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Smart Poultry Feed Optimization using IoT

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ABSTRACT

Poultry production plays a crucial role in global food security, yet inefficiencies in feed management remain a persistent challenge that directly impacts cost, productivity, and sustainability. Traditional manual feeding practices often result in overfeeding, underfeeding, or feed spoilage, leading to inconsistent bird growth and resource wastage. This research presents an advanced *Smart Poultry Feed Optimization* system, designed using Internet of Things (IoT) and Machine Learning (ML) technologies to enable automated, data-driven feed control. The proposed system integrates environmental monitoring sensors, feed weight sensors, and an ESP32 microcontroller to collect and transmit real-time data to a cloud platform. A supervised ML algorithm processes the collected data to determine optimal feed dispensing intervals and quantities. Experimental analysis shows significant improvements in feed efficiency and bird health consistency compared to conventional systems. The study demonstrates that integrating IoT and ML can revolutionize poultry farm automation, minimizing operational costs and promoting sustainable agricultural practices.

Keywords**:** Internet of Things (IoT), Poultry Automation, Machine Learning, Feed Optimization, ESP32, Smart Farming

1. INTRODUCTION

The poultry industry constitutes one of the fastest-growing sectors of global agriculture, accounting for a major source of animal protein supply worldwide. According to the Food and Agriculture Organization (FAO), poultry meat consumption has increased by over 40% in the past decade, largely due to its affordability and nutritional value [1]. However, feed costs alone contribute approximately 60–70% of total production expenses, making feed management a key determinant of farm profitability and sustainability [2].

In conventional poultry farms, feeding is often carried out manually or via semi-automated mechanisms that lack adaptability to environmental and physiological factors. Such systems are prone to inaccuracies due to human error, irregular feeding schedules, and poor monitoring of environmental conditions such as temperature, humidity, and gas concentration. These factors not only reduce bird productivity but also elevate the risk of disease outbreaks and feed spoilage.

With the advent of *Industry 4.0* technologies, the integration of IoT and AI/ML models into smart agriculture systems has demonstrated transformative potential. IoT devices enable continuous data acquisition from farm environments, while ML algorithms process and analyze the data to generate predictive insights for decision-making. The *Smart Poultry Feed Optimization* system designed in this study seeks to automate feed dispensing, ensure consistency in feed supply, and maintain environmental stability through real-time monitoring and intelligent analytics.

2. LITERATURE REVIEW

Several studies have investigated the role of IoT and ML in enhancing livestock productivity and operational efficiency.

In a study by Kumar et al. [3], the authors developed an IoT-based poultry management system that monitored temperature and humidity using a NodeMCU microcontroller. While the system demonstrated effective environmental monitoring, it lacked predictive control mechanisms for feed optimization.

Similarly, Bhattacharya et al. [4] proposed a semi-automated feeding system that utilized Arduino-based sensors to dispense feed at fixed intervals. The absence of adaptive control led to limited accuracy, as feeding was not influenced by real-time environmental fluctuations or bird growth patterns.

Recent developments in AI-assisted agriculture, such as those by Chen et al. [5], demonstrate the effectiveness of integrating machine learning models—particularly regression-based and neural network algorithms—to predict feed requirements based on temperature, humidity, and behavioral data.

Despite these advances, limited studies have successfully implemented a fully integrated IoT–ML architecture for poultry feeding that is both cost-effective and scalable. This research bridges that gap by developing a practical, modular system using low-cost sensors, real-time data transmission, and cloud-based analytics for predictive feed control.

3. METHODOLOGY

3.1 System Architecture

The proposed *Smart Poultry Feed Optimization* system consists of hardware and software components connected through an IoT-based communication framework (Fig. 1).

- **Microcontroller (ESP32):** Serves as the core computational unit that acquires sensor data, executes control logic, and transmits data to the cloud.
- **Sensors:**
  - *DHT11* measures temperature and humidity.
  - *MQ135* detects harmful gases such as ammonia and CO_2.
  - *Load Cell with HX711 amplifier* measures real-time feed weight.
- **Actuators:** A servo motor or relay-controlled dispenser releases feed automatically based on model predictions.
- **Communication:** Data is transmitted via Wi-Fi using the MQTT protocol or Blynk API for real-time monitoring.
- **Dashboard:** The cloud interface visualizes environmental and operational data, enabling farm operators to track performance remotely.

3.2 Software and Machine Learning Model

The software component is implemented using **Arduino IDE** for sensor control and **Python (TensorFlow)** for predictive modeling. The algorithm collects sensor data and feeds it into an ML regression model that estimates optimal feeding intervals and amounts based on the formula:

$$Fopt=\alpha 1T+\alpha 2H+\alpha 3G+\alpha 4W+\varepsilon$$

where:

Fopt = optimized feed quantity, T = temperature,

H = humidity,

G = gas concentration, W = feed weight,

A dataset of 1,000 instances was simulated for training, representing environmental variations and feeding responses. The model achieved a Mean Absolute Error (MAE) of 0.15 and an R^2 score of 0.92, indicating strong predictive accuracy.

3.3 System Operation Workflow

1. **Data Collection:** Sensors continuously record environmental conditions and feed levels.
2. **Data Processing:** ESP32 preprocesses the data and uploads it to the cloud in real-time.
3. **ML Prediction:** The trained regression model computes the required feed amount.
4. **Actuation:** Feed dispenser activates through servo or relay mechanisms.
5. **Feedback Loop:** The system validates output using sensor data and updates predictions dynamically.

4. RESULTS AND DISCUSSION

The system was tested in a controlled poultry environment with 20 birds over a 7-day trial period. Environmental data were collected every 10 minutes, and feeding was adjusted automatically by the ML model.

4.1 Performance Analysis

The system demonstrated reliable wireless data communication, stable sensor readings, and consistent feed dispensing accuracy. Compared to manual feeding, feed wastage decreased by **18.6%**, and feed uniformity improved by **23.4%**. Gas concentration monitoring helped reduce ammonia buildup, indirectly improving bird comfort and respiratory health.

4.2 Comparative Evaluation

Parameter	Manual Feeding	Proposed System	Improvement
Feed Wastage (%)	21.5	2.9	18.6
Feed Uniformity (%)	70	93.4	+23.4
Human Intervention (hrs/day)	5	1.2	-76%
Energy Consumption (W)	58	64	+10.3 (automation overhead)

The system's energy trade-off due to continuous IoT operation was minimal compared to labor cost reduction.

4.3 Discussion

The integration of IoT sensors and ML algorithms demonstrates significant advantages in predictive feed management. The correlation between temperature, humidity, and feed consumption suggests that dynamic environmental changes must be incorporated into feed prediction models for higher accuracy. Furthermore, the model's ability to adaptively retrain ensures continuous optimization as farm conditions evolve.

5. ADVANTAGES AND APPLICATIONS

- Significant reduction in feed wastage and human dependency.
- Enhanced monitoring of microclimate conditions for disease prevention.
- Scalable design applicable to small- and medium-scale poultry farms.
- Real-time analytics enabling predictive maintenance of feeding systems.
- Potential for integration with energy-efficient or solar-powered units for remote farms.

6. FUTURE SCOPE

Future improvements can focus on integrating **computer vision** for real-time bird activity tracking and **AI-based anomaly detection** for disease prediction. Advanced neural network models can be deployed for precise feed forecasting based on behavioral cues.

Additionally, implementing **blockchain-based traceability** can ensure transparency in poultry product supply chains. Integration with solar energy modules could enhance sustainability, reducing reliance on grid electricity.

7. CONCLUSION

This study presents an IoT and machine learning–based system for intelligent poultry feed optimization. The proposed design effectively automates feeding, monitors environmental conditions, and adapts to varying farm dynamics using real-time analytics. The experimental outcomes confirm improved feed efficiency and bird health, demonstrating a practical pathway toward digital transformation in the poultry sector.

By integrating low-cost hardware, scalable architecture, and adaptive machine learning, the system provides a sustainable, affordable solution for small and medium poultry farms. This approach exemplifies the synergy between IoT, AI, and agriculture in realizing the vision of *smart farming ecosystems*.

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