Smart Warehouse and Crop Monitoring System

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Abstract— **In India, agriculture is crucial for both economic gain and food security. However, farmers face challenges in storing agricultural products, leading to significant losses. Food wastage, accounting for almost fifty percent of global production, exacerbates the problem. Storage losses, especially in granaries and warehouses, pose a threat to farmers.**

To address this, we present an IoT-enabled solution—a sensor based module for monitoring and controlling the storage process. Deployable in remote areas with limited accessibility, this system aims to reduce food losses, enhance food safety, and improve overall food accessibility for farmers relying on warehouses for crop protection.

Keywords— smart agriculture, food security, remote monitoring, smart warehouse

I. Introduction

In the Indian agricultural landscape, where the sector plays a pivotal role in economic growth and food security, challenges persist in the storage of agricultural products, resulting in significant losses. A staggering fifty percent of global food production is lost to wastage, exacerbating the difficulties faced by farmers. Storage losses, especially in granaries and warehouses, not only impact the economic viability of farming but also pose a threat to the livelihoods of those dependent on agriculture. To tackle this issue, a transformative solution is presented—an Internet of Things (IoT)-enabled system incorporating a sensor-based module designed to monitor and control the storage process. This innovative system, deployable in remote areas with limited accessibility, aims to mitigate food losses, enhance food safety, and improve overall food accessibility for farmers relying on warehouses for crop protection.

The proposed system comprises four distinct types of sensors—DHT11, PIR, MQ2, and Vibration sensor. These sensors collectively measure temperature, humidity, motion, gas levels, and vibration levels within the warehouse. At the core of the system is the ESP32 microcontroller, acting as both a Wi-Fi and Bluetooth module. The voltage inputs of the sensors and the microcontroller are interconnected, and the power supply can be sourced from parallel-connected batteries or via a DC data cable for a stable and consistent current supply throughout the setup.

The ESP32 microcontroller gathers sensor data and uploads it to the Blynk cloud using the Arduino Integrated Development Environment (IDE) as the software platform. The embedded-C language is utilized to write instructions to the sensor through the microcontroller. The processed data resides in the Blynk cloud, accessible for viewing. Security measures are implemented as the data is transferred through the secured Blynk server, ensuring the confidentiality and integrity of the information.

Each sensor in the system plays a distinct role in ensuring comprehensive monitoring of the warehouse environment. The DHT11 sensor captures temperature and humidity levels, providing critical data for the preservation of stored crops. The PIR sensor detects motion within the warehouse, alerting the system to potential intrusions or unauthorized access. The MQ2 sensor monitors gas levels, addressing concerns related to the presence of harmful gases that could compromise food safety. The Vibration sensor helps detect any unusual movements or disturbances within the storage space.

The ESP32 microcontroller acts as the central processing unit, collecting data from these sensors and transmitting it to the Blynk cloud. In the cloud, the data undergoes further processing and is presented for viewing through the Blynk application on the user's mobile phone. The seamless integration of sensor functionalities and data processing ensures a comprehensive and real-time monitoring solution.

The Blynk application serves as the user interface, allowing farmers and stakeholders to access critical data about the warehouse environment directly from their mobile phones. The application offers a user-friendly display of temperature, humidity, motion, gas levels, and vibration levels, providing valuable insights into the storage conditions. Additionally, the Blynk cloud's secure data transfer ensures the confidentiality and integrity of the information, addressing concerns related to data security.

In conclusion, this IoT-enabled system stands as a pioneering solution to the storage challenges faced by Indian farmers. By leveraging advanced sensor technology, microcontrollers, and cloud-based processing, the system not only addresses the immediate concerns of food losses but also contributes to enhancing overall food safety and accessibility. As technology continues to play a pivotal role in modern agriculture, this system represents a promising step towards a more sustainable and efficient future for Indian farmers.

II. EXISTING SYSYTEM

Nowadays, warehouses are increasingly seeking technologies with low operating costs that require minimal managerial intervention for effective storehouse management administration. Over the past few decades, advanced technologies have been integrated into storehouse management systems, reducing labor intensiveness through efficient and time-saving processes. For instance:

A. Data Entry and Paperwork:

The time spent on working with spreadsheets and ledger maintenance has significantly decreased, thanks to advancements in data entry and paperwork processes within the management system.

B. Selection Efficiency:

Computer-guided systems such as Warehouse Management Systems (WMS) enable operatives to work faster by systematically arranging tasks in real-time, enhancing overall selection efficiency.

C. Task Interleaving:

Modern technology, particularly in forklift operations, has become a powerful tool for extending system guidance to various activities, making task interleaving more effective.

The current system relies on a Quasi-Distributed Fiber Optic Temperature and Humidity Detection System for monitoring grain storage in granaries. It primarily focuses on detecting mold development on crops stored in granaries. Continuous monitoring of conditions conducive to mold growth is crucial, and today's technology is not readily available for monitoring internal humidity in large quantities. This fiber optic detector observes both the temperature of the granary itself and within the grain pile, providing longitudinal insights into temperature and humidity changes, reflecting alterations in moisture content.

Another existing system employs a mathematical model to optimize the storage and transport of food grains for the public distribution system in India. The study revealed that improper planning and scheduling of food grain movements led to increased food grain losses, higher transportation costs, underutilization of storage capacity, and subsequently elevated operational costs for FCI

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III. PROPOSED SYSTEM

This system has been intricately designed to create a highly cost-effective solution aimed at safeguarding crops from post-harvest losses. It incorporates a variety of sensors, including DHT11, MQ2, PIR, and Vibration sensors, all powered by a DC power supply that provides the necessary current for the entire system. The ESP32 Wi-Fi module serves as the central hub, connecting and coordinating these sensors.

Continuous monitoring of the crop warehouse is achieved through these sensors and modules. Data such as temperature, humidity, gas levels, smoke detection, and motion radiation is continuously gathered by the sensors and transmitted to the Blynk Cloud for processing. To ensure effective control, threshold values are set for each sensor's data. In the event that these threshold limits are surpassed, an alert is triggered, activating a buzzer alarm. Simultaneously, a notification is promptly dispatched to the user's mobile device via the Blynk application, allowing for a customized and user-friendly interface.

By implementing this innovative system, the potential for substantial crop losses in warehouses is mitigated, making a significant contribution towards alleviating food scarcity and supporting those in need. This comprehensive approach not only protects crops from post-harvest losses but also ensures timely intervention through real-time alerts, ultimately aiding in the noble cause of alleviating hunger.

IV. METHODOLOGY

The methodology employed in this research project follows a systematic approach to design and implement an effective system for maintaining optimal environmental conditions in crop storage warehouses. The key steps involve sensor selection, microcontroller integration, power supply management, data acquisition, and cloud-based data processing. The following outlines the methodology:

1. Sensor Selection:

Four types of sensors, namely DHT11 (temperature and humidity), PIR (motion), MQ2 (gas levels), and Vibration sensor (vibration levels), were carefully chosen based on their suitability for monitoring warehouse conditions.

2. Microcontroller Integration:

The ESP32 microcontroller was selected as the central processing unit due to its dual functionality as a Wi-Fi and Bluetooth module, facilitating wireless communication and data transfer. The microcontroller acts as the hub for collecting data from the sensors.

3. Power Supply Management:

Voltage inputs of all sensors and the microcontroller were interconnected to ensure a streamlined power supply. Power can be sourced from either parallel-connected batteries or a DC data cable for consistent and stable current flow throughout the system.

4. Data Acquisition:

The ESP32 microcontroller collects sensor data, incorporating temperature, humidity, motion, gas levels, and vibration levels. This data is utilized for real-time monitoring of warehouse conditions.

5. Data Transmission to Blynk Cloud:

The Arduino IDE serves as the software interface, enabling the ESP32 microcontroller to upload the collected data to the Blynk cloud. This cloudbased platform offers a secure and centralized location for processing and storing the information.

6. Programming with Embedded C Language:

Instructions for the sensors are communicated through the microcontroller using embedded-c language. This programming language ensures efficient control and coordination between the microcontroller and sensors.

7. Cloud-Based Data Processing:

The Blynk cloud processes the received data, performing necessary calculations and analyses. The processed information is then made available for visualization and further interpretation.

8. User Interface via Blynk Application:

The Blynk application on the user's mobile phone provides a user-friendly interface for accessing and viewing the monitored data. This enhances the system's usability and allows users to stay informed about the warehouse conditions remotely.

9. Secured Data Transfer:

To ensure data security and user privacy, the data is transferred through a secured Blynk server, implementing encryption protocols to safeguard sensitive information.

V. SYSTEM ARCHITECTURE

The system comprises four distinct sensors, namely the DHT11, PIR, MQ2, and Vibration sensor, designed for measuring temperature, humidity, motion, gas levels, and vibration levels within a warehouse environment. Central to the project is the ESP32 microcontroller, serving as both a Wi-Fi and Bluetooth module. The voltage inputs of the sensors and the microcontroller are interconnected. Power is supplied to these components through either parallel-connected batteries or a DC data cable commonly used for mobile phone charging, ensuring a stable and consistent flow of current throughout the system.

All sensor values are accessible to the ESP32 microcontroller, which subsequently uploads this data to the Blynk cloud using the Arduino IDE as the software interface. Instructions are communicated to the sensors through the microcontroller, employing embedded-c language for programming. The data undergoes processing within the cloud and is made available for visualization. Users can conveniently access and view the data on their mobile phones through the Blynk application. The data transfer occurs through a secured Blynk server, ensuring the security and privacy of user information.

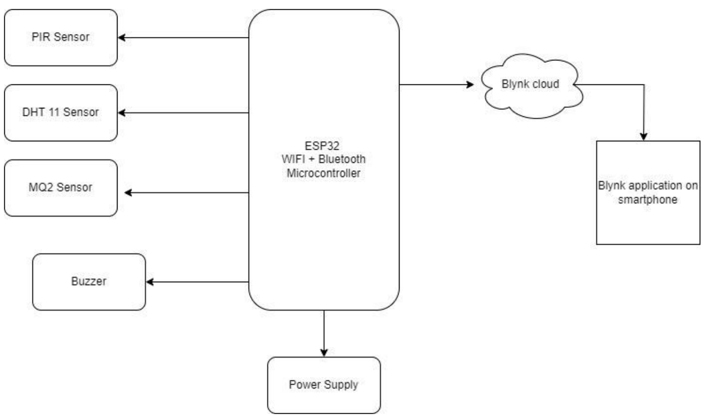

Fig1. Block Diagram

VI. EXPERIMENTAL RESULT

The experimental outcomes elucidate the process by which parameter readings are transmitted to the cloud and subsequently presented on the Blynk mobile application, accessible on a mobile device. Within the cloud platform, a comprehensive display of all readings obtained from each sensor is available. Conversely, the mobile application offers real-time representations of current parameter values, facilitating immediate oversight of the warehouse conditions. The mobile application's User Interface can be tailored to meet specific requirements.

Establishing a connection between the cloud and the mobile device mandates the transmission of an authentication pin to the user. Access to the cloud and application is contingent upon the successful validation of this authentication pin. Upon establishing the connection, the design of the mobile application can be personalized, dictating the number of buttons to be displayed in correspondence with the connected sensors. In this particular project, five buttons were integrated to exhibit values associated with Temperature, Humidity, Gas detection, Vibration Detection, and Motion Detection.

MQ2 sensor readings

Formula : Average = Sum of total readings / Total number of readings

Empty	Good Onion	Rotten Onion
2780	2612	2607
2762	2598	2629
2743	2586	2640
2731	2576	2662
2703	2559	2678
Average : 2743.8	Average : 2586.2	Average : 2643.2

VII. CONCLUSION

This project effectively addresses the challenges inherent in designing and implementing a system for maintaining optimal environmental conditions in crop storage warehouses. Beyond monitoring these conditions, the system promptly notifies users of abnormal parameter variations through a combination of a buzzer alarm and notifications. The seamless wireless communication between four sensor nodes and a central node facilitates the efficient uploading of sensing data into the Blynk Cloud, enabling the creation of sensing curves and ensuring the efficacy of the alarm system.

Looking forward, the potential applications of this system extend beyond mitigating storage losses to addressing issues such as transportation losses and crop losses in the field. By deploying suitable systems in specific areas, this project offers a cost-efficient solution that brings significant benefits, saving time and reducing labor requirements. The technology holds promise in playing a crucial role in combating hunger, enhancing the economic value of crops, and improving the lives of farmers who, despite prioritizing their work, face economic setbacks due to crop losses.

The user-friendly interface integrated into this system simplifies the monitoring of crops in the warehouse with minimal effort. Future applications could broaden the scope of this innovation to various sectors, with opportunities for numerous enhancements to ensure accessibility across different domains. In essence, this research project presents opportunities for widespread implementation and ongoing improvement, aiming to benefit diverse sectors and contribute to overall societal well-being.

VIII. FUTURE SCOPE

Smart crop monitoring and warehouse systems, leveraging sensors and ESP32 devices, enable real-time monitoring, predictive analytics, and remote control via IoT apps. Integration with AI enhances decision-making for optimized productivity, efficiency, and sustainability in agriculture and storage management.

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