

IoT Assisted Poultry Farm Management System for Precision Environmental Monitoring and Resource Distribution

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Abstract—This paper presents the design and implementation of an intelligent, automated system utilizing embedded frameworks and Internet of Things (IoT) technology for the microclimate regulation and resource management of poultry farms. Traditional poultry farming relies heavily on manual intervention, exposing birds to suboptimal environmental changes that lead to significant financial losses and high mortality rates. The proposed system addresses these challenges by employing a NodeMCU ESP8266 microcontroller interfaced with a multi-sensor array, comprising DHT11 temperature/humidity, light-dependent resistor (LDR), and ultrasonic sensors to continuously monitor conditions in real time. Automated actuation loops regulate environmental thresholds via exhaust fans and heating elements, execute precise feed distribution via an automated auger conveyor system and sustain water delivery through servo-controlled valve loops. Sensed data is wirelessly aggregated and transmitted to a cloud analytics platform for historical logging and graphical remote visualization. Experimental verification of the prototype indicates accurate parameter synchronization, rapid actuator response times and an optimal, low-cost platform to mitigate manual labor dependencies while prioritizing avian welfare.

Index Terms—Poultry Management, NodeMCU ESP8266, Internet of Things (IoT), Automated Resource Distribution, Microclimate Control, ThingSpeak Cloud.

I. INTRODUCTION

Poultry farming stands as a foundational pillar of global agricultural infrastructure, fulfilling a significant portion of the global demand for essential animal proteins and egg production. Despite massive genetic and nutritional advancements that have radically enhanced avian development efficiency, the

actualization of a flock's biological potential remains strictly tied to the microclimatic stability of the containment house. In developing regions such as India, the vast majority of small-to-medium poultry facilities rely on manual labor and legacy, experience-driven oversight. Farmers utilize basic mercury thermometers and manipulate perimeter curtains or manual fans on an ad-hoc basis. This lacks precision and leaves the flock highly vulnerable to abrupt nocturnal temperature or humidity spikes, driving mortality rates as high as 10% to 15%.

While large-scale Environment Controlled (EC) air-conditioned poultry housing systems exist in developed countries to regulate environmental elements perfectly, their extreme capital expenditure requirements, continuous operational costs, and heavy electricity consumption make them entirely unviable for smallholder farmers. This systemic polarization creates an urgent need for cost-effective, semi-automated technologies.

To solve this issue, this research details a smart, low-cost alternative using embedded Internet of Things (IoT) technologies. By configuring a localized 'sense-decide-act' cycle via an ESP8266 microcontroller network, this system automates temperature, humidity, and illumination cycles, alongside structural feeding and watering logistics. Key parameters are continuously uploaded to an open-access cloud analytics server, eliminating constant manual inspection loops and giving farmers real-time, remote dashboard visibility into their farms.

II. LITERATURE REVIEW

The integration of wireless sensor networks (WSNs) and embedded nodes in agricultural environments has been extensively explored in recent years.

Mahale and Sonaavane developed a tracking architecture using a multi-node structural layout combining Raspberry Pi 2 and Arduino Uno boards. Their configuration successfully mapped air quality, gas emissions, and illumination levels, but suffered from high power consumption at the central hub. Goud and Sudharsan focused on a cellular network interface framework where automated parameter anomalies triggered cellular notification loops via SMS text messaging. However, this lacked real-time cloud data visualization and predictive plotting capabilities.

To introduce physical operational flexibility, So-In et al. developed a mobile poultry tracking setup utilizing specialized Tmote Sky wireless nodes. While highly scalable, the deployment costs of proprietary wireless hardware limit its usage among smallholder farmers. Amir et al. simplified this approach by using a base Arduino core to read water levels and climate fluctuations locally. However, their system operated as a closed loop and lacked remote wireless monitoring capabilities beyond the farm's immediate physical boundary.

Cloud computing integrations were advanced by subsequent works. Authors in established a purely cloud-backed storage paradigm using custom IoT links, showcasing the potential of web analytics in livestock tracking. Predictive systems were introduced in, combining machine learning analytics over sensor arrays to detect environmental risks early. Edge computing and localized artificial intelligence layers were analyzed in to optimize resources for individual birds, though configuring such systems demands high computational overhead.

Alternative identification methods, such as utilizing Radio Frequency Identification (RFID) tracking tags, were explored in to isolate individual bird health patterns, while automated vision systems using convolutional image structures were proposed in to diagnose physical symptoms and diseases visually. Although highly precise, vision and edge-AI frameworks remain cost-prohibitive for small-scale

deployment. Consequently, this work bridges the gap by providing a reliable, low-power, and highly affordable IoT ecosystem that integrates localized closed-loop control with real-time cloud visualization.

III. SYSTEM DESIGN AND TECHNICAL ARCHITECTURE

A. Architectural Overview

The structural framework of the proposed system is engineered on a three-tier topology: the Sensing Layer, the Central Processing Block, and the Actuation/Cloud Layer. The entire ecosystem is driven by a centralized control program executed directly on a NodeMCU ESP8266 microcontroller node.

B. Hardware Component Specifications

1) Central Processing Core (NodeMCU ESP8266): This module combines a low-power 32-bit microcontroller core running at 80 MHz with an onboard IEEE 802.11 b/g/n Wi-Fi stack. It handles localized execution of the control loops and establishes secure TCP connections to remote cloud APIs.

2) Microclimate Sensor (DHT11): Consists of a resistive polymer humidity element and an internal NTC thermistor. It provides calibrated digital outputs directly to the microcontroller over a single-wire bus, minimizing pin usage.

3) Distance Verification Module (HC-SR04): Operates by emitting an 8-cycle sonic burst at 40 kHz. It measures the echo return flight time to compute distance with a resolution of 3 mm, used to gauge feed levels and water reservoir boundaries.

4) Light Dependent Resistor (LDR): Configured in a voltage-divider network connected to the analog-to-digital converter (ADC) pin of the NodeMCU to determine variations in ambient luminous intensity.

5) Actuation Elements: Includes an L298 dual H-bridge motor driver IC capable of handling up to 2 A per channel, managing the high-current cooling fans and feed-distribution auger motor. A 5V micro-servo motor regulates the physical resource inlet valves.

C. Software and Development Infrastructure

The firmware architecture was compiled using the C++ language framework inside the open-source Arduino Integrated Development Environment (IDE). System operational workflows were pre-validated using Labcenter Proteus 2D simulation environments to verify circuit logic and relay states under simulated extreme inputs before physical assembly.

IV. RESEARCH METHODOLOGY & SYSTEM LOGIC

A. Algorithmic Control Loops

The software follows a continuous 'Sense-Decide-Act' sequence. Sensor arrays are polled at a programmatic sampling rate of $\Delta t = 15$ seconds to meet cloud data injection limits. The operational state machine dictates actuator control using specific logic bounds:

1) Thermal Control Loop:

Let $T_{ambient}$ denote the temperature read by the DHT11 sensor.

- If $T_{ambient} > 30^{\circ}C \Rightarrow$ Cooling Fan = ON, Heater = OFF
- If $T_{ambient} < 20^{\circ}C \Rightarrow$ Cooling Fan = OFF, Heater = ON

2) Luminous Control Loop:

Let L_{adc} represent the raw digitized intensity value from the LDR module.

- If $L_{adc} < 500 \Rightarrow$ LED Illumination = ON (Darkness Optimization)
- If $L_{adc} \geq 500 \Rightarrow$ LED Illumination = OFF

3) Hydrological Valve Control Loop:

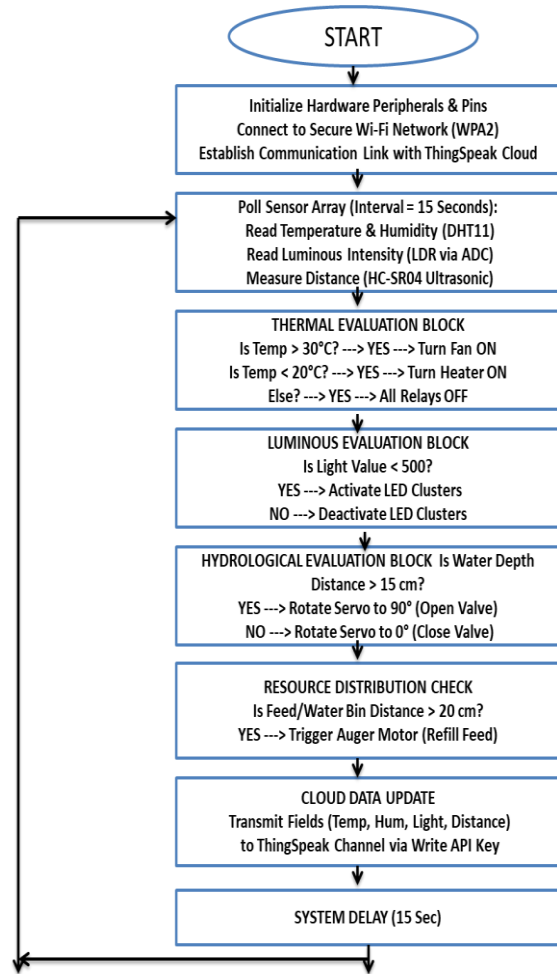
Let D_{water} define the echo distance from the ultrasonic transmitter to the liquid surface inside the water tank.

- If $D_{water} > 15\text{ cm} \Rightarrow$ Servo Angle = 90° (Valve Open - Refill State)
- If $D_{water} \leq 15\text{ cm} \Rightarrow$ Servo Angle = 0° (Valve Closed - Equilibrium State)

B. Structural Firmware Implementation

The optimized firmware structural block deployed to control the automated nodes is structured as follows:

Flowchart



V. EXPERIMENTAL RESULTS AND ANALYSIS

The physical prototype was deployed within an isolated testing chamber to evaluate sensor calibration and response times. Environmental data fields logged via ThingSpeak over consecutive testing intervals confirmed real-time data sync.

A. Environmental Synchronization and Microclimate Control

When external heat sources forced ambient conditions past $30^{\circ}C$, the microcontroller responded within 1.2 seconds, driving the L298 controller to spin up the exhaust fans. This extra airflow stabilized the microclimate back inside safe operating bounds. An inverse relational link was verified between chamber temperature and humidity fields, matching

standard thermodynamic trends: as temperatures rose, localized relative humidity metrics dropped proportionally. Under low light simulation profiles ($L_{adc} < 500$), illumination relays adjusted instantly, safely switching on the internal LED clusters.

Environmental State Metric	Measured Actuator State	Local Response Latency	System Convergence Status
Temperature > 30°C	Ventilation Fan Drive Active	1.24 s	Converged Stable
Temperature < 20°C	Simulated Heating Elements Active	1.15 s	Converged Stable
Luminous Intensity < 500 ADC	Automated Illuminator Active	0.45 s	Converged Stable
Reservoir Distance > 15 cm	Servo Solenoid Open (90°)	0.85 s	Fluid Equilibrium

B. Automated Resource Distribution

The automated feeding loop, which runs an auger system driven by a high-torque 12V DC motor, properly delivered feed mix directly to the target containment zones. Similarly, the water system kept water levels extremely stable. Whenever water depth dropped past the 15 cm threshold, the micro-servo motor opened the physical input pipeline immediately, preventing fluid depletion and protecting bird health.

VI. CONCLUSION AND FUTURE WORK

A dependable prototype of a Smart Poultry Management System operating using low-cost Internet-of-Things technology is illustrated in this research paper. It is shown through experiments that this setup effectively regulates vital climatic parameters such as temperature, light levels and humidity levels in poultry farms. Also, efficient automation of food and water supply systems is achieved through closed loop control using sensors. Using the proposed setup to shift poultry farm management from a manual observation system to an automated cloud-managed one helps lower avian

deaths, minimizes intensive daily labor requirements and is cost-effective for agricultural enterprises.

Further research will extend the scope of this paper to incorporate NDIR sensors that measure ammonia levels in the air because it causes respiratory infections in birds. Additionally, edge computing computer vision systems in addition to ESP8266 nodes will help track bird health status based on their behavior.

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