# DEVELOPMENT OF AN IOT-BASED POULTRY MANAGEMENT SYSTEM

Supported by tetfund

**Folasade Durodola[1], Samuel Owoeye[1], Olugbenga Omotainse[2], Omanma Uche[3], Ahmed Malik[1], Jim Pearse[1].**
[1]Department of Mechatronics Engineering, Federal University of Agriculture, Abeokuta, Nigeria
[2]Department of Agricultural and Bioresources Engineering, Federal University of Agriculture Abeokuta, Nigeria
[3]Department of Computing, Anchor University, Lagos, Nigeria
Corresponding author: * durodolafo@funaab.edu.ng

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**Abstract:** Poultry farming faces significant challenges, including high labour costs, human error, environmental impact, and disease outbreaks. This research aims to use IoT to control and monitor various poultry management parameters such as feeding, watering, waste, and egg collection. The system uses various sensors, actuators, microcontrollers, and communication modules to collect and transmit data from the poultry farm to a cloud server. It also uses a web dashboard and a web app to display real-time and historical data about the poultry farm, as well as to provide farmers with real-time information on the state of the poultry farm. The evaluation results showed that all the main units of the embedded system, including power supply, feed control, sensing, water, and display, were completely operational, and the system performed satisfactorily overall. Though due to unstable internet connection, some downtimes were noticed in connecting with the IoT. It is observed that our IoT-based automated poultry farming system can improve the productivity, profitability, and sustainability of poultry farming, as well as reduce labour costs and human error.

**Keywords*:*** Actuators, Automated, Embedded system, IoT, Microcontrollers, Poultry, Sensors,

**Introduction**:

Agriculture stands at the threshold of a technological renaissance, where the marriage of traditional farming practices with cutting-edge technologies holds the promise of unprecedented efficiency and productivity (Canton, 2021; Canfield *et al.,* 2021). The poultry industry, a cornerstone of global agriculture, is no exception (Erdaw & Beyene, 2022). Recognizing the immense potential for improvement, this project endeavours to propel poultry farming into the future through the development of the "IoT-Based Poultry Management System."

Poultry farming, a critical component of the food supply chain, faces multifaceted challenges ranging from operational inefficiencies to resource management complexities (Nielsen &Zhao, 2012; Pesti & Choct, 2023). Manual oversight of tasks such as waste removal, egg collection, and feeding not only consumes valuable time and effort but also introduces the risk of human error (Wu *et al.,* 2022*;* Edan *et al.,* 2023*)*. The need for a transformative solution that embraces the technological advances offered by the Internet of Things (IoT) has never been more pressing (Abbas *et al.,* 2022). One of the promising solutions is the application of Internet of Things (IoT) technology for poultry farming. The Internet of Things (IoT) is simply a network of devices that can sense, communicate, and actuate data from the physical environment to the cyber domain, facilitating intelligent and autonomous control of various systems and processes. IoT has been widely used in various domains such as smart cities, smart homes, smart health, smart agriculture, and smart industry, providing various benefits such as enhanced productivity, improved quality, reduced waste, increased safety, and optimized resource utilization.

The IoT-Based Poultry Management System seeks to address these challenges comprehensively. By infusing poultry farming with smart, interconnected devices and an intelligent mobile application, it aims to empower farmers with real-time monitoring, automation, and data-driven decision-making capabilities. This project is not just about automating tasks; it's about ushering in a paradigm shift in how we approach and manage poultry farming, ensuring sustainability, efficiency, and, above all, the well-being of the livestock.

Various studies have been conducted to create an effective automated poultry management system using diverse technologies, as evidenced in the available literature. Zheng *et al.,* (2021) implemented a poultry farming information management system utilizing a cloud database. Zhao &Yang, 2022 employed smart sensors, big data, and the Internet of Things (IoT) in developing a smart poultry management system. Ojo *et al.,* (2022) introduced real-time poultry monitoring using edge computing and artificial intelligence. Balachandar and Chinnaiyan focused on IoT-based real-time disease monitoring in poultry farming through imagery analytics. Adebisi *et al.,* (2023), devised an Internet of Things-based tool for environmental monitoring in poultry farms. Revanth *et al.,* (2021) designed an IoT-based smart poultry farm. Choukidar and Dawande created a microcontroller-based poultry control system to monitor crucial parameters like water and ammonia levels, humidity, and temperature effectively. Gunawan *et al.,* (2019) explored smart poultry farming using RTOS on Arduino, while Thomas *et al.,* (2020) introduced a microcontroller-based automated system for monitoring poultry parameters along with a conveyor mechanism. The existing literature indicates an unexplored area in simultaneously monitoring poultry environmental conditions, feed, and water levels. Consequently, this study devised and put into action a microcontroller-based automated regulating system. This system is adept at overseeing fundamental poultry parameters like feed and water levels to enhance overall poultry production efficiency.

The objective of this project is to design and build an Automated Poultry System with an IOT-controlled feeding, waste management and egg collection system. The system will consist of a software-hardware solution that will automate the processes of feeding and making water available for the birds, collecting and disposing of the waste, and collecting the eggs. The system is connected to a cloud-based platform that will provide a user-friendly dashboard for the farmers to monitor and control the system remotely via a web or mobile application. The system will also provide alerts and notifications for any abnormal or critical situations that require immediate attention.

## MATERIALS AND METHODS

An IOT-based automated poultry farming system that can perform the following functions was designed and developed:

a) **Feeding**: The system will automatically dispense the required amount of feed to the birds according to their age and weight. The system will also monitor the feed level in the feeding hooper and notify the farmer when it is low.

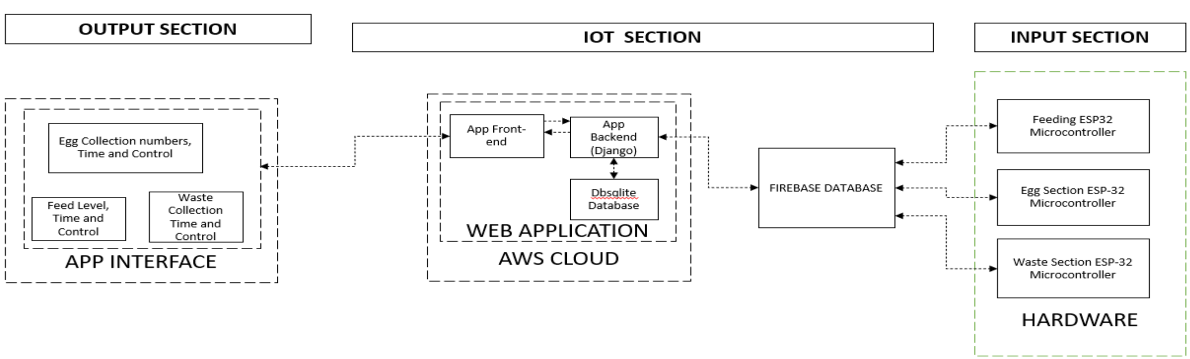
b) **Watering**: The system will automatically supply clean and fresh water to the birds according to their demand.

c) **Waste management:** The system will automatically collect and dispose of the waste generated by the birds. The system will also prevent the accumulation of ammonia and other harmful gases in the poultry house.

d) **Egg collection:** The system will automatically detect and collect the eggs laid by the birds.

### a) System Overview

Figure 1 depicts the general structure block diagram of the IoT-based poultry management system developed in this work. The system comprises three main sections: the input section, the output section, and the IoT Section. The input section consists of the Feed Control Unit (ESP32 Microcontroller), the Egg Collection control unit (ESP32 Microcontroller), and the Waste Control Unit (ESP32 Microcontroller). The Output section contains the app interface, which displays the Egg Collection display (Egg collection numbers, Time, and Control button), the Feed Management Display (Feed Level, Time, and Control button), and the Waste Management Display (Waste Collection Time and Control button). The IoT section consists of the App frontend built with web technologies, including HTML, CSS, and JavaScript; the App Backend built with Python Django and Rest Framework; the Firebase Database for real-time monitoring and control; and the DB SQLite Database and the AWS Cloud Platform the app is hosted on. The ESP32 is the main microcontroller used in this system; it is responsible for enabling data collection, monitoring, and control of poultry parameters. Each subsection (feed, waste, and egg collection) has an ESP32 microcontroller for collecting data and controlling actuators in the sections. The system is powered by two 12V 180WAh solar panels and two 12V 40Ah batteries, both connected in parallel to get a 24V DC Power Supply to the system.



**b) Hardware Development**

The development process involves the design and implementation of the IoT devices that are used to monitor and control the poultry farming system. The hardware components include sensors, actuators, microcontrollers, and wireless modules. The sensors are used to measure various parameters such as water level, feed level, egg count, and waste level. The actuators were used to perform various actions, such as water pumps, feed dispensers, and waste collectors. Microcontrollers are used to process the sensor data and control the actuators according to predefined logic and rules. The wireless modules are used to communicate with cloud databases via a Wi-Fi internet connection.

For this project, the Arduino IDE, an open-source software platform, is used to program microcontrollers. The Arduino IDE supports various types of microcontrollers, such as ESP32, which is used in this project. Additionally, the project involves utilizing the Firebase library for Arduino, which is a software library that enables communication between the ESP32 and the Firebase database. The Firebase library provides functions for sending and receiving data from the Firebase database using JSON format. The Firebase library also supports authentication and security features to ensure data integrity and privacy.

**c) Database Integration**

The process involves the design and implementation of the cloud database that is used to store and retrieve the data from the IoT devices. The cloud database also serves as an intermediary between the hardware and the backend. The cloud database used in this project is Firebase Real-time Database, which is a NoSQL database service provided by Google. Firebase is a cloud-hosted database that stores and syncs data in real-time across multiple clients. Firebase Real-time Database supports various data types, such as strings, numbers, booleans, arrays, and objects.

Four distinct sections within the Firebase Real-time Database are established to gather data from various poultry farming system components: feeding, waste, egg collection, and water. Each section has its data structure and attributes that correspond to the sensor data and actuator commands from the hardware. For example, the feeding section has attributes such as feed level, feed-dispense time, feed-dispense amount, etc.

**d) Backend Development**

The process involves the design and implementation of the web server that is used to fetch data from the cloud database and save it in a local database. The web server also provides an application programming interface (API) for the front end to access and manipulate the data. The web server used in this project is the Django REST framework, a powerful and flexible toolkit for creating web APIs using Python language. Django REST framework supports various features such as serialization, authentication, permissions, pagination, filtering, etc. Furthermore, the creation of models for each segment of the poultry farming system, utilizing Django models, is a part of this process. Django models are Python classes that define the structure and behaviour of the data in the local database. Django models also provide methods for querying and manipulating the data in the local database. The local database used in this project is SQLite, which is a self-contained, serverless, zero-configuration SQL database engine. SQLite supports various data types such as text, integer, real, blob, etc.

Additionally, creating views for each section of the poultry farming system is crucial. Django views, implemented as Python functions, handle HTTP requests and generate respective responses. Django views can also perform various operations such as validation, authentication, authorization, etc. The view for each section uses the Django REST framework's generic views to provide common functionality such as list view, detail view, create view, update view, delete view, etc.

**e) Frontend Development**

The process involves the design and implementation of the web interface that is used to display and interact with the data from the backend. It also provides various features and functionalities such as dashboards, charts, graphs, tables, forms, buttons, etc. The web interface used in this project is developed using HTML and CSS languages. HTML is a markup language that defines the structure and content of a web page. The layout and view of a web page are defined by a style sheet language called CSS.

**f) Web Hosting**

The process involves the deployment and maintenance of the web application on a remote server that is accessible by anyone over the internet. The web hosting used in this project is the AWS EC2 instance, which is a virtual machine that runs on the Amazon Web Services (AWS) cloud platform. AWS EC2 instance provides various features such as scalability, reliability, security, performance, etc.

It involves the use of Route 53 service to route the traffic from a custom domain name to the AWS EC2 instance. Route 53 is a DNS service that provides various features such as domain registration, DNS management, health checking, etc.

It also involves the use of Smartweb.com.ng to purchase a custom domain name for the web application. Smartweb.com.ng is a domain name registrar that provides various features such as domain search, domain transfer, domain renewal, etc.

The web app can be accessed at the URL: funaabautomatedpoultry.com.ng

**g) Overall Operation**

The flowchart in Figure 2 shows how the feed, water, and sensor control units of the system operate in order, with the microcontroller serving as the central component.

## RESULTS AND DISCUSSION

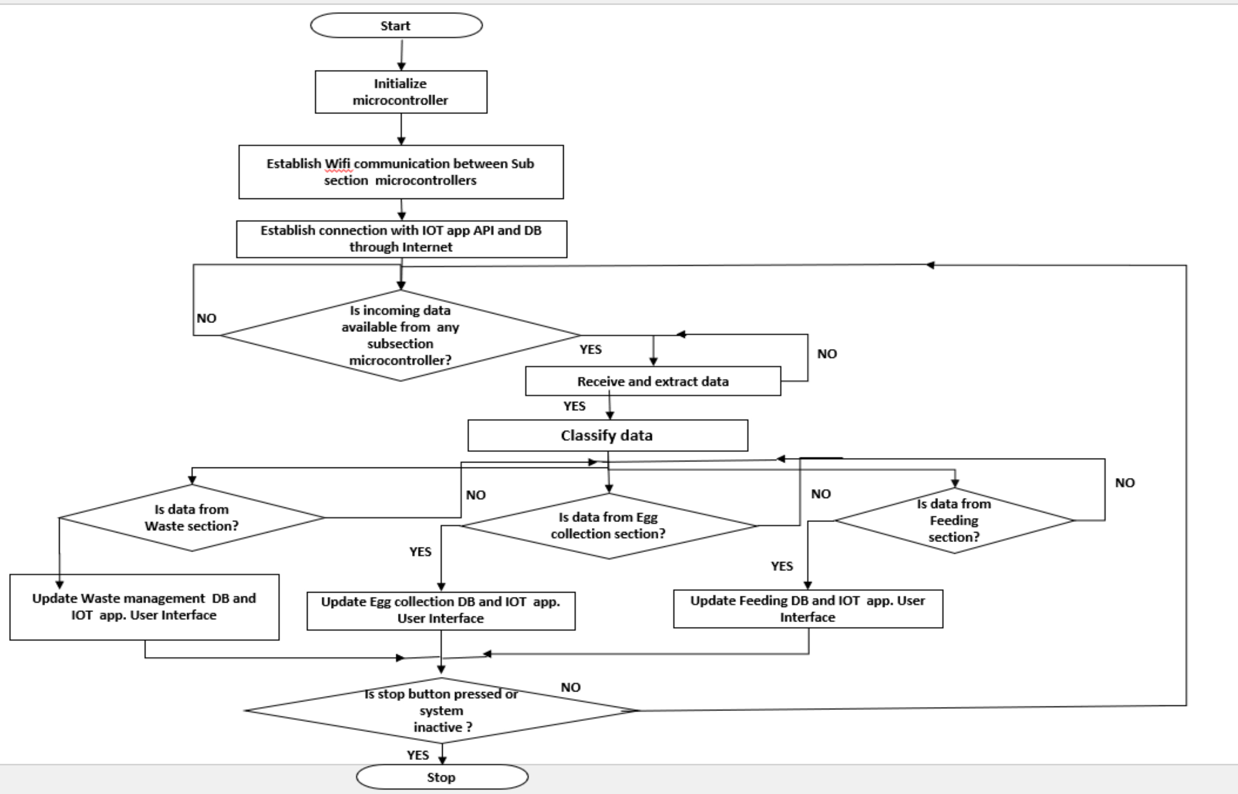



Figure 1: Flowchart for the system

Following the design and implementation of the Internet of Things (IoT)-based automated poultry management system, each subsystem of the system underwent a performance test, including evaluation of the feed and water components, waste management section, egg collection section, power supply section, and the display app section, to examine their functionality.

**a) The Developed System**

Figure 3 shows the automated poultry cage system with the various parts that are needed for the automation. The level sensors that send signals to our IoT are placed in the feeding hopper and the water collection bowl. The App interface is shown in Figure 4, the interface is divided into four sections; feeding, egg collection, watering and waste disposal. It can be observed that all the sections can be started and stopped from the interface, the number of eggs collected can also be seen on the interface. Figures 5 and 6 show when the feeding and water level are low and high respectively, the next feeding time can also be observed on the App.

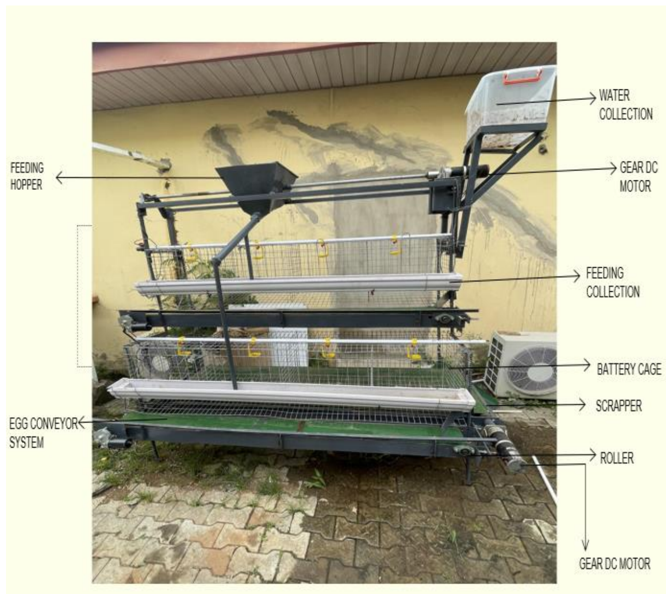


**Figure 2:** Front view of the developed IoT-based poultry management system

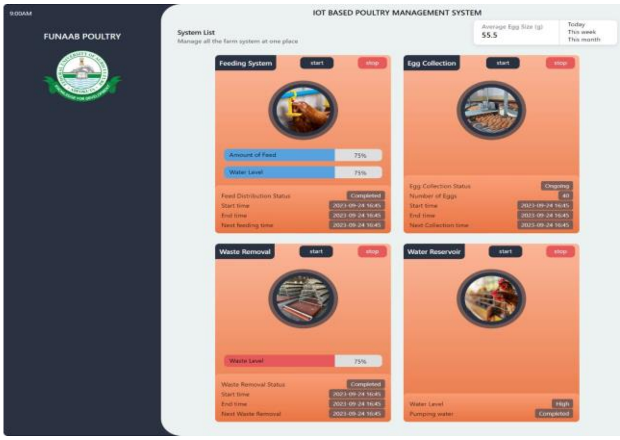



Figure 4: App Interface of the IoT-Based Poultry Management System


**Test Results**

The Performance tests conducted on the different subsections of the poultry system showed that the system is fully functional. Table 1 shows the feeding data obtained from the backend of the App, showing the feed levels before and after dispensing

Figure 5: App Interface showing the amount of feed and water level when low


Figure 6: App Interface showing the amount of feed and water level when they are high

for the five days. The automated feed dispenses occur four times a day, it can be observed that after Day 5, there is a decrease of 40 per cent in the level of the feed in the feeding hopper. The waste disposal system for the days is also shown in Table 2

**Table 1:** Shows the Feed Dispensing Rate

| Day | Feed dispense time (hh:mm) | Feed level (%) before dispensing | Feed level (%) after dispensing |
|---|---|---|---|
| 01/10/2023 | 7:00 am | 100 | 98.2 |
| | 10:00am | 98.2 | 96.4 |
| | 2:00pm | 96.4 | 94.6 |
| | 6:00pm | 94.6 | 92.8 |
| 02/10/2023 | 7:00 am | 92.8 | 90.9 |
| | 10:00am | 90.9 | 89.0 |
| | 2:00pm | 89 | 87.1 |
| | 6:00pm | 87.1 | 85.2 |
| 03/10/2023 | 7:00 am | 85.2 | 83.2 |
| | 10:00am | 83.2 | 81.2 |
| | 2:00pm | 81.2 | 79.2 |
| | 6:00pm | 79.2 | 77.2 |
| 04/10/2023 | 7:00 am | 77.2 | 75.1 |
| | 10:00am | 75.1 | 73.0 |
| | 2:00pm | 73 | 70.9 |
| | 6:00pm | 70.9 | 68.8 |
| 05/10/2023 | 7:00 am | 68.8 | 66.6 |
| | 10:00am | 66.6 | 64.4 |
| | 2:00pm | 64.4 | 62.2 |
| | 6:00pm | 62.2 | 60.0 |

**Table 2:** Shows the Waste Disposal System

| DATE | WASTE COLLECTION TIME | AMOUNT OF WASTE COLLECTED (Kg) | TOTAL WASTE PER DAY (Kg) | WASTE PER BIRD (g) |
|---|---|---|---|---|
| 01/10/2023 | 06:30<br>18:00 | 1.70<br>1.50 | 3.20 | 160 |
| 02/03/2023 | 06:30<br>18:00 | 1.10<br>2.06 | 3.16 | 158 |
| 03/10/2023 | 06:30<br>18:00 | 0.90<br>2.02 | 2.92 | 146 |
| 04/10/2023 | 06:30<br>18:00 | 0.92<br>2.08 | 3.00 | 150 |
| 05/10/2023 | 06:30<br>18:00 | 0.98<br>2.10 | 3.08 | 154 |

**CONCLUSION**

This paper presents the design and development of an IoT-based automated poultry farming system that can monitor and control various poultry parameters such as feed and water supply, egg collection, and waste management for poultry birds. Various hardware and software components, such as microcontrollers, sensors, actuators, communication modules, programs, applications, and cloud services, were used to implement and test our system. Communication and data processing modules, such as protocols, methods, and algorithms, were used to enable the data flow and exchange between the hardware and software components. We evaluated the performance and functionality of our system in a real-world battery cage poultry system setting and compared it with the existing systems.

The developed system is robust, cost-effective, and exhibited satisfactory performance when the functionality of its various subunits was tested. The system can provide a smart and convenient way for the farmers and veterinarians to monitor and control the poultry farm remotely and efficiently. The system can also provide a rich and reliable source of data and information for researchers and policymakers to analyze and improve poultry farming practices and policies.

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