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IoT-Based Smart Poultry Farm Monitoring and Controlling Using Raspberry Pi

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Abstract: This research paper presents the implementation of an intelligent system for monitoring and controlling a poultry farm using a Linux-based web server, Raspberry Pi, and Arduino Uno. The proposed system monitors environmental conditions and adjusts them accordingly. The paper also demonstrates the serial peripheral communication and USB protocol communication between Raspberry Pi and Arduino Uno. The Raspberry Pi acts as an embedded web server, while the Arduino Uno reads sensor values. The integration of an embedded web server enables the utilization of Internet of Things (IoT) principles. The objective of this study is to monitor and control the environmental conditions within the poultry farm, including parameters such as humidity, temperature, brightness, and air quality. The system offers remote management capabilities, allowing farmers to effectively monitor and control their farms from remote locations. This remote accessibility contributes to cost reduction, improved quality, and efficient management of the poultry farming process. The findings of this research highlight the usefulness of the proposed system in enhancing farm management in remote areas. By leveraging IoT principles and the combined power of Raspberry Pi and Arduino Uno, farmers can monitor and adjust environmental conditions to ensure optimal conditions for the poultry. This system empowers farmers with real-time data, enabling them to make informed decisions and improve the overall productivity and well-being of their poultry farms.

Keywords: *IoT (Internet of Things), Raspberry Pi, DHT11, MQ 135, Arduino.*

1. Introduction & Literature Review

This study focuses on the agricultural wealth of Maharashtra state in India, particularly in terms of food production and environmental resources. Poultry farming, especially the production of eggs and chicken meat, plays a significant role in providing a rich source of protein, vitamins, and minerals. The poultry industry contributes to the income and employment opportunities of numerous farmers in Maharashtra. However, despite its prosperity, agricultural productivity and farmer incomes remain relatively low.

The growth and health of chickens are heavily influenced by environmental conditions such as temperature, humidity, air quality, and gas concentrations within the poultry farm. Unsuitable environmental conditions can lead to growth problems and health issues among the chickens. Ensuring the optimal environmental conditions for chickens is crucial for their rapid growth and market demand. Poultry farms are designed to control environmental parameters through facilities such as ventilation, cooling, and lighting systems on roofs, walls, and floors. Micro-level climate control is essential for the well-being of the birds.

Research on advanced automation technologies in poultry farming is increasing, with a focus on monitoring and controlling environmental parameters such as temperature, humidity, air quality, and gas concentrations. Deviations from suitable environmental conditions can negatively impact the chickens' digestion, respiration, and behavior. By providing chickens with suitable atmospheric conditions and proper nutrition, they can grow rapidly and maintain good health, resulting in increased weight gain within a specific time frame. Climate also plays a vital role in chicken growth. Smart poultry farms are designed to control or adjust climate conditions through ventilation, cooling, heating, and other systems, thereby maximizing chicken production and farmers' income.

The continuous advancement of automation technologies in poultry farming contributes to increased production and improved income for farmers. By optimizing and maintaining favorable environmental conditions for

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chickens, farmers can achieve better results and enhance the overall efficiency of the poultry farming industry.

Study 1: "IoT-Based Smart Agriculture: A Review". This comprehensive review paper explores various aspects of IoT-based monitoring and control systems in agriculture. It covers topics such as sensor technologies, data analytics, communication protocols, and decision support systems. The paper discusses the potential benefits of IoT in improving crop yield, resource management, and environmental sustainability.

Study 2: "Smart Poultry Farm: An IoT-based Approach for Poultry Monitoring" .This research paper focuses specifically on IoT-based monitoring systems for poultry farms. It discusses the integration of sensors for monitoring environmental parameters like temperature, humidity, and air quality. The paper highlights the advantages of real-time data collection and remote monitoring, enabling farmers to make informed decisions for optimal poultry management.

Study 3: "Wireless Sensor Network for Poultry Farm Monitoring and Controlling System". This study presents a wireless sensor network (WSN) for monitoring and controlling poultry farms. It emphasizes the use of WSN technology to collect data on temperature, humidity, and gas concentrations. The paper discusses the implementation of a control system that adjusts environmental conditions based on sensor data to ensure optimal poultry health and growth.

Study 4: "An IoT-Based Smart Farming System for Poultry Farm Monitoring and Control". This research paper proposes an IoT-based smart farming system specifically designed for poultry farms. It discusses the integration of sensors, actuators, and IoT platforms to monitor and control parameters such as temperature, humidity, and lighting. The paper presents a prototype implementation and highlights the benefits of remote monitoring and control in improving poultry farm management.

Study 5: "IoT-Based Environmental Monitoring and Control System for Sustainable Agriculture". This study focuses on the development of an IoT-based environmental monitoring and control system for sustainable agriculture. It discusses the integration of sensors, actuators, and cloud-based platforms to collect and analyze environmental data. The paper emphasizes the importance of real-time monitoring and control in optimizing resource utilization and improving crop yield.

Study 6: "Smart Agriculture: IoT-Based Monitoring System for Crop Cultivation". This research paper explores the application of IoT-based monitoring systems in crop cultivation, including aspects related to irrigation, soil moisture, and pest control. While not specifically focused on poultry farming, the paper discusses the potential of IoT technologies in improving agricultural practices and reducing resource wastage.

These research papers provide valuable insights into the development and implementation of IoT-based monitoring and control systems in agriculture and poultry farming. They highlight the advantages of real-time data collection, remote monitoring, and adaptive control mechanisms, emphasizing the potential for improved productivity, resource management, and environmental sustainability in the agricultural sector

System Model:

A. Transmitter Section

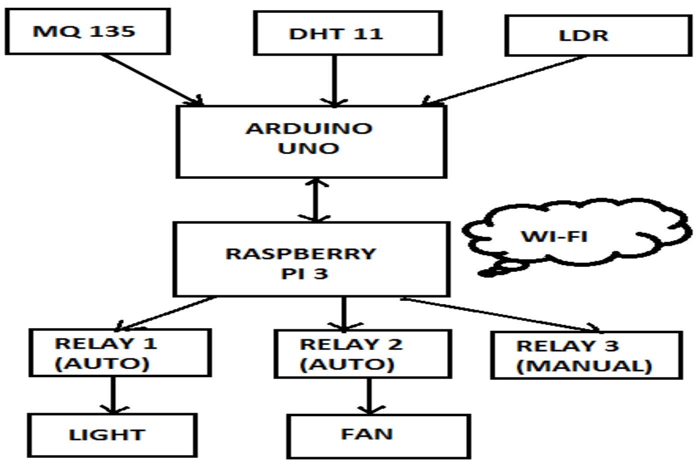

Fig. 1: Block Diagram of Transmitter of System

B. Receiver Section

Fig. 2: Block Diagram of Receiver of System

2. Problem Formulation:

In April 2015, Siwakorn Jindarat developed a system called "Smart Farm monitoring using Raspberry Pi and Arduino Uno." However, that system had some disadvantages, including the reliance on a mobile communication network for communication, limited number of users, and restricted access to information only through a Smartphone. Additionally, the system only had an automatic mode, whereas the proposed system includes both automatic and manual modes to cater to different requirements. In the proposed system, a separate network is created for communication between the farm and the user, allowing data access on various devices such as laptops, computers, tablets, and smart phones.

The main components of the developed system are Arduino Uno and Raspberry Pi 3. These systems are responsible for controlling, monitoring, and making decisions regarding the environmental conditions inside the poultry farm. Raspberry Pi hardware comes in different versions with variations in performance, memory capacity, and peripheral device support. The developed system monitors and reads all environmental parameters inside the poultry farm using the Arduino Uno controller. After reading the data, it is inserted into a database and compared with predefined threshold values. If the data value exceeds the threshold, a high output signal is sent to the corresponding port. If the value is below the threshold, the system continues to read the environmental parameters. The system focuses on monitoring temperature, humidity, and luminescence inside the poultry farm. For example, if the humidity exceeds the threshold value, the FAN OUT will be activated to control the humidity. If not, the system continues to monitor the environmental data. Similarly, for luminescence, if the change is significant, the lights will be turned on, and if not, the system continues to read the data. Real-time notifications and results are sent to a computer, Smartphone, or laptop via IoT. The system generates alert notifications if any of the environmental conditions change. The values of temperature, humidity, gases, and light intensity are displayed on electronic devices such as smart phones, desktop computers, or laptops. The real-time values of the environmental conditions are stored in a database for predictive analysis. The outputs from temperature, humidity, and light sensors are fed to Raspberry Pi via Arduino, allowing control of the environmental conditions by turning on/off fans, lights, etc. The respective sensor values are also displayed on a web page using an IoT application.

3. Hardware:

A. Raspberry Pi

Raspberry Pi is a versatile and compact computer that operates on the Linux operating system. It can be connected to a computer monitor, keyboard, and mouse, making it a convenient option for various applications. One of the simplest uses of a Raspberry Pi is as a desktop computer. In addition to the Raspberry Pi itself, a micro SD card and power supply are required. To connect the Raspberry Pi to a display, an HDMI cable and a compatible monitor are needed. Similarly, like a traditional computer setup, a USB keyboard and mouse are essential peripherals for interaction. The GPIO (General Purpose Input/output) pins of the Raspberry Pi can be utilized as digital input or output channels, both requiring a 3.3V voltage level. It's important to note that the Raspberry Pi does not have any built-in analog inputs. To obtain analog data input, an external analog-to-digital converter (ADC) must be employed. Alternatively, connecting the Raspberry Pi to an interface board that incorporates ADC functionality is another viable option. Overall, the Raspberry Pi offers a compact and flexible computing solution, and its GPIO pins provide the ability to interface with various sensors, actuators, and external devices through digital input/output.

B. Arduino

The Arduino Uno is an open-source microcontroller board that is widely used and compatible with various development platforms. It offers the capability to read inputs from different sources, such as sensors or buttons, and convert them into outputs, such as activating motors or LEDs, or even publishing data online. One of the advantages of the Arduino Uno is its onboard analog-to-digital converter (ADC), which enables easy interaction with analog signals. This allows for precise measurements and control of analog inputs and outputs, expanding the range of applications that can be implemented. The Arduino Uno can be connected to a computer via a USB port, which serves as both a power source and a means of communication. This allows for seamless integration with the Arduino IDE (Integrated Development Environment), enabling programming and uploading of code directly to the board. Additionally, the USB connection enables communication with other devices or accessories, both in analog and digital formats, expanding the possibilities for creating interactive projects. Overall, the Arduino Uno provides a user-friendly and versatile platform for developing interactive projects and prototypes. Its compatibility with a wide range of development environments and its ability to handle both analog and digital signals make it a popular choice for makers, hobbyists, and professionals alike.

C. Gas sensor

The MQ-135 gas sensor is a popular choice for detecting gas leakage in both household and industrial settings. It is specifically designed to detect gases such as LPG (liquefied petroleum gas), i-butane, propane, methane, alcohol, hydrogen, and smoke. The selection of the MQ-135 sensor is based on its beneficial features, which are as follows:

- Fast Response: The MQ-135 sensor exhibits a fast response time, allowing for quick detection of gas presence. This is crucial for timely identification and mitigation of potential gas leaks, ensuring the safety of individuals and property.

- Adjustable Sensitivity: The sensitivity of the MQ-135 sensor can be adjusted, enabling customization based on specific application requirements. This flexibility allows for fine-tuning the sensor's response to different gas concentrations, optimizing its performance for various scenarios.

- Wide Gas Coverage: The MQ-135 sensor is designed to detect a range of gases, including LPG, i-butane, methane, alcohol, hydrogen, and smoke. This broad gas coverage makes it versatile and suitable for detecting multiple types of potential gas leaks, providing comprehensive safety monitoring.

- Grove Connector Compatibility: The MQ-135 sensor is equipped with a Grove connector, which simplifies its integration into electronic systems and sensor networks. The Grove connector facilitates easy and secure connections, ensuring reliable communication with microcontrollers or other devices for gas leakage detection.

By utilizing the MQ-135 gas sensor, the detection of gas leakage in various environments becomes more efficient and effective. Its fast response, adjustable sensitivity, wide gas coverage, and compatibility with Grove connectors make it a valuable component for ensuring the safety and security of both residential and industrial settings.

D. Humidity Sensor

A humidity sensor is a device used to sense, measure, and report the relative humidity present in the air. One commonly used humidity sensor is the DHT11, which is capable of measuring both moisture and air temperature. The sensor consists of a dedicated Negative Temperature Coefficient (NTC) element for temperature measurement and an 8-bit microcontroller that provides serial data output for both temperature and humidity values. The DHT11 humidity sensor incorporates a capacitive sensor for detecting moisture levels, high-precision temperature measurement components, and is connected to a high-performance 8-bit microcontroller. The sensor is known for its excellent quality, rapid response time, strong anti-jamming capabilities, and relatively low cost, making it a popular choice in various applications. It’s important to note that relative humidity is influenced by changes in temperature. As air temperature increases, it can hold more moisture, resulting in a decrease in relative humidity. Conversely, as air temperature decreases, the capacity to hold moisture decreases, causing an increase in relative humidity. By utilizing a humidity sensor like the DHT11, accurate measurements of humidity and temperature can be obtained. This information is essential in various industries and applications, including climate control systems, agriculture, storage facilities, and many more, where monitoring and controlling humidity levels are crucial for optimal performance and environmental conditions.

E. LDR

A Light Dependent Resistor (LDR), also known as a photo-resistor, photoconductor, or cadmium sulfide

(CdS) cell, is a type of passive component that operates based on the principle of photoconductivity. It functions as a resistor whose resistance value decreases as the intensity of light increases. The LDR consists of a semiconductor material, typically cadmium sulfide (CdS), which exhibits photoconductive properties. When light falls on the sensor, photons are absorbed by the semiconductor material, liberating electrons and increasing its conductivity. As the intensity of light surpasses a certain threshold, the photons absorbed by the semiconductor provide enough energy for electrons to move from the valence band to the conduction band. This results in the conduction of electricity by the free electrons or holes, causing a significant drop in resistance. The resistance of an LDR varies inversely with the amount of light falling on it. In bright conditions, the LDR exhibits low resistance, allowing current to flow more easily. In contrast, in low-light or dark conditions, the LDR has high resistance, restricting the flow of current .LDRs find extensive use in various applications, including light-sensing circuits, automatic lighting control systems, photography, solar panels, and many more. Their ability to change resistance based on light intensity makes them valuable components in circuits that require light detection or ambient light measurement. Overall, LDRs provide a simple and cost-effective solution for light sensing and control applications. Their characteristic resistance variation with light intensity enables them to respond to changes in the surrounding illumination, making them widely used in numerous electronic devices and systems.

System Connection:

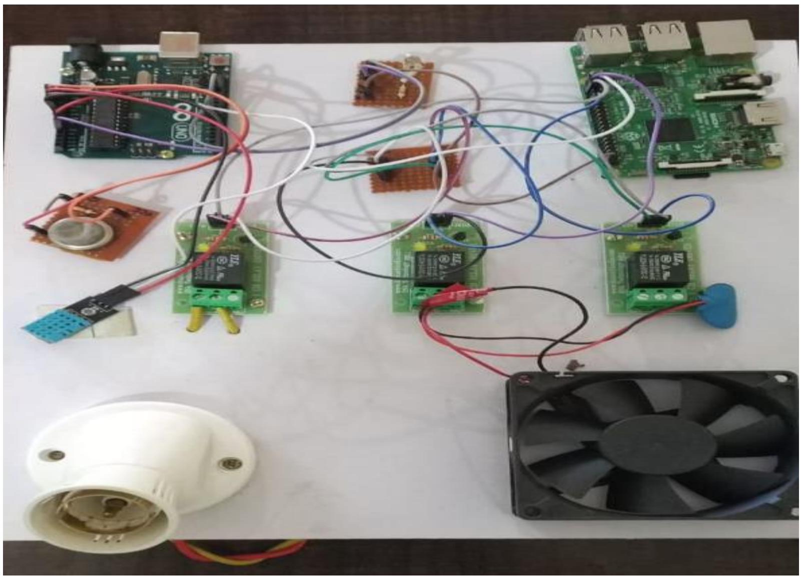

Fig. 3: Show the connection of the system.

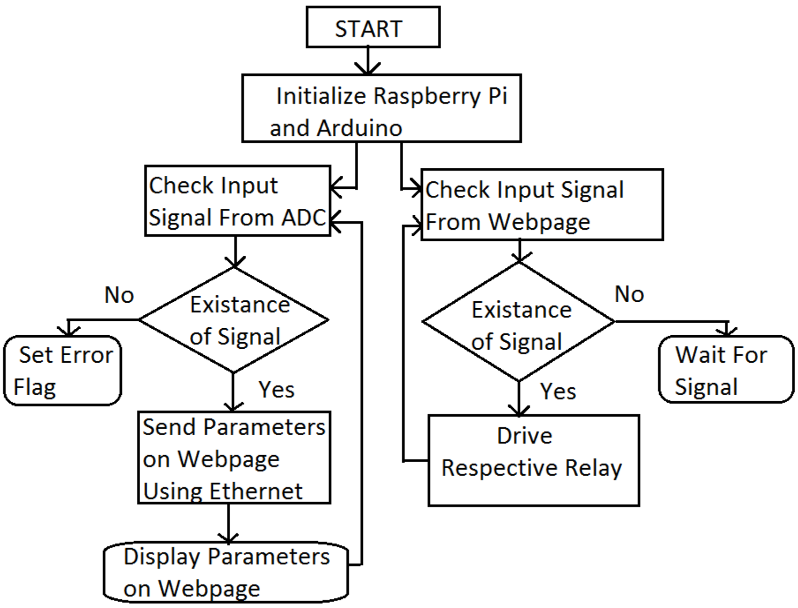

Fig. 4: Flowchart of the System.

The flowchart represents the operation of an IoT-based smart poultry farm system. Arduino Uno measures the data values from various sensors present in the poultry farm, such as temperature, humidity, and other environmental parameters. The measured data values are compared with predefined threshold values that have been set to ensure optimal conditions in the poultry farm. If the measured values exceed the predefined threshold, indicating a deviation from the desired conditions, a notification is sent to a webpage through the internet. This notification could be in the form of an alert or status update. Additionally, the controlling device, which is connected to the Raspberry Pi, is turned on or off based on the measured values and threshold comparison. The controlling device could be a fan, heater, or any other equipment used to regulate the environmental conditions in the poultry farm. The Arduino Uno communicates the measured data to the Raspberry Pi via a USB connection. The Raspberry Pi acts as a central control unit, receiving the data from Arduino Uno and making decisions based on the predefined thresholds. The Raspberry Pi utilizes the received data to control the environmental conditions in the poultry farm. It interacts with external devices, such as turning on or off the controlling device, to maintain the desired parameters.

Overall, the flowchart illustrates the sequence of operations in the IoT-based smart poultry farm system, where Arduino Uno collects sensor data, Raspberry Pi analyzes and controls the conditions, and notifications are sent when necessary.

4. Result and Discussion:

The developed system for the poultry farm focuses on monitoring and controlling the environmental conditions and climate. The system includes a webpage with the following features:

1. Login Form: The main screen of the webpage presents a login form to ensure secure access to the sensor information. Users are required to enter their username and password to gain access to the system.
2. Dashboard Screen: Upon successful login, the webpage displays a dashboard screen. The dashboard provides real-time information about the environmental conditions in the poultry farm. This includes the current temperature, air moisture level, light intensity, air quality, and other relevant parameters. These values are continuously updated to provide an accurate representation of the farm's environment.
3. Environmental Control: The system allows for both automatic and manual control of the environmental conditions inside the poultry farm. Users have the option to select either auto or manual mode for controlling the conditions.
4. Automatic Mode: In automatic mode, the system utilizes predefined thresholds and algorithms to automatically regulate the environmental conditions. This may involve controlling the lights, fans, or other devices based on the measured values and desired parameters.
5. Manual Mode: In manual mode, users have direct control over the environmental conditions. The webpage provides controls for adjusting the lights and fans manually. This allows users to override the automatic control and make immediate changes as per their requirements.

The system's webpage provides a user-friendly interface, allowing poultry farm owners or personnel to easily access sensor information, monitor the environmental conditions, and make necessary adjustments for maintaining an optimal climate inside the farm.

5. Conclusion:

The implemented system for the poultry/chicken farm has undergone thorough testing and has been found to be highly effective. The system has the capability to transform traditional farms into "Automatic Smart Farms," bringing automation and advanced monitoring to the poultry industry. The system's compatibility with computers, smart phones, and laptops makes it easily accessible for users. With just a few clicks, farmers can access real-time information about the environmental conditions within the poultry farm. This accessibility enhances convenience and enables farmers to monitor and manage the farm remotely. By adopting this system, poultry farmers can benefit in various ways.

- Firstly, it reduces the need for manual monitoring and intervention, saving valuable time and reducing labor costs.
- The system automates tasks and provides real-time updates, allowing farmers to make informed decisions and take necessary actions promptly.
- Moreover, the user-friendly interface of the system ensures that farmers can navigate and utilize the system without extensive technical knowledge.
- This ease of use eliminates barriers and empowers farmers to leverage the system's capabilities effectively.

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