Journal of IoT in Social, Mobile, Analytics, and Cloud (ISSN: 2582-1369)
www.irojournals.com/iroismac/

Smart System for Monitoring and Controlling Harmful Gases in Avian Farming using IOT

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Abstract

The poultry industry is vital for sustaining global food production, yet it faces challenges concerning environmental sustainability and animal welfare. Among these, management of ammonia (NH3) and carbon dioxide (CO2) gas emissions, temperature, humidity fluctuations, and dust control, are critical considerations. Current methodologies often lack real-time monitoring capabilities and effective mitigation efforts. To address these issues, this research proposes an IoT-based monitoring and control system tailored for poultry farms, focusing on managing and controlling gas emissions, temperature, humidity, dust, and light levels. Employing an ESP32 microcontroller and sensors such as MQ135 for NH3 and CO2 detection, DHT for temperature and humidity, and LDR for light intensity, the system ensures continuous monitoring and adjustment of environmental parameter. It monitors and controls the dust by managing the proper temperature and humidity to reduce the health issues in poultry and as well as regulates light by turning ON/OFF light during dark. The system activates ventilation when the gas exceeds its limit and sends alerts through GSM. By using Wi-Fi connectivity, remote monitoring through a Blynk app is facilitated, while data logging on Thing Speak enables comprehensive analysis. The system aims to control ventilation and prevent dust for better environmental conditions and poultry welfare.

DOI: https://doi.org/10.36548/jismac.2024.2.004
Received: 07.04.2024, received in revised form: 27.04.2024, accepted: 12.05.2024, published: 21.05.2024

Keywords: Gases, IOT, ESP32, Sensors, Controlling, Remote monitoring

1. Introduction

Poultry farming involves raising domestic birds such as chickens, ducks, turkeys, and geese for their meat, eggs, or feathers. It typically includes housing, feeding, healthcare, and management practices to ensure the birds' welfare and optimal productivity. Farmers may utilize different production systems, including free-range, organic, or intensive methods. Poultry farming plays a significant role in food production globally, providing a vital source of protein-rich meat and eggs. However, challenges such as disease outbreaks, environmental concerns, and animal welfare issues require careful management and regulation. Sustainable practices, proper hygiene, and efficient resource utilization are crucial for the long-term viability of poultry farming.

Gases such as ammonia and carbon dioxide can accumulate in poorly ventilated poultry houses, posing respiratory risks to birds and farm workers alike. Maintaining optimal temperature and humidity levels is essential for ensuring bird comfort, health, and productivity. Fluctuations in these factors can lead to stress, reduced feed intake, and compromised immune function. Dust and airborne pathogens present respiratory health hazards and can exacerbate disease outbreaks among poultry. Additionally, managing odour emissions from manure and bedding materials is critical to mitigate environmental impacts and maintain community relations. Effective ventilation systems, biosecurity protocols, and waste management practices are essential for addressing these challenges and promoting sustainable poultry farming practices.

To address these issues, this research proposes an IoT-based monitoring and control system tailored for poultry farms, focusing on managing and controlling gas emissions, temperature, humidity, dust, and light levels. The system employs an ESP32 microcontroller along with sensors such as the MQ135 for NH3 and CO2 detection, the DHT sensor for temperature and humidity, and the LDR for light intensity, ensuring continuous monitoring and adjustment of environmental parameters.

2. Litrature Survey

[1]Moses Oluwafemi Onibonoje, IEEE-April 2021, "IoT-Based Synergistic approach for poultry management system." This paper presents a system integrating sensors, mobile phones, and autonomous devices to remotely monitor and control farm environments. Parameters like temperature, humidity, water level, food valve level, ammonia gas, and illumination are sensed, compared to thresholds, and wirelessly communicated to a sink node and the internet cloud. [2]M.Mohana Priya, K.Pavithraa, B.Pavithra Devi, Dr.V.Sureshkumar, Mar 2021- International Research Journal of Engineering and Technology (IRJET), "Smart poultry farm incorporating GSM and IOT" In this proposed system, temperature, humidity, and harmful gases like ammonia are monitored. If the temperature goes below the threshold value, a bulb will turn ON. If it exceeds the threshold value, then DC Fan will turn ON. If harmful gas is detected, a cooling fan will turn ON. Additionally, the security measures like fire detection and theft are implemented and an alert message is sent to the user through mobile phones using GSM Module. Furthermore, automatic food and water feeding is controlled with the help of a servomotor and DC pump motor using an RTC. All the data is fetched into the cloud.

[3] Faisal Syafar, Misita Anwar, Ridwansyah, October 2021-International Journal of New Technology and Research (IJNTR), "Smart Chicken Poultry Farm Using IoT Techniques" This paper focuses on designing an IoT-based monitoring system for chicken coops using

DHT22 and MQ-135 sensors for temperature, humidity, and ammonia gas levels. Controlled fan/lights stabilize conditions. Data transmitted via ESP8266 and Arduino Mega 2560 to an LCD and smartphone app with GSM SIM. Aims to improve chicken farming efficiency.

[4] Shoba K., Sushmitha V., Umashree N., Yashaswini D.M., Priyanka K., April 2020 - International Research Journal of Engineering and Technology (IRJET), "An Effective Automated Monitoring and Controlling of Poultry Farm Using IoT." This project focuses on the automation of poultry farms using IoT technology to manage tasks such as maintaining room temperature and feeding chickens. By maintaining these parameters, the production and quality of chicken can be increased.

[5] Prof. Shruthi B. Gowda, Rashmitha K., Rakshitha K., Vijaylaxmi, 2020 - International Research Journal of Engineering and Technology (IRJET), "A Witted Management of Poultry Farm Using IoT." In this paper, automation of poultry farming using IoT monitors environmental factors (temperature, humidity, light, ammonia gas) and manages tasks like feeding, water supply, and cleanliness. Alerts for chick monitoring and weight measurement ensure improved production and quality.

3. Problem Statement

The poultry industry faces challenges related to the management of ammonia and carbon dioxide gas emissions, as well as temperature, humidity, and dust control. Current monitoring methods lack real-time capabilities, making it difficult to detect and mitigate these environmental factors promptly. This research aims to address these challenges by developing an automated sensor model utilizing IoT technology for accurate, real-time monitoring and management of gas emissions, temperature, and humidity, light and dust control in poultry facilities.

4. Design Methodology

The proposed system has various units to monitor and control the different parameters in order to achieve a smart avian farming and a sustainable environment within the poultry.

These parameters and the hardware and software design are discussed below.

1. System Consideration

These include the following: gas control unit, light switching unit, climate control unit, dust and odour control, real-time monitoring and alert system.

a. Gas Control Unit

The gas control unit within this poultry management system is pivotal for monitoring and regulating harmful gas levels, such as ammonia (NH_3) and carbon dioxide (CO_2), within the poultry house. Equipped with MQ135 sensors, it detects elevated gas concentrations and triggers actions like activating ventilation systems. This unit integrates actuators, such as exhaust fans and alarms, to promptly respond to gas-related incidents, ensuring optimal

environmental conditions. By efficiently managing gas levels, the unit safeguards poultry health and productivity, enhancing overall welfare within the poultry house.

b. Climate Control Unit (Temperature and Humidity Control)

This unit incorporates a temperature and humidity sensor, specifically the DHT11, to continuously monitor environmental conditions within the poultry house. Based on the sensor readings, the system activates actuators such as ventilation systems, heaters, and humidifiers to regulate temperature and humidity levels within optimal ranges. During hot periods, ventilation fans are activated to circulate air and reduce heat stress, while in cold conditions, heaters are triggered to maintain warmth. Additionally, ultrasonic humidifiers are utilized to increase humidity levels when necessary, ensuring a comfortable and healthy environment for the poultry.

The threshold values of the parameter such as gases, temperature and humidity was shown in the table.1 given below;

Table 1. Threshold Values of Parameters

Parameters	Threshold values (Gases-ppm; Temperature- °C; Humidity-%)
Ammonia (NH3)	20 ppm
Carbon di oxide (CO2)	1000 ppm
Temperature	At daytime- 23°C At nighttime-30°C
Humidity	At daytime- 60% At nighttime-80%

c. Light Switching Unit

The automated light switching unit in this poultry management system enhances energy efficiency and promotes the well-being of poultry by intelligently controlling lighting conditions within the poultry house. Integrated with light intensity sensors, the unit

automatically adjusts lighting levels based on ambient light conditions, ensuring appropriate illumination for the birds throughout the day. During cloudy weather, when the poultry house experiences darkness, the LDR sensor detects the ambient light and turns on the LED lights. This automation optimizes energy usage and creates a conducive environment for poultry health and productivity.

d. Dust and Odour Control Unit

Dust and odour produced inside the poultry house can be controlled by maintaining proper temperature and humidity levels. Decreasing the temperature during the daytime and increasing it at night, as well as decreasing humidity during the daytime and increasing it at night, can help control the dust and odour issues faced by the poultry.

e. Real-Time Monitoring and Alert System

This system is equipped with WiFi connectivity, allowing the poultry management system to connect to the internet and communicate with remote servers, IoT platforms, or mobile devices for data transmission, monitoring, and control purposes, thus enhancing the system's functionality and versatility. Additionally, it features GSM capability for sending alerts to mobile devices whenever the threshold value of the parameters exceeds its limit. The values and alert messages are also displayed on the OLED display. Furthermore, an RTC (real-time clock) provides accurate date and time data for future reference.

2. Hardware Design

The hardware design of the poultry management system is carefully designed to facilitate efficient monitoring, control, and optimization of environmental conditions within the poultry house. At the core of the system lies the ESP32 microcontroller, acting as the central processing unit. It interfaces with a network of sensors strategically positioned throughout the poultry house, including temperature, humidity, gas (such as NH3 and CO2), and light intensity sensors, to capture important environmental data. These sensors feed information to the microcontroller, which processes it using programmed algorithms to determine necessary control actions. Actuators such as ventilation fans, halogen bulbs for heating, ultrasonic humidifiers, and LED lights are controlled by the microcontroller through relay modules, adjusting environmental conditions based on sensor readings. Communication modules, including GSM and WiFi, enable connectivity for remote monitoring, control, and alerting

functionalities. The system also integrates a Real-Time Clock (RTC) module for accurate timekeeping, essential for scheduling tasks and maintaining precise timing operations. A stable power supply, enclosure for protection, and display for local parameter visualization complete the hardware setup. Together, these components form a robust infrastructure that empowers the poultry management system to promote optimal welfare and productivity for the poultry inhabitants.

The block diagram of this proposed system and its circuit diagram was shown in the figure 1 and figure 2.

Figure 1. Block Diagram of this Project

The circuit diagram of the entire system was designed with fritzing software which shows the detailed connection of the components which have used in this project.

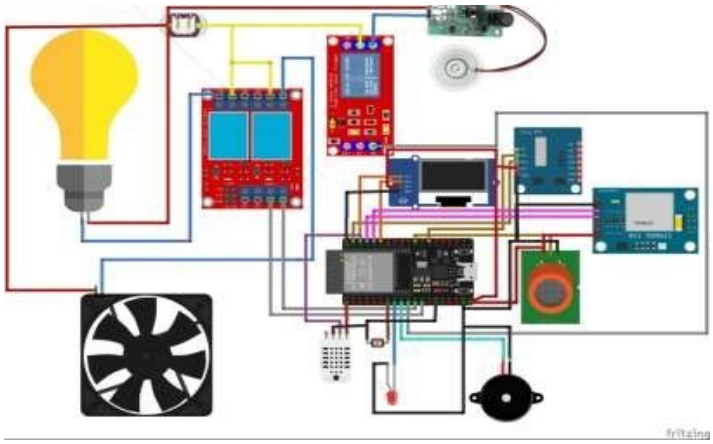


Figure 2. Circuit Connection of the System

3. Software Design

The software design of the poultry management system is meticulously crafted to facilitate seamless integration, efficient processing, and effective control of environmental parameters within the poultry house. At its core, the system utilizes the Arduino IDE for programming the ESP32 microcontroller, enabling it to interface with sensors, execute control algorithms, and communicate with actuators and communication modules. Various libraries are employed to facilitate sensor data acquisition, actuator control, and communication protocols such as WiFi and GSM. Additionally, the Blynk app serves as a user-friendly interface for remote monitoring and control, allowing users to visualize sensor data, adjust settings, and receive alerts on their mobile devices. Thinkspeak is utilized as a cloud platform for data logging and analysis, providing valuable insights into environmental trends and patterns. Overall, the software design emphasizes reliability, scalability, and user accessibility, empowering poultry farmers to optimize environmental conditions and enhance poultry welfare with ease and efficiency.

4. Libraries

The proposed system utilizes several libraries to facilitate sensor acquisition:

- Adafruit Sensor Library: for interfacing with a wide range of sensors.
- Adafruit MQTT Library: for communication with MQTT servers for data transmission.
- Arduino Wire Library: for I2C communication with compatible sensors and devices.
- Adafruit Unified Sensor Library: for simplified sensor data reading.
- Blynk Library: for remote monitoring and control via a mobile app.
- ESP32 WiFi Library: for connecting to WiFi networks for internet connectivity.
- Arduino JSON Library: for formatting and transmitting sensor data in JSON format.

These libraries streamline the sensor acquisition process, enabling efficient data collection and transmission for further analysis and monitoring.

5. Result and Discussions

The figure 3 shows the hardware implementation of the poultry management system which effectively monitors and adjusts environmental conditions in poultry houses. Using the ESP32 microcontroller for real-time processing, the system regulates temperature, humidity, gas levels, and lighting to optimize poultry welfare. Actuators like ventilation fans and heaters respond promptly to maintain ideal conditions, promoting poultry health and productivity.

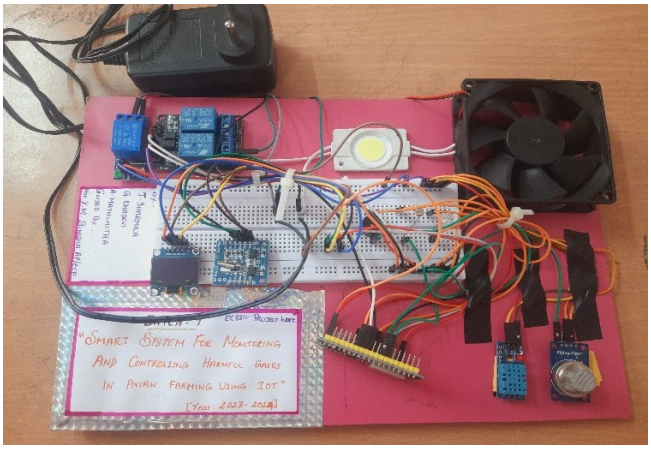
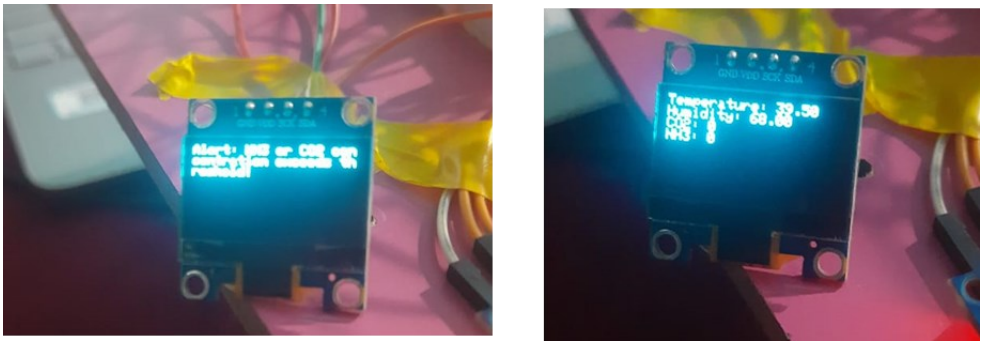


Figure 3. Hardware Implementation of Poultry Management System

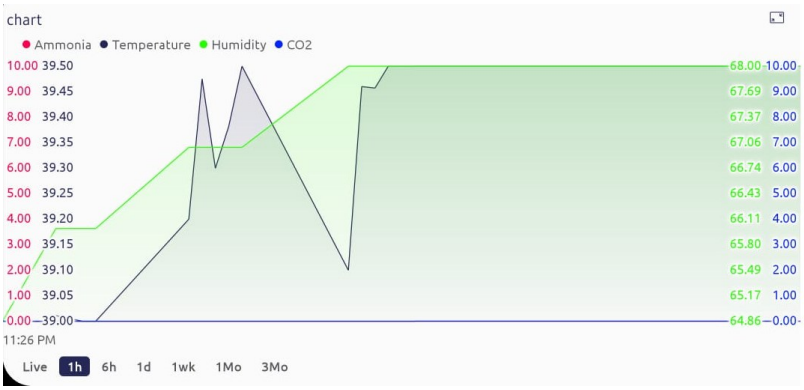


(a) Alert message **(b)**Parameter value

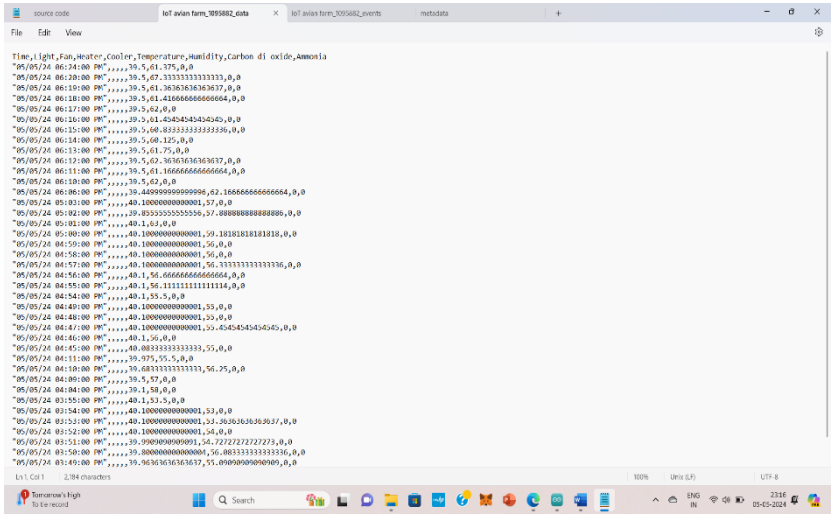
Figure 4. Output in the OLED

The figure 4 indicates the output in the OLED, in that (a) shows the alert message that whenever the parameter exceeds its threshold value, the alert message was displayed in the display as “Alert: NH3 or CO2 concentration exceeds its threshold” and (b) shows the values of the parameters as, the value of Temperature in degree Celsius, Humidity in percentage, Ammonia and Carbon dioxide in ppm.

Additionally, the readings are continuously monitored by the Blynk application and the online Blynk Platform. Figure 5 below displays the output observed in the Blynk application. In (a), the chart provides parameter readings over a one-hour duration, clearly illustrating the alternating values of the parameters. In (b), the report from the Blynk platform, which continuously monitors the parameters, is shown, providing a snapshot of the parameters at a particular instant in time.



(a) Chart Showing the Parameter Values in Blynk App



(b) Report from the Blynk Platform

Figure 5. Outputs in Blynk Application

According to the report provided by the Blynk platform, the parameter values measured on the date 2024-05-01 from 8:00 AM to 9:00 PM have been tabulated below,

Table 5.1. Output Report from the Blynk Application on the Date 2024-05-01 at the Time Interval from 8.00AM to9.00PM

Parameter	Value	Date	Time	Actuator State
Temperature	25°C	2024-05-01	08:00 AM	Cooler ON
Humidity	70%	2024-05-01	08:00 AM	-
Ammonia	20 ppm	2024-05-01	08:15 AM	Ventilation ON
CO2	800 ppm	2024-05-01	08:30 AM	-
Light Level	High	2024-05-01	08:50 AM	-
CO2	1298	2024-05-01	09:00 AM	Ventilation ON
Humidity	68%	2024-05-01	09:15 AM	Heater ON
Temperature	25°C	2024-05-01	10:00 AM	Cooler ON
Humidity	70%	2024-05-01	10:19 AM	-
Ammonia	18 ppm	2024-05-01	10:24 AM	-
CO2	800 ppm	2024-05-01	11:00 AM	-
Light Level	High	2024-05-01	11:20 AM	-
Temperature	26°C	2024-05-01	09:00 PM	Ventilation ON
Humidity	68%	2024-05-01	09:25 PM	-
Ammonia	22 ppm	2024-05-01	09:45 PM	Ventilation ON
CO2	850 ppm	2024-05-01	09:00 PM	-
Light Level	Low	2024-05-01	09:00 PM	Light ON

6. Conclusion and Future Enhancement

In conclusion, the poultry management system represents a significant advancement in poultry farming technology, offering a holistic approach to environmental control and monitoring. By leveraging IoT technology, the system not only improves poultry welfare and

productivity but also provides valuable data-driven insights for enhanced decision-making and management efficiency. Overall, the research holds great promise for revolutionizing poultry management practices and contributing to the sustainability and profitability of the poultry industry.

Future enhancements to the poultry management system focuses on the AI technology and machine learning which could revolutionize poultry farming practices by providing advanced predictive capabilities, automated decision-making, and personalized management strategies.

Acknowledgment

We extend our heartfelt gratitude to our guide, Mrs. X.M. Binisha, Assistant Professor, Department of Electronics and Communication Engineering for her invaluable guidance, support, and encouragement throughout the duration of this project. We are truly privileged to have had the opportunity to learn and grow under her mentorship.

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