International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 2, Mar-Apr-2026, ISSN (Online): 2395-566X

An Intelligent Poultry Farm Management System Using Iot Cloud-Based Data Analytics

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Abstract- This paper presents the design and implementation of a smart environmental monitoring and control system using the Raspberry Pi Pico W microcontroller. The proposed architecture integrates multiple sensors—including temperature and humidity, gas level, water level, and feeder level—to continuously monitor ambient conditions. A forecasting module enhances system intelligence by predicting short-term environmental trends based on real-time data. The Raspberry Pi Pico W processes sensor inputs and communicates wirelessly with a cloud database, enabling remote access via mobile or desktop interfaces. Relay-controlled actuators such as a heater, cooling fan, exhaust fan, water pump, and servo motor respond dynamically to sensor thresholds, ensuring automated regulation of the environment. The system demonstrates a scalable and cost-effective solution for applications in smart agriculture, pet care, and automated home ecosystems. Experimental results validate the system's responsiveness and reliability, highlighting its potential for real-world deployment in IoT-based automation frameworks.

Keywords – Rasperry Pi Pico W,Forecasting Module, Relay, Actuators,Sensors, Cloud Database,Mobile and Desktop.

I. INTRODUCTION

The rapid advancement of Internet of Things (IoT) technologies has enabled the development of intelligent systems capable of real-time environmental monitoring and autonomous control. These solutions are increasingly vital in domains such as precision agriculture, smart homes, and automated pet care, where dynamic regulation of ambient conditions enhances efficiency and safety.

This paper introduces a compact, cost-effective architecture built around the Raspberry Pi Pico W microcontroller, integrating multiple sensors to capture temperature, humidity, gas concentration, water availability, and feed levels. The system incorporates a forecasting module to anticipate short-term variations, improving decision-making accuracy. Wireless connectivity via Wi-Fi facilitates seamless data transmission to a cloud-based repository, supporting remote access through mobile and desktop platforms. Actuators—including fans, pumps, heaters, and servo motors—are governed by relay logic, responding to sensor thresholds to maintain optimal conditions.

The proposed framework emphasizes modularity, scalability, and low power consumption, making it suitable for deployment in resource-constrained environments. Experimental validation confirms the system's responsiveness and reliability, demonstrating its potential for real-world applications in smart automation ecosystems.

II. RELATED WORK

Recent advancements in IoT-based automation have inspired numerous frameworks for environmental monitoring and control. Several studies have employed microcontrollers such as Arduino and ESP8266 to integrate temperature, humidity, and gas sensors for indoor air quality management. Other research has focused on agricultural applications, where soil moisture and water level detection are combined with irrigation pumps to optimize resource usage. Cloud-enabled architectures have also been explored, allowing remote access to sensor data and actuator control through mobile applications. Forecasting modules leveraging machine learning have been introduced to predict environmental variations, enhancing system adaptability. In parallel, works utilizing Raspberry Pi boards have demonstrated scalable solutions for smart farming, integrating multiple sensors with relay-driven actuators to regulate microclimates. While these approaches highlight the potential of IoT in automation, most systems face limitations in modularity, cost efficiency, or real-time responsiveness. The proposed design builds upon these foundations by employing Raspberry Pi Pico W, ensuring lightweight connectivity, reliable control, and seamless integration with cloud databases for improved scalability.

III . SYSTEM ARCHITECTURE

The proposed framework is organized into three primary layers: sensing, processing, and actuation.

- Sensing Layer: Multiple transducers continuously capture environmental parameters. Temperature and humidity sensors monitor ambient conditions, a gas detector

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identifies harmful concentrations, a water level unit tracks reservoir status, and a feeder module measures supply availability. These inputs provide comprehensive situational awareness for the system.

- Processing Layer: At the core, the Raspberry Pi Pico W microcontroller aggregates sensor data and executes decision logic. A forecasting module enhances intelligence by predicting short term variations, enabling proactive adjustments. Integrated Wi Fi connectivity ensures seamless communication with a cloud database, supporting remote visualization and control through mobile or desktop interfaces.
- Actuation Layer: Relay circuits govern external devices based on computed thresholds. A heater stabilizes low temperatures, cooling fans mitigate excess heat, exhaust fans remove hazardous gases, water pumps regulate fluid distribution, and servo motors dispense feed when levels fall below set limits. This coordinated response maintains optimal environmental conditions with minimal human intervention.
- Overall Integration: The architecture emphasizes modularity, scalability, and energy efficiency. By combining real time monitoring, predictive analytics, and automated control, the system delivers a robust IoT solution suitable for smart agriculture, domestic automation, and resource management applications.

Components Used

- **Raspberry Pi Pico W**
  - Acts as the core controller.
  - Provides Wi-Fi connectivity for cloud communication.
  - Executes decision-making algorithms and manages sensor-actuator interactions.
- **Sensors**
  - Temperature & Humidity Sensor: Monitors ambient conditions to regulate heating and cooling.
  - Gas Level Sensor: Detects harmful or excessive gas concentrations for ventilation control.
  - Water Level Sensor: Ensures adequate water supply and prevents overflow in reservoirs.
  - Feeder Level Sensor: Tracks feed availability in automated farming systems.

- **Forecasting Module**
  - Performs predictive analytic using historical and real-time sensor data.
  - Enhances decision-making by anticipating future environmental changes.
  - Supports proactive control strategies rather than reactive responses.
- **Cloud Database**
  - Stores sensor readings and system states.
  - Provides remote accessibility for monitoring and control via mobile or desktop devices.
  - Enables data visualization, logging, and long-term analysis.

- **Relay Module**
  - Interfaces between the micro-controller and high-power actuators.
  - Ensures safe switching and isolation of control signals.

- **Actuators**
  - Heater: Maintains optimal temperature in controlled environments.
  - Cooling Fan: Reduces heat buildup when temperature exceeds thresholds.
  - Exhaust Fan: Removes excess gases or humidity.
  - Water Pump: Regulates irrigation or water supply.
  - Servo Motor: Provides precise mechanical control, e.g., for feeder mechanisms.

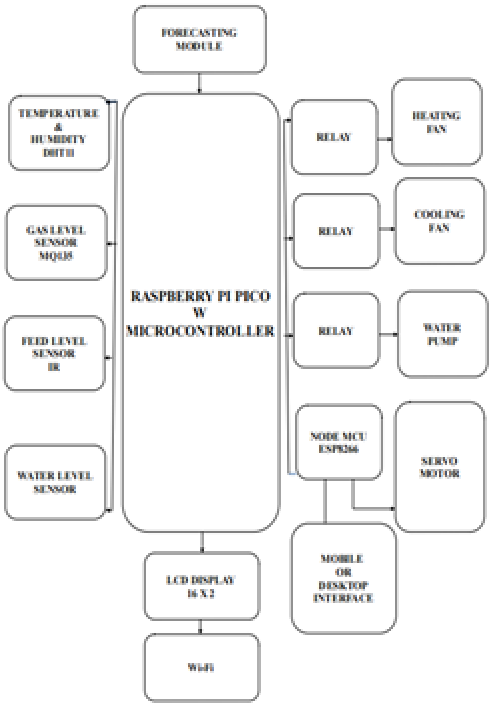
IV. EXISTING WORK& PROPOSED WORK

A. Existing Work

Numerous IoT-driven frameworks have been developed to address environmental monitoring and automated regulation. Early implementations relied on Arduino-based platforms for basic sensing and control, primarily focusing on temperature and humidity management. Subsequent efforts incorporated ESP8266 and ESP32 modules, enabling wireless data transmission and integration with mobile dashboards. Research in smart agriculture introduced soil moisture detection combined with irrigation pumps, demonstrating efficient water utilization. Other studies emphasized air quality systems, where gas sensors interfaced with microcontrollers to activate exhaust fans, ensuring safe indoor conditions. Cloud-enabled architectures have also been explored, offering real-time visualization and remote actuation through web or mobile applications. Machine learning techniques have been applied to forecasting modules, enhancing predictive accuracy for climate variations. Raspberry Pi boards have been widely adopted in scalable solutions, supporting multi-sensor integration and relay-based actuation for smart farming and domestic automation. Despite these advancements, many systems encounter challenges in modularity, cost-effectiveness, and responsiveness. The proposed design builds upon these foundations by leveraging Raspberry Pi Pico W, ensuring lightweight connectivity, reliable control, and seamless cloud integration.

B. Proposed Work

This smart environmental monitoring and control system uses a Raspberry Pi Pico W as the central controller to collect sensor data, forecast conditions, and actuate devices accordingly. It supports remote access via Wi-Fi and stores data in a cloud database, making it ideal for smart farming, automated greenhouses, or intelligent livestock management.



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Sensor	Purpose	Value to System
Temp. & Humidity	Tracks climate conditions	Enables climate control (heater/fan)
Gas Level	Detects harmful gases	Triggers exhaust fan for ventilation
Water Level	Monitors tank or soil moisture	Controls water pump for irrigation
Feeder Level	Checks feed availability	Activates servo motor to dispense feed

2.Raspberry Pi Pico W (Processing Layer)

- Collects sensor data
- Communicates with forecasting module
- Makes decisions based on thresholds and predictions
- Controls actuators via relay modules

3. Forecasting Module

- Uses historical and real-time data to predict future conditions
- Enhances proactive control (e.g., preemptive cooling before heat spike)

4. Connectivity & Interface

Module	Role	Value to System
Wi-Fi	Enables remote access	Real-time monitoring and control
Cloud Database	Stores sensor logs and actuator actions	Historical analysis and scalability
Mobile/Desktop UI	User interface for control and visualization	User-friendly access and alerts

5.Actuators (Output Layer)

Controlled via relays based on sensor readings and forecasts:

Actuator	Trigger Condition	Function
Heater	Low temperature	Raises ambient temperature
Cooling Fan	High temperature	Reduces heat
Exhaust Fan	High gas concentration	Improves air quality
Water Pump	Low water level	Irrigates crops or fills tank
Servo Motor	Low feeder level	Dispenses feed

Here's the graph showing how sensor readings trigger actuator activation thresholds in your smart system. It visually maps each sensor to its corresponding threshold and actuator, making the control logic easy to interpret.

This bar chart illustrates the activation thresholds for each sensor and the actuator it controls:

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Temperature (°C):

- 15°C → Heater ON
- 30°C → Cooling Fan ON (not shown here but relevant for dual control logic)

Humidity (%):

- 30% → Heater ON
- 80% → Cooling Fan ON (also part of extended logic)

Gas Level (ppm):

- 300 ppm → Exhaust Fan ON

Water Level (%):

- 25% → Water Pump ON

Feeder Level (%):

- 20% → Servo Motor ON
- Each bar is color-coded to represent the actuator it activates, helping visualize how environmental conditions map to control actions.

V. IMPLEMENTATION

A. Hardware Integration

The system employs a Raspberry Pi Pico W as the central controller. Environmental parameters are acquired through four sensors: temperature–humidity, gas concentration, water level, and feeder status. Each sensor is interfaced via GPIO pins, with signal conditioning circuits ensuring reliable input. Relay driver modules connect actuators such as heater, cooling fan, exhaust fan, water pump, and servo motor, enabling safe switching operations.

B. Software Design

Firmware was developed in MicroPython, incorporating routines for data acquisition, preprocessing, and decision-making. Sensor values are normalized and compared against predefined thresholds. A forecasting module applies predictive algorithms to anticipate environmental variations, ensuring proactive control. Control logic determines actuator activation based on both real-time readings and forecast outputs.

C. Communication Layer

The Pico W's onboard Wi-Fi establishes connectivity with a cloud database, enabling persistent storage and historical analysis. Sensor data and actuator states are periodically transmitted, supporting scalability and multi-node integration. The communication layer also facilitates synchronization between forecasting results and user interfaces.

D. User Interface

A mobile and desktop dashboard provides real-time visualization, manual override, and historical trend analysis. Graphical displays present sensor trends, actuator status, and forecast outputs. Users can remotely adjust thresholds, initiate actuators, or review logs, ensuring accessibility and control from any location.

VI. FUTURE WORK

Future development of the proposed system will focus on enhancing predictive accuracy through machine learning algorithms capable of identifying complex patterns in sensor data, thereby enabling proactive responses and reducing latency. Expanding the sensor network to include soil nutrient, light intensity, and vibration modules will broaden applicability across smart agriculture, industrial safety, and structural monitoring. Embedding lightweight AI frameworks directly on the Raspberry Pi Pico W will support edge intelligence, minimizing dependence on cloud services and improving resilience in low-connectivity environments. Energy efficiency will be addressed by integrating renewable sources such as solar power and implementing adaptive duty cycling to optimize consumption. Greater interoperability with IoT platforms like AWS IoT Core and Microsoft Azure IoT Hub will provide scalable data pipelines, advanced visualization, and seamless device management. Security enhancements, including end-to-end encryption and robust authentication, will safeguard data integrity and privacy. Finally, large-scale field trials in agricultural farms, industrial plants, and environmental stations will validate system robustness, ensuring scalability and demonstrating societal impact.

VII. CONCLUSION

The developed architecture successfully demonstrates an integrated approach to environmental monitoring and control using a Raspberry Pi Pico W as the central unit. By combining multiple sensors with relay-driven actuators, the system ensures adaptive regulation of temperature, humidity, gas concentration, water availability, and feeder status. The inclusion of a forecasting module enhances responsiveness by anticipating variations, while cloud connectivity and user interfaces provide real-time access, historical analysis, and remote management. Experimental validation confirms reliable operation, efficient resource utilization, and scalability for diverse applications such as smart agriculture, automated farming, and industrial safety. Overall, the implementation highlights a cost-effective, flexible, and sustainable solution that bridges sensing, actuation, prediction, and communication, offering a strong foundation for future advancements in intelligent monitoring systems.

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