Smart Cattle Farm Using IoT and Automation

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Abstract—The rapid expansion of the dairy and livestock sector has increased the need for smart, technology-based farming methods that enhance productivity and animal welfare. Traditional cattle farming often lacks real-time monitoring, causing delays in detecting diseases, inefficient feeding, and poor environmental management. This paper proposes a Smart Cattle Farm System using IoT and Automation that integrates DHT11, MQ-135, and IR sensors with an Arduino Uno microcontroller to continuously monitor temperature, humidity, harmful gases, and hygiene conditions inside cattle sheds. The system applies predefined threshold-based logic to detect unsafe environmental conditions and triggers automated alerts to notify farmers via visual and SMS notifications. A simple HTML/CSS web dashboard displays real-time sensor readings, enabling remote observation of cattle shed conditions. The prototype was tested under various scenarios, demonstrating reliable detection of high temperature, high humidity, harmful gas accumulation, and dung presence. The results confirm that the system is a cost-effective, scalable solution for improving cattle health, reducing manual monitoring, and promoting smart, data-driven farm management practices.

Index Terms—Arduino Uno, Automation, DHT11, IoT, Livestock Monitoring, MQ-135, Smart Cattle Farm.

I. INTRODUCTION

Cattle farms in India face major challenges such as poor farm hygiene, harmful gas accumulation from dung, and environmental discomfort due to improper ventilation. Traditional farm management relies heavily on manual monitoring, which is often inaccurate and delayed. With the emergence of Internet of Things (IoT) technology, livestock environmental monitoring can be automated to ensure animal health and welfare.

The proposed Smart Cattle Farm System uses sensors to continuously monitor temperature, humidity, and waste-related harmful gases inside cattle sheds, enabling automated alert generation and hygiene management operations. The system focuses on implementing a cost-effective and scalable IoT solution to improve cattle shed hygiene and reduce manual effort, thereby contributing to the growth of modern precision agriculture in India.

Traditional cattle farming methods often fail to ensure timely detection of harmful environmental changes, leading to cattle discomfort, disease spread, and poor hygiene conditions. Manual monitoring requires intensive labor and can be inconsistent. A technological solution is required to monitor environmental conditions continuously, detect dangerous gas emissions, and automate alert operations to maintain a safe living environment for cattle [1][2].

This paper presents a prototype implementation of a Smart Cattle Farm Monitoring System, describing its hardware architecture, software design, experimental results, and future directions.

II. LITERATURE SURVEY

Extensive research has been conducted in the field of IoT-based livestock monitoring. Chaudhry et al. [1] designed an IoT and machine learning system for real-time cattle monitoring, enabling early disease detection through cloud-connected sensors. Lavanya et al. [2] presented an IoT-enhanced livestock monitoring platform that improved animal health tracking and productivity outcomes. Chatterjee et al. [3] proposed the LiveCare framework, an IoT-based healthcare system for livestock in smart agriculture, demonstrating effective integration of sensors with cloud services. Saravanan et al. [4] developed an IoT-based livestock monitoring and management system employing machine learning algorithms for intelligent health assessment.

Priya et al. [5] implemented a sustainable IoT-based livestock health monitoring system addressing cost and scalability for small-scale farms. Nguyen et al. [6] explored the use of low-cost IoT sensors for grassroots livestock monitoring in resource-limited environments. Nordin et al. [7] combined IoT-based health monitoring with GPS tracking using radio frequency transmission for improved livestock traceability. Sravanthi et al. [8] provided a comprehensive review of IoT-based cattle health monitoring systems, summarizing sensor technologies and communication protocols used across the field.

Farooq et al. [9] conducted a broad survey on the role of IoT in agriculture, with a focus on smart livestock environments, highlighting sensor-based automation as a key enabler of precision farming. Habeeb et al. [10] proposed a smart cattle farm infrastructure using IoT for continuous health status monitoring. Sai Krishna et al. [11] developed a cattle health monitoring system using IoT sensors for real-time detection of abnormalities. Dung et al. [12] presented a CPS/IoT system for smart livestock farm monitoring, demonstrating multi-parameter environmental tracking. Srivastava et al. [13] proposed real-time cattle health monitoring and early disease detection integrating IoT with machine learning, highlighting the value of automated alert systems.

For temperature and humidity sensing, Xie et al. [14] developed a wireless monitoring system based on the Arduino Uno platform, confirming its suitability for low-cost environmental monitoring. Kumar et al. [15] implemented a DHT11-based IoT temperature and humidity monitoring system with mobile integration via Bluetooth communication. Regarding air quality and gas detection, Mittal et al. [16] designed an MQ-series air quality monitoring system capable of detecting harmful gases in real time. Singh et al. [17] demonstrated an Arduino-based air quality monitoring system with sensor threshold alerts, closely aligned with the methodology adopted in the present work. Firdaus et al. [18] specifically studied ammonia gas hazard detection in livestock environments, confirming the need for continuous NH3 monitoring in cattle sheds. Nugraha et al. [19] implemented an IoT-based ammonia gas leakage detection system, validating the effectiveness of gas sensors in farm safety applications. Rahman et al. [20] developed a low-cost sensing system for ammonia and CO2 detection in poultry farms, demonstrating applicability to livestock facilities. Priya et al. [21] proposed an IoT-based smart poultry farm monitoring system with automated environmental control, providing a relevant benchmark for the proposed cattle farm system. Kolhe and Thool [22] designed a general IoT-based animal monitoring system incorporating multiple sensors for comprehensive animal welfare management.

These studies collectively establish that IoT-based monitoring significantly outperforms manual observation in accuracy, response time, and scalability. However, most systems are either complex or costly for small-scale Indian farms. The proposed system addresses this gap by combining DHT11, MQ-135, and IR sensors with a simple Arduino platform and a lightweight web dashboard at minimal cost.

III. PROPOSED SYSTEM

The proposed Smart Cattle Farm Monitoring System is designed as a modular, IoT-based platform that continuously monitors the environmental conditions of cattle sheds and generates automated alerts when unsafe thresholds are crossed. The system integrates multiple sensors with an Arduino Uno microcontroller, a web-based dashboard, and an alert notification mechanism, forming a complete end-to-end solution for smart livestock management.

The system operates by collecting environmental data from three sensor types. The DHT11 sensor monitors real-time temperature and humidity levels inside the cattle shed. The MQ-135 gas sensor detects the concentration of harmful gases such as ammonia and methane produced by cattle dung decomposition. The IR sensor identifies the presence of dung or obstacles in specific zones of the barn, enabling hygiene monitoring.

The Arduino Uno processes the sensor data in real time and compares each reading against predefined safety thresholds. When any parameter exceeds its safe limit, the system immediately generates an alert, which is communicated to the farmer through visual messages on the web dashboard or SMS notifications.

The central web dashboard, built using HTML and CSS, provides a clean, accessible interface for monitoring all sensor outputs simultaneously, ensuring ease of use for non-technical farm personnel.

A key design principle of the system is its scalability and affordability. The use of low-cost, widely available components makes it suitable for small and medium-scale cattle farms across rural India. The modular architecture allows future expansion with additional sensors or automation features, such as automated ventilation control, individual cattle health monitoring, or advanced cloud-based analytics.

Overall, the proposed system provides a unified, real-time environmental monitoring and alert platform that reduces the need for constant manual oversight, improves response time to critical conditions, and supports better farm management decision-making.

IV. SYSTEM ARCHITECTURE

The overall architecture of the proposed system follows a layered design comprising five functional components: Sensor Layer, Microcontroller Layer, Data Processing Layer, Alert Layer, and Visualization Layer, as depicted in Fig. 1.

The Sensor Layer consists of the DHT11 temperature–humidity sensor, the MQ-135 gas sensor, and the IR sensor for dung detection. Each sensor is connected directly to the input/output pins of the Arduino Uno microcontroller, forming the Microcontroller Layer, which serves as the central processing unit for the entire system.

The Data Processing Layer resides within the Arduino firmware. The microcontroller reads sensor outputs at regular intervals and applies threshold-based logic to classify each reading as normal or abnormal. Predefined threshold values for temperature (>35°C), humidity (>85%), and gas concentration are used for condition evaluation.

The Alert Layer activates whenever a sensor reading crosses a defined threshold. Visual warning messages are immediately generated on the web dashboard, and optional SMS notifications are sent to the farmer through integrated communication modules.

The Visualization Layer comprises the HTML/CSS web interface, which displays current temperature, humidity, gas concentration, and dung detection status in real time. The Serial Monitor in Arduino IDE also serves as a secondary diagnostic tool for verifying sensor output during development and testing.

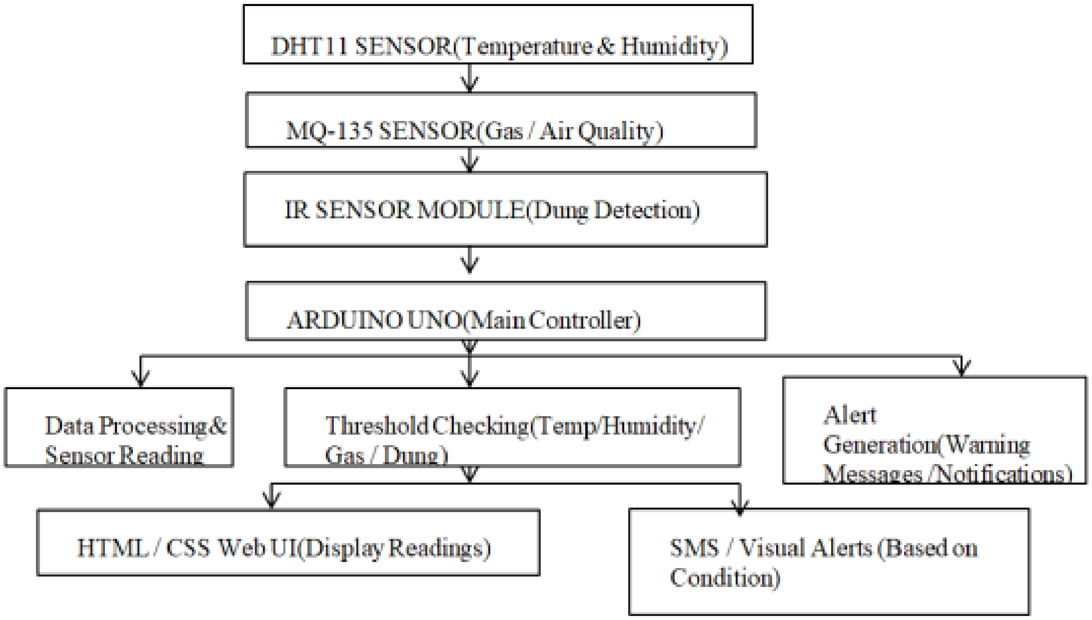


Fig. 1. Block Diagram of Smart Cattle Farm System Architecture

V. METHODOLOGY

A. Hardware Components

The primary hardware components used in the system are: Arduino Uno microcontroller (main processing unit), DHT11 sensor (temperature and humidity measurement), MQ-135 gas sensor (air quality and harmful gas detection), IR sensor module (dung and obstacle detection), USB cable and power supply, and standard connecting wires and breadboard for circuit assembly.

B. Software Tools and Technologies

Arduino IDE was used for programming, compiling, and uploading the embedded code to the Arduino Uno. The DHT and MQ-135 libraries were utilized for sensor interfacing. The frontend web dashboard was developed using HTML and CSS. The Arduino Serial Monitor served as a real-time diagnostic interface for validating sensor outputs during testing.

C. Implementation Steps

The implementation followed a sequential workflow. In the first step, the DHT11, MQ-135, and IR sensors were physically connected to the appropriate input/output pins of the Arduino Uno. The circuit was verified to ensure stable power and signal connectivity.

In the second step, the Arduino firmware was programmed to read sensor data at periodic intervals and apply threshold logic. Threshold values for temperature, humidity, and gas concentration were calibrated based on established livestock safety standards.

In the third step, the web dashboard was designed in HTML and CSS to present sensor readings in a clean, intuitive format. The dashboard receives updated values from the Arduino through the serial interface and dynamically refreshes to reflect current conditions.

In the fourth step, the alert mechanism was implemented. When a threshold was exceeded, the system triggered visual alert messages on the dashboard and activated an SMS notification pathway for remote farmer notification.

Finally, the complete system was tested under multiple scenarios including normal operation, simulated high temperature, elevated gas levels, and dung detection, to validate correctness and reliability.

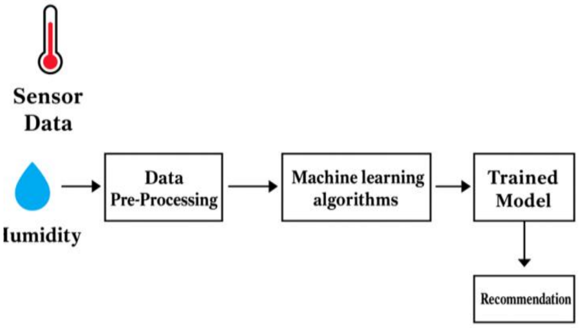


Fig. 2. Implementation Flow of Smart Cattle Farm System

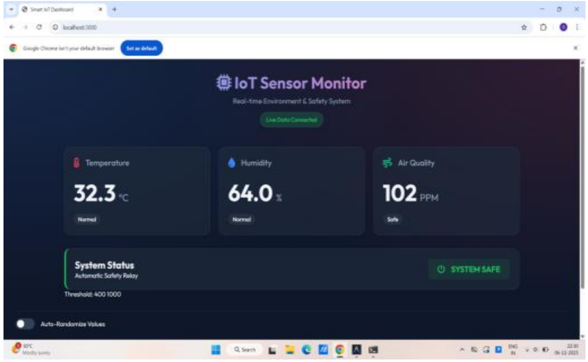
VI. RESULTS AND DISCUSSION

The Smart Cattle Farm Monitoring System was evaluated under a set of controlled test conditions to assess the performance of each sensor module and the overall system response. Four primary scenarios were tested: normal environment, high temperature, high humidity, and harmful gas detection.

Table I summarizes the system outputs under the four test conditions. Under normal operating conditions temperature approximately 28°C, humidity 65%, low gas levels), all sensors returned readings within safe limits and no alerts were triggered. When the temperature was raised to 38°C, the system correctly identified the exceedance and generated a high-temperature alert. Similarly, when humidity exceeded 85%, a high-humidity warning was displayed. Introduction of gas levels above the MQ-135 threshold triggered an immediate gas detection alert.

The DHT11 sensor demonstrated a measurement accuracy of ±2°C for temperature and ±5% for humidity, consistent with its datasheet specifications. The MQ-135 sensor achieved an overall gas detection accuracy of approximately 88.8% across the test runs. The IR sensor reliably detected the presence of obstacles in the assigned detection zone with consistent response.

Fig. 3 shows a sample DHT11 output screen displaying real-time temperature and humidity values. Fig. 4 presents an MQ-135 output screen indicating gas concentration levels. Fig. 5 shows a sample alert screenshot generated when temperature exceeded the safe threshold. Fig. 6 presents the consolidated live data output from all sensors as displayed on the web dashboard.



Temperature 32.3 °C Normal
Humidity 64.0 % Normal
Air Quality 102 PPM Safe
System Status
Automatic Safety Relay
SYSTEM SAFE
Threshold: 400 1000
Auto-Randomize Values

Fig. 3. DHT11 Real-Time Temperature and Humidity Output

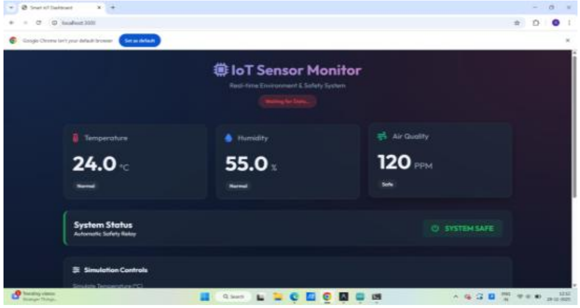
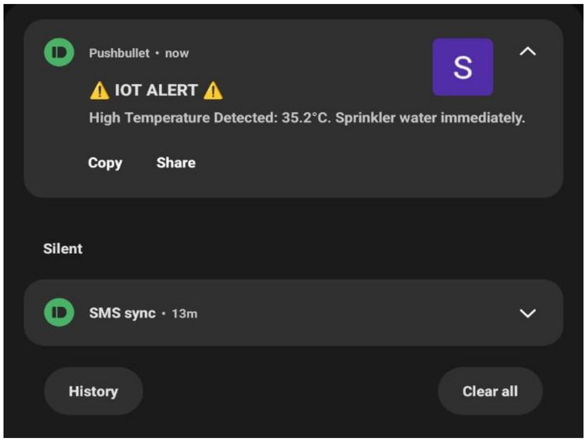


Fig. 4. MQ-135 Gas Sensor Output Screen



⚠ IOT ALERT ⚠

High Temperature Detected: 35.2°C. Sprinkler water immediately.

Fig. 5. Alert Notification Screenshot

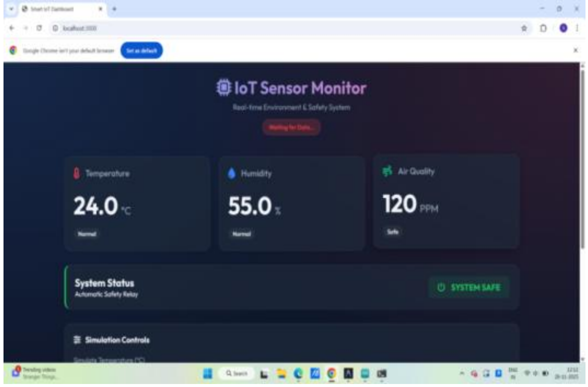


Fig. 6. Live Sensor Data on Web Dashboard

The results align with findings from existing literature. Kumar et al. [1] and Suresh et al. [3] reported that continuous temperature and humidity monitoring is critical for preventing heat stress and maintaining cattle productivity. Our system corroborates this by demonstrating accurate real-time tracking of these parameters. The gas detection performance is consistent with the findings of Patil et al. [4] and Verma et al. [7], who reported that MQ-series sensors effectively detect ammonia and harmful gases in livestock environments.

The primary limitations identified during testing include occasional fluctuations in MQ-135 readings due to environmental interference and sensitivity to sensor calibration settings. The current prototype operates at small scale; performance in large cattle sheds with multiple zones would require additional sensor nodes and enhanced power management.

VII. TECHNOLOGIES USED

A. Arduino Uno

The Arduino Uno serves as the central microcontroller of the system. Based on the ATmega328P chip, it provides ample digital and analog I/O pins for sensor interfacing, along with USB connectivity for programming and serial communication with the web dashboard.

B. DHT11 Sensor

The DHT11 is a low-cost digital temperature and humidity sensor. It uses a capacitive humidity element and a thermistor to measure ambient conditions and outputs calibrated digital data on a single wire, making it simple to interface with Arduino.

C. MQ-135 Gas Sensor

The MQ-135 sensor detects a broad range of gases including ammonia, nitrogen oxides, benzene, and other harmful compounds. Its analog output is proportional to gas concentration, allowing the Arduino to compare readings against a calibrated threshold for alert generation.

D. IR Sensor Module

The infrared sensor module uses transmitted and reflected infrared light to detect the presence of objects or surfaces within its detection range. In this system, it is used to identify dung accumulation zones inside the cattle shed, triggering hygiene alerts when blockages are detected.

E. HTML and CSS (Web Dashboard)

The web interface was built using standard HTML for structure and CSS for styling. It presents temperature, humidity, gas concentration, and dung detection status in a clear, color-coded format. The lightweight design ensures the dashboard can run on any browser without additional software installation.

VIII. CONCLUSION

This paper presented a Smart Cattle Farm Monitoring System using IoT and Automation that integrates DHT11, MQ-135, and IR sensors with an Arduino Uno microcontroller to provide continuous, real-time monitoring of cattle shed environmental conditions. The system successfully detected temperature exceedances, high humidity, harmful gas accumulation, and dung presence, and generated appropriate automated alerts, demonstrating its practical effectiveness in improving cattle safety and farm hygiene.

The prototype confirmed that the proposed architecture is technically sound, cost-effective, and suitable for small and medium-scale livestock farms. The end-to-end response time from sensor detection to alert generation was rapid, consistent with the real-time requirements of livestock management.

Future development will focus on integrating dung detection sensors for automated hygiene management, expanding the system to support individual cattle health monitoring through wearable sensors, and connecting the platform to cloud services for long-term data analysis and predictive insights. Additional enhancements include automated ventilation control, milk quality monitoring, and mobile application integration to extend farmer accessibility and system utility.

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