convenient for users to monitor and operate the egg incubation system. Niranjan L et al., (2021) Make incubator available to all small-scale farmers and rooster enthusiasts to make sure it’s far an affordable and smooth to use. Educate customers on proper egg incubation practices to improve hatch rates.[5]

The desire of this studies hassle is driven by way of a choice to enhance the performance and accessibility of egg incubation processes within the rooster enterprise. Our organization has seen the struggles of small-scale farmers who can’t control to pay for expensive and complicated incubators. Using the IoT era and mobile monitoring, we goal to offer a modern-day manner to those problems. This study focuses on developing a mobile embedded application for an egg incubator, specifically designed for poultry raisers. The system sends and receives data from a mobile application, including date, time, number, and type of eggs. The system responds to real-time mobile inquiries about hatching information. Romy S. Lopez, (DIT) (2019) This venture shows our commitment to innovation and assisting our network, aligning with our intention to reinforce agricultural development and productivity. [6]

IoT-based smart egg incubator with cell monitoring, we address key troubles of affordability, reliability, and convenience. This will help enhance the achievement costs of egg incubation, particularly for small-scale farmers who need sensible and contemporary answers.[7]

**1.2 PURPOSE AND DESCRIPTION**

The researcher needs to solve considerable problems in a manual incubator, which are maintaining a regular and appropriate temperature, proper humidity levels essential to prevent eggs from loss of life out or up too moist, power outages, egg turning, constant monitoring, and occasional adjustment are necessary to make certain most effective situations, setting a wrong temperature or humidity levels. Those problems require careful monitoring, everyday preservation, and sometimes, backup gadgets to make certain the incubator operates effectively and consistently.

This proposed system will solve these risks. This system specializes in developing a smart egg incubator that uses sensors to monitor temperature and automatically controls mild to preserve the choicest conditions for egg incubation. The machine integrates both hardware components (sensors, light, manage devices) and a software program software that allows for real-time tracking and facts processing, making sure of specific manipulation and simplicity of use.

﻿﻿﻿﻿Smart egg incubator ensures that temperature and moderate degrees are maintained with amazing accuracy. This precision leads to higher hatch prices and greater healthful chick, appreciably reaping rewards for customers through optimizing the incubation gadget. Moreover, the covered software program

software application utility lets customers reveal conditions in actual time, supplying critical symptoms and updates. This actual time monitoring guarantees that instant movements can be taken to address any discrepancies, thereby safeguarding the incubation surroundings, and enhancing overall ordinary performance.

Additionally, our project is designed with a user-friendly interface, making it accessible to both experienced poultry farmers and beginners. The software is intuitive, enabling users to navigate and manage the system effortlessly. The advantage of our project not only streamlines the incubation process but also contributes to more successful and efficient poultry farming.

The smart egg incubator project stands out with several unique and innovative features. Unlike traditional incubators, our system seamlessly combines hardware and software comprehensive control monitoring, enhancing user experience and functionality. The automatic adjustment of light and temperature reduces the need for manual intervention, making the incubation process more efficient and less labor-intensive.

* 1. **OBJECTIVES**

*1.3.1 GENERAL OBJECTIVES*

The study's General objective is to improve, automate, and broaden a sensible smart egg incubator device for the hatch

costs and ensuring healthier chicks. The device will integrate each hardware and software application component to provide environmental management, real-time monitoring, and consumer-friendly operation, making it accessible and beneficial for every skilled rooster farmer and beginner.

*1.3.2 SPECIFIC OBJECTIVES*

1.3.2.1 To design and assemble the hardware components of the smart egg incubator, including temperature and humidity sensors, and automated lighting systems, ensuring compatibility and cost-effectiveness.

1.3.2.2 To develop and integrate automated systems that maintain optimal temperature and humidity levels within the incubator, achieving stable environment conditions.

1.3.2.3 To install a camera within the incubator to provide clear, real-time video feeds of egg development, accessible via the software application, using commercially available cameras.

1.3.2.4 To conduct comprehensive testing of the integrated systems to ensure all components function correctly together, aiming for a minimum hatch rate improvement of 20% compared to traditional methods.

* 1. **SCOPE AND LIMITATION**

﻿Smart egg incubator encompasses the design; improvement integrates advanced sensors and automated manipulation mechanisms to keep the most efficient

temperature and humidity stages. The entire device is made sure of actual time tracking through a dedicated software program software. The task will deliver a functional prototype that combines both hardware and software components to decorate the egg incubation manner. Its number one attention is on automating and optimizing the incubation conditions for commonplace poultry eggs. This will aim at benefitting small-scale chicken farmers by way of presenting a reliable and green incubation answer.

The mission does now not include guide egg incubation techniques or comparisons with such strategies. It does now not deal with species-precise requirements past commonplace rooster eggs like chook, duck, and quail. The development is restrained to creating a prototype without scaling for mass commercial production. The geographical scope is confined to managed development and testing surroundings, without discipline testing in numerous places. The challenge will be used without problems to be had and fee-powerful additives, heading off experimental or excessive-stop technologies. Operating inside a described finance, the task will now not encompass high-fee additives or advanced capabilities. Initial prototypes could have restricted customization options for quit customers, that specialize in general features and functionalities.

**2. METHODOLOGY**

This chapter discusses the methodology process that is being used and applied for this investigation on how to create the project system.

**2.1 DATA GATHERING**

The researcher will interview a person who has a business of incubating chicken eggs to understand the specific problem and requirements. The interview will cover the ideal temperature and humidity ranges for egg incubation, current methods for monitoring and controlling these conditions, and common issues faced during the process.

**2.2 SYSTEM ANALYSIS**

The Smart Egg Incubator project leverages the latest in the Internet of Things (IoT) and its fullest and mobile application technologies to create an efficient, user-friendly, and convenient way to monitor the incubator system, ensuring the condition of the egg and overall hatch rates. Enhancing the accuracy and reliability of the incubation process, this

the project aims to make it more accessible and manageable for those who have small-scale farming the Smart Egg Incubator offers a scalable and efficient solution to meet modern incubation needs.

Smart Egg Incubator consists of different kinds of hardware and software:

* + 1. ***Hardware:***

1. ESP32 Wi-Fi Module: Connectivity of hardware and software.
2. Temperature and Humidity Sensors: measuring temperature and humidity inside the incubator.
3. Camera: real-time monitoring of the eggs.
4. Motor: Rotational function of the egg holder*.*
   * 1. ***Software:***
5. *Cloud Services* For data storage, synchronization, and notification management, ensuring secure and reliable performance.
6. *Mobile Application* User interface for monitoring and control, compatible with Android, communicating with the microcontroller via Wi-Fi.
7. *Embedded Firmware* Runs on the microcontroller, responsible for real-time sensor data processing and actuator control.

***2.6.3 Network:***

1. *Wireless Connectivity:* Use of Wi-Fi, and Bluetooth for reliable and low-power wireless communication between the incubator, sensors, and mobile application.
2. *Cloud Integration:* Leveraging cloud services for data storage, processing, and remote access. This allows users to monitor and control the incubator from anywhere.

**2.6.4 *User:***

1. *Egg Hatchery Manager:* The person who manages or owns a business for incubation.

A thorough analysis of the system requirements, components, interactions, and architecture is conducted for the Internet of Things (IoT) smart egg incubator. Maintaining ideal temperature (37.5°C to 38.5°C) and humidity (50% to 60%), automating egg turning, and offering real-time monitoring and alerts via an intuitive mobile application are the major functional requirements.

Continuous data from sensors is fed into the microcontroller, which uses it to process and regulate the heating elements and egg turner to maintain ideal conditions. Real-time monitoring, user control, and data synchronization with cloud services are made possible via the microcontroller's Wi-Fi communication with the mobile application. In the end, this architecture supports small-scale poultry producers by increasing hatch rates and lowering the barrier to entry for sophisticated incubation technologies. It also guarantees smooth operation by enabling users to monitor conditions in real time and receive alerts.

**2.3 SYSTEM DESIGN**

The system design will align with the plan and processes of the system. We will use a prototyping approach, which will significantly help in developing and improving the system's features and solving any issues that arise.

**A close-up of a computer

Description automatically generated**

***2.3.1*** *ESP32 Wi-Fi Module*, is a potent and adaptable microcontroller. It is intended for a

variety of uses, particularly those that need Bluetooth and Wi-Fi connectivity.

***2.3.2*** *C++,* one of the languages that are being used in ESP32. Object-oriented programming in C++ reduces development costs by providing programs with a clear structure and allowing code reuse. Applications written in C++ can run on multiple platforms and are portable.

***2.3.3*** Firebase Cloud Storage is a backend platform that may be used to create iOS, Android, and Web applications. It provides a hosting platform, several APIs, many authentication methods, and real-time databases.

***2.3.4*** *Kotlin,* is used to build or create Android applications. It is an Android programming language a statically typed, open-source programming language that may be used for both functional and object-oriented programming.

**2.4 SYSTEM DEVELOPMENT**

The researcher will implement the Agile Software Development Method. Using this method, the researchers will be able to monitor quick responses and manage the system's evolution. This could also entail maintaining testing performance during the development process and producing a high-quality product in line with expectations using this development strategy. Agile minimizes risks through optimal job and resource allocation, suitable planning, and the use of efficient prediction tools.

A diagram of a process

Description automatically generated***Figure 2.* Agile Software Development**

Agile principles and practices offer a dynamic framework for project management and software development, emphasizing flexibility, collaboration, and adaptability. By embracing Agile, researchers can proactively manage system development and swiftly respond to evolving requirements. This approach mitigates risks through meticulous planning, efficient task execution, resource allocation, and accurate prediction techniques.

In Addition, the study aims to comprehensively assess all facets of the proposed research, ensuring alignment with the product's needs and expectations upon launch. Software design will prioritize architectural clarity while coding efforts will concentrate on implementing functional features and meeting user demands. Overall, Agile fosters iterative improvement and customer-centricity, enhancing project management effectiveness and software delivery outcomes.

**2.5 TESTING**

In this phase, researchers will employ exploratory testing to stay agile and responsive to changes. They'll engage in user testing to evaluate the proposed system, using its prototype version to gauge its usability and compatibility. This investigation focuses on how testers determine the system's effectiveness. Drawing from their insights, testers will develop and execute detailed test plans to gain a comprehensive understanding of the system's performance and user experience.

**2.6 IMPLEMENTATION**

Once the development and the initial testing are completed, the incubator will be set up in a chosen business specializing in chicken egg incubation, which has agreed to take part in the initial testing stage. Regular communication will be maintained with the business owner, who will act as the main tester, to monitor performance, collect feedback, and offer essential maintenance and support. This cooperative method will guarantee that the system is improved and enhanced based on actual usage before being more widely implemented.

1. **RESULTS AND DISCUSSION** 
   1. ***System Functionality:***

For the convenience of remote monitoring, we verify the status of the incubated egg to ensure its functionality. Multiple tests ensure the system operates as expected in various conditions.

*Temperature Control:* The temperature inside the incubator is between 99° and 100°F.

*Camera:* It gives a real-time video update for remote monitoring.

*Egg Turner:* It turns the egg at the exact time set.

Results of the test show that the intelligent egg incubator effectively manages temperature and humidity with high accuracy and precision. Maintaining this precision is essential for the successful hatching of eggs, as even small variations can affect hatch rates. The system's capacity to consistently remain within close limits guarantees a steady environment for embryo development.

* 1. ***System Reliability:***

To know if the system project is reliable within the given period. The project system continuously runs for 30 days to monitor if there’s any malfunction or failure in the system.

*Uptime:* The uptime of the system was 99.8%, and there were only minor interruptions caused by power fluctuations, but they were rapidly resolved.

*Durability:* The test period showed that all parts operated properly without any indications of damage or malfunction.

The system's durability has been proven through reliability tests conducted over an extended period. The incubator has showcased a high uptime percentage and has experienced no significant component failures, making it a trustworthy solution for poultry farmers. Maintaining continuous operation and ensuring high hatch rates relies on this essential reliability.

* 1. ***Application UI/UX:***

Evaluate the mobile application's effectiveness and usability by gathering feedback from the user or tester on the app’s overall experience.

*Usability:* The app was found to be intuitive and easy to navigate by 90% of users.

*Navigation:* The average navigation time for users to access all features and settings is 3 minutes, allowing for efficient use.

*User Satisfaction:* Satisfaction overall rated as 4.5 out of 5.

Feedback from users regarding the mobile app emphasizes how easy it is to use and how effective it is for remote monitoring and control. The high satisfaction ratings indicate that the app's design fulfills the requirements of the intended users, delivering a smooth experience that improves the overall performance of the smart incubator.

* 1. **CONCLUSION AND RECOMMENDATION**

Using this automated smart egg incubator including improved environmental control, remote monitoring, and automated adjustments gives a high advantage and high rates of hatching eggs and reduces the manual labor and time required for successful incubation. For future guidance, the system could expand more that can support any type of egg which could broaden its applicability and market reach.

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