Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 12 Issue 1, January - 2025

Design And Implementation Of Iot System For Monitoring Environmental Conditions Of Poultry Farm

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***Abstract*— In this work, design and implementation of IoT system for monitoring environmental conditions of poultry farm is presented. The aim of this work is to design and implement an IoT-based environmental monitoring system for poultry farm that supports machine learning (ML) algorithms to enable analyse of the data collected and to be able to predict and detect anomalies in the poultry farm environmental condition. The architecture of the IoT-based system is presented along with the circuit diagram designed using Proteus software. The sensors used include DHT22 for temperature and humidity, MQ135 for air quality, and DS3231 RTC for time and date data. Each of the four sensors is linked to the microcontroller (Wemos D1 Mini), which takes care of the raw data, making it ready for transmission. The data collected and transmitted and model predictions are sent to Google Sheets for storage and further analysis.**

Keywords—Machine Learning Algorithms, IoT System, Environmental Conditions Monitoring, Poultry Farm, Wemos D1 Microcontroller, Proteus software

1. Introduction

The poultry industry is one of the agricultural sectors that has a significant impact on food security, economic growth, and employment at large [1,2]. Supply of poultry has doubled in the last two decades, reaching over 130 million metric tons per year [3]. Today, effective poultry farm management systems have become more vital to monitor environmental factors that influence growth and health [4,5].

Deviation from the ideal conditions of environmental factors, including temperature, humidity, and air quality, has been found to cause physiological disorders such as heat stress, respiratory diseases, and mortality [6]. For instance, research has shown that a high level of ammonia (NH_3) can cause serious harm to the birds' lungs, slow their growth, and make them more vulnerable to illnesses [7]. Also, low humidity levels lead to the growth of pathogens that cause disease outbreaks, such as avian influenza [8].

Conventional poultry farm surveillance including workers conduct farm observations by physically measuring thermometers, hygrometers, and gas detectors at a specific location. Yet it requires that people be involved in the process, is time-consuming, is often based on personal interpretation, and does not yield real-time results [9,10]. W The authors in [11] observed in their studies that manual control systems cannot detect transient environmental changes fast enough to trigger timely intervention. This inefficiency is the reason for the need of intelligent monitoring solutions to provide continuous, accurate, and actionable data.

The advance of Internet of Things (IoT) has experienced the significant transformation of agricultural monitoring, which results from the ability to collect data in real time, transmit data wirelessly and analyse in cloud [12,13]. Systems of the IoT are comprised of a networked sensors, which are capable of monitoring multiple environmental conditions and communicating the data to a central processing facility [14]. In poultry industries IoT applications have offered extensive support in early disease detection, feed optimization and energy management [15,16].

Even with these developments, a number of technical and practical problems need to be solved for current IoT systems. The high energy consumption is one of the primary issues; the sensor's continuous working is followed by massive battery loss and thus the battery needs to be replaced frequently [17]. To address this, energy-efficient sleep scheduling algorithms have been introduced, and IoT devices are put in a waking and sleeping state depending on the stability of the environment [18] Nevertheless, a large part of them cannot achieve the accuracy of data records or need heavy hardware programming, which does not suit for the use in poultry industry.

Another important problem is the unavailability of predictive intelligence in traditional IoT systems. The majority of existing works are based on static threshold-based alarms. For instance, notifications are issued only if sensor readings cross the predefined thresholds [19]. This method is limited, however, in that it cannot account for progressive, protracted damage or interrelations between various factors (e.g. temperature increasing ammonia volatility). Machine leaning (ML) provides a powerful solution to prevent such situations by taking a deep understanding of historical and real-time data in order to prevent adversities before they happen. Accordingly, in this work, the design and implementation of an IoT-based environmental monitoring system for poultry is presented. The IoT-based system supports the use of machine learning (ML) algorithms for analysing the data collected and also to be able to make predictions as well as detection of anomalies is in the environmental conditions of the poultry farm.

2. Methodology

2.1 The system model of the IoT System for Environmental Conditions Monitoring of Poultry Farm

The aim of this work is to design and implement an IoT-based environmental monitoring system for poultry farm that supports machine learning (ML) algorithms to enable analyse of the data collected and to be able to predict and detect anomalies is presented in this section. The architecture of the IoT-based system is presented in Figure 1. The system is developed to measure and control important environmental factors such as temperature, humidity and gas balance for maintaining optimal poultry health and productivity. When IoT devices and ML models are combined, it enables real-time data gathering, preprocessing, and real-time predictions. The system is organized in four main stages (data collection, data transmission, data storage, and remote access) as shown in Figure 1.

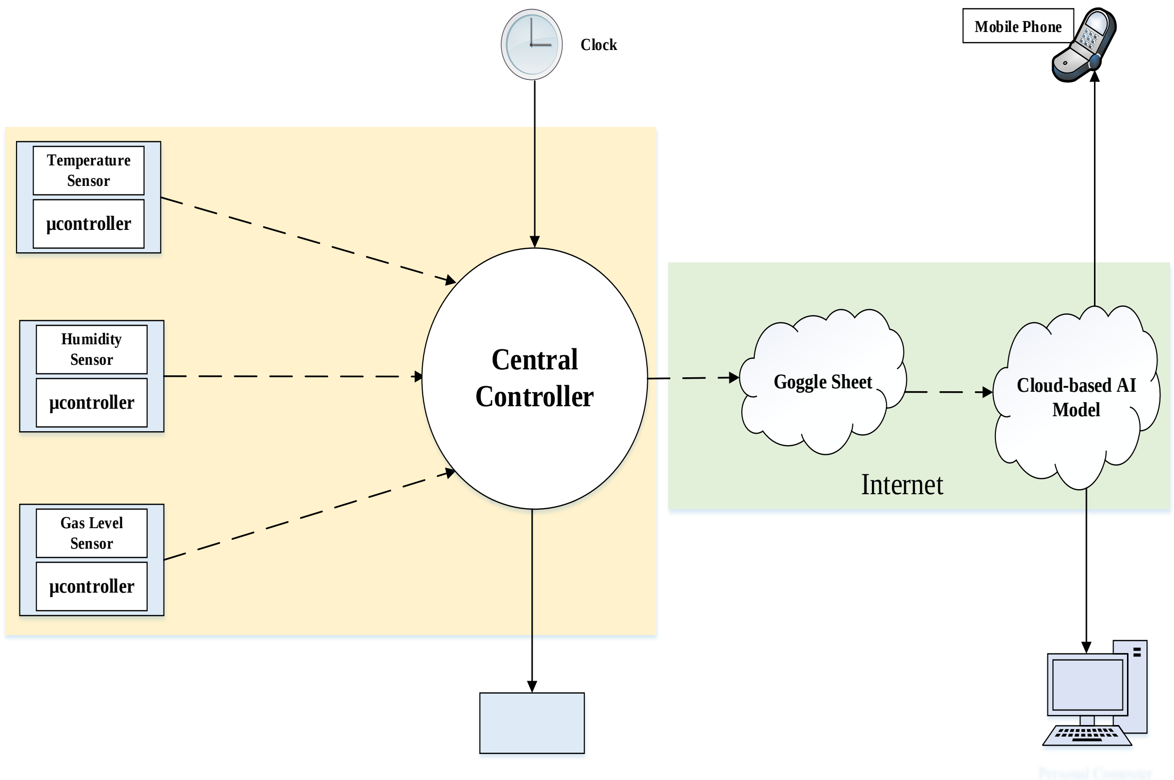


Figure 1: Architecture of the IoT System for Environmental Conditions Monitoring of Poultry Farm.

2.2 Data Collection

The workflow contains several stages: starting from the monitoring of environmental parameters, which include temperature, humidity and gas levels, in real time using dedicated sensors. These sensors (DHT22 for temperature and humidity, MQ135 for air quality, and DS3231 RTC) are strategically placed throughout the poultry farm to ensure comprehensive coverage. Each sensor is linked to a microcontroller (Wemos D1 Mini), which takes care of the raw data, making it ready for transmission. The circuit diagram illustrating the connection of sensors to Wemos D1 microcontroller designed in Proteus is shown in Figure 2.

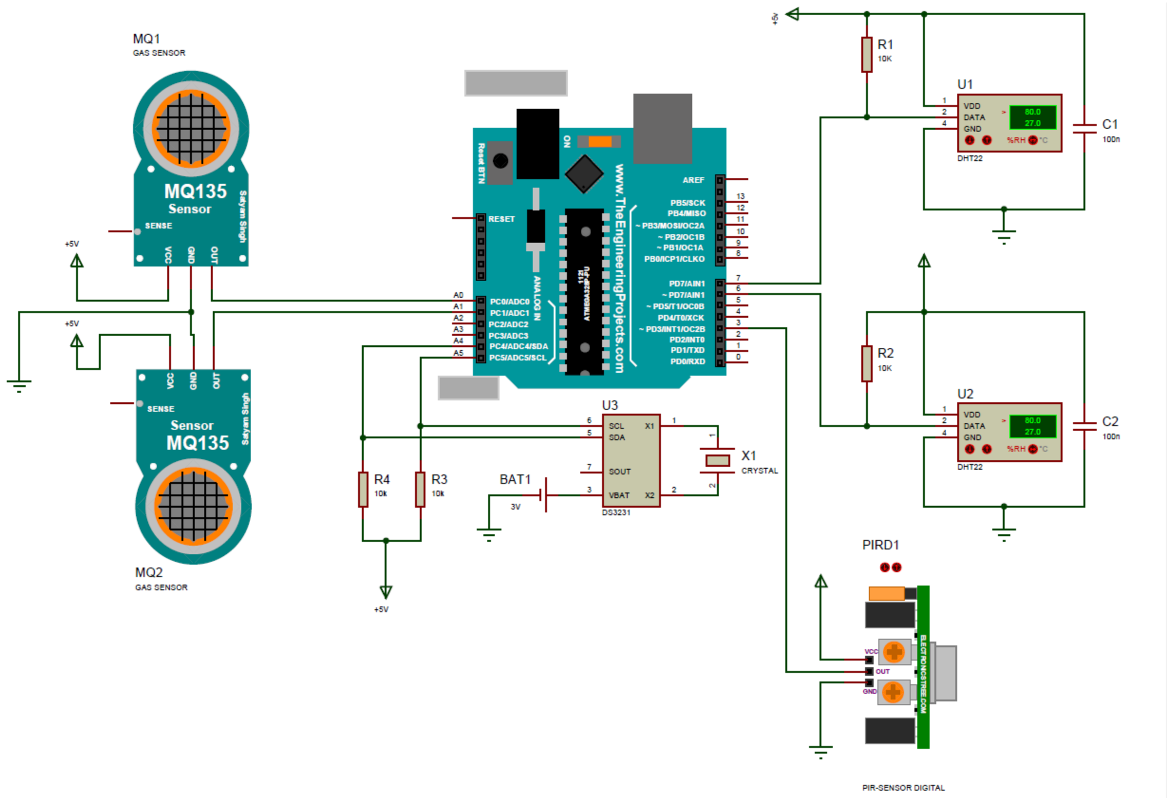


Figure 2: Circuit Diagram Showing Connection of Sensors to Wemos D1 Microcontroller.

2.3 Data Transmission

The microcontroller receives and processes the collected data, which is then sent to a central controller (Raspberry Pi) through a local area network (LAN). The system is driven by the Raspberry Pi which contains the machine learning based environmental condition prediction model. By using the LAN to replace wired communications between the microcontrollers and the central controller, fast and reliable communication between devices is achieved, and the system can be easily expanded without additional wired connections. The Raspberry Pi processes the data, runs the prediction model and derives some in-sights about the situation in the environment.

2.4 Data Storage

Post-processing, the input features and model predictions are sent to Google Sheets for storage and further analysis. With historical data all in one place, accessible over any internet connection, farmers and researchers can now do trend and pattern analysis all in real time, making much more informed decisions. The collected information can be leveraged to retrain and evolve the machine learning model with time to scale over repeated conditions such that the system continues to be accurate and effective. The process described here effectively secures all the data and it can be easily accessed whenever needed.

2.5 Remote Accessibility

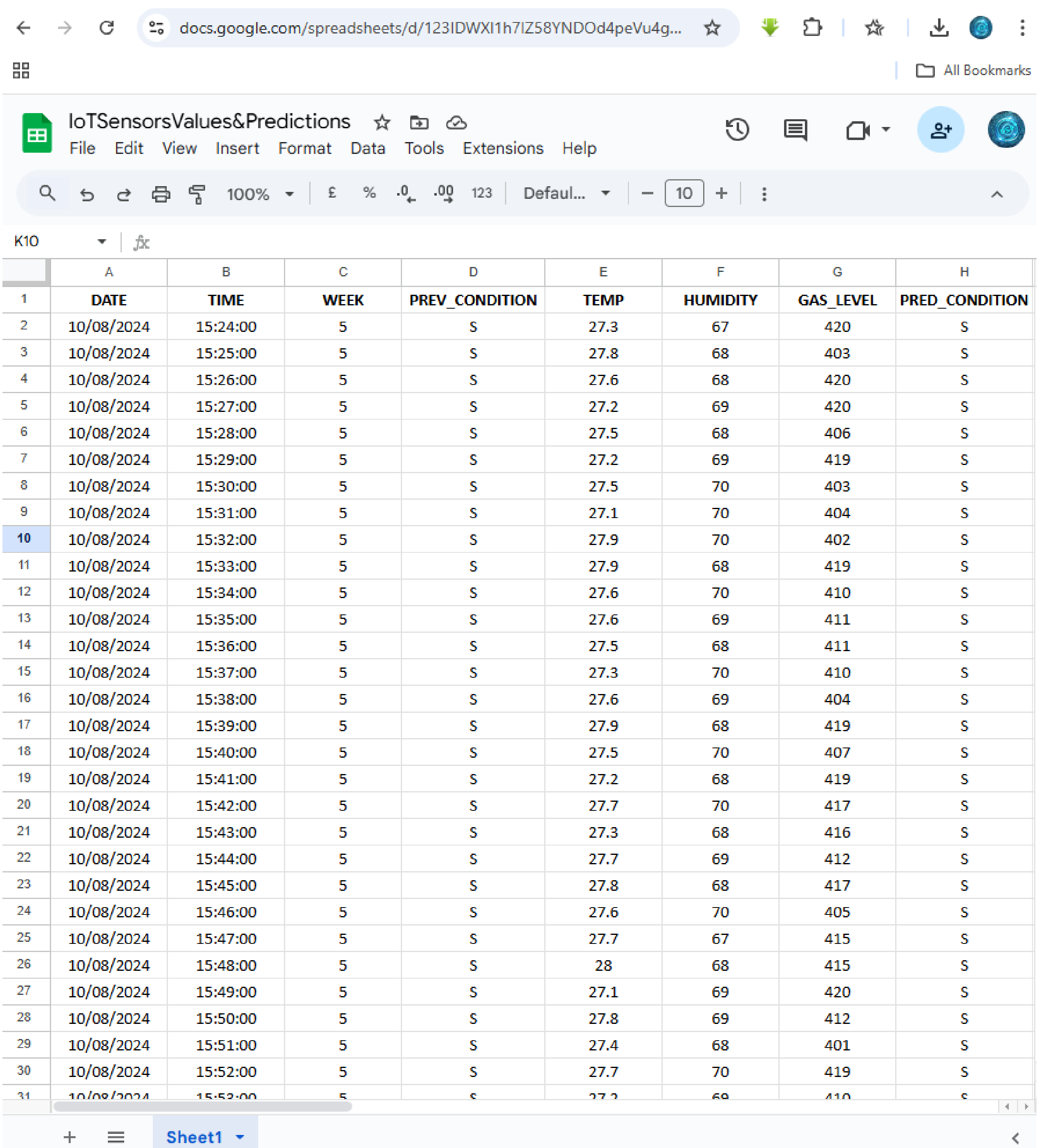
To enable farmers to check climate and get early warning from anywhere, an online version of the AI model is implemented on a cloud platform. This cloud based system further allows access to both forecasts and in-field wetness in real time data through a mobile phone or PC, which gives the farm recording a transparent possibility to follow the farm even when they are away from their farm. The cloud-based platform also enables the creation of alerts for irregularities, like unexpected temperature fluctuations, or the presence of noxious gases so the appropriate action can be initiated.

3. Results and discussion

3.1 Implementation of the IoT-based system for monitoring environmental conditions of poultry farm

The designed IoT-based system was implemented and physically deployed in a poultry farm located in Uyo, Nigeria, to monitor and predict environmental conditions in real-time. The constructed IoT-based monitoring systems are strategically placed throughout the case study poultry farm in Uyo to ensure comprehensive coverage as shown in Figure 3. The deployed IoT-based monitoring systems consisting of integrated IoT sensors, microcontrollers, and cloud-based data storage, enabled seamless data collection, transmission, and analysis. The system successfully captured environmental parameters such as temperature, humidity, and gas levels, which were processed by some selected AI models to generate predictions. These predictions, along with the raw sensor data, were transmitted and stored in a Google Spreadsheet for real-time monitoring and further analysis. A snapshot of the live-streamed data, illustrating the AI-generated predictions and sensor readings recorded during deployment of the IoT system is presented in Figure 4.

Figure 3: Snapshot of the case study poultry farm with the IoT sensors.



	A	B	C	D	E	F	G	H
1	DATE	TIME	WEEK	PREV_CONDITION	TEMP	HUMIDITY	GAS_LEVEL	PRED_CONDITION
2	10/08/2024	15:24:00	5	S	27.3	67	420	S
3	10/08/2024	15:25:00	5	S	27.8	68	403	S
4	10/08/2024	15:26:00	5	S	27.6	68	420	S
5	10/08/2024	15:27:00	5	S	27.2	69	420	S
6	10/08/2024	15:28:00	5	S	27.5	68	406	S
7	10/08/2024	15:29:00	5	S	27.2	69	419	S
8	10/08/2024	15:30:00	5	S	27.5	70	403	S
9	10/08/2024	15:31:00	5	S	27.1	70	404	S
10	10/08/2024	15:32:00	5	S	27.9	70	402	S
11	10/08/2024	15:33:00	5	S	27.9	68	419	S
12	10/08/2024	15:34:00	5	S	27.6	70	410	S
13	10/08/2024	15:35:00	5	S	27.6	69	411	S
14	10/08/2024	15:36:00	5	S	27.5	68	411	S
15	10/08/2024	15:37:00	5	S	27.3	70	410	S
16	10/08/2024	15:38:00	5	S	27.6	69	404	S
17	10/08/2024	15:39:00	5	S	27.9	68	419	S
18	10/08/2024	15:40:00	5	S	27.5	70	407	S
19	10/08/2024	15:41:00	5	S	27.2	68	419	S
20	10/08/2024	15:42:00	5	S	27.7	70	417	S
21	10/08/2024	15:43:00	5	S	27.3	68	416	S
22	10/08/2024	15:44:00	5	S	27.7	69	412	S
23	10/08/2024	15:45:00	5	S	27.8	68	417	S
24	10/08/2024	15:46:00	5	S	27.6	70	405	S
25	10/08/2024	15:47:00	5	S	27.7	67	415	S
26	10/08/2024	15:48:00	5	S	28	68	415	S
27	10/08/2024	15:49:00	5	S	27.1	69	420	S
28	10/08/2024	15:50:00	5	S	27.8	69	412	S
29	10/08/2024	15:51:00	5	S	27.4	68	401	S
30	10/08/2024	15:52:00	5	S	27.7	70	419	S
31	10/08/2024	15:53:00	5	S	27.2	69	410	S

Figure 4 A snapshot of the live-streamed data, illustrating the AI-generated predictions and sensor readings recorded during deployment of the IoT system

The machine learning model was deployed using Streamlit, a Python-based framework for creating interactive web applications. The results are accessible remotely through any internet-enabled device. The platform offers three data input options, each optimized for different user needs as shown in Figure 5 to Figure 7. The three data input options include:

i. Manual Input – Real-time single entry predictions, allowing instant feedback.
ii. CSV Upload – Batch processing of stored sensor data with downloadable results.
iii. Real-Time Monitoring – Live streaming of environmental conditions with graphical analysis.

The data acquired through the IoT system are used in the machine learning model training, validation and application in prediction of the poultry farm environmental conditions.

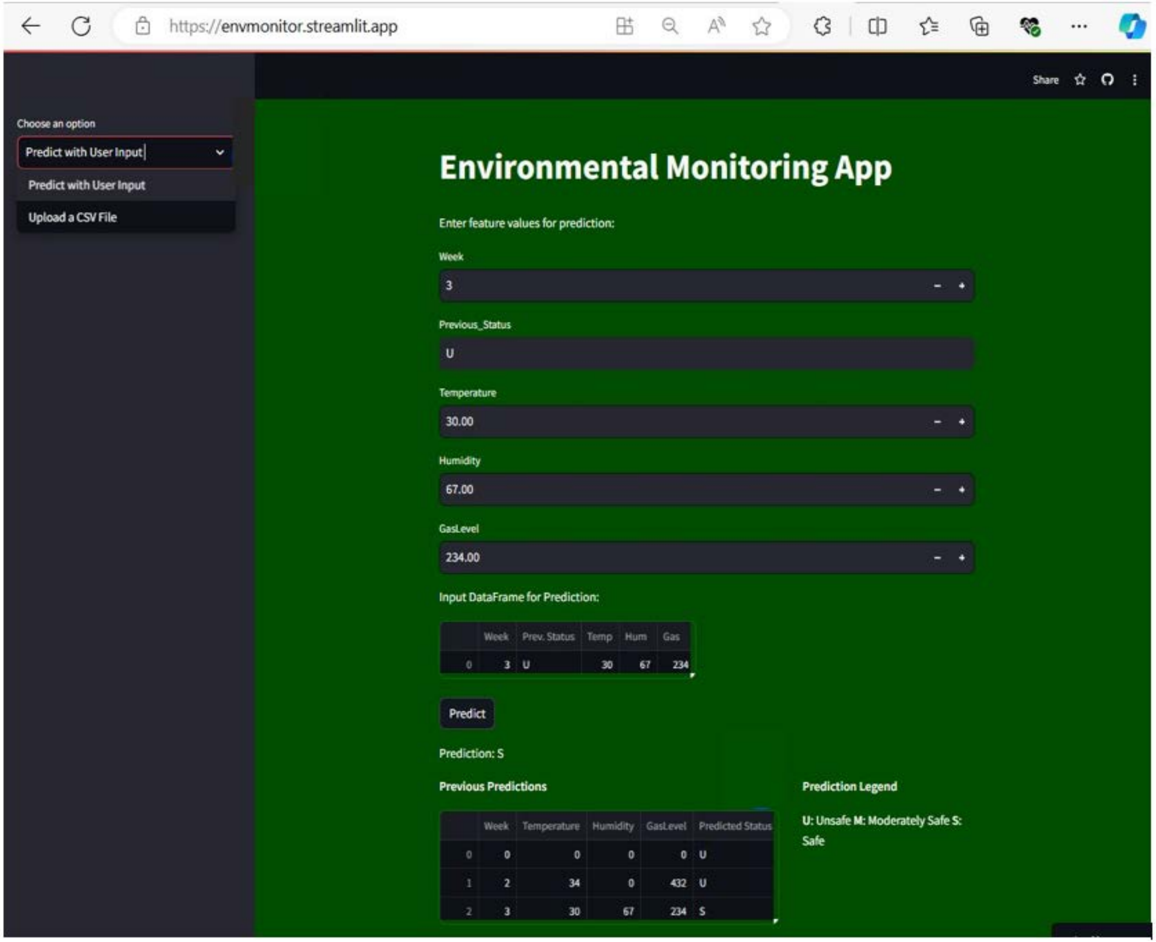


Figure 5: **Web App Displaying the Interface for User Input Option.**

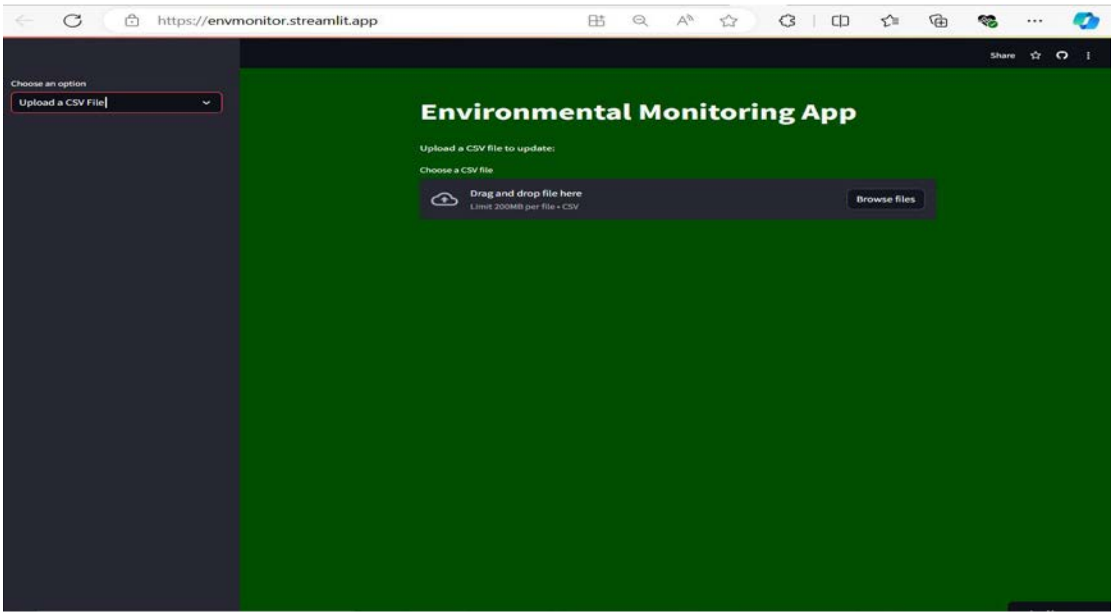


Figure 6: **Web App Displaying the Interface for CSV file upload Option.**

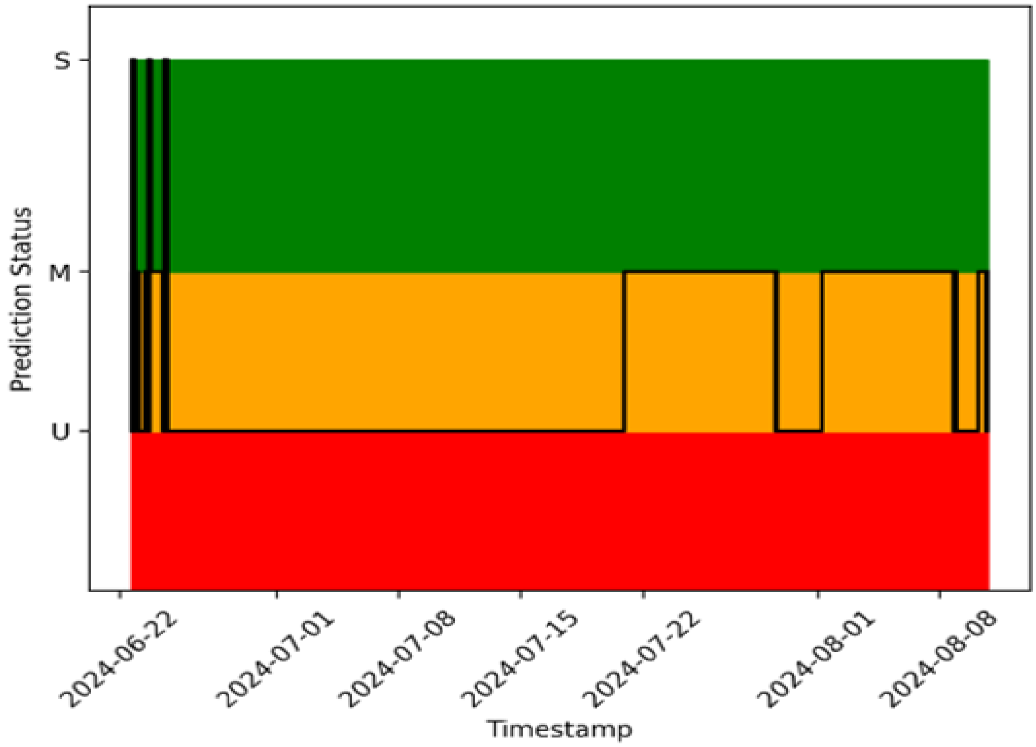


Figure 7: Plot of Prediction Status.

4. Conclusion

Design and implementation of an IoT-based environmental monitoring system for poultry is presented. The IoT-based system supports the use of machine learning (ML) algorithms for analysing the data collected and also to be able to make predictions as well as detection of anomalies is in the environmental conditions of the poultry farm. The system monitors the following environmental factors; temperature, humidity and gas balance for maintaining optimal poultry health and productivity. The system is organized in four main stages (data collection, data transmission, data storage, and remote access). In addition, the system combined IoT devices and machine learning models to enable real-time data gathering, preprocessing, and real-time predictions of the environmental conditions being monitored. The designed system was implemented and deployed in a case study poultry farm in Uyo Akwa Ibom State and data stream on the listed environmental parameters were acquired and stored according the system design operations. This present work reports on the design and implementation of the IoT system while future publications will focus on the other aspects of the research such as the machine learning model predictions and forecasting of the environmental parameters of the poultry farm.

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