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

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1. **INTRODUCTION**

**Project Context**

An egg incubator is a device that allows an embryo to grow in a fertilized egg. This innovation offers activity possibilities, especially for individuals who need to emerge as skilled farmers.

It is an energy-saving incubator with a multiple-drawer design that minimizes heat loss when opening drawers one at a time, maximizes heat, and minimizes 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 regular egg turning [1].

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

Despite the development in the egg incubation era, prevailing problems still 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 concern is keeping the environmental situations right, which is critical for an excellent hatch price. This may be incredibly challenging in locations with intense climate situations in which temperature and humidity can exchange loads [3].

Moreover, many small-scale farmers and poultry enthusiasts need more entry to low-cost and reliable incubators. The excessive charge of advanced incubators makes it challenging to put money into such an era, limiting their capability to expand their operations and improve productivity. Industrial raising of homestead creatures under cosmically limited versatility Is regularly known 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 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].

A Smart egg incubator is a user-friendly, IoT-primarily based innovative egg incubator with cell tracking abilities. It provides a reliable way to hold specific temperature and humidity levels via the IoT era. Egg fertilization is one of the main factors to consider in poultry farming. ﻿The egg incubation machine is designed to combine the IoT era with smartphones to make it more convenient for users to display and function the egg incubation system. Niranjan L et al. (2021). An incubator is available to every farmer who has started using an incubator and needs to emerge as a skilled farmer to ensure it is lower priced and clean to apply. Educate clients on proper egg incubation practices to improve hatch charges [5].

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. Smart egg incubation system, integration of IoT with a smartphone for better user interaction and control over the egg incubating system. Niranjan L et al. (2021) Give incubator open accessibility to all females or small-scale fowl farmers and roaster-keepers in different ways that ought to be affordable and easy to operate. Teach consumers the best egg-incubating practices to enhance the number hatched [6].

The desire for this study is driven by the 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 aim to offer a modern-day manner to those problems. This study focuses on developing a mobile-embedded application for an egg incubator designed explicitly 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 [7].

We use an IoT-based smart egg incubator with cell monitoring to address critical problems 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 [8].

**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 sure most practical situations, setting a wrong temperature or humidity levels. Those problems require careful monitoring, everyday preservation, and sometimes, backup gadgets to ensure the incubator operates effectively and consistently.

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

﻿﻿﻿﻿ It ensures that the temperature and moderate degrees are accurately maintained, hence increasing hatch prices and creating more outstanding healthy chicks, in return giving rich rewards to the customers upon optimizing the incubation gadget. Moreover, it is covered by software programs.

Software utility application lets one screen conditions in actual time. It provides symptoms and updates of essential nature. This actual-time tracking ensures that immediate moves may be taken to deal with discrepancies, thereby safeguarding the incubation environment and enhancing universal performance.

Smart egg incubator ensures that temperature and moderate degrees are maintained precisely. This accuracy results in higher hatch prices, more wonderful and wholesome chick, readily reaping customer rewards by means of optimizing the incubation gadget. Furthermore, the covered software program will ensure comfort and ease in temperature management and specialized variables.

The smart egg incubator project has various new features that set it apart. Our system comes with comprehensive control monitoring in both hardware and software, thus improving the user experience in its functionality, unlike the other traditional incubators that lack this innovative feature. Light and temperature are adjusted automatically; hence, there is a reduced need for manual intervention, therefore making the incubation process more efficient and less labor-intensive.

**OBJECTIVES**

*GENERAL OBJECTIVES*

The general objective of the study is to enhance, automate, and expand a practical, intelligent egg incubator device for the hatch.

Costs and ensuring healthier chicks: The device will integrate every hardware and software application component to provide an environmental management system in real-time, monitoring, and friendly consumer operation that makes it accessible and useful to both skilled rooster farmers and newbies.

*SPECIFIC OBJECTIVES*

Design and build up the hardware components of the Smart Egg Incubator by using temperature and humidity sensors and automated lighting systems to ensure compatibility and cost-effectiveness.

Design and integrate automatic systems that will be able to maintain the best temperature and humidity inside the incubator and realize stable environmental conditions.

Fit a camera inside the incubator to capture clear and live video footage with respect to the development of eggs from this software application itself by using commercially available cameras.

Integration Testing The integrated systems will be tested to ensure the functioning of all components. This is expected to bring an absolute minimum hatch rate improvement of 20% compared to traditional methods.

**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 to benefit small-scale chicken farmers by 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. Operate 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.

**DATA GATHERING**

The researcher will interview someone who owns a business incubating chicken eggs to understand the specific problem and requirements. These will include the optimum temperature and humidity ranges for incubation, the prevalent methods of controlling and checking these conditions, and frequent problems that may be encountered during the process.

**SYSTEM ANALYSIS**

This Smart Egg Incubator project enables the latest in the Internet of Things and its most integral and mobile application technologies, giving an efficient, user-friendly, and convenient way to monitor the incubation system for the condition of the egg and overall hatch rates.Enhancing theaccuracy and reliability of the incubation process, this

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:

***Hardware:***

ESP32 Wi-Fi Module: Connectivity of hardware and software.

Temperature and Humidity Sensors: measuring temperature and humidity inside the incubator.

Camera: real-time monitoring of the eggs.

Motor: Rotational function of the egg holder*.*

***Software:***

*Cloud Services* For data storage, synchronization, and notification management, ensuring secure and reliable performance.

*Mobile Application* User interface for monitoring and control, compatible with Android, communicating with the microcontroller via Wi-Fi.

*Embedded Firmware* Runs on the microcontroller, responsible for real-time sensor data processing and actuator control.

***Network:***

*Wireless Connectivity:* Use of Wi-Fi, and Bluetooth for reliable and low-power wireless communication between the incubator, sensors, and mobile application.

*Cloud Integration:* Leveraging cloud services for data storage, processing, and remote access. This allows users to monitor and control the incubator from anywhere.

***User:***

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

This paper in-depth analyzes the system requirements, components, interactions, and architecture of an IoT-based smart egg incubator. The main functional requirements are maintaining an optimum temperature between 37.5°C and 38.5°C and humidity between 50% and 60%, automating egg turning, and providing a real-time monitoring and alert system through a user-friendly mobile application.

It continuously receives data from the sensors, which it processes to control the heating elements and the egg turner for creating appropriate conditions. Through Wi-Fi communication, the microcontroller communicates with the mobile application for real-time monitoring and user control and synchronizes data to cloud services. This architecture eventually helps the small-scale poultry producer through increased hatch rates and decreased barrier to entry for sophisticated incubation technologies. In addition, it guarantees smooth running by allowing users to monitor the conditions in real-time and receive alerts.

**SYSTEM DESIGN**

The system design will follow through with the system plan and processes. In creating the system, we will use a prototyping approach that will greatly aid in developing and improving its features and solving any arising problems.

*ESP32 Wi-Fi Module*, the microcontroller is very strong and adaptable. This was purposively designed to serve various purposes, especially those that require Bluetooth and Wi-Fi connectivity.

One of the languages used in ESP32 is C++. The object-oriented programming of C++ makes programs have a clear structure and allows code reuse hence reducing development cost. Programs written in C++ can run on multiple platforms and hence are portable.

Firebase Cloud Storage This is a back end for developing iOS, Android, and Web applications. It provides its users with a hosting platform, several APIs, numerous authentication methods, and real-time databases.

*Kotlin,* this language is going to be used in the creation or building of Android applications. It is an open-source language; statically typed language for Android programming which can also be used for functional and object-oriented programming.

**SYSTEM DEVELOPMENT**

***Figure 1.* Input, Process, and Output Diagram.**

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. Agile minimizes risks through optimal job and resource allocation, suitable planning, and efficient prediction tools.

**A close-up of a computer

Description automatically generated**A diagram of a process

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

Agile principles and practices introduce a dynamic framework of project management and software development. It lays immense emphasis on flexibility, collaboration, and adaptability. Through Agile, researchers will be able to proactively manage the development of a system, respond to requirements as they evolve, and minimize risks through rigorous planning, efficient execution of tasks, resource allocation, and prediction techniques.

It also attempts to reassess each phase of the proposed research in detail so that it will meet all requirements and needs when launched. All activities about the software design process would be centered on the clarity of architecture, and for coding, it would be working features and meeting customer needs. Agile advocates for iterative enhancement and customer-centricity, which fuels the efficiency of project management and software delivery.

**TESTING**

At this stage, exploratory testing will be used to make the researchers agile and responsive to changes. User testing will be performed to assess the proposed system through its prototype version on criteria of usability and compatibility. The concern of this study is how testers determine the system's effectiveness. Based on their experiences, the testers will create test plans that they will perform comprehensively to understand the system's performance and user experience.

**IMPLEMENTATION**

After development and initial testing are completed, the incubator will be installed at a selected business involved in chicken egg incubation that has accepted participating in the testing phase. The incubator's performance will be continuously monitored through regular contact with the business owner, who will be the primary tester; this will complement gathering constructive feedback and the needed maintenance and support. This cooperative approach will ensure that the system is refined and upgraded by active use before being rolled out more extensively.

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