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Smart IoT System for Gas Monitoring and Environmental Control in Poultry Farms

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ABSTRACT

This paper focuses on a gas-monitoring and environmental control system that utilizes Internet of Things technology for poultry farms. Its main objective is to tackle the issue of toxic gas formation, specifically ammonia and hydrogen sulfide. The system is based on an ESP32 microcontroller and is capable of detecting ammonia, hydrogen sulfide, as well as temperature and humidity levels. Relay modules are utilized to actively manage exhauster fans and submersible pump motors in order to prevent the accumulation of gas and regulate temperature, thereby ensuring the well-being of both the birds and employees at the poultry farm. When there is an unexpected buildup of gas, a GSM module sends immediate warnings to farmers via SMS. The system transmits the collected data to the cloud server. Consequently, the data can be remotely accessed and utilized for the purposes of monitoring, storage, and analysis. Therefore, integrating IoT in this manner for gas monitoring and environmental control at poultry farms serves to address the crucial parameter that needs to be maintained. This system enables the control of conditions in a poultry house as needed. Consequently, farms are able to achieve higher productivity while minimizing energy and time requirements.

Keywords: ESP32; IoT farm module; GAS monitoring module; Ammonia sensor (MQ135); H_2S sensor (MQ136); LCD display; Exhaust fan; Submersible pump motor; Alarm; GSM module; Cloud server.

1. Introduction

Poultry farming plays a crucial role in promoting economic growth and ensuring universal access to food [1]. To meet the needs of a growing global population, the industry guarantees a reliable supply of protein and healthier substitutes for products that contain cholesterol. Effective management is crucial for maintaining steady production rates and improving yields in order to meet the growing demand for poultry products. Under such conditions, automated and remote control systems for chicken farming are extremely beneficial. The poultry industry faces multiple challenges in maintaining optimal conditions on farms. Effectively managing hazardous gases such as Hydrogen Sulfide (H_2S), Ammonia (NH_3), and Carbon dioxide (CO_2) has the added benefit of preserving avian health and ensuring that birds can fulfill their ecological duties [2]. Emissions of gases that can harm air quality and therefore endanger avian species are commonly released when poultry litter is recycled.

Ammonia, a byproduct of bacterial decomposition of nitrogenous substances, poses a substantial threat to animals [3]. The broiler's detection capabilities can detect levels as low as 15 parts per million. The established legal threshold is set at 20 parts per million. Concentrations surpassing 200 ppm elevate the likelihood of respiratory ailments and infections in hens, which can result in fatality. To maintain the ongoing egg-laying well-being of chickens, it is necessary to monitor ammonia levels.

Aside from the regulation of hazardous gases, maintaining optimal temperature, humidity, and airflow values is equally vital. In certain geographical areas, such as Indonesia, chickens necessitate a coop temperature that is lower than 27 degrees Celsius in order to guarantee optimal growth and a plentiful supply of eggs. Integrating these components into the construction of a chicken coop is crucial for guaranteeing the overall well-being and efficiency of the poultry [4]. The technological revolution in the poultry industry has made it possible to implement new methods for monitoring and controlling the environment. The ESP32 hardware module exemplifies the use of advanced technology. The ESP32 module utilizes advanced algorithms to process information from a variety of sensors. It performs data processing and serves as the central processing unit. If the gas levels deviate from the acceptable range, the system is promptly alerted and automatic measures are activated to ensure the air quality in the barn is maintained at a high standard. The ESP32 module demonstrates exceptional performance in gas detection and environmental improvement [5]. Furthermore, the process of establishing connections with other Internet of Things devices is made more straightforward. This allows for the incorporation of supplementary functionalities, such as fish food management systems, remote monitoring tools, and water quality monitoring systems. The integration of ESP32 hardware with Internet of Things technology offers a wide range of tools for managing and monitoring flocks, while also providing chicken farmers with valuable insights obtained through data analysis [6].

Modern Poultry farming is primarily automated and remotely monitored. These advancements enable accurate control of air temperature, relative humidity, and gas concentrations, providing hens with the best possible living conditions. This stringent control system significantly decreases the requirement for manual labor. This allows the system to quickly adjust to changes in its surroundings. Consequently, both agricultural revenue and poultry output experience a substantial rise [7]. By harnessing real-time data, the use of automated systems enables farmers to make immediate decisions. This precautionary measure guarantees the welfare of the hens and typically enhances productivity. By employing remote and automated monitoring systems, farms can enhance animal welfare and optimize operational efficiency. The main goal of integrating Internet of Things sensors into environmental control systems of poultry farms is to optimize farm management by enabling real-time monitoring, prompt responses, and data-driven decision-making. These systems enable continuous monitoring of the temperature, NH_3, and H_2S levels in the poultry area. By utilizing these sensors, farmers can access current data on air quality. As a result, they have the authority to protect individuals by promptly identifying potential health hazards. Timely identification and rigorous adherence to predetermined thresholds are crucial to prevent serious health complications in poultry. Early detection and timely intervention are crucial for maintaining the optimal health of a farm owner's avian livestock [8]. The farm's financial situation will be positively impacted in a similar manner as the chickens' success. The use of Internet of Things (IoT) sensors is a major step forward in developing sustainable and efficient techniques for chicken farming.

The poultry farming industry actively contributes to economic stability and global food security [9]. Moreover, the chicken industry needs to devise innovative production management strategies to meet the increasing demand for poultry products, while also increasing production levels. Poultry farmers can potentially overcome their challenges by integrating advanced technologies such as the ESP32 module and Internet of Things (IoT) sensors. These technological advancements provide farmers with data-driven insights to aid in decision-making and streamline environmental management practices on chicken farms. These systems enhance farm productivity, animal welfare, and income by providing optimal living conditions for hens. To satisfy the increasing global demand for poultry products and maintain effective and environmentally-friendly farming methods, it is crucial to adopt cutting-edge technologies as the poultry industry advances.

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2. Related Works

The investigation of the ESP32 module's implementation in a poultry farm demonstrated its effectiveness in maintaining air quality. The module monitored ammonia concentrations accurately and activated ventilation systems when they approached hazardous thresholds. By taking this proactive approach, the farm was able to prevent health issues and increase its overall productivity. A number of poultry farms have adopted Internet of Things (IoT) systems for the purpose of monitoring and controlling environmental variables [10]. These mechanisms have exhibited the capacity to optimize the well-being of poultry through the regulation of temperature, humidity, and gas concentrations to remain below hazardous limits. Furthermore, the ability to remotely monitor and adjust conditions has empowered farmers to expeditiously resolve any issues, thus reducing the probability of disease outbreaks and other complications.

In poultry farms, automation has been integrated to regulate feeding and watering systems, as well as environmental conditions. These systems ensure that avian species receive appropriate amounts of food and water at designated intervals, promoting healthy growth and reducing inefficiency [11]. Empirical evidence supports the notion that the integration of automated feeding and watering systems can substantially improve feed conversion ratios and the overall performance of poultry. Integration of IoT and automation with additional agricultural technologies is critical for the survival of the poultry industry. Through the integration of environmental control systems and precision farming techniques, it is possible to attain improved efficiencies and notable strides in the health and productivity of poultry. In order to effectively execute this all-encompassing strategy, it is imperative to persistently seek progress and allocate resources to the creation of novel technologies. Although there are benefits associated with the implementation of these technologies in poultry farms, there are also challenges. Resistance to change, high initial costs, and a dearth of technical expertise may impede adoption [12]. In order to address these challenges, it will be imperative to establish targeted training initiatives, offer monetary incentives, and endeavor to demonstrate the lasting benefits associated with technology adoption.

Ensuring data security and privacy will become increasingly critical as the degree of connectivity in poultry farms continues to flourish. Preserving the accuracy and dependability of data collected by IoT devices and safeguarding sensitive information against cyber threats will be essential for the continued success and trustworthiness of these technologies. Significant strides have been made in the management of environmental conditions through the implementation of advanced technologies in poultry farming, which has led to enhanced welfare and productivity of the birds [13]. By utilizing the ESP32 module and Internet of Things (IoT)-enabled sensors, poultry farms are able to ensure that optimal conditions are consistently maintained through automated responses and continuous monitoring.

Technological advancements serve to enhance farm profitability and efficiency by enabling data-driven decision-making and reducing labor and operational costs. To ensure sustainable and efficient farming practices and satisfy the rising global demand for poultry products, it is critical that the poultry industry adopts innovative technologies. In order to optimize the benefits derived from these developments in poultry farming, it is imperative to persist in the pursuit of research and development while proactively addressing the obstacles that may arise during their execution [14]. An environmental monitoring system that makes use of Internet of Things (IoT) technology, TerraSense. The manufacturer is Terra Sphere Systems. The system integrates a variety of sensors for the purpose of quantifying temperature, humidity, ammonia, and carbon dioxide levels within poultry houses. Through an intuitive interface, the system furnishes farmers with real-time notifications and an alert system, enabling them to manage environmental conditions in a proactive manner [15].

The Internet of Things (IoT) platform PoultrySense was designed and manufactured by Evonik Digital GmbH [16]. Its purpose is to supervise and control the environmental conditions inside poultry houses. The system utilizes wireless sensor networks to collect data on air quality, air temperature, humidity, and other significant parameters. PoultrySense offers farmers valuable insights regarding poultry farm operations and automated control features that are specifically designed to enhance the productivity of poultry farmers. Additionally, PoultrySense utilizes machine learning and cloud-based analytics systems. Poultry Sense created Poultry-Pal, a poultry farm management system that utilizes the Internet of Things (IoT) technology. The sensor network system monitors supplementary environmental variables in real time, including temperature, humidity, and gas concentrations. This tool enables farmers to create customized systems and receive suggestions for the optimal environmental conditions. Consequently, the survival and productivity of birds are improved [17]. Its purpose is to monitor and automate the environment of the poultry house. Sensors that regulate ventilation and detect gases, temperatures, and humidity comprise the system. SmartBarn is an all-encompassing system that integrates data analysis, mobile application platforms, and cloud computing in order to furnish farmers with up-to-date information and the ability to exercise remote control. Although poultry farms have the capacity to implement diverse Internet of Things (IoT) models for environmental control and gas monitoring, it is critical to acknowledge that every system might possess distinct attributes and possible susceptibilities [18].

The Internet of Things devices employed for the surveillance of gases and environmental parameters in poultry farms face a number of disadvantages. The aforementioned obstacles are evident in the form of substantial initial investments, complex system implementation, potential malfunctions of sensors and software, increased power consumption resulting in escalated expenses, concerns regarding data privacy and security, scaling difficulties, and restricted customization possibilities. However, these detrimental characteristics pose difficulties for poultry farmers due to the complexity they introduce into environmental management and the obstruction they impede on the optimization of farm operations.

3. Proposed System

The investigation of the ESP32 module's implementation in a poultry farm demonstrated its effectiveness in maintaining air quality. The module monitored ammonia concentrations accurately and activated ventilation systems when they approached hazardous thresholds. By taking this proactive approach, the farm was able to prevent health issues and increase its overall productivity. A number of poultry farms have adopted Internet of Things (IoT) systems for the purpose of monitoring and controlling environmental variables. These mechanisms have exhibited the capacity to optimize the well-being of poultry through the regulation of temperature, humidity, and gas concentrations to remain below hazardous limits. Furthermore, the ability to remotely monitor and adjust conditions has empowered farmers to expeditiously resolve any issues, thus reducing the probability of disease outbreaks and other complications. In poultry farms, automation has been integrated to regulate feeding and watering systems, as well as environmental conditions. These systems ensure that avian species receive appropriate amounts of food and water at designated intervals, promoting healthy growth and reducing inefficiency. Empirical evidence supports the notion that the integration of automated feeding and watering systems can substantially improve feed conversion ratios and the overall performance of poultry. Integration of IoT and automation with additional agricultural technologies is critical for the survival of the poultry industry.

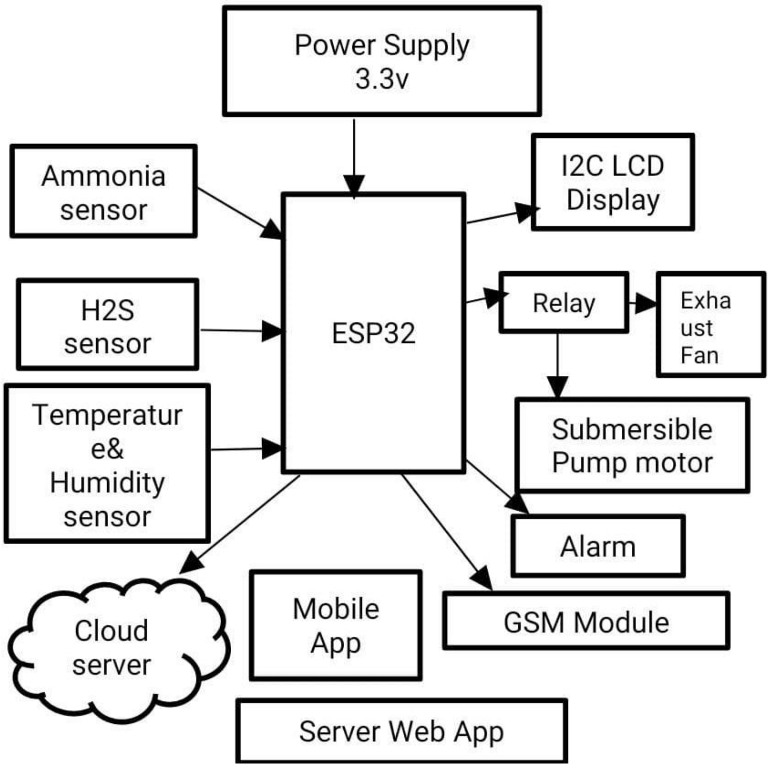

Figure 1. Block diagram of the proposed system

Through the integration of environmental control systems and precision farming techniques, it is possible to attain improved efficiencies and notable strides in the health and productivity of poultry. In order to effectively execute this all-encompassing strategy, it is imperative to persistently seek progress and allocate resources to the creation of novel technologies. Although there are benefits associated with the implementation of these technologies in poultry farms, there are also challenges. Resistance to change, high initial costs, and a dearth of technical expertise may impede adoption. In order to address these challenges, it will be imperative to establish targeted training initiatives, offer monetary incentives, and endeavor to demonstrate the lasting benefits associated with technology adoption. Ensuring data security and privacy will become increasingly critical as the degree of connectivity in poultry farms continues to flourish. Preserving the accuracy and dependability of data collected by IoT devices and safeguarding sensitive information against cyber threats will be essential for the continued success and trustworthiness of these technologies. Significant strides have been made in the management of environmental conditions through the implementation of advanced technologies in poultry farming, which has led to enhanced welfare and productivity of the birds. By utilizing the ESP32 module and Internet of Things (IoT)-enabled sensors, poultry farms are able to ensure that optimal conditions are consistently maintained through automated responses and continuous monitoring. Technological advancements serve to enhance farm profitability and efficiency by enabling data-driven decision-making and reducing labor and operational costs. To ensure sustainable and efficient farming practices and satisfy the rising global demand for poultry products, it is critical that the poultry industry adopts innovative technologies. In order to optimize the benefits derived from these developments in poultry farming, it is imperative to persist in the pursuit of research and development while proactively addressing the obstacles that may arise during their execution.

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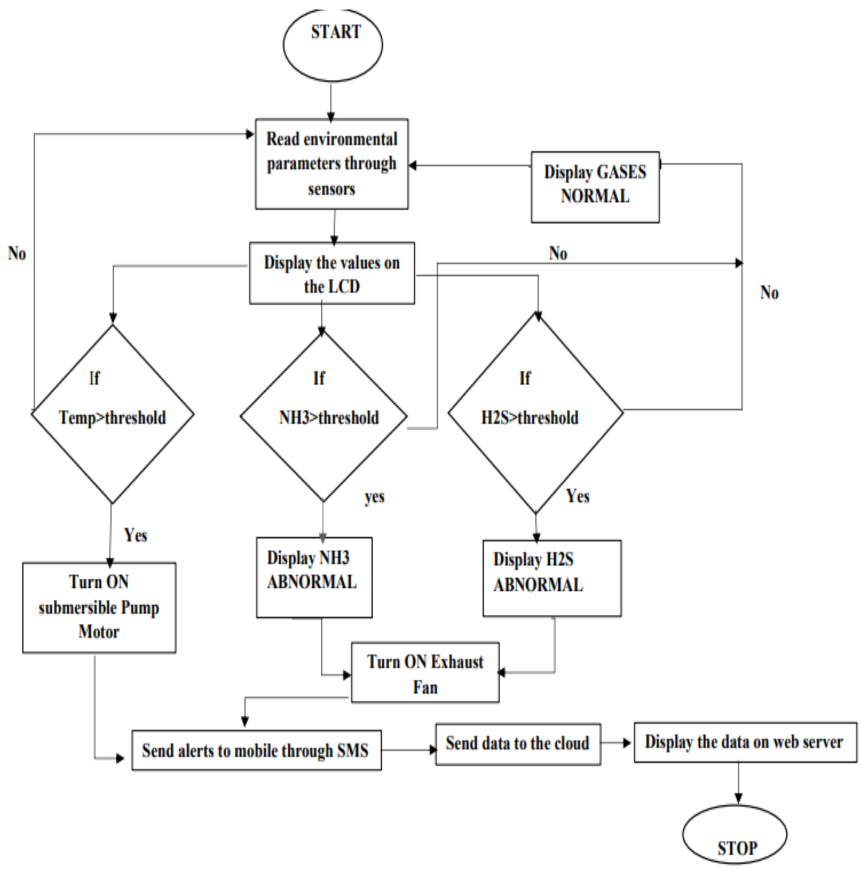

Figure 2. Flowchart of the proposed system

In addition to temperature, humidity, and gas concentrations, the sensor network system monitors additional environmental variables in real time. This instrument empowers farmers to develop individualized systems and obtain recommendations for the most favorable environmental circumstances. As a result, avian survival and productivity are enhanced. Its purpose is to monitor and automate the environment of the poultry house. Sensors that regulate ventilation and detect gases, temperatures, and humidity comprise the system. SmartBarn is an all-encompassing system that integrates data analysis, mobile application platforms, and cloud computing in order to furnish farmers with up-to-date information and the ability to exercise remote control. Although poultry farms have the capacity to implement diverse Internet of Things (IoT) models for environmental control and gas monitoring, it is critical to acknowledge that every system might possess distinct attributes and possible susceptibilities. The Internet of Things devices employed for the surveillance of gases and environmental parameters in poultry farms face a number of disadvantages. The aforementioned obstacles are evident in the form of substantial initial investments, complex system implementation, potential malfunctions of sensors and software, increased power consumption resulting in escalated expenses, concerns regarding data privacy and security, scaling difficulties, and restricted customization possibilities. However, these detrimental characteristics pose difficulties for poultry farmers due to the complexity they introduce into environmental management and the obstruction they impede on the optimization of farm operations.

The Real Time gas monitoring system offers numerous advantages to poultry farmers. Constant monitoring of gas, temperature, and humidity levels ensures the provision of optimal conditions for individuals, while the automation of control mechanisms enables swift responses by activating the ventilation system when deviations are detected. Warning systems provide farmers with immediate information about anomalies, enabling them to promptly take preventive measures to avoid any potential losses. Remote monitoring and computer functions provide users with significant convenience and flexibility. Integration with cloud technology facilitates the management, analysis, and sharing of data with colleagues. The system's power efficiency guarantees a simple operation, while its flexibility allows for seamless integration with farms of various sizes. Additionally, the system's built-in environmental compliance features greatly simplify user routines, resulting in increased productivity and sustainability in the agricultural sector.

Data Collection: The information from status sensors is fed to ESP32 and updated frequently. Both Data Processing and Decision Making are critical. The ESP32 receives data and software algorithms to make decisions about which reactions to take based on predefined values, such as turning on the exhaust fan once ammonia levels exceed safe thresholds.

Action Implementation: For instance, the activation of the relay that may be a fan or pump will occur due to the decisions made by the ESP32.

Data Display and Communication: In real time, data and status are in LCD view. On the concurrent notes, the data is shipped to cloud system for remote observations and retrospective data analysis.

Remote Monitoring and Control: The GSM transmitter and mobile app will enable the user to receive alerts and control the system remotely, to improve flexibility and user responsiveness of the system.

4. Results and Discussion

The ESP32 board was programmed using the Arduino version 2.3.2 software, along with multiple libraries, to facilitate seamless integration with ThingSpeak. The temperature level, humidity, ammonia, and hydrogen sulfide (H2S) data were sensed and then transmitted to ThingSpeak for ongoing analysis and visualization. The programming logic facilitated the retrieval of sensor data from connected devices and converted it into real-time measurements of environmental parameters in a poultry farm. The experiment utilizes the technical capabilities of the ESP32 microcontroller and the ThingSpeak platform. The results demonstrated the capacity of IoT technology to conduct thorough environmental monitoring in poultry farming.

Based on the data presented in Figure 3, it can be observed that certain environmental parameters remain constant at certain points, while they experience abrupt increases and decreases in other instances. The graph remains stable in the absence of any testing gases or deliberate temperature increases. The parameters experienced a sudden increase during the system's testing with external testing gases, while the subsequent decrease can be attributed to the gradual reduction of the testing gases.

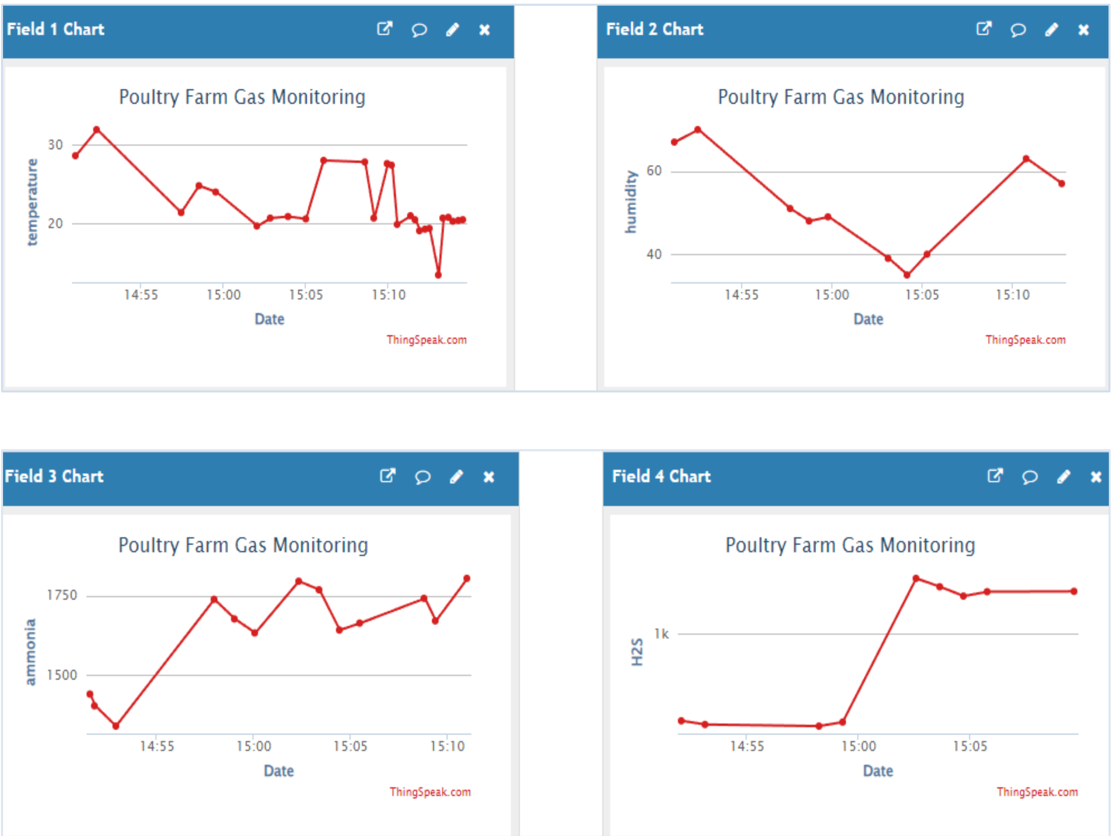

Figure 3. ThingSpeak

The profound transformations in gas monitoring and environmental control systems for chicken farms are facilitated by emerging technological trends and consumer demands. The integration of artificial intelligence and machine learning is expected to lead to proactive environmental management. This will be accompanied by precision farming techniques that enable targeted solutions based on detailed spatial distribution maps of gas concentrations. Integrating blockchain ensures the security and traceability of data, and smart farming platforms can be seamlessly integrated without compromising their performance. The utilization of 5G and satellite internet allows for remote monitoring and control, which is crucial for making decisions in real-time.

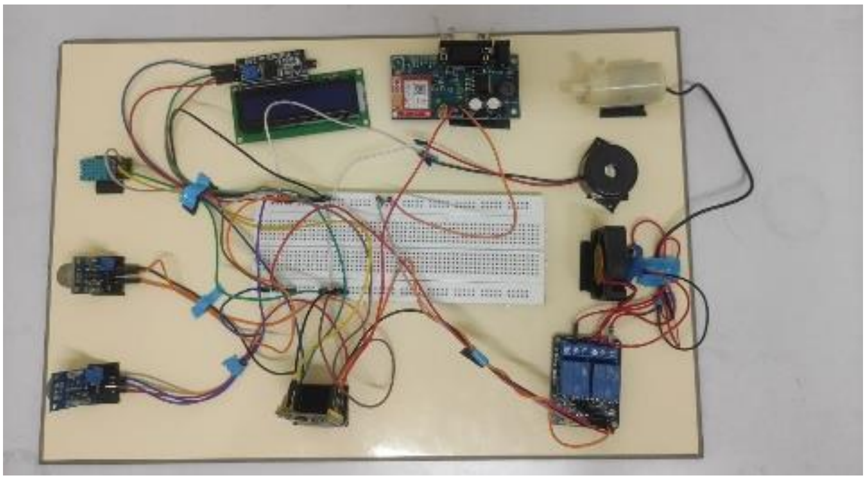

Figure 4. Working model

The primary catalysts for innovation are environmentally sustainable practices and adherence to legal regulations. The integration of research and development is crucial for advancing the development of IoT-enabled environmental control systems, which in turn guarantees sustainability and efficiency in poultry farming.

5. Conclusion

Conclusively, realizing IoT technology-driven gas monitoring and climate regulating techniques in poultry farming could probably be the answer to conventional techniques considering their current thrown-out scenario. The utilization of the sensors, connectivity and data analytics capabilities allows the systems to perform in real-time conditions, providing precise environmental control according to the level of the gas in the poultry houses through monitoring and makes the systems proactive in management. One advantage of the IoT Systems goes beyond the increase productivity and efficiency, since it includes provision for improved animal welfare, diminished environmental impact and also compliance with regulatory laws. As such, the early alerts, remote monitoring capabilities, and the integration between these systems and alarm systems, allows the farm managers to be up to date on their decisions which are based on current facts and are timely actions taken to hinder risks and fine-tune the farm operations.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis and manuscript writing equally.

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