SmartFarm Transport: IoT-Integrated System for Reducing Vegetable Spoilage in Transit

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Abstract

In modern agricultural supply chains, ensuring the freshness and quality of vegetables during storage and transportation is a critical challenge. This project presents an IoT-based smart monitoring system designed to track and maintain the freshness of vegetables using real-time sensor data. The system is built using an ESP32 microcontroller, integrating multiple sensors to monitor environmental and transport conditions. A MQ135 gas sensor is used to detect gases released by decomposing vegetables, indicating spoilage. A DHT11 sensor monitors the temperature and humidity, which are key factors affecting vegetable freshness. To enhance transportation safety, an MPU6050 accelerometer and gyroscope module is included to detect vehicle accidents. Additionally, an ultrasonic sensor is used to monitor the petrol level of the transport vehicle. All collected data is transmitted to the ThingSpeak IoT cloud platform, where it is stored, visualized, and analyzed. The data is also accessed and displayed on a custom-built website using Java (JSP, Servlets) as the front end and MySQL as the back-end database, ensuring a user-friendly interface for real-time monitoring.

Keywords: *IoT Monitoring, Vegetable Freshness, ESP32 Microcontroller, Sensor Integration, Real-time Data, Cold Chain Management*

1.INTRODUCTION

In the agricultural sector, maintaining the freshness and quality of vegetables from farm to market is a major concern. Vegetables are highly perishable, and their quality can deteriorate quickly due to improper Environmental conditions such as temperature, humidity, and exposure to certain gases. In addition, transportation issues like fuel shortages or accidents can further impact delivery and product condition. To address these challenges, the integration of Internet of Things (IoT) technology offers a promising solution for real-time monitoring and management. This project proposes an IoT-based smart system that monitors the freshness of vegetables using various sensors connected to an ESP32 microcontroller. The system continuously measures gas levels using the MQ135 sensor to detect signs of vegetable spoilage. It also tracks temperature and humidity with a DHT11 sensor, as these parameters directly affect vegetable shelf life. To ensure safety during transport, an MPU6050 sensor detects sudden movements or accidents, while an ultrasonic sensor monitors the fuel level of the transport vehicle.All the sensor data is sent to the ThingSpeak cloud platform, where it is stored and analyzed. This data is then fetched and displayed on a web interface developed using JSP, Servlets, and Java, with MySQL serving as the back-end database. This setup allows users, including farmers, logistics providers, and retailers, to access real-time information about vegetable freshness and transport conditions from any location. By implementing this system, we aim to reduce vegetable wastage, improve food quality, and enhance supply chain efficiency through smart monitoring and data-driven decision-making.Aim of this project is to design and implement an IoT-based

smart monitoring system for ensuring the freshness and safety of vegetables during storage and transportation by utilizing real-time sensor data and cloud-based analytics.

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

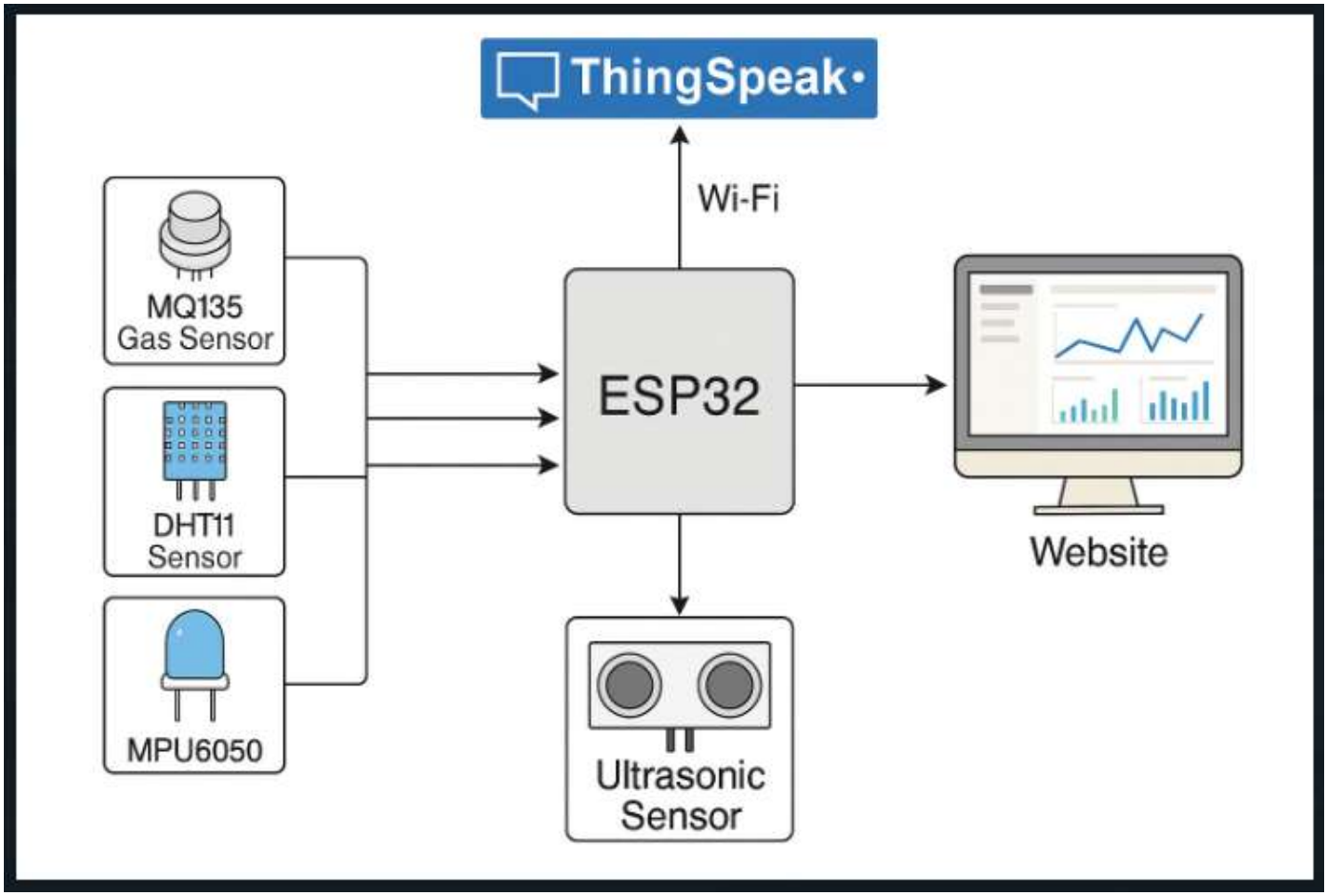

Figure 1: BLOCK DIAGRAM OF THE PROPOSED SYSTEM

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

It 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

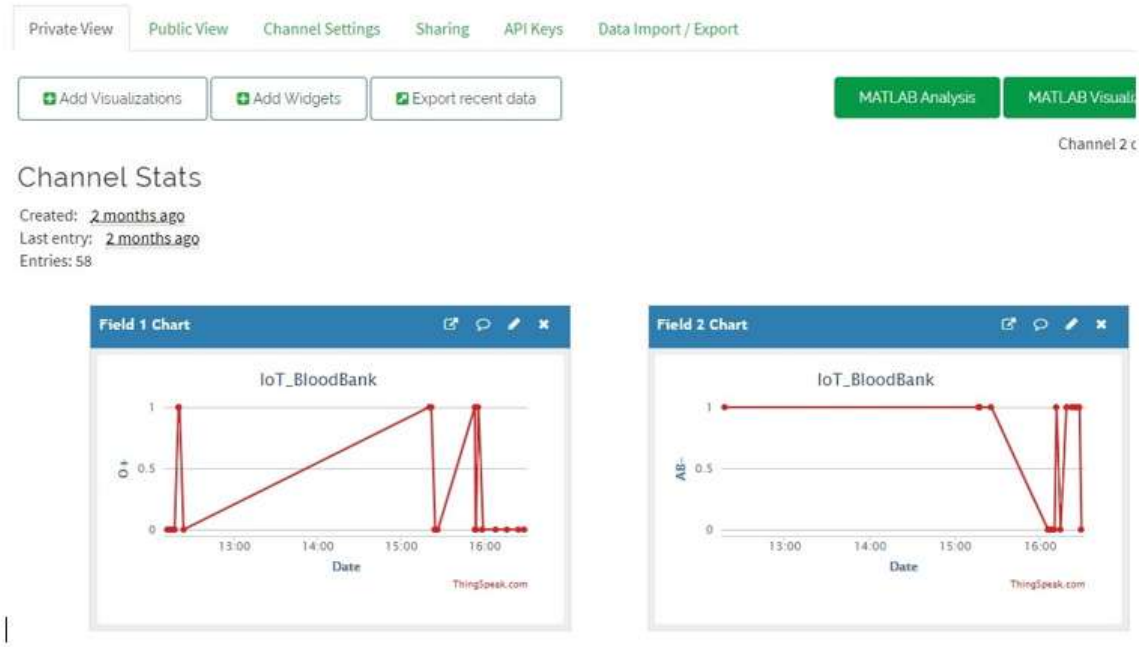

Figure 3. Final output of Thingspeak server

The implemented system successfully demonstrated the ability to monitor vegetable freshness and transport conditions in real time using IoT technology. The MQ135 gas sensor effectively detected variations in air quality caused by the release of gases from decaying vegetables, providing early spoilage alerts. The DHT11 sensor accurately tracked temperature and humidity, enabling users to maintain optimal storage conditions. The MPU6050 sensor detected unusual movements and impacts, confirming its capability to sense vehicle accidents. The ultrasonic sensor reliably measured petrol levels, ensuring timely refueling and avoiding transportation disruptions. All sensor data was transmitted to ThingSpeak, where it was visualized through dynamic charts and graphs. The integration with the web application allowed users to access real-time data and historical logs conveniently. The system proved to be cost-effective, scalable, and reliable, making it suitable for small to medium-scale agricultural logistics. It significantly improves freshness monitoring, reduces manual inspection efforts, and enhances decision-making through real-time insights

4. RESULT AND DISCUSSION

SmartFarm Transport: IoT-Integrated System for Reducing Vegetable Spoilage in Transit 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, anultrasonic 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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