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Smart Inventory System for Expiry Date Tracking

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Abstract

This paper presents a Savvy Stock Framework for Expiry Date Follow-Up based on an ESP32 microcontroller. The framework organizes different products in different sections of a clever rack. One week prior to the product's expiration, the system notifies the owner of its shelf location. These alerts are displayed on an LCD screen and sent as notifications. The system also monitors inventory levels and issues low-stock alerts to ensure timely restocking. To increase product safety, the shelves are equipped with a smoke and moisture sensor. If the system detects unusual moisture levels or smoke, it instantly alerts the owner and sounds a buzzer alarm to ensure prompt action.

Keywords: Expiry Date Follow-Up, ESP32, QR module, IOT, Shrewd Rack, LCD, Low-Stock Caution, Dampness Sensor, Smoke Sensor, Buzzer, RTC module, Bluetooth (HC-05).

1. Introduction

In stores, warehouses, and other storage facilities, inventory control is essential, especially when working with perishable goods. Real-time tracking is frequently not possible with traditional inventory systems, which leads to losses from out-of-pocket stock shortages or expired goods. In order to overcome these obstacles, this project uses the ESP32 microcontroller to present an Intelligent Inventory System for Expiry Date Tracking.

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A smart shelf with compartments is a feature of the suggested system, where different products are kept and watched separately. The integration of a QR scanner allows for the tracking of stored items' expiration dates. Early alerts are generated by the system, informing the owner one week before a product's expiration date and the precise shelf location of the product. To ensure prompt action, these alerts are sent as notifications and shown on an LCD screen. The system helps store managers and warehouse operators maintain ideal stock levels by providing low-stock alerts through its inventory monitoring feature, which also tracks expiration dates. The system has smoke and moisture sensors to improve product safety. It immediately notifies the owner and sounds a buzzer alarm for quick action if unusual moisture levels or smoke are found. Remote connectivity is made possible by the ESP32 microcontroller.

To increase productivity, cut waste, and improve safety, this intelligent inventory system makes use of automation and Internet of Things technology. The system is a scalable and affordable option for companies handling perishable inventory because of the ESP32 microcontroller's ability to facilitate remote access and real-time data processing.

2. Literature Survey

Current developments in smart stock management systems depict a continuing revolution spearheaded by IoT, AI, and cloud computing technologies. Almurashi et al. [1] designed a Smart Expiry Food Tracking System to enhance food safety and minimize waste by monitoring expiration in real time. This idea is further developed by Sarkar et al. [2], who proposed a smart refrigeration system integrating proactive inventory management and temperature-sensitive storage, where food quality and stock levels are both retained effectively. Likewise, Chai et al. [3][4] came up with an adaptable IoT-based inventory system for retail, showing the adaptability of modular systems to meet varying business requirements and streamlining real-time decision-making.

Essam et al. [5] discussed the application of LSTM models in stock forecasting and inventory tracking, demonstrating the incorporation of deep learning in demand forecasting and proactive management of stocks. Benson-Emenike et al. [6] highlighted how the incorporation of emerging technologies like sensors and cloud-based analysis can increase visibility and traceability in inventory management systems, something of value especially in dynamic supply chains. Srivatsa et al. [7][8] solved storage issues through a smart cold storage monitoring system, integrating IoT-enabled sensors with automated notifications to maintain

temperature-sensitive products, catering to the requirements of agriculture, pharmaceutical, and perishables sectors.

In terms of wider industry contribution, Mondol [9] emphasized how the implementation of blockchain technology integrated with smart inventory systems can greatly enhance trust and transparency in retail supply chains. In construction, Bose et al. [10] presented an IoT and cloud-based inventory management model customized to monitor materials in real-time, preventing project delays and cost overruns via effective resource management. Such studies collectively indicate that a future where smart, automated inventory systems will play a key role in improving efficiency, minimizing waste, and facilitating real-time supply chain responsiveness across industries is likely to emerge.

3. Existing System

Traditional expiry date tracking techniques, like printed labels and barcodes, are the mainstay of the current framework for managing perishable food supply chains. These techniques require manual inspections and are prone to human error. Batch-level tracking, or at best item-level monitoring, is frequently used by retailers and distributors, which results in ineffective inventory management and more food waste. Because traditional supply chains do not have real-time environmental monitoring, it is difficult to evaluate the quality of products after the printed expiration date. Additionally, financial concerns have restricted investments in RFID technology. Although some retailers have started using RFID at the pallet level, item-level tracking is still uncommon. Food loss is made worse by the lack of digital tools that can forecast remaining shelf life based on current conditions. Retailers must periodically check inventory levels in retail settings. An out-of-stock product in the grocery store frequently goes unnoticed until a manual check is done, costing retailers a lot of money and requiring more employees to handle inventory.

4. Design System

An innovative Internet of Things (IoT) solution called the Keen Stock Framework for Expiry Date Monitoring was created to automate and simplify inventory management by continuously monitoring product expiration dates, stock levels, and storage rack environmental conditions. In order to arrange different products according to type or category, the system has an intelligent rack that is separated into separate compartments. A QR code with important

product information is attached to the label of every item. When a product is about to expire within a week, an LCD screen displays an alert from a Real-Time Clock (RTC) module. Additionally, a GSM module automatically notifies the owner via SMS, allowing for prompt action to prevent waste.

The system also keeps track of stock levels and sends out an alert if the number of items drops below a predetermined threshold. It updates inventory data to the server over Wi-Fi for remote access and effective inventory management. Moisture and smoke sensors constantly check the conditions inside the racks to improve security. To reduce possible damage or hazards, the system notifies the owner via SMS and sounds a buzzer when it detects smoke or unusual humidity levels.

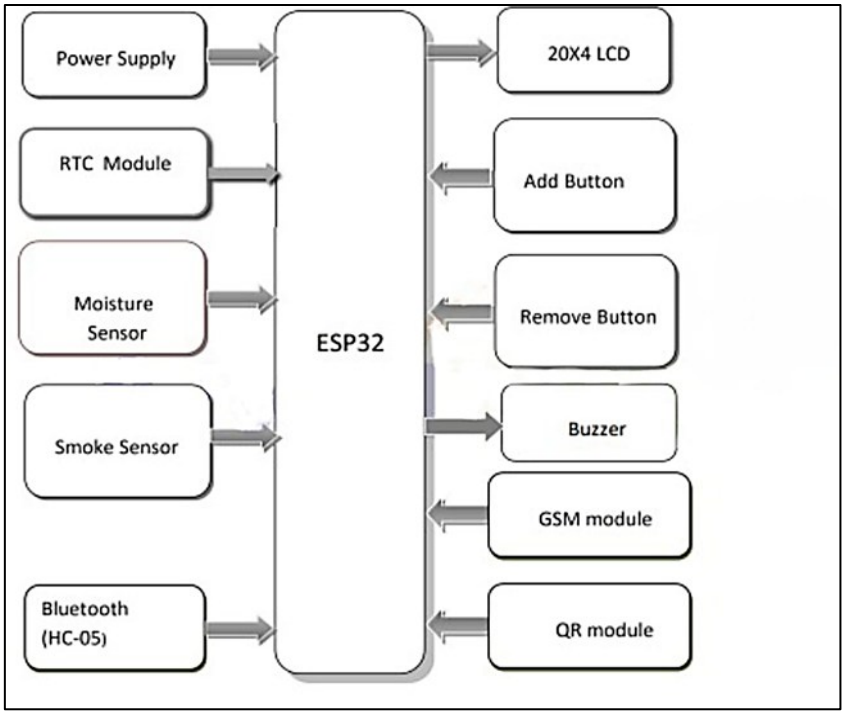


Figure 1. Block Diagram of Smart Inventory System

This system guarantees effective inventory management, reduces product waste, and improves storage safety by combining real-time monitoring, automated alerts, and cloud connectivity. Moisture and smoke sensors are essential for keeping an eye on environmental elements that could hasten spoiling or present safety hazards. Even before perishable goods reach their expiration dates, high humidity levels can damage packaging and compromise their integrity. In the storage area, smoke detection also acts as an early warning system for possible electrical problems or fire hazards. In addition to monitoring expiration dates, these sensors

contribute to better inventory security by ensuring that goods are stored in ideal conditions. The accompanying block diagram (Figure 1) shows the functional modules, which include the ESP32, QR scanner, sensors, RTC, GSM, LCD, and communication interfaces.

5. Materials & Components

- **Prototype Implementation**

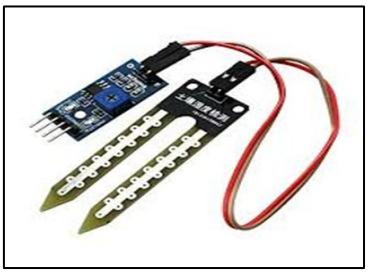
We created a working prototype using a rack model with an ESP32 microcontroller and various integrated components, such as an LCD display, GSM module, RTC module, QR scanner, and moisture and smoke sensors, to demonstrate real-world deployment. Product samples were labeled and tracked in a regulated lab setting. Successful notifications for products that were about to expire, low stock conditions, and the identification of unusual humidity or smoke levels confirmed the design's real-time functionality.

- **ESP-32**

For Internet of Things (IoT) applications, the ESP32 is a highly efficient and adaptable microcontroller that combines Bluetooth and Wi-Fi capabilities. Espressif Systems created this affordable system on a chip (SoC). The ESP32 is a good choice for many Internet of Things applications because of its low power consumption, small size, and good cost-to-performance ratio.

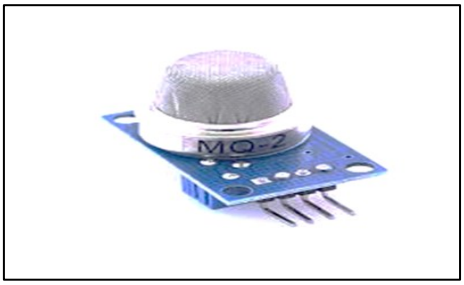
- **Moisture Sensor**

One tool for determining the soil's moisture content is the soil moisture sensor. Changes in moisture levels are wirelessly detected and communicated as unambiguous electrical signals. In order to optimize irrigation systems and avoid overwatering, this device provides data on water content.



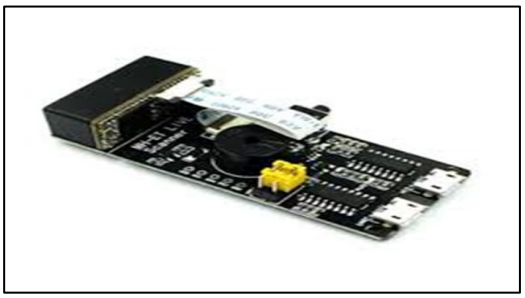
- **Smoke Sensor**

Simple safety devices called smoke sensors are made to identify smoke, which could be a sign of an impending fire. Smoke sensors that are integrated with the ESP32 can detect smoke and send notifications and activate alerts.



- **QR Module**

Devices that read Quick Response (QR) codes which can hold a variety of data, such as URLs, product details, and contact details are known as QR scanners. QR scanners can speed up data entry or identification procedures in Wi-Fi applications when they are integrated with the ESP32. They can be used, for instance, to swiftly log items in inventory management systems.



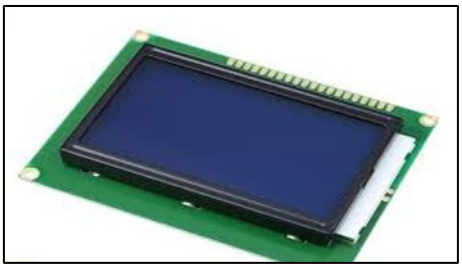
- **GSM Module**

Devices can send and receive SMS messages and make phone calls thanks to GSM modules, which enable cellular communication. Common GSM modules like the SIM800L

and SIM900 are widely used in IoT projects to improve connectivity when integrated with the ESP32. In the event of an emergency, the ESP32 can monitor sensors and send timely SMS alerts, ensuring that users are informed and able to react quickly.

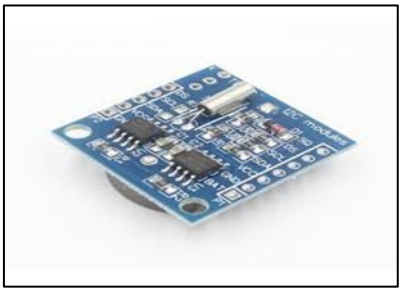
- **LCD**

In electronic applications, liquid crystal displays, or LCDs, are frequently used to give users a visual interface. They can display text, numbers, and images and come in a variety of formats, such as graphical and character displays. LCDs can be used in conjunction with the ESP32 to show system status messages, user prompts, or real-time data from sensors. Usually, I2C or SPI communication protocols are used to accomplish this integration.



- **RTC Module**

A low-power, full binary-coded decimal (BCD) clock/calendar with 56 bytes of NV SRAM is the DS1307 serial real-time clock (RTC). I2 C, bidirectional shipping is used to exchange data and statistics serially. Records for seconds, minutes, hours, days, dates, months, and a full year are provided by the clock/calendar. With the exception of Wi-Fi cations for jump years, the belief of the month date is thereby balanced for months with significantly fewer than 31 days. The clock has an AM/PM indicator and can be set to run in either a 24-hour or 12-hour format.



- **QR Code Mapping Logic**

The system makes use of a manually selected product dataset with QR codes that include embedded data like the product name, expiration date, and rack location. A unique script was created for the ESP32 to scan and decipher these codes in order to enable accurate expiration tracking and alert generation without depending on machine learning. To confirm that the mapping between the alert generation logic and expiration dates was accurate, sample data was used. Although machine learning is not heavily used in this version, time-series data will be used in subsequent iterations to forecast item deterioration based on sensor readings.

6. Results and Discussion

By guaranteeing real-time tracking of expiration dates, inventory levels, and environmental conditions of internal storage shelves, the Savvy Inventory Framework for Expiry Date Management greatly improves inventory management. By sending GSM alerts one week before expiration, the Wi-Fi-enabled system minimizes product waste and allows for prompt intervention. While automated inventory checks increase efficiency by sending out alerts when item counts drop below predetermined thresholds, QR code-based tracking guarantees accurate record-keeping and reduces human error. Furthermore, by identifying anomalous conditions and sounding a buzzer alarm to stop damage or dangers, moisture and smoke sensors enhance product safety. The LCD display makes it simple to identify and remove near-expiry items by providing a real-time list of them along with their shelf locations.

By minimizing losses, optimizing inventory levels, and keeping a safe and orderly stock, the framework significantly impacts organizations. All things considered, it is incredibly effective, reliable, and Wi-Fi enabled.

Figure 2. Hardware Implementation of the Proposed Research Work

The hardware configuration used to test environment monitoring, expiry tracking, and notification alerts is depicted in this figure 2. The ESP32 interfaces with all sensors and modules to manage data collection and notification.

- **Testing and Validation**

The system was evaluated using twenty different sample products from five categories. To create alerts for tracking expiration, items with upcoming expiration dates (within 3 to 7 days) were scanned and verified. To verify sensor validation, buzzer alerts and sensor response were evaluated in controlled smoke and humidity environments. Sensor reaction time, rack location display accuracy, and alert generation time were all tracked in logs. The system correctly identified 98% of expiration alerts and detected 100% of simulated smoke and moisture events.

- **Evaluation Tools**

For evaluation purposes, logging tools attached to the ESP32 serial monitor were used to record timestamps for every event. GSM delivery was confirmed using the timestamps of the SMS messages that were received. Calibration of the sensor was made easier by reference values from a smoke generator and a digital hygrometer. To evaluate latency, accuracy, and false alarm rates, data logs were examined. Although sensor fusion methods will be improved in the future to increase accuracy, this version did not include any optimization algorithms.

- **Practical Limitations**

Despite the successful implementation, a number of practical difficulties arose. For precise QR code detection, steady lighting was necessary. Additionally, because GSM notifications rely on network strength, alerts in remote areas may be delayed. Sensor sensitivity adjustments were necessary to reduce false alarms brought on by ambient fluctuations. Additionally, cloud-based storage and sophisticated data management have been identified as necessary for scalability to larger inventory systems, and these aspects are being taken into account for future development.

7. Future Scope

The proposed scope of the Eager Stock Framework for Expiry Date Tracking incorporates integration with artificial intelligence and machine learning for predictive analytics, facilitating automated order processing and optimized restocking. Enhancing compatibility with voice assistants and mobile applications will improve customer accessibility and management. Additionally, integrating automation for item sorting and retrieval can streamline operations. The framework can also be tailored for various industries, including pharmaceuticals, grocery stores, and warehouses, ensuring greater relevance and improved efficiency in inventory management.

8. Conclusion

With the integration of QR code Wi-Fi scanning, real-time continuous expiry tracking, cloud capabilities, GSM notifications, and user-friendly searching, the Eager Inventory Framework for Expiry Date improves stock management. This system enhances stock efficiency through real-time inventory tracking, reduces product waste by sending out timely expiry alerts, and guarantees product safety with features that detect moisture and smoke. The LCD display and cloud-based monitoring also make it simple to overlook and take quick action, which improves the effectiveness, dependability, and affordability of the inventory process. For companies in the food, pharmaceutical, and retail sectors—where product safety and shelf life are crucial to preserving operational effectiveness—this system is especially beneficial.

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