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Automated Food Grain Monitoring System Using IOT

Dr. M. Vasu Babu[1], K. Sreya[2], J. Rithwik Reddy[3], G. Satish[4]
[1]Associate Professor, [2, 3, 4]Students, Electronic Instrumentation Engineering (EIE), Vignan Institute of Technology and Science, Dheshmuki , Hyderabad, India

Abstract: Post-harvest grain loss due to suboptimal storage conditions remains a significant challenge in agriculture, particularly in developing nations. To address this issue, this paper presents the design and development of a real-time, IoT-enabled food grain warehouse monitoring system utilizing the ESP32 microcontroller. The proposed system leverages multiple environmental and physical sensors to ensure optimal grain storage conditions, minimize spoilage, and improve operational efficiency. The monitoring system incorporates a DHT11 sensor for ambient temperature and humidity detection, an MQ135 gas sensor to detect hazardous gases such as CO_2 and NH_3, and a flame sensor to identify potential fire hazards. A a PIR sensor are used to detect unauthorized access or disturbances within the storage facility. To monitor grain weight, a force-sensitive resistor (FSR) is employed, replacing the traditional load cell. Additionally, a moisture sensor is repurposed to measure the internal moisture content of the stored grains—an essential parameter for preventing fungal growth and spoilage. An ESP32 microcontroller serves as the central processing unit, interfacing with all sensors and actuators. Actuation components include a fan and a water pump controlled via an L293D motor driver to regulate temperature and suppress fires. A servo motor is used for automated door control to manage physical access based on Blynk input. All sensor readings are displayed in real time on an I2C LCD and transmitted wirelessly to the Blynk IoT application, enabling remote monitoring and alerting via smartphone. Control logic is implemented to trigger auto4mated responses based on preset threshold values. For instance, if the temperature exceeds a safe limit, the fan is activated; if smoke or gas is detected, an alert is sent and ventilation begins; if motion is detected during unauthorized times, the door locks automatically and a notification is pushed via Blynk. The system was tested through a prototype model, and real-time data visualization confirmed its capability to monitor critical environmental variables and automate responsive actions. This integrated, low-cost IoT solution offers a scalable and user-friendly approach to enhancing food grain storage practices, reducing spoilage, and improving food security.

Keywords: Pir sensor,MQ135, DHT11, ESP32, wireless, Blynk IoT.

I. INTRODUCTION

Post-harvest losses in grain storage are a persistent issue, especially in regions where traditional storage methods prevail. Grains are highly susceptible to spoilage due to variations in temperature, humidity, pest infestation, microbial activity, and gas accumulation. Maintaining optimal storage conditions is critical for preserving grain quality and ensuring food security. Manual monitoring methods are labor-intensive, inconsistent, and often fail to detect early signs of spoilage or hazards. With the rapid advancement of the Internet of Things (IoT), automated systems now offer a reliable and scalable solution for continuous environmental monitoring and responsive control in storage warehouses. This project presents an IoT-based automated grain monitoring system utilizing an ESP32 microcontroller, environmental sensors, and smart actuators integrated with the Blynk IoT platform for remote access and alerts. In developing nations like India, agriculture serves as a vital pillar of the economy. However, post-harvest grain losses due to poor storage infrastructure, improper environmental conditions, and manual inefficiencies continue to plague food security efforts. Traditional warehouse management systems rely heavily on human intervention, which is often slow, error-prone, and inefficient when it comes to maintaining optimal storage conditions. With the advancement of the Internet of Things (IoT), there exists a promising opportunity to automate and enhance warehouse monitoring systems. This project presents a smart, low-cost, real-time monitoring system designed specifically for food grain warehouses using the ESP32 microcontroller and a range of environmental and physical sensors. The system is capable of measuring temperature, humidity, harmful gases, fire hazards, moisture content in grains, and physical disturbances like vibrations and unauthorized motion. A force sensor replaces the conventional load cell for weight measurement, and a servo motor facilitates automatic door control based on security conditions. To simplify remote monitoring and control, data is transmitted wirelessly to the Blynk IoT app, providing a user-friendly mobile interface.

The system offers autonomous control actions to maintain safety and quality. For example, a rise in temperature activates a fan, gas or smoke detection triggers ventilation or alarms, and unusual activity results in alerts or restricted access. Real-time data visualization is also provided on an I2C LCD. This smart system not only minimizes food spoilage and operational inefficiencies but also enables warehouse managers and farmers to monitor conditions remotely, reducing labor requirements and improving responsiveness. By integrating modern technology with agricultural infrastructure, this system provides a scalable and reliable solution to address food grain loss and storage inefficiencies.

A. Objective

- To designed a implement an IoT-based real-time monitoring system for food grain warehouses that ensures optimal environmental conditions for storage.
- To reduce post-harvest grain spoilage by monitoring key parameters such as temperature, humidity, gas levels, moisture content, and grain weight.
- To detect hazardous conditions such as fire (using a flame sensor) and toxic gas build-up (using MQ135) and trigger automated responses to prevent damage.
- To enhance warehouse security by detecting unauthorized access or movement using a PIR sensor and automatically locking doors through a servo mechanism.
- To provide remote monitoring and control capabilities via the Blynk IoT platform, enabling warehouse managers to receive real-time alerts and interact with the system using a smartphone.
- To automate environmental control systems such as fans and water pumps using the ESP32 and L293D motor driver based on sensor thresholds.
- To develop a cost-effective and scalable system using readily available components such as ESP32, FSR sensor, and moisture sensors to make the solution accessible for rural and large-scale grain storage facilities.
- To display live sensor data on an I2C LCD for on-site monitoring in addition to remote access through mobile devices.

II. LITERATURE SURVEY

Several research efforts have explored the application of IoT in agricultural storage systems. A study by Sharma et al. (2021) developed a temperature-humidity monitoring system using Arduino and GSM modules, but lacked real-time remote control. Kumar and Singh (2020) proposed a grain warehouse model using DHT22 and MQ2 sensors, which provided data logging but no active control response. More advanced models have employed load cells and cloud dashboards for grain weight and moisture monitoring; however, they often require expensive components or lack scalability. Our proposed system enhances these efforts by introducing FSR-based grain weight estimation, flame detection, gas sensing via MQ135, and integration of a servo-controlled access system—all centrally controlled and wirelessly monitored through ESP32 and Blynk. This system offers a low-cost, responsive, and mobile-friendly solution suitable for rural and urban storage environments.

Numerous studies have emphasized the need for real-time grain storage monitoring systems to reduce post-harvest losses and ensure food quality. Traditionally, grain storage relied on manual observation, which proved inadequate for detecting changes in temperature, humidity, and gas levels that can severely impact stored grains. To address these challenges, researchers have introduced IoT-based solutions that incorporate various sensors and communication modules.

For instance, Michael A. Omodara et al. (2022) developed a grain bag monitoring system using Arduino and onboard temperature and humidity sensors, achieving reliable environmental tracking in Nigerian warehouses. Similarly, Valmor Ziegler et al. (2021) presented a review of grain storage systems, highlighting the critical role of maintaining temperature and humidity to prevent fungal growth and weight loss in grains.

Recent advancements include IoT systems with GSM or Wi-Fi modules for wireless communication. Talpur et al. (2021) implemented an Android-based grain monitoring system using ESP32 and multiple sensors, improving real-time awareness and reducing the need for manual checks. However, many of these systems still use traditional load cells for weight measurement and GSM modules for communication, which can increase cost and complexity.

In this context, the proposed system adopts a cost-effective force sensor instead of a load cell and uses the ESP32 microcontroller, which supports integrated Wi-Fi and Bluetooth for seamless connectivity with the Blynk IoT platform. Additionally, the use of a moisture sensor specifically targets grain spoilage risk by detecting moisture levels inside the grain, a feature often neglected in earlier systems.

By integrating fan and pump control via L293D and automatic door management through a servo motor, this system advances previous designs by offering enhanced automation and real-time alerting, making it well-suited for modern, smart warehouse applications in agriculture.

III. METHODOLOGY

The system begins operation with the ESP32 microcontroller continuously collecting data from multiple sensors. The DHT11 sensor measures temperature and humidity inside the warehouse. If the temperature exceeds a safe threshold, the fan is triggered via the L293D motor driver to cool the environment. Similarly, if humidity is too low, the water pump is activated to maintain appropriate moisture levels. The MQ135 gas sensor monitors the air quality for hazardous gases such as CO_2 and NH_3. On detecting dangerous concentrations, the system initiates ventilation and sends an alert to the user via the Blynk IoT app. The flame sensor provides early fire detection; if triggered, the water pump is activated as a basic fire suppression method, and an emergency alert is sent. The PIR sensor detects unauthorized human motion especially during restricted hours and signals the servo motor to lock the door, while pushing a notification through Blynk. To monitor the weight of stored grain, a force-sensitive resistor (FSR) is used as a cost-effective alternative to traditional load cells. A moisture sensor is inserted into the grain to track internal moisture, helping prevent spoilage and fungal growth. All sensor values are displayed in real-time on an I2C LCD and simultaneously uploaded to the Blynk mobile app via Wi-Fi. Users can remotely monitor the warehouse and receive alerts in case of abnormal readings or unauthorized access. This ensures timely intervention and automation of control actions without manual oversight.

A. Block Diagram

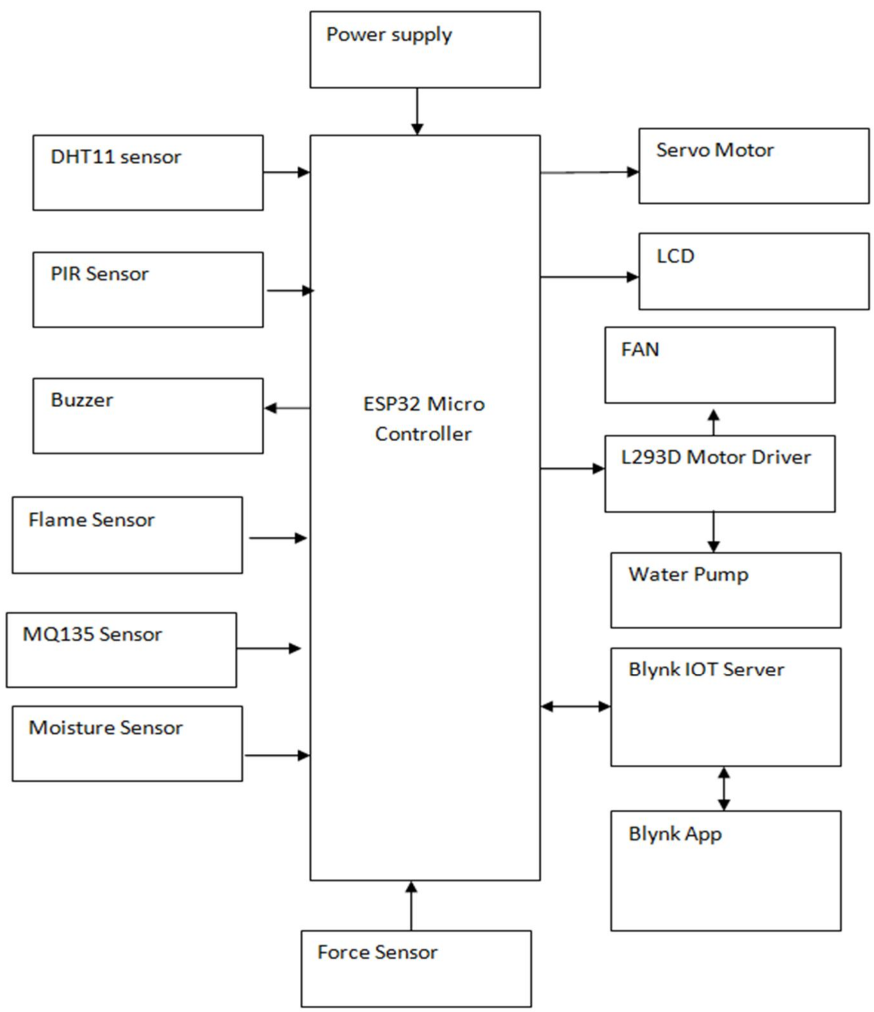


Fig 1: Block Diagram

1. ESP32 Microcontroller (Central Processing Unit)
- The ESP32 acts as the brain of the system.
- It collects data from all connected sensors, processes the readings, and makes real-time decisions based on threshold values.
- It connects to Wi-Fi and communicates with the Blynk IoT platform for remote monitoring and control.

2. DHT11 Sensor (Temperature & Humidity Monitoring)
- Monitors ambient temperature and humidity inside the warehouse.
- If temperature exceeds a set threshold, the fan is automatically turned on.
- Low humidity may trigger the **water pump** to maintain ideal grain storage conditions.

3. MQ135 Gas Sensor (Toxic Gas Detection)
- Detects hazardous gases such as CO_2**,** NH_3**,** and other volatile organic compounds.
- If gas levels are unsafe, the system:
- Sends an alert to the user via Blynk.
- Turns on ventilation or activates the fan for air circulation.

4. Flame Sensor (Fire Detection)
- Detects infrared radiation from flames.
- On detection:
- A water pump is triggered as a basic fire suppression method.
- An emergency alert is sent to the user.

5. PIR Sensor (Intruder Detection)
- Detects motion or unauthorized entry into the warehouse.
- If movement is detected during off-hours:
- The servo motor locks the door.
- An alert is sent via the Blynk app.

6. FSR Sensor (Grain Weight Monitoring)
- Measures the pressure or force applied by the grain sack.
- Used as a cost-effective alternative to load cells for tracking grain weight levels.
- Helps identify theft or depletion of grains over time.

7. Moisture Sensor (Internal Grain Moisture Monitoring)
- Inserted into the grain to detect moisture content.
- High moisture can lead to mold and fungal growth.
- Alerts the user and may trigger drying mechanisms (e.g., turning on the fan) to control humidity.

8. Fan & Water Pump (Environmental Control Actuators)
- Fan is used to lower temperature or improve ventilation when gases or heat rise.
- Water pump is used to increase humidity or act as a fire suppression device when flame is detected.

9. L293D Motor Driver
- Acts as an interface to control high-current devices like fan**,** water pump, and servo motor.
- Controlled by signals from the ESP32 to switch actuators ON or OFF safely.

10. Servo Motor (Automated Door Lock)
- Opens or closes the warehouse door based on input from Blynk or the PIR sensor.
- Used for security control to restrict access.

11. I2C LCD Display
- Shows live sensor values like temperature, humidity, gas levels, moisture, and weight.
- Helpful for local monitoring by warehouse staff.

12. Blynk IoT Platform (Remote Monitoring & Alerts)
- Displays real-time sensor data on a smartphone.
- Sends alerts when any sensor crosses preset limits (e.g., high temperature, gas, motion).
- Allows remote control of actuators (fan, pump, door) from anywhere.

IV. RESULT ANALYSIS

The proposed IoT-based food grain monitoring system was successfully developed and tested in a prototype warehouse setup. The system integrated multiple sensors for real-time monitoring of key environmental and physical parameters critical to grain preservation. The ESP32 microcontroller efficiently processed input data from all sensors and executed timely responses through connected actuators. All readings were accurately displayed on the I2C LCD and transmitted to the Blynk mobile application for remote access. During testing, the DHT11 sensor consistently measured ambient temperature and humidity. When the temperature was increased artificially (using a heat source), the system successfully triggered the fan when the temperature crossed the preset threshold, demonstrating automated climate control. Similarly, decreasing humidity levels led to the activation of the water pump, confirming the system's response to dryness that could impact grain longevity.

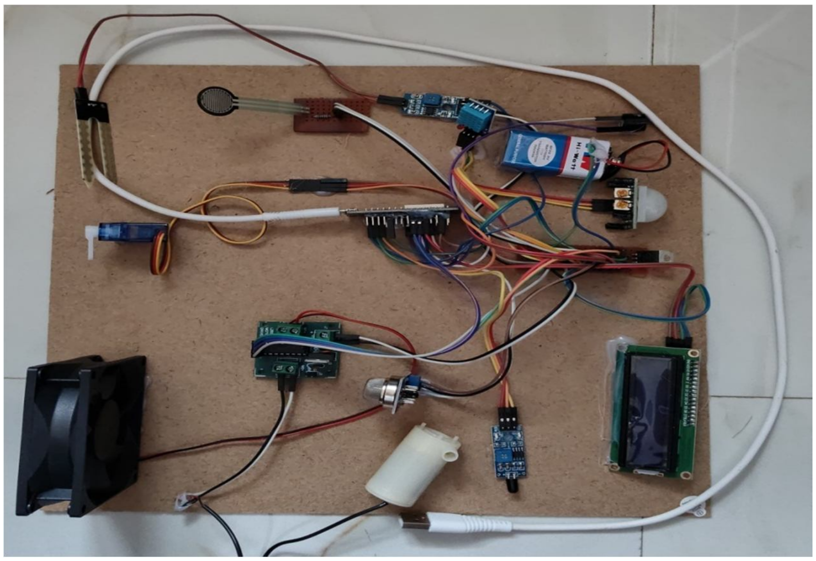


Fig 2: Hardware setup of Food Grain Monitoring System Using IOT

The MQ135 gas sensor effectively detected increased levels of CO_2 or NH_3 when exposed to simulated gas emissions. The system responded promptly by activating ventilation and notifying the user via the Blynk app. The flame sensor accurately detected small flame sources, leading to the activation of the water pump and the generation of an emergency alert on the app.
The PIR sensor detected unauthorized motion, which caused the servo motor to lock the warehouse door and send a security alert to the user. The FSR sensor registered variations in grain weight, indicating potential grain usage or loss. The moisture sensor provided real-time feedback on internal grain moisture, which is crucial for identifying potential spoilage risks.

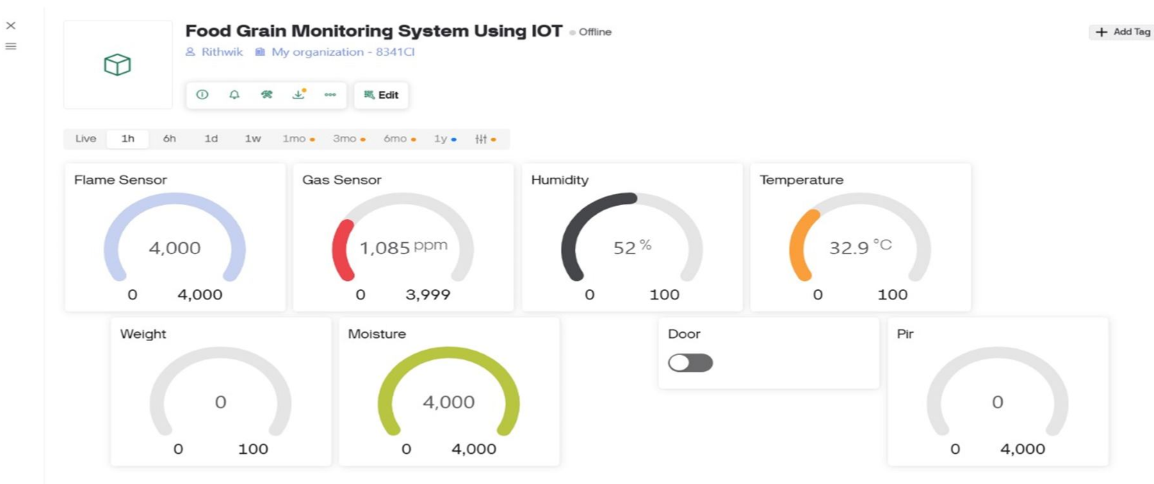


Fig 3: Food Monitoring Parameters and Alerts

Overall, the system demonstrated reliable performance in real-time data acquisition, automated control, and remote alerting. It proved to be an efficient, low-cost solution for warehouse grain monitoring, enhancing food preservation, reducing manual intervention, and improving overall warehouse management through IoT-based automation.

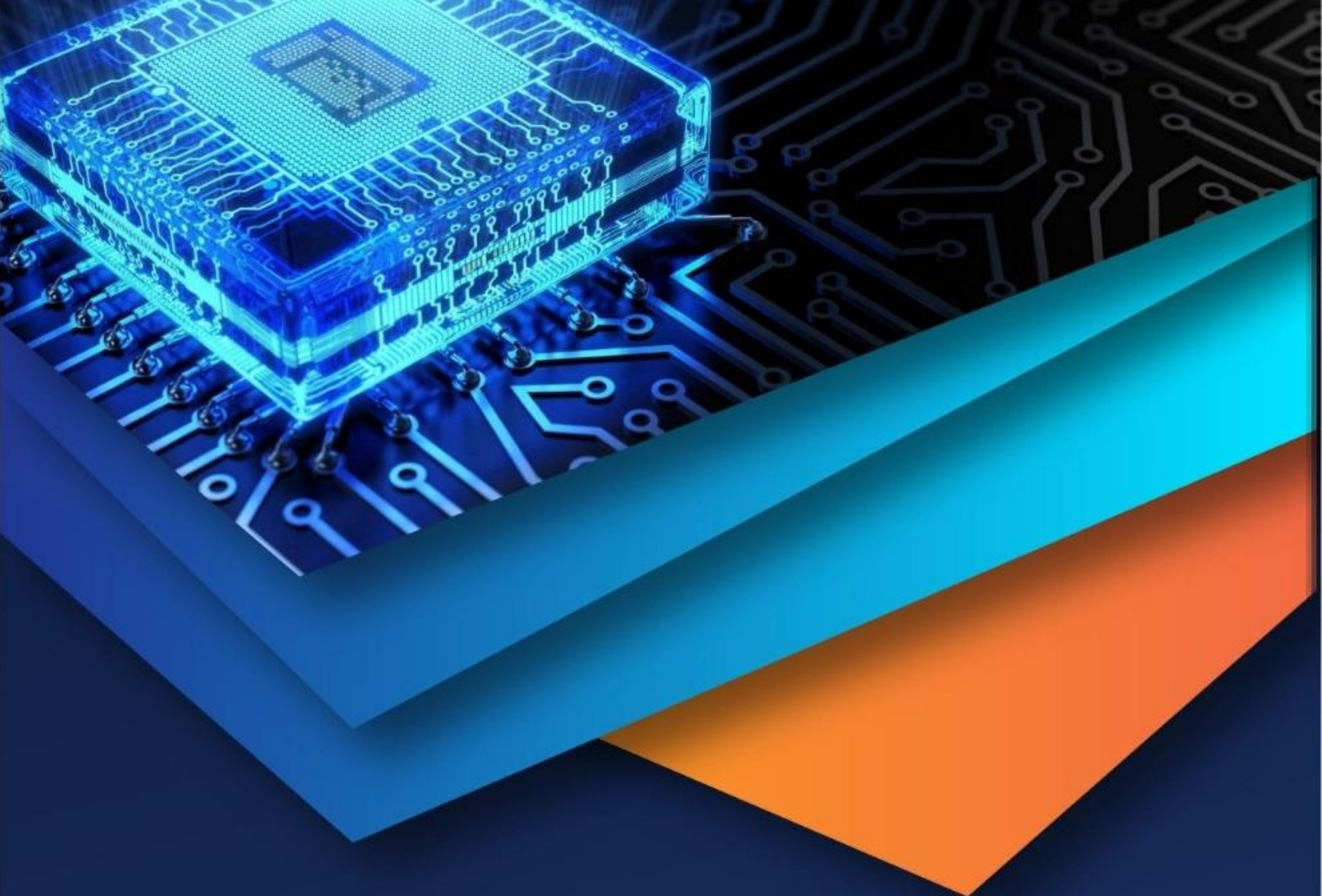
V. CONCLUSIONS

The proposed IoT-based automated food grain monitoring system demonstrates an effective solution for ensuring optimal storage conditions in warehouses. By integrating sensors such as DHT11, MQ135, flame sensor, PIR, moisture sensor, and FSR with the ESP32 microcontroller, the system provides comprehensive real-time monitoring of environmental and physical parameters. The use of Blynk IoT enables remote access and instant notifications, significantly reducing the need for manual supervision. The system not only detects critical issues such as high temperature, gas leaks, fire, moisture, and unauthorized access but also responds automatically through actuators like fans, pumps, and servo-controlled door locks. Prototype testing validated the functionality and responsiveness of the system under various simulated scenarios. The system performed reliably and accurately, proving its potential as a scalable, cost-effective solution for grain preservation. By reducing spoilage and increasing storage safety, this system contributes to improved food security and warehouse management efficiency.

In the future, this system can be further enhanced by integrating machine learning algorithms to predict spoilage trends and automate corrective actions more intelligently. Solar-powered modules can be added to make the system energy-efficient and suitable for remote rural warehouses with unreliable power supply. Integration with cloud storage for historical data analysis and visualization dashboards could provide deeper insights into warehouse conditions over time. Real-time SMS could be added as a backup communication method. Additionally, expanding the system to include pest detection sensors**,** RFID-based inventory tracking**,** and automated reporting features would further enhance warehouse automation and security. This would make the solution more robust, self-sustaining, and adaptable to diverse agricultural storage environments.

REFERENCES

[1] D. K. Fisher and H. A. Kebede, A low-cost microcontroller based system to monitor crop temperature and water status, Compute Electron Agriculture, vol. 74, no. 1, pp.168–173, Oct. 2010.
[2] A report on Warehousing & inventory Management, in CII Institute of Logistics, Chennai Vol.3 pp.34-40.2001
[3] S. Li, J. Cui, Wireless Sensor Network for Precise Agriculture Monitoring, in Fourth International Conference on Intelligent Computation Technology and Automation, Shenzhen, China, March 28-29, 2011
[4] Bah A., S.K. Balasundram, Sensor Technology for Precision Soil Nutrient Management and Monitoring, in American Journal of Agricultural and Biological Sciences 2012.
[5] Yang Shulian, Zhang Yu, Wireless Measurement and Control System for Environmental Parameters in Greenhouse, at Measuring Technology and Mechatronics Automation (ICMTMA), 2010
[6] G. Kantor and S. Singh, Integrated wireless sensor/actuator networks in an agricultural applications, In Second ACM International Conference on Embedded Networked Sensor Systems (SenSys), Maryland, USA, Nov. 2004.
[7] Z. Hao, Y. Zhao, Y. Cao, D. Li, T. Zhen, P. Fu and J. Wu, Basic statistical characteristics of spatial and temporal distribution of temperature in the cube grain warehouse, Grain Storage Technology vol. 39, no. 4, pp. 15–20, 2010
[8] Mohanraj I, Kirthika Ashokumar, Naren J(2016), Field Monitoring and Automation using IOT in Agriculture Domain, B.Tech Computer Science and Engineering, School of Computing, SASTRA University, Thanjavur - 613401, India.
[9] Ming Taoa, Jinglong Zuob,, Zhusong Liuc, Aniello Castiglioned, Francesco Palmierid(2016), Multi-layer Cloud Architectural Model and Ontology-based Security Service Framework for IoT-based Smart Homes, College of computer and network security, Dongguan University of Technology, Dongguan, China.
[10] A. Ramaa, K.N. Subramanya, T.M. Rangaswamy, Impact of warehouse inventory management system in a supply chain, Int. J. Comput. Appl. 54 (6) (2012) (0975-8887).



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