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IoT based Smart Poultry Management System

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Abstract

This research focuses on the development of an intelligent system utilizing embedded frameworks and smartphone technology for monitoring and managing chicken farms. The proposed system aims to control environmental parameters and automate feeding and water supply, offering a cost-effective, asset-saving, and quality-oriented approach to poultry farming. By leveraging smart devices and IoT technologies, this system can replace manual labour, addressing industry labour challenges and introducing semi-automation. The system encompasses tasks such as feeding using a container, water supply through nipple waterers, temperature and humidity regulation with fans and heaters, automatic lighting, and real-time environmental monitoring accessible through IoT cloud data. This technology-driven solution holds promise for enhancing productivity and efficiency in poultry farming and broader agricultural applications.

Keywords: Poultry, Temperature, Humidity, Automation, Feeding, Water Supply, Automatic Lighting, IoT.

1. Introduction

1.1 Background

Poultry farming involves raising domestic birds like chickens, ducks, turkeys, and geese for meat and egg production, with chickens being the most commonly farmed species worldwide. In Nepal, where agriculture is a vital occupation, both local and improved breeds

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are reared. Genetic and nutritional advancements have boosted farming efficiency, but optimal conditions within poultry houses are crucial for realizing birds' genetic potential [20]. Modern poultry facilities in developed countries rely on electronic controllers to regulate lighting, temperature, and humidity, ensuring birds' comfort and optimal growth conditions [11-14]. An automated poultry farming aims to monitor and control indoor parameters such as temperature, lighting, feeding, water supply, and live feed streaming to smart devices [19]. This includes continuous sensor-based monitoring of temperature and humidity, with automated adjustments using microcontrollers to maintain ideal conditions. Additionally, automated feeding and watering systems ensure efficient distribution of food and water, enhancing productivity while prioritizing bird welfare [15-18].

1.2 Problem Statements

Most poultry farms in Nepal need lots of human labor to maintain. Unhygienic farms raising chickens may produce low-quality meat. Feeding and watering several times a day may be tedious. The poultry farm environment may not be ideal.

1.3 Objectives

The main objectives of the research is:

- To implement automation for lighting, feeding, and watering processes in the poultry farm.
- To develop systems to continuously monitor and maintain a healthy environment for poultry birds, especially chickens, on the farm.
- To connect wirelessly to servers to send real-time farm data to smart devices of users.

1.4 Research Scope

The research primarily emphasizes automatic feed distribution and environmental monitoring within poultry farming. However, further enhancements can lead to complete automation of the poultry farm, incorporating features like automatic cleaning technologies, ongoing visual monitoring of the farm, and additional advancements tailored to specific requirements. This scope also extends to hatching technology, facilitating monitoring and control of ambient temperature and humidity to optimize conditions for successful hatching.

2. Literature Review

Poultry farming has undergone remarkable transformations in recent years, with advancements in technology aimed at bolstering productivity and refining management practices. This review delves into notable contributions in the domain of smart poultry farming systems, spotlighting innovative methodologies and technological interventions.

Mahale and Sonaavane [1] introduced an innovative system for smart poultry farm monitoring utilizing IoT and wireless sensor networks. Their solution, leveraging Raspberry Pi 2, Arduino UNO, and remote sensors, revolutionizes traditional farming methods by providing real-time data on essential parameters such as temperature, humidity, light, and gas levels through wireless networks.

Goud and Sudharsan [2] proposed an internet-based smart poultry farm integrating wireless sensors and mobile system networks. This system facilitates remote monitoring of critical parameters like temperature and humidity, with notifications sent to registered mobile numbers, ensuring prompt interventions by farm personnel.

So-In, Poolsanguan, and Rujirakull [3] discussed smart mobile poultry farming systems employing Tmote Sky WSNs. Their emphasis on integrating electronic and mechanical components in farm establishments enhances mobility and flexibility, enabling efficient management of key factors such as temperature, humidity, light, and population density, alongside nutrition and genetic selection.

Amir et al. [4] presented a comprehensive chicken farm monitoring system utilizing wireless communication units and sensors to detect temperature, humidity, light, and water levels. Monitoring and control are facilitated through an Arduino microcontroller, ensuring efficient management practices and optimal conditions for poultry growth.

In [5], the authors proposed a cloud-based poultry farm monitoring system, integrating IoT devices and cloud computing for real-time data analysis and decision-making. This system offers enhanced scalability, flexibility, and accessibility, empowering poultry farmers with actionable insights for improved farm management.

In [6], the authors developed a smart broiler house monitoring system utilizing wireless sensor networks and machine learning algorithms for predictive analytics. Their system enables proactive identification of potential issues, allowing for timely interventions to optimize broiler production efficiency and welfare.

In [7], the authors introduced a precision poultry farming system integrating IoT, AI, and edge computing for real-time monitoring and decision support. This system offers personalized management solutions tailored to individual bird needs, maximizing productivity while minimizing resource wastage.

In [8], the authors proposed a smart poultry farm management system employing RFID technology for automated tracking and monitoring of poultry health and behavior. Their system enhances traceability and enables early detection of health issues, ensuring timely interventions to prevent disease outbreaks.

In [9], the authors developed a wireless sensor-based poultry farm automation system for remote monitoring and control of environmental parameters and feeding systems. Their system improves operational efficiency, reduces labor costs, and enhances overall farm productivity.

In [10], the researchers introduced a vision-based poultry health monitoring system utilizing image processing techniques for automated detection of poultry diseases and abnormalities. Their system enables early disease diagnosis and intervention, minimizing economic losses, and ensuring optimal bird health and welfare.

These pioneering studies underscore the diverse strategies and technologies driving advancements in smart poultry farming systems. Real-time monitoring and control mechanisms play a pivotal role in optimizing poultry management practices, ensuring sustainable and efficient operations.

3. Feasibility Study

3.1 Operational Feasibility

In the feasibility analysis, questions such as how smart poultry farming will benefit farmers, what challenges might arise, and how efficient and convenient it will be for users to adopt it are considered. This research aims to assist poultry farmers in effectively monitoring and maintaining the farm environment to ensure optimal conditions for the chickens. The automation of feeding and water distribution reduces the need for frequent visits to the farm, saving time and enhancing operational efficiency.

3.2 Technical Feasibility

Technical feasibility pertains to the availability of necessary technology and expertise in the field. The hardware components needed for this research include a NodeMCU, a temperature sensor (such as DHT11), a motor fan (operating between 5-12V), an LDR (Light Dependent Resistor), an LED, a heater, a water pump (also operating between 5-12V), a servo motor, and a motor driver—all readily accessible on the market. Successful implementation of the research necessitates fundamental skills in NodeMCU programming and familiarity with hardware integration.

3.3 Schedule Feasibility

The estimated timeline for completing the research is approximately two months, and it is feasible to meet this deadline within the allotted timeframe.

3.4 Economic Feasibility

The economic analysis of the research involves evaluating the estimated costs associated with developing the product, integrating it into the system, and operating the system against the benefits derived from the research. This assessment confirms that the research is economically viable and feasible.

4. Requirements

4.1 Hardware Requirements

4.1.1 NodeMCU

Figure 1 shows a NodeMCU, an open-source IoT platform comprising firmware designed to operate on the ESP8266 Wi-Fi System-on-Chip (SoC) developed by Espressif Systems, paired with hardware built around the ESP-12 module. In this context, “NodeMCU” primarily denotes the firmware rather than the development kits themselves. The firmware is programmed using Lua, a scripting language tailored for embedded systems and IoT applications.

Figure 1. Node MCU

4.1.2 DHT 11

Figure 2 shows a DHT11 sensor, a fundamental and cost-effective digital temperature and humidity sensor that utilizes a capacitive humidity sensor and a thermistor to measure ambient air conditions. It generates a digital signal on the data pin and can also provide an analog signal on the analog pin for temperature readings. This sensor is widely used for monitoring environmental parameters in various applications due to its simplicity and affordability.

Figure 2. DHT 11

4.1.3 L298 Motor Driver

The L298 motor driver as shown in Figure 3 is a dual H-bridge IC used to control and drive DC motors or stepper motors. It can handle high currents and voltages, making it suitable for robotics and mechatronics applications.

Figure 3. L298 Motor Driver

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4.1.4 HC-SR04 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor as shown in Figure 4 is a popular distance measuring module. It emits ultrasonic waves and measures the time taken for the waves to bounce back after hitting an object, allowing it to calculate distance. This sensor is widely used in robotics, automation, and proximity sensing applications for accurate distance measurements.

Figure 4. Ultrasonic Sensor

4.1.5 LDR Sensor

An LDR (Light Dependent Resistor) sensor as shown in Figure 5 is a type of photocell that changes resistance based on light levels. In low light, its resistance is high, and in bright light, its resistance decreases. LDRs are used in light-sensing applications like streetlights and camera exposure control.

4.1.6 Other Electronic Devices

Various electronic components such as jumper cables, breadboard, LED, heater, fan, DC power supply, 5-12V DC motor, relays, switches, and more were employed in the research.

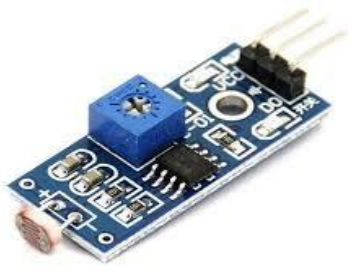

Figure 5. LDR Sensor

4.2 Software Requirements

4.2.1 ThingSpeak

ThingSpeak is an IoT analytics platform service designed for aggregating, visualizing, and analyzing realtime data streams in the cloud. It enables users to create visual representations of data transmitted by their devices to the ThingSpeak platform, facilitating instant data visualization and analysis.

4.2.2 Proteus

Proteus is a software tool utilized for simulating, designing, and creating electronic circuits. Developed by Labcenter Electronics, Proteus enables the creation of two-dimensional circuit designs and facilitates circuit simulation for analysis and testing prior to physical implementation.

4.2.3 Arduino IDE

The Arduino IDE (Integrated Development Environment) is dedicated software for programming Arduino microcontrollers. It functions as a comprehensive text editor with specialized features tailored for writing, compiling, and uploading code to Arduino boards. This software also supports NodeMCU, enabling users to develop and deploy code seamlessly across compatible platforms.

5. Methodology

5.1 Hardware Development

For our hardware setup, we used the NodeMCU ESP8266 microcontroller board to integrate essential sensors for poultry farm automation. This included the DHT11 sensor for monitoring temperature and humidity, an ultrasonic sensor for distance measurement, and an LDR sensor for light detection. Additionally, we employed an L298 motor driver to control a fan, heater, and a DC motor connected to a spiral conveyor belt for automated feeding. This setup enabled precise environmental monitoring and efficient farm operation management.

5.2 Software Development

In the software domain, we developed code using C++ within the Arduino IDE to program the NodeMCU ESP8266 board. This software implementation was vital for establishing seamless communication with the ThingSpeak software platform. Through this integration, we were able to send real-time temperature and humidity data collected by the DHT11 sensor to ThingSpeak for remote monitoring and analysis. Furthermore, we leveraged the capabilities of the ultrasonic sensor and LDR sensor within our software to implement automation features. This allowed us to automate the lighting and watering systems in the poultry farm based on sensor inputs, contributing to improved efficiency and operational control.

5.3 Block Diagram

Figure 6 shows the block diagram of our research where temperature and pulse sensors are connected to Arduino and the data sensed by sensors is displayed in an LCD screen interfaced with I2C. Arduino is connected to NodeMCU by serial communication. Similarly, GPS Module is connected to NodeMCU which traces the location. The data sensed by sensors and location traced by GPS module is sent to the IOT cloud and further retrieved to MySQL database. Finally, the data is fetched on our website where we can inspect and monitor for further enhancement and efficiency.

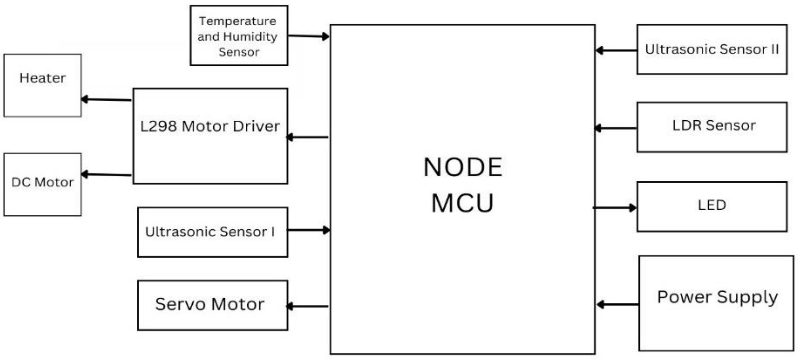

Figure 6. Block Diagram

5.4 Circuit Diagram

As shown in Figure 7, we used the NodeMCU microcontroller for our circuit setup. The DHT11 temperature and humidity sensor is connected to the NodeMCU through the D2 data pin to monitor temperature and humidity levels, and this data is sent to a website. An LDR sensor is connected to the NodeMCU using the A0 analog pin to detect ambient light levels. Additionally, we integrated an ultrasonic sensor with the NodeMCU through the D4 data pin for measuring distances, and an LED is connected to the NodeMCU through the D6 data pin for visual indication. We used an L298 motor driver with the NodeMCU, connected through four data pins (D0, D1, D2, D3), to control a DC motor attached to the OUT3 and OUT4 terminals of the motor driver. Furthermore, a servo motor operates using the 3V output and is connected to the D8 data pin of the NodeMCU.

This description outlines the detailed circuit connections enabling sensor interfacing and motor control using the NodeMCU microcontroller.

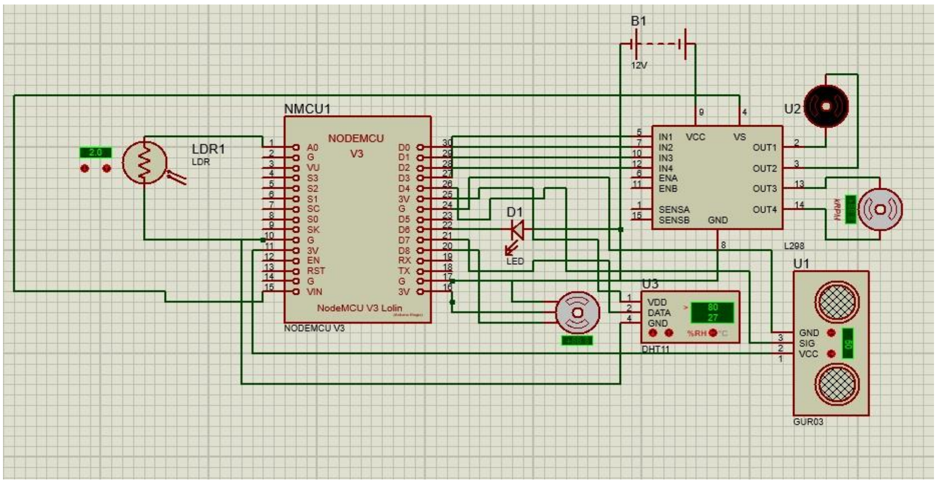

Figure 7. Circuit Diagram

5.5 Working Principle

5.5.1 Environment Management

As shown in Figure 8, we have designed a system utilizing the NodeMCU microcontroller as the central processing unit. The entire system's program logic is stored within this microcontroller. Integrated within the system is a DTH11 temperature and humidity sensor. When the temperature rises above a certain threshold, indicating high temperature, the system triggers a fan. Conversely, when the temperature drops below a specified threshold, signaling low temperature, the system activates a heater (a prototype LED is used to simulate this). Recognizing the inverse relationship between temperature and humidity, the system adjusts humidity levels accordingly. As the temperature rises, humidity decreases, and vice versa. Realtime data captured by the temperature and humidity sensor is transmitted to the ThingSpeak server. This data can be accessed through any internet-connected smart device, allowing users to monitor temperature and humidity levels through the ThingSpeak GUI. Additionally, the system incorporates a Light Dependent Resistor (LDR) to determine ambient light conditions. When it detects darkness, the system automatically switches on an LED for illumination. Conversely, when light levels increase, the LED is turned off.

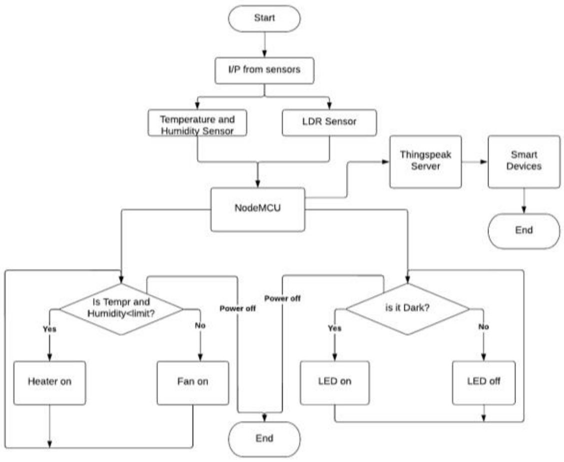

Figure 8. Flowchart for Environment Automation

5.5.2 Feeding and Water Automation

As shown in Figure 9, we designed and implemented a feed distribution system utilizing an auger system, which operates as a spiral conveyor to deliver feed from a container to the feeders. A 12V DC motor drives the auger. When the feeding container is empty, I manually activate the auger system using a switch as needed. For water distribution to chickens, nipple waterers were employed. To monitor water levels in the main reservoir, an ultrasonic sensor was integrated. When the water level falls below a certain threshold, a servo motor was programmed to regulate the flow of water through a direct pipe into the reservoir, ensuring a constant water supply.

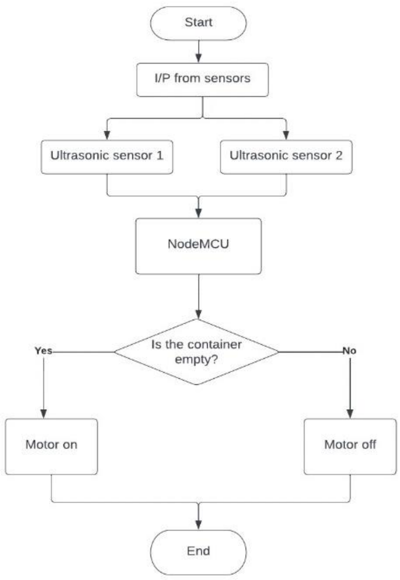

Figure 9. Flowchart for Feeding and Water Automation

6. Results and Discussion

After the successful completion of the research, it was observed that the system demonstrated remarkable capabilities. These included self-maintenance of humidity and temperature levels through the integration of a fan and heater. Additionally, it incorporated automated lighting systems that adjusted according to environmental conditions. Furthermore, an automated food and water feed system, employing ultrasonic sensors and motors, was implemented. Real-time monitoring of temperature and humidity parameters was achieved by sending data to a remote server, accessible through smart devices. The designed prototype is depicted in Figure 10, showcasing its physical manifestation. Additionally, a snapshot of the software implementation and observations is presented in Figure 11, providing insights into the system's functionality and performance.

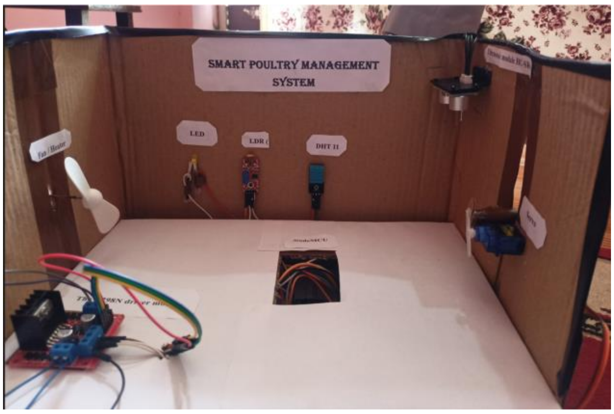

Figure 10. Designed Prototype

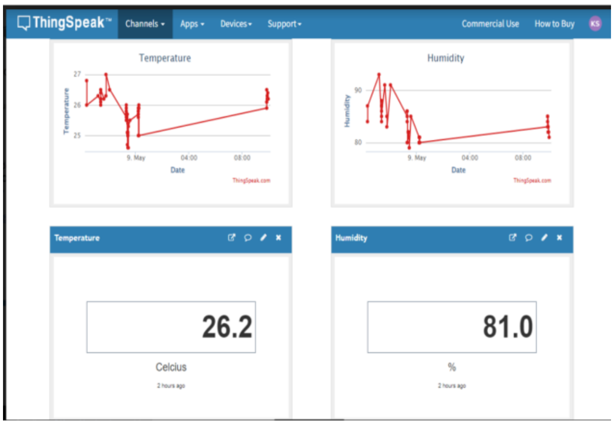

Figure 11. Software Implementation

7. Conclusion

The prototype of the smart poultry management system was successfully designed according to planned procedures and an appropriate circuit diagram. The output of the project was exactly as per intentions within the expectations and margin of error. The prototype was able to maintain environmental conditions like temperature, humidity, and lighting and send the data to the remote server, SmartThings, for remote monitoring. The prototype was also able to bring automation in food and water supply to the poultry farm using sensors and motors.

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