SMART BROODING SYSTEM FOR POULTRY

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Abstract— This system, designed for poultry farmers, is a Smart Brooding System for Poultry. The researchers used a prototyping model to develop the system. The design can give the farmers an easy way to monitor their brooder through their mobile phones using the internet. The system was evaluated using ISO 25010, an International Standard of Software Evaluation. Farmers can monitor the water, ammonia gas, humidity, and temperature status, and they can monitor the chicks through live viewing. Internet access is needed for this mobile monitoring app, where the application displays the value of the sensor reading inside the brooder and the time when the data was retrieved. This design is an improved brooder system that uses the Internet of Things (IoT). It is possible to get the information from the water, ammonia gas, humidity, and temperature sensors and analyze it digitally from anywhere in the world. The IoT using Arduino Microcontroller is easy and fun to use. Presented here is a water, ammonia gas, humidity, and temperature monitoring system using Arduino and the Internet of Things applied in the field of agriculture.

***Keywords*— Computer System, Internet of Things (IoT), Brooder, Arduino, Water, Ammonia Gas, Humidity and Temperature Monitoring, Water, Ammonia Gas, Humidity and Temperature Sensor.**

I. INTRODUCTION

Brooding is widely recognized as the most critical stage in poultry production, occurring immediately after hatching when day-old chicks are highly vulnerable. At this stage, chicks possess underdeveloped thermoregulatory systems, making them entirely dependent on external environmental support to survive. Inadequate management—such as improper temperature control or poor air quality—often leads to severe consequences, including high mortality rates, stunted growth, and increased susceptibility to respiratory infections. A critical barrier to effective brooding is the reliance on manual oversight, which often fails to identify the early warning signs of environmental stress, limiting the capacity for proactive intervention by poultry farmers.

Traditional brooding practices typically rely on manual monitoring of heat lamps, ventilation, and water supplies. While this method has been used for years, it is labor-intensive and frequently prone to human error, inconsistency, or delayed responses to shifting conditions. Although the emergence of the Internet of Things (IoT) has introduced opportunities for automation, a core limitation of many existing IoT-based solutions is their narrow focus. Most systems prioritize basic temperature and humidity control while overlooking critical factors such as ammonia gas accumulation and real-time visual monitoring of chick behavior. This lack of comprehensive data collection severely compromises the reliability of the system, making it less dependable for formal health assessment and preventative management.

To establish a more consistent and accurate understanding of a flock's condition, integrating advanced sensor technologies and behavioral analysis into the monitoring process is essential. Ammonia, a byproduct of manure decomposition, poses significant health risks that remain invisible without specialized sensors, and signs of chick distress—such as abnormal clustering—are often missed without continuous camera monitoring. By integrating gas-detection sensors and computer vision with an automated monitoring system, the accuracy of environmental data can be significantly improved, supporting more objective decision-making. Furthermore, operational efficiency is crucial for the success of any large-scale poultry operation; research indicates that automated alert systems significantly reduce response times and encourage timely, evidence-based adjustments to the brooder environment.

This study addresses the aforementioned gaps by introducing "Smart Brooding," an integrated IoT-based solution designed to offer a comprehensive and reliable approach to poultry management. Smart Brooding combines environmental sensing (including ammonia detection) with AI-powered visual behavior analysis to ensure data objectivity. Crucially, the system is designed to automatically notify farmers when environmental conditions or chick behavioral patterns exceed predefined risk thresholds. By strategically combining real-time environmental monitoring, advanced sensor data, and a direct channel for automated alerts, Smart Brooding aims to improve bird health, enhance the reliability of brooding management, and facilitate early, evidence-based intervention in poultry production.

III.METHODOLOGY

Conceptual Framework

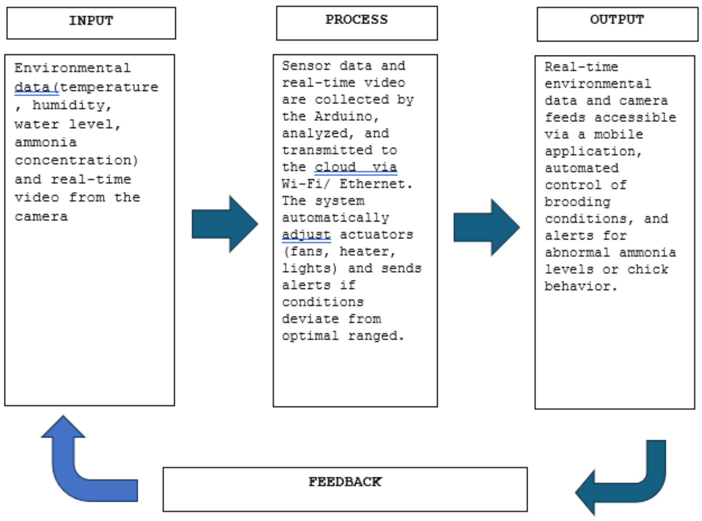

Fig. 1. The Conceptual Framework of Smart Brooding System

Figure 1 illustrates the Input–Process–Output (IPO) conceptual framework that guides the design and development of the Smart Brooding System. The **input** component consists of environmental data including temperature, humidity, water level, and ammonia concentration, along with real-time video captured from the camera. These inputs provide the raw data necessary for the system to understand the current state of the brooding environment.

The **process** component represents the core operations and data handling of the system. Sensor data and real-time video are collected by the Arduino microcontroller, where they are analyzed and subsequently transmitted to the cloud via Wi-Fi or Ethernet connectivity. Based on this analysis, the system automatically adjusts actuators—such as fans, heaters, and lights—to maintain optimal conditions. Additionally, the system is programmed to send automated alerts if environmental conditions deviate from the predefined optimal ranges.

The **output** of the framework is a functional monitoring and control interface that provides real-time environmental data and camera feeds accessible via a mobile application. This includes automated control of brooding conditions and targeted alerts for abnormal ammonia levels or irregular chick behavior. These outputs ensure timely intervention and a stable environment for poultry growth.

The **feedback** component facilitates continuous system improvement and regulation. By creating a loop between the output and input, the system can constantly refine its responses to environmental changes, ensuring that the automated adjustments lead to the desired atmospheric outcomes within the brooder.

Research Design

This study employed a **developmental-descriptive research design** in the development and evaluation of the **Smart Poultry Brooding System**. The developmental aspect focused on the systematic design, hardware integration, and software implementation of the IoT-based brooder, while the descriptive component was utilized to evaluate the system's performance and effectiveness based on real-time environmental data and user feedback.

The study aimed to develop an IoT-based poultry monitoring system that integrates automated temperature and humidity regulation, ammonia gas detection using the MQ137 sensor, water level sensing with the JSN-SR04T, and real-time visual monitoring via an ESP8266 camera. The research design allowed the researchers to observe, describe, and analyze the system's functionality, accuracy, and reliability in maintaining optimal brooding conditions without manipulating the natural behavior of the chicks.

The evaluation of the system was conducted using selected characteristics of the **ISO/IEC 25010 software quality model**, assessing key dimensions such as functionality (the accuracy of sensor readings and automated triggers), usability (the interface of the Android application), and reliability (the consistency of data transmission via the cloud). This design ensured that the developed system was both technically robust and responsive to the practical needs of poultry farmers in ensuring the survival and growth of day-old chicks.

Respondent and Sampling Techniques

To ensure the reliability and relevance of the evaluation results, the study employed a purposive sampling technique in selecting participants who had direct involvement and interaction with the Smart Poultry Brooding System. A total of 36 respondents participated in the study, consisting of 10 poultry farmers, 4 IT experts, and 1 agricultural specialist or veterinarian.

The poultry farmers served as the primary users of the system and were chosen because they represent the target beneficiaries of the technology. They actively tested the system's features, including the Android mobile dashboard, real-time sensor data monitoring (temperature, humidity, ammonia, and water levels), and the live video stream. The IT experts were included to evaluate the technical quality of the system, particularly in terms of hardware-software integration, cloud data reliability, and performance efficiency of the IoT architecture. Meanwhile, the agricultural specialist assessed the appropriateness of the automated environmental triggers, the accuracy of the ammonia risk-level detection, and the overall impact on chick welfare.

The use of purposive sampling ensured that all participants had adequate experience interacting with the automated brooder prior to completing the evaluation questionnaire, thereby enhancing the validity and credibility of the collected data.

Research Instrument

The primary data gathering instrument used in this study was a structured evaluation questionnaire based on the ISO/IEC 25010 software quality model. The questionnaire was designed to assess the overall quality and performance of the Smart Poultry Brooding System. It was divided into two main parts. The first part gathered the demographic information of the respondents, including their classification as poultry farmers, IT experts, or agricultural specialists.

The second part evaluated the system according to the key software quality characteristics defined under ISO/IEC 25010, specifically functionality, reliability, usability, efficiency, compatibility, portability, maintainability, and security. Each statement in the questionnaire was rated using a 5-point Likert Scale, where 5 indicated Excellent, 4 indicated Very Good, 3 indicated Good, 2 indicated Fair, and 1 indicated Poor.

Prior to distribution, the instrument underwent expert validation to ensure clarity, relevance, and alignment with the agricultural and technical objectives of the study. The collected responses were statistically analyzed using the weighted mean to determine the overall performance rating of the system.

3.4 Software Development Methodology

The researchers proposed the use of the Prototyping-based Model as the Software Development Life Cycle (SDLC) methodology in the development of the Smart Poultry Brooding System. Prototyping was selected due to its iterative and trial-and-error approach, which allows for the continuous refinement, regular testing, and reworking of system components until an acceptable final product is achieved. This methodology ensured that system features were developed systematically and aligned with the objectives of delivering a reliable, automated solution for poultry management.

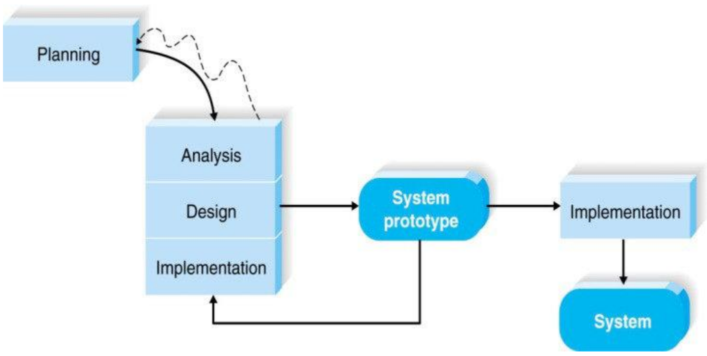

Figure 2. The Prototyping-based Model

During the Requirements Gathering phase, the researchers identified critical features such as temperature and humidity control using DHT sensors, ammonia gas monitoring with the MQ137 sensor, water level sensing via the JSN-SR04T, and live video streaming integration. This was followed by System Analysis and Design, where UML diagrams—including Activity, Use Case, Sequence, and Deployment Diagrams—were developed to map how the Lolin Wemos D1 R1 would communicate with the mobile application via the Internet of Things.

In the Development and Implementation stage, the Arduino IDE was used for microcontroller programming, integrating the hardware to trigger the system fan and heating wire, while the ESP8266 was configured for real-time video transmission to an Android interface. Comprehensive Testing and Integration were then conducted to verify sensor accuracy and the stability of automated triggers. Finally, in the Deployment and Maintenance phase, the prototype was pilot-tested in a real-world brooder environment, with maintenance procedures focused on power stability and sensor recalibration. This systematic methodology ensured that the Smart Poultry Brooding System was thoroughly evaluated and refined according to established software and hardware quality standards.

III. RESULTS AND DISCUSSION

The Smart Brooding System was designed and developed to provide poultry farmers with an efficient way to monitor and manage their brooder environment. The system was built based on the specific goals outlined in the previous chapter, integrating both hardware and software to control humidity, temperature, water level, and ammonia levels. The results of the study showed that all of the research objectives were successfully met, allowing farmers to easily monitor real-time sensor data through their mobile phones using a simple and user-friendly application.

System Performance in Terms of Functionality

Functionality is a set of attributes that bear on the existence of an asset of functions and their specified properties. The functions are those that satisfy stated or implied needs.

Table 1 shows the system's functionality results. The system had a grand mean of 4.7, indicating Very Good performance, as determined by evaluations from farmers and agricultural experts. In the three areas of Functionality, the system received the highest rating of 5.00 in Suitability and Accurateness from the Agriculture Expert, while the lowest rating among the evaluators was for interoperability from farmers.

Result of the Functionality of the System

Functionality Sub-characteristics	Farmers Mean	Agri Experts/IT Experts Mean	Grand Mean	Description
Suitability	4.8	5.0	4.9	Very Good
Accurateness	5.0	5.0	5.0	Very Good
Interoperability	4.2	4.2	4.2	Very Good
TOTAL	4.7	4.73	4.7	Very Good

TABLE II

Result Of The Effiency Of The System

System Performance in Terms of Efficiency

Table 2 shows the efficiency results of the Smart Brooding System for Poultry. The result showed that the system was rated as very good with a grand mean of 4.7. Based on evaluations by farmers and agricultural experts, the system was efficient for monitoring via a mobile app over the internet.

Table 6

Result of the Efficiency of the System

Efficiency Sub-characteristics	Farmers Mean	Agri Experts/ IT Experts Mean	Grand Mean	Description
Resources	4.8	4.6	4.7	Very Good
Utilization	4.6	4.8	4.7	Very Good
TOTAL	4.7	4.7	4.7	Very Good

TABLE III

Result Of The Usability Of The System

System Performance in Terms of Usability

Based on the evaluation by Farmers and Agriculture Experts, the Smart Brooding System for Poultry was usable for farmers in terms of Internet of Things-based monitoring.

The result showed that the system met the user's standards for water level, ammonia, humidity, and temperature in the mobile app.

Result of the Usability of the System

Usability Sub-characteristics	Farmers Mean	Agri Experts/IT Experts Mean	Grand Mean	Description
Understandability	4.8	4.4	4.6	Very Good
Learn ability	4.4	4.4	4.4	Very Good
Operability	4.4	4.4	4.4	Very Good
Attractiveness	4.2	4.8	4.5	Very Good
TOTAL	4.45	4.5	4.47	Very Good

TABLE IV

Result Of The Reliability Of The System

System Performance in terms of Reliability

As shown in Table 4, in terms of reliability, the system was rated by farmers (M=4.2) and by agricultural experts (M=4.3) as very good. The results showed that the system was reliable for monitoring water level, ammonia, humidity, and temperature via the Internet of Things.

Result of the Reliability of the System

Reliability Sub-characteristics	Farmers Mean	Agri Experts/IT Experts Mean	Grand Mean	Description
Compatibility	4.2	4.2	4.2	Very Good
Operability	4.2	4.4	4.3	Very Good
Maturity	4.2	4.4	4.3	Very Good
TOTAL	4.2	4.3	4.27	Very Good

TABLE V

Result Of The Portability Of The System

System Performance in Terms of Portability

Table 5 shows the results of the system portability. The farmers rated the system 4.4 (very good), while the agricultural experts also rated it 4.27 (very good). The result showed that the system is portable because the user can use the monitoring app easily, using the internet.

Table 9

Result of the Portability of the System

Portability Sub-characteristics	Farmers Mean	Agri Experts/IT Experts Mean	Grand Mean	Description
Adaptability	4.8	4.8	4.8	Very Good
Install ability	4.0	4.0	4.0	Very Good
Conformance	4.4	4.0	4.2	Very Good
TOTAL	4.4	4.27	4.33	Very Good

TABLE VI

Result Of The Maintainability Of The System

System Performance in Terms of Maintainability

Table 6 shows the system's maintainability results. The system was rated very good by farmers (mean 4.65) and by an agriculture expert (mean 4.4). The result showed that the system is maintainable, as indicated by the evaluation rating. Errors in system hardware and software applications can be diagnosed, modified, and upgraded to meet the needs of the farmer.

Result of the Maintainability of the System

Maintainability Sub-characteristics	Farmers Mean	Agri Experts/IT Experts Mean	Grand Mean	Description
Stability	4.4	4.0	4.2	Very Good
Analyzability	5.0	5.0	5.0	Very Good
Testability	4.6	4.4	4.4	Very Good
Changeability	4.6	4.2	4.2	Very Good
TOTAL	4.65	4.4	4.62	Excellent

TABLE VII

OVERALL RESULT OF SYSTEM EVALUATION

Overall Evaluation of the System

The system was rated as very good. The evaluation results met the study's main objective: to develop a system that helps poultry farmers easily monitor water level, ammonia level, humidity, and brooder temperature, even in remote locations, using a mobile phone and the internet. However, the system has some limitations, such as interruptions in the internet signal.

Overall result of System Evaluation

Maintainability Sub-characteristics	Farmers Mean	Agri Experts/IT Experts Mean	Grand Mean	Description
Functionality	4.7	4.73	4.7	Very Good
Efficiency	4.7	4.7	4.7	Very Good
Usability	4.45	4.5	4.47	Very Good
Reliability	4.2	2.3	4.27	Very Good
Portability	4.4	4.27	4,33	Very Good
Maintainability	4.65	4.4	4.62	Very Good
TOTAL	4.51	4.48	4.51	Very Good

Conclusion

The Smart Brooding System for Poultry was found to be effective, efficient, and reliable in achieving its objectives. Its intuitive interface enabled poultry farmers to monitor water level, ammonia, humidity, and temperature seamlessly. The live monitoring feature provided real-time environmental data, allowing timely adjustments to ensure optimal brooder conditions. Overall, the system demonstrated its capability to support remote brooder management, meeting both practical and operational requirements for poultry farmers.

It is recommended that poultry farmers adopt the Smart Brooding System to improve monitoring and management of brooders. To enhance system performance and usability, the researchers suggest integrating a water quality sensor, implementing an automated water feeder, and incorporating an adjustable mounting system for heating bulbs. These improvements would further optimize environmental control, improve efficiency, and ensure better welfare for the chicks.

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