Smart Agro-Vehicle Freshness Monitoring System

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Abstract

In the modern agricultural sector, preserving the freshness and quality of harvested vegetables during storage and transport is critical. This project presents an IoT-based solution for monitoring the freshness of vegetables using Wi-Fi technology. The system integrates a network of sensors, including the DHT11 for measuring temperature and humidity, the MQ135 gas sensor to detect spoilage-indicating gases, and an ultrasonic sensor, which is repurposed to measure the quantity of fuel in vehicles. Additionally, an MPU6050 accelerometer sensor detects accidents

The data collected from these sensors are processed using an ESP32 microcontroller, which triggers corrective actions such as activating a DC fan for ventilation or sounding a buzzer when spoilage is detected. This Project allows farmers or warehouse managers to receive real-time data from distant storage locations or vehicle systems.

This IoT-based system ensures a cost-effective and reliable solution for monitoring environmental factors affecting vegetable freshness and vehicle safety. By addressing challenges in storage management and transportation, the system reduces post-harvest losses, improves supply chain efficiency, and enhances safety decision-making through real-time data access.

Keywords: *IoT technology, vegetable freshness, Wi-Fi, DHT11, MQ135, ESP32 microcontroller, MPU6050, storage, transportation safety and real-time monitoring,*

1.INTRODUCTION

The agricultural sector faces challenges in preserving vegetable freshness due to humidity, temperature fluctuations, and spoilage gases, leading to significant post-harvest losses. Traditional manual monitoring methods are inefficient, labor-intensive, and prone to human error. To overcome these issues, this project introduces an IoT-based wireless system using Wi-Fi to enable real-time monitoring of storage conditions.

The system integrates multiple sensors to track essential parameters: the DHT11 sensor measures temperature and humidity, the MQ135 detects spoilage gases, and an ultrasonic sensor monitors fuel levels in transport vehicles and the positioning of stored vegetables. These sensors continuously collect data, which is processed by an ESP32 microcontroller. When spoilage conditions are detected, the system triggers corrective actions such as activating a DC fan for ventilation or sounding a buzzer to alert users.

A key advantage of this system is remote monitoring, allowing farmers and warehouse managers to track storage conditions from anywhere. This reduces spoilage, extends vegetable freshness, and ensures timely intervention. The automated nature of the system improves efficiency, lowers operational costs, and enhances food safety.

By integrating IoT and wireless communication, this project contributes to sustainable agricultural practices. It optimizes resource utilization, minimizes food wastage, and strengthens the agricultural supply chain. Ultimately, this solution plays a crucial role in improving food security and reducing post-harvest losses.

1.1. Objectives

1. Real-time freshness monitoring – Continuously tracks temperature, humidity, and spoilage gases in storage and transport.

2. Automated spoilage detection – Detects adverse conditions and triggers corrective actions like ventilation or alerts.

3. Minimize post-harvest losses – Reduces spoilage by ensuring optimal storage conditions for perishable vegetables.

4. Remote accessibility – Enables farmers and warehouse managers to monitor storage conditions from any location via Wi-Fi.

5. Enhanced food security – Helps maintain vegetable quality, reducing waste and supporting sustainable agriculture

2. BLOCK DIAGRAM

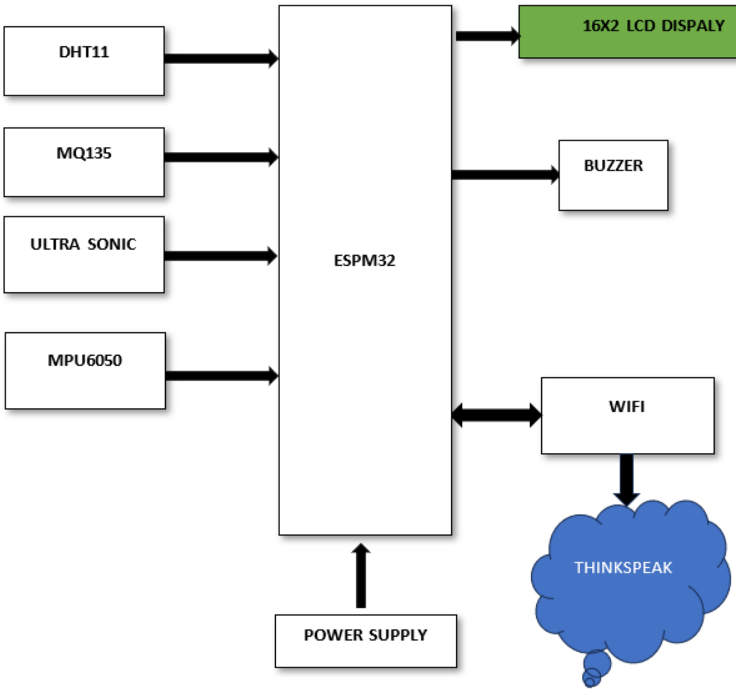

Figure 1: BLOCK DIAGRAM OF THE PROPOSED SYSTEM

The block diagram represents the Smart Agro-Vehicle Freshness Monitoring System designed to ensure optimal storage conditions for perishable vegetables. At its core, the ESP32 microcontroller integrates multiple sensors to monitor environmental parameters affecting freshness. The DHT11 sensor measures temperature and humidity, while the MQ135 gas sensor detects spoilage gases such as ammonia and carbon dioxide. An ultrasonic sensor monitors fuel levels in transport vehicles and assesses vegetable positioning, while the MPU6050 sensor detects motion and vibrations. The ESP32 processes the collected data and triggers necessary actions when abnormal conditions are detected. A buzzer alerts users of spoilage risks, and a 16x2 LCD display presents real-time sensor readings. Additionally, Wi-Fi connectivity enables data transmission to ThingSpeak, allowing remote monitoring and visualization of storage conditions. This automated system improves post-harvest management, minimizes spoilage, and enhances agricultural sustainability through IoT and wireless communication.

3. WORKING

The Smart Agro-Vehicle Freshness Monitoring System is an automated solution designed to ensure real-time monitoring of vegetable storage and transportation conditions. It utilizes an ESP32 microcontroller to integrate multiple sensors, including a DHT11 sensor for temperature and humidity measurement, an MQ135 gas sensor to detect spoilage gases, an ultrasonic sensor for monitoring fuel levels and vegetable positioning, and an MPU6050 sensor for motion and vibration tracking. These sensors continuously collect environmental data, which is processed by the ESP32 to assess storage conditions.

If abnormal conditions such as high temperature, excessive humidity, or harmful gas levels are detected, the system triggers immediate corrective actions. A buzzer is activated to alert users, while a 16x2 LCD display provides real-time data updates. Additionally, the Wi-Fi-enabled ESP32 transmits sensor readings to ThingSpeak, a cloud-based IoT platform, enabling remote monitoring from any location. This ensures that farmers and warehouse managers can take timely actions to prevent spoilage and reduce post-harvest losses.

The system enhances post-harvest management by minimizing manual inspections and providing automated alerts, reducing food wastage and improving supply chain efficiency. By integrating IoT technology and wireless communication, this innovative solution helps maintain vegetable freshness, promotes sustainable agricultural practices, and contributes to global food security.

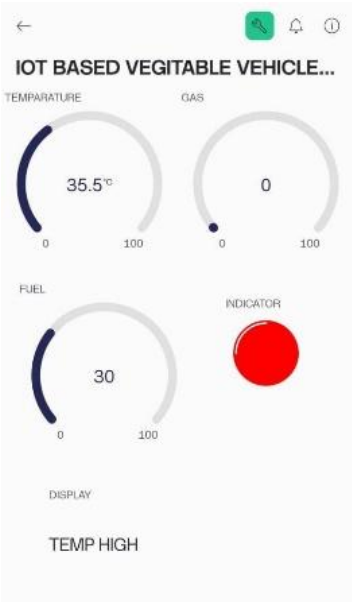

Figure 2. HARDWARE MODEL

4. RESULT AND DISCUSSION

The Smart Agro-Vehicle Freshness Monitoring System was successfully developed to monitor vegetable storage conditions and ensure vehicle safety. The system integrated sensors such as DHT11 for temperature and humidity, MQ135 for spoilage gas detection, an ultrasonic sensor for storage monitoring, and MPU6050 for vehicle movement tracking. Data was processed using an ESP32 microcontroller and transmitted via Wi-Fi to the cloud for remote access through ThinkSpeak. Experimental results confirmed the system's ability to monitor environmental parameters in real time, detect spoilage gases, and provide automated alerts. The accident detection feature accurately identified sudden vehicle movements, triggering emergency notifications. The Wi-Fi-based communication enabled seamless remote monitoring, reducing manual intervention and improving efficiency.

While the system performed effectively, challenges such as sensor calibration and network reliability need further optimization. Future improvements could include machine learning integration, mobile application support, and expanded monitoring capabilities. Overall, the system provides a cost-effective IoT solution for ensuring vegetable freshness and vehicle safety in agriculture and logistics.

Overall Purpose:

i. Ensure real-time monitoring of vegetable freshness and vehicle safety using IoT technology.
ii. Integrate multiple sensors with an ESP32 microcontroller for efficient environmental monitoring.
iii. Reduce post-harvest losses by detecting temperature, humidity, and spoilage gases.
iv. Enhance vehicle safety by monitoring sudden movements and detecting potential accidents.
v. Enable remote access to real-time data through Wi-Fi-based cloud integration.

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