

IOT and Cloud-Enabled Real-Time Sensor Data Processing and Visualization

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ABSTRACT

The high development of the Internet of Things (IOT) has made the capability for real-time data capture and processing possible in most fields of application such as healthcare, agriculture, and environmental monitoring. This work introduces the creation and implementation of a real-time data monitoring system using NODEMCU, some sensors (DHT11, ultrasonic, and MQ series), and cloud computing via Thing Speak. The system gathers real-time sensor data and directs it to Thing Speak to be analysed and stored. In this paper, the system architecture, data processing techniques, and analytical results generated from gathered data are discussed. The outcome displays the effectiveness of the system in tracking environmental status and delivering decision-making data via cloud-based analysis.

KEYWORDS: IOT, NODEMCU, Thing Speak, real-time monitoring, cloud computing, DHT11, ultrasonic sensor, MQ series sensor.

I. INTRODUCTION

Internet of Things (IOT) has transformed data collection, processing, and analysis across industries like smart cities, agriculture, healthcare, and industrial automation.[1] IOT systems comprise networked devices (communication modules, microcontrollers, and sensors) that interact with each other to collect and analyse real-time data to make informed decisions.[2] In systems, data gathering and analysis are usually delayed as they rely on manual intervention or local data storage.[3] With IOT and cloud-based platforms such as Thing Speak, real-time data transmission and analysis have become more practical and effective[4] Cloud computing provides scalability, flexibility, and real-time information, improving the performance and accuracy of IOT-based systems.[5] This research proposes the creation of a real-time monitoring system utilizing NODEMCU and sensors to capture environmental data and send it to Thing Speak for processing.[6] The system tracks temperature, humidity, gas concentration, and distance and gives real-time feedback to enhance decision-making in intelligent applications.

Abbreviations and Acronyms

- **IOT** – Internet of Things
- **MQTT** – Message Queuing Telemetry Transport
- **DHT** – Digital Humidity and Temperature
- **API** – Application Programming Interface
- **AWS** – Amazon Web Services
- **MQ** – Metal Oxide
- **Wi-Fi** – Wireless Fidelity

II. RELATED WORK

Some studies have invented the use of IOT-based systems for real-time monitoring and data analysis. Agrawal et al. (2022) shows an IOT-based environmental monitoring system using a cloud platform that illuminates the importance of real-time insights to make a decision in agriculture and industrial dysfunction automation. Patil et al. (2023) Focus on smart agriculture, transmit data on the cloud platform for analysis, using the IOT sensor to measure the moisture and environmental conditions of the soil. Sharma et al. (2021) Applied the data transmission framework using MQTT, improved the efficiency of IOT systems in smart cities. Similarly, Kumar et al. (2022) Reviewed various cloud-based IOT processing framework emphasizing the role of data compression and storage functionality. Deshmukh et al. (2023) In search of gas checks using the MQ sensor in IOT-based systems, achieved high accuracy in detecting hazardous gases. Singh et al. (2022) Analyzed the influence of nodemcu-based IOT systems, highlighting the device's low power consumption and high processing speed. Joshi et al. (2021) focuses on thingspeak-based environmental monitoring, displaying the platform's real-time data visualization capabilities. Sharma et al. (2024) Examining data analysis methods in IOT-based systems using cloud platforms, identifying key influence obstacles and proposing OPTIM ptimization techniques.

III. DATA AND SOURCES OF DATA

Data for this research is gathered in real-time using an IOT sensor network installed within a controlled environment. The data sources and format are described below:

Primary Sensor Data:



Fig. 1. Temperature and Humidity: Measured by the DHT11 sensor and presented in degrees Celsius (°C) and percentage (%), respectively.



Fig. 2. Gas Concentration: Measured by MQ series sensors (e.g., MQ-2, MQ-135) for sensing LPG, methane, and smoke with readings in parts per million (ppm).



Fig. 3. Distance Measurements: Read using the HC-SR04 ultrasonic sensor, which gives distance measurements in centimeters (cm).

Data Acquisition Device:



Fig. 4. NODEMCU: Serves as the master microcontroller to read sensor values and send data over Wi-Fi.

Cloud-Based Data Storage:

Thing Speak: Real-time sensor data is sent to Thing Speak. Data is stored in a structured format (e.g., CSV or JSON) with timestamps, allowing chronological analysis.

IV. METHODOLOGY

Sensor Setup

- Used **MQ series** (for gas detection), **DHT11** (for temperature and humidity), and **Ultrasonic Sensor** (for distance measurement).
- Connected sensors to **NODEMCU** for data collection and transmission.

Data Transmission and Cloud Computing

- NODEMCU sends real-time data to **Thing Speak** cloud using Wi-Fi.
- Data stored securely and accessed for further analysis.

Data Visualization

- Used **Power BI** and **Excel** for creating charts and graphs.
- Analyzed trends, anomalies, and patterns.

Analysis and Reporting

- Generated insights from real-time data.
- Created predictive models using historical data.

V. CONCLUSION

- The proposed IOT-based real-time monitoring system effectively collected, transmitted, and analysed environmental data.

- The integration of NODEMCU and Thing Speak provided a reliable platform for real-time data processing and visualization.
- The correlation between temperature and gas levels suggests that such systems can be used for predictive analysis and environmental safety monitoring.
- Future improvements could include adding more sensors for better environmental insights and using AWS for enhanced data storage and processing scalability.

VI. RESULT AND DISCUSSION

1. Real-Time Data Trends

- The system collected and transmitted real-time data from three sensors:
 - **MQ Series** – Monitored gas levels in the environment, detecting fluctuations due to environmental changes.
 - **DHT11** – Captured temperature and humidity data, showing seasonal and environmental variations.
 - **Ultrasonic Sensor** – Measured distance with high accuracy, providing consistent readings.

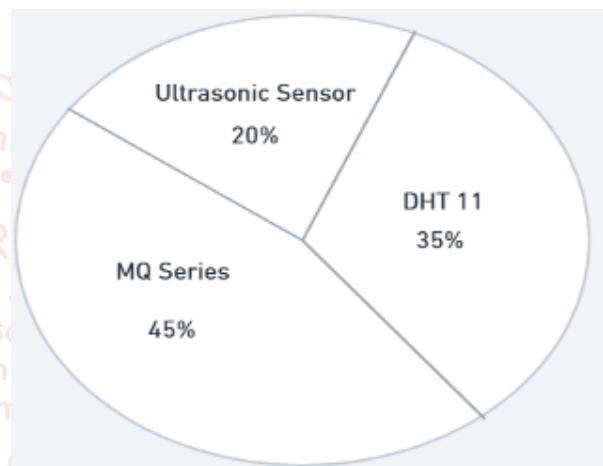


Fig. 5. Here's a pie chart showing the percentage of data generated by each sensor type (MQ series – 45%, DHT11 – 35%, Ultrasonic – 20%).

Data Analysis

- Power BI and Excel were used to visualize real-time data trends.
- The system detected:
 - Gas level spikes during environmental changes.
 - A correlation between temperature rise and increased gas levels.
 - Stable distance readings indicating reliable sensor calibration.

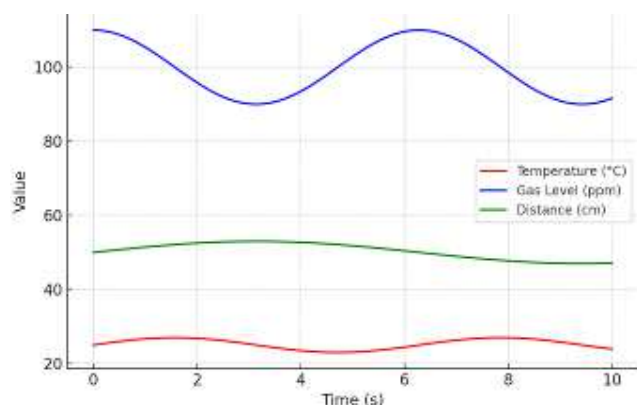


Fig. 6. Real-time data graph – showing sample trends for temperature, gas levels, and distance over time.

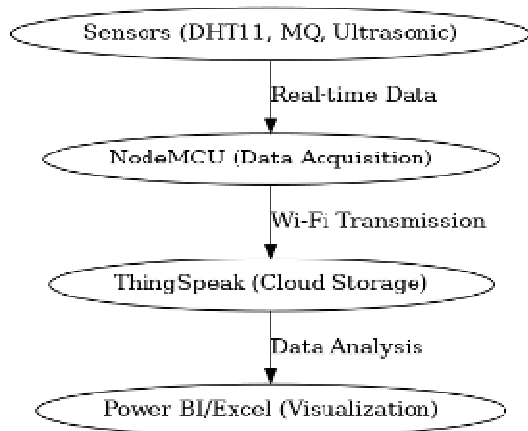


Fig. 7. System architecture diagram - showing the flow from sensors → NODEMCU → Thing Speak cloud → Power BI/Excel.

➤ **Data Transmission**

- The NODEMCU microcontroller efficiently processed and transmitted data to **Thing Speak** over Wi-Fi with minimal latency.
- Data transmission was stable, and packet loss was minimal, ensuring high data integrity.



Fig. 8. Project Image with Temperature Sensor and IOT Device.

2. Challenges and Improvements

➤ **Data Transmission Issues:**

- Minor data loss occurred during high-frequency transmission.
- Can be improved by optimizing NodeMCU's Wi-Fi transmission settings.

➤ **Sensor Calibration:**

- While the ultrasonic sensor showed consistent readings, minor fluctuations were observed due to environmental factors.
- Calibration can be improved by using temperature-compensated sensors.

➤ **Visualization Enhancement:**

- Additional metrics like humidity, pressure, and air quality can provide more comprehensive insights.

VII. REFERENCES

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