

A Smart Storage System and Non-Invasive Technique for Spoilage Detection

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Abstract

Fresh vegetables are widely recognized as a vital source of essential nutrients for a healthy diet, including vegetable sprouts which are consumed globally for their high nutritional value. Only high-quality fruits and vegetables are preferred by those who are health-conscious. Consequently, it is crucial to check the quality of fruits and vegetables. However, consuming raw vegetables poses a significant risk of transmitting intestinal parasites. With a growing awareness of quality in the food and health industry, there is an increasing need for research on defined quality production, preservation during marketing, and evaluation of quality parameters. By addressing these concerns, this proposed non-invasive system presents a promising technique for detecting the quality of stored fruits and vegetables. The suggested system can help ensure the availability of safe and nutritious produce for consumers, thereby contributing to the improvement of public health.

Keywords: IoT, MQ-4 and MQ-135 sensors, Quality detection, Hyper spectral, Freshness of fruits and vegetables.

1. Introduction

A network of connected devices with interactions between people, objects, and data is being created by the fast-developing Internet of objects (IoT), which is changing how various sectors operate. The IoT infrastructure enables remote sensing and control of objects across existing network infrastructure, allowing for more direct integration of the physical world into

computer-based systems. In the food industry, the quality of fruits and vegetables is critical, and proper storage is necessary to maintain their quality after harvesting. Quality is a complex perception based on many attributes simultaneously evaluated by consumers, both objectively and subjectively. Due to their highly perishable nature, effective monitoring of temperature, humidity, and other ecological conditions inside a distribution center has become a vital field of research in many developing countries worldwide

2. Related Works

- A typical computer vision system has been designed with four fundamental components: illumination, a picture capture board (digitizer or frame grabber), a camera, and constituents. [4]
- The standard, multispectral, and hyperspectral computer vision systems have been defined extensively for the standard analysis of food and agricultural products. [5]
- There is already an existing solution that detects the standard of food using image processing and a hyperspectral camera that is affordable for a large-scale industry. [2]
- The application of wireless sensor networks in environmental monitoring is regarded as one of the most complex and demanding domains where this emerging technology is employed. [1]
- Hyperspectral images obtained from advanced sensors such as Hyperion, CASI, and Headwall Micro-Hyperspec offer a significant advantage in environmental monitoring. With their extensive range of hundreds of bands, these images possess the ability to capture intricate spectral responses, enabling the detection of even the slightest variations in ground covers and their dynamic changes over time. [3]
- Computer vision and image processing techniques have proven to be immensely valuable in the fruit industry, particularly in the realm of quality detection. These advanced technologies have gained significant traction due to their effectiveness in analysing fruit attributes and characteristics through visual data, thereby enhancing the overall quality assessment process. [10]

- A collection of sensor nodes, a base station, and an internet data centre make up the entire system architecture. [6]
- A biological process has been employed for analyte detection in biosensors, which are a subset of chemical sensors. [7][8][9]
- Volatile compounds emitted by fruits and other plants can serve as indicators of their specific status, encompassing factors such as plant disease, self-protection, freshness, maturity, and nutritional composition. [11]
- The implementation of WASPMOTE facilitates the detection of diverse environmental conditions, enabling monitoring of food contamination and degradation throughout the supply chain. Through these techniques, notifications are promptly transmitted to relevant authorities, ensuring timely intervention and response to maintain food safety and quality standards. [12]
- The presence of microorganisms, including naturally-occurring spoilage microflora, on lettuce and strawberries exhibited heterogeneous distribution from one batch to another. [13]
- The detection of carbon dioxide levels enables the identification of rotten fruit effectively. [14][15].

3. Proposed Work

This work proposes a system for monitoring the environment in which the food is stored and transported. The suggested solution evaluates the surrounding environment's temperature, humidity, alcohol content, and other light characteristics since they have an impact on the nutritional value of food. This system uses gadgets that are implanted with many digital sensors that can check the parameters affecting food. The environmental factors can be managed through refrigeration facilities, vacuum unit, etc. For logging and tracking sensor data, the suggested system is built to use an IoT platform. The storage unit's environmental elements can be observed from any location, at any time, using any device, thanks to the power of the Internet of Things. The proposed system must be able to:

- Check the store's temperature and relative humidity.
- Identify the depth of light inside the store.

- Detect emissions in the form of ethanol.

If the methane level is below three hundred, a yellow light turns on indicating medium i.e., the food is 55% spoiled. If the methane level is above three hundred, soft crimson light turns on. The red light means the food is 88% spoiled. After indicating, the digital digicam module captures the image and mails to the concerned person.

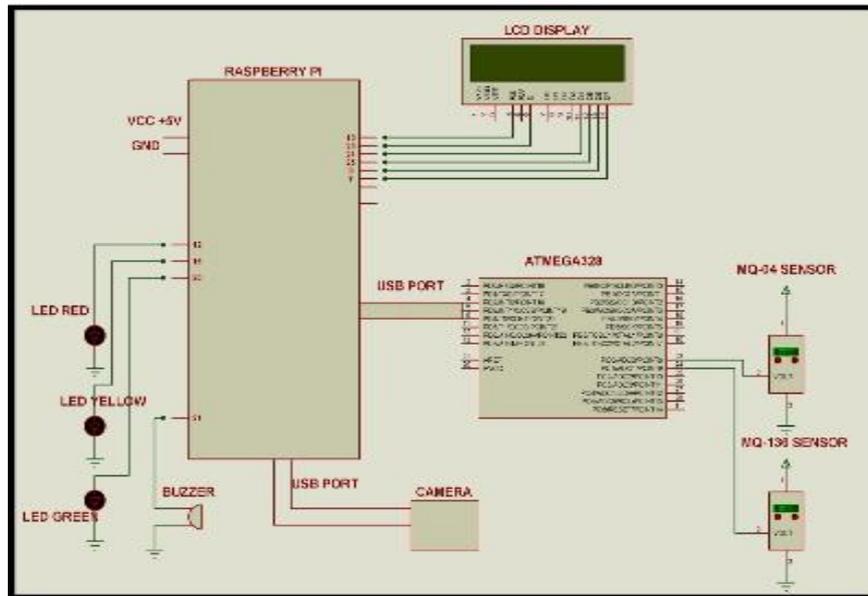


Figure 1. Circuit Diagram

A gas sensor measures the amount of gas in the unit and transforms that amount of gas into an equivalent voltage. While the humidity sensor gauges relative humidity, and the temperature sensor gauges the air temperature. To cut expenses, two sensors are frequently combined. To measure light intensity, a light sensor is employed. Data from all sensors is displayed on the display device. The data gathered by the sensors are sent to the Internet as part of the monitoring system. Through an open-source Internet platform, the storekeeper can keep tabs on the storage unit's gas concentration, temperature, humidity, and light intensity.

The suggested system can detect concentrations between the lowest and highest values and upload the data to an online site. In this investigation, the temperature ranged from 0°C to 50°C, while the humidity ranged from 20% to 90%. The light sensor's operating range is 0 to 1023, with 1023 serving as its maximum value and representing a +5 volt supply. The circuit requires 5V DC to function.

3.1. Methodology

The system's electronics consists of a Raspberry pi-based embedded system and a prototyping board, which interfaces with gas sensors such as MQ-04 and MQ-135 to detect odors. The Arduino Uno microcontroller board, in conjunction with the MQ-04 food detection sensor, detects gases emitted by vegetables and transfers the signal to the Raspberry Pi for processing.

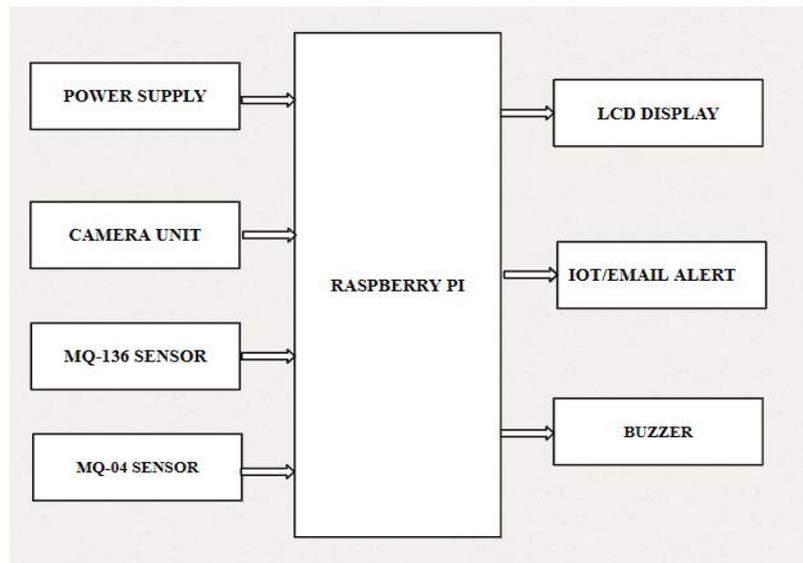


Figure 2. Overall Design

3.2. Technology Stack

			
Raspberry pi 3 B+	Arduino Uno	Peltier TEC-12706	Arduino Nano

Figure 3. Hardware Components Used

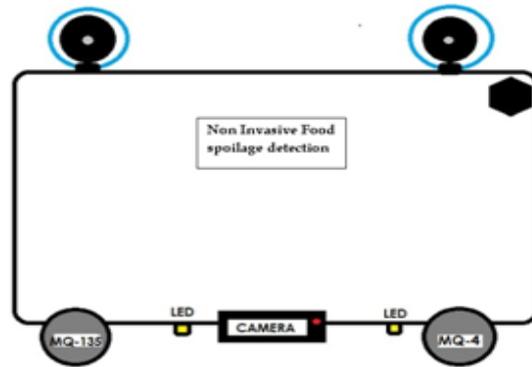


Figure 4. Food Spoilage Detection Circuit

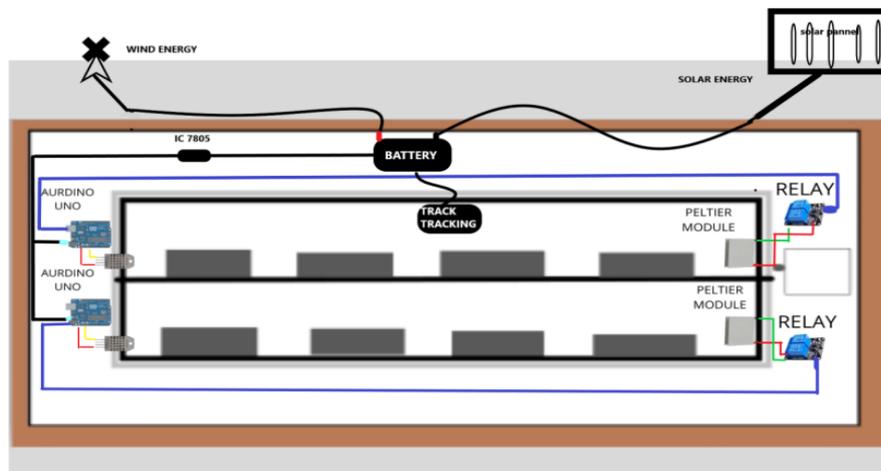


Figure 5. Storage Unit

4. Result

The proposed system utilizes methane and humidity sensors to detect the quality of food, providing an affordable and efficient option for storekeepers. By leveraging this technology, this solution reduces the time required for detection.



Figure 6.1 and 6.2. Monitoring Device

5. Conclusion

A non-invasive tracking system is designed to detect rotten or spoiled fruits and vegetables at an early stage. Based on sensor technology, it detects air quality and alerts users with a buzzer and notifies via email to the higher officials. The system also includes a camera module that captures images of the carton containing spoiled produce for easy identification. The system is suitable for small-scale industries, however it has the potential for future expansion to assess quality parameters such as contamination, ethylene, microbial attack, internal disorders, taste, sugar content, etc., using hyper-spectral imaging, making it ideal for large-scale industries.

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