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SMART WAREHOUSE MONITORING AND CONTROL SYSTEM USING IOT

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Abstract
Efficient monitoring and control of storage environments are essential for reducing post-harvest losses and improving a country's agricultural supply chain sustainability. Traditional warehouses rely heavily on manual inspection to monitor environmental parameters such as temperature, humidity, and air quality, which often results in delayed responses to unfavorable conditions and increased spoilage of stored grains. This paper presents a Smart Warehouse Monitoring and Remote-Control System that integrates Internet of Things (IoT) sensing technologies with a GSM-based remote-control module. The proposed system uses low-cost sensors to continuously monitor parameters including temperature, humidity, air quality, light intensity, and movement inside the warehouse. Sensor data is processed using a microcontroller and transmitted through a wireless network for real-time monitoring in dashboard. In addition to environmental monitoring, a SIM800L GSM module is incorporated to enable remote control of critical electrical devices. The GSM-based smart switch was implemented to operate agricultural pumps remotely using phone calls or SMS, addressing common challenges faced by farmers such as night-time irrigation, long travel distances to fields, and management of multiple farming locations. This remote switching mechanism can also be extended to control warehouse equipment such as ventilation systems, lighting, or safety mechanisms. The proposed solution offers a low-cost, scalable, and practical approach for integrating smart monitoring and remote automation in agricultural storage infrastructure.

Keywords: *Internet of Things, Environmental Monitoring, Post-Harvest Loss Reduction, Agricultural Storage Systems, Industry 4.0*

1. Introduction
Efficient storage and management of agricultural produce is a critical component of the supply chain and self-sufficiency, particularly in developing countries where a large portion of food loss occurs after harvest. In India, a significant percentage of stored grains and perishable commodities deteriorate during storage due to poor environmental monitoring and delayed intervention. Traditional warehouse relies on manual inspection to monitor parameters such as temperature, humidity, air quality, and security conditions. These approaches are often inconsistent and incapable of detecting rapid environmental changes, leading to mould formation, pest infestation, and degradation of stored food materials. As a result, warehouses experience substantial economic losses and reduced food quality. Recent advances in the Internet of Things (IoT) have introduced new possibilities for real-time

environmental monitoring and automation in storage facilities. IoT-enabled sensor networks allow continuous observation of critical parameters such as temperature, humidity, gas concentration, light intensity, and movement. By integrating these sensors with microcontrollers and wireless communication technologies, warehouse managers can obtain real-time insights into storage conditions and receive alerts when environmental thresholds are exceeded. Such systems help prevent spoilage, improve operational efficiency, and reduce dependency on manual monitoring. In addition to monitoring, remote control of electrical equipment plays an important role in agricultural infrastructure. Farmers often face practical challenges when operating irrigation pumps or electrical devices located far from residential areas or spread across multiple fields. Night-time irrigation, long travel distances, and the absence of reliable automation mechanisms create inconvenience and safety risks. To address this issue, a GSM-based remote switching mechanism using the SIM800L module can enable users to control electrical devices through mobile phone calls or SMS commands. This paper presents a smart system that combines IoT-based warehouse monitoring with GSM-enabled remote-control capabilities. The proposed framework integrates multiple environmental sensors with a microcontroller for real-time monitoring while incorporating a GSM-based smart switch for remote device operation. The system is designed to be low-cost, scalable, and suitable for agricultural and rural applications. By combining environmental sensing with remote automation, the proposed approach contributes to improved storage management, reduced post-harvest losses, and enhanced convenience for farmers and warehouse operators.

2. Methodology / Proposed System

The proposed system integrates Internet of Things (IoT) based environmental monitoring with GSM-enabled remote control to create a smart and automated warehouse management framework. The architecture is designed to continuously observe storage conditions, detect abnormal environmental changes, and enable remote operation of electrical devices when required. The system consists of three primary layers: the sensing layer, the processing layer, and the communication and control layer.

Sensor Layer:

The sensing layer is responsible for collecting environmental data from different parts of the warehouse. Multiple low-cost sensors are deployed to monitor parameters that directly affect the quality and safety of stored agricultural products. The DHT11 temperature and humidity sensor measures ambient temperature and relative humidity levels, which are critical factors influencing mould growth and grain deterioration. Maintaining stable humidity and temperature helps prevent moisture accumulation and microbial activity inside storage units. To monitor air quality, the MQ-135 gas sensor is used to detect gases such as ammonia, carbon dioxide, and other volatile compounds that may indicate fermentation, decomposition, or poor ventilation inside the warehouse. Early detection of such gases allows timely corrective actions before stored materials become spoiled. A PIR motion sensor is incorporated to detect movement within the warehouse. This helps identify unauthorized access, pest activity, or human presence during restricted periods, thereby improving security and safety. Additionally, an LDR (Light

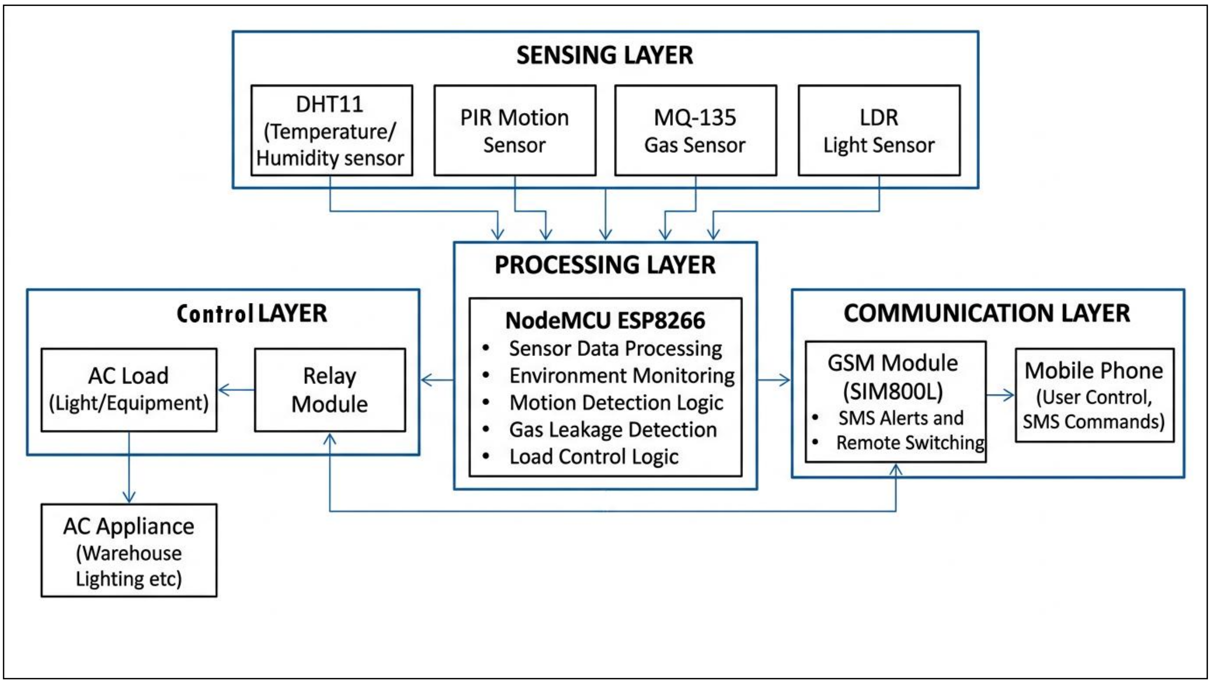
Dependent Resistor) is used to monitor ambient light intensity. Sudden changes in light levels may indicate door openings, human activity, or improper storage conditions.

Processing Layer:

The processing layer is responsible for collecting, analysing, and managing the data obtained from the sensors. A NodeMCU development board based on the ESP8266 microcontroller is used as the central processing unit. The microcontroller receives signals from the connected sensors, processes the data, and determines whether the readings fall within safe operational limits. If any environmental parameter exceeds predefined threshold values, the system generates alerts and sends the information through the communication network for monitoring. The microcontroller's built-in Wi-Fi capability allows seamless connectivity with cloud platforms or monitoring dashboards where warehouse conditions can be observed in real time.

Communication and Control Layer:

The communication and control layer ensure remote monitoring and device automation. Sensor data collected by the microcontroller is transmitted through wireless communication to a monitoring interface where warehouse managers can observe environmental conditions and receive alerts. In addition to monitoring, the system incorporates a GSM-based smart switching mechanism using the SIM800L module. This module enables remote control of electrical equipment through mobile phone calls or SMS commands. The GSM module communicates with the microcontroller to activate or deactivate connected devices such as irrigation pumps, ventilation systems, lighting units, or other electrical loads. The GSM smart switch was initially implemented for controlling agricultural water pumps, allowing farmers to operate irrigation systems remotely without physically visiting the field. This feature is particularly beneficial during night-time irrigation or when farmers manage multiple agricultural locations. The same remote-control mechanism can also be extended to warehouse applications, enabling operators to remotely activate ventilation systems, security lighting, or other equipment when abnormal environmental conditions are detected. By combining IoT-based sensing with GSM-enabled remote control, the proposed system provides an integrated solution for smart monitoring and automation in agricultural storage and infrastructure management.



Block Diagram

3. Results and Discussion

The proposed smart warehouse monitoring and remote-control system was successfully implemented using a combination of IoT sensors, a microcontroller platform, and a GSM communication module. The integrated system demonstrated the capability to continuously monitor environmental conditions inside a storage environment and enable remote control of electrical devices when required. During system operation, the deployed sensors successfully collected real-time data related to temperature, humidity, air quality, light intensity, and motion within the monitored area. The NodeMCU microcontroller processed these sensor readings and transmitted them through wireless communication, allowing environmental conditions to be observed remotely. When environmental parameters approached unsafe levels, the system generated alerts that could prompt corrective actions such as improving ventilation or adjusting storage conditions. Continuous monitoring helped identify fluctuations that could potentially lead to grain spoilage or deterioration if left unattended. The GSM-based remote switching mechanism using the SIM800L module was also tested successfully. The system allowed users to control electrical devices such as irrigation pumps through mobile phone calls or SMS commands. This functionality proved particularly useful for agricultural applications where farmers may need to operate pumps during night hours or from distant locations. The GSM module reliably received commands and triggered the corresponding switching operation through the connected relay module. The combined use of IoT monitoring and GSM-based remote control enhances the practicality of the system by addressing both environmental monitoring and device automation. The proposed approach demonstrates that low-cost hardware components can be effectively integrated to create scalable and efficient smart infrastructure solutions for agricultural storage and rural applications. The system provides a foundation for future improvements such as cloud-based analytics, mobile applications, and predictive monitoring capabilities.

4. Conclusion

This paper presented a smart warehouse monitoring and remote-control system that combines Internet of Things (IoT) sensing technologies with GSM-based automation. The proposed system enables continuous monitoring of critical environmental parameters such as temperature, humidity, air quality, light intensity, and motion within a warehouse environment. By using low-cost sensors integrated with an ESP8266 microcontroller, the system provides real-time data collection and helps detect unsafe storage conditions that may lead to spoilage or degradation of agricultural products. In addition to environmental monitoring, the integration of a GSM-based smart switching mechanism using the SIM800L module enables remote control of electrical devices through mobile phone calls or SMS commands. This functionality addresses common challenges faced by farmers and warehouse operators, particularly when managing irrigation systems or electrical equipment located at remote sites. The system reduces the need for constant physical supervision while improving operational efficiency. The proposed framework demonstrates that affordable IoT and GSM technologies can be effectively used to enhance agricultural infrastructure and storage management. Future improvements may include cloud-based analytics, mobile application integration, solar-powered operation, and AI-based predictive monitoring to further enhance automation, scalability.

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