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Smart Refrigerator with RFID-Based Expiry Alert System Using ESP32

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Abstract- Food waste resulting from the unnoticed expiration of stored food is a prevalent issue in both home and commercial settings. Traditional refrigerators lack an automated way to track food expiration dates, leading to the unnecessary disposal of still-edible items. To address this problem, this study introduces a Smart Refrigerator with an RFID-based expiry notification system utilizing Internet of Things (IoT) technology. Each food item is given an RFID tag, which is scanned prior to placing the item in the refrigerator. The expiry date is then input through the Blynk mobile application connected to an ESP32 microcontroller. The ESP32 retains the food item information in its internal memory and continuously checks the expiry dates. A day before the expiration date, a cautionary message appears on an OLED display attached to the refrigerator. If the food item is taken out before it expires, the RFID tag is scanned again to refresh the system. The proposed solution is cost-effective, easy to use, and aids in minimizing food waste by sending timely notifications.

Keywords: Smart Refrigerator, RFID, ESP32, IoT, Expiry Alert System, OLED Display.

I. INTRODUCTION

Food waste poses a significant global challenge impacting homes, eateries, and food storage units. A key factor contributing to food waste is the inability to keep track of the expiration dates of food kept in refrigerators. People frequently forget about the items they have stored or fail to notice their expiration dates, resulting in health hazards and financial losses.

With the progress made in Internet of Things (IoT) technology, smart appliances are gaining more popularity in contemporary households. IoT allows devices to interact and execute automated functions, thereby enhancing efficiency and convenience. Utilizing IoT principles on refrigerators can greatly improve food management by monitoring food items and their expiration dates.

This initiative concentrates on creating an intelligent refrigerator system that tracks food expiration using RFID technology and sends timely notifications to users. The goal of the system is to minimize food waste and enhance food safety.

II. PROBLEM STATEMENT

Conventional refrigerators lack an automated method for monitoring food expiration dates. Relying on manual checks is labor-intensive and prone to errors, frequently resulting in spoiled food and waste. As a result, an intelligent and automated solution is necessary to keep track of food items and alert users prior to their expiration.

III. PROPOSED SYSTEM

The system that is being proposed includes an ESP32 microcontroller, an RFID reader, RFID tags, and an OLED display. Each food item is equipped with a unique RFID tag for identification. Prior to placing the food item in the refrigerator, the RFID tag is scanned, and the expiry date is inputted via the Blynk mobile application.

The ESP32 saves the RFID tag ID along with the expiry date in its internal memory, functioning as a local database. The system constantly monitors the current date against the saved expiry dates. When a food item is just one day from expiring, a warning message appears on the OLED screen. If the food

item is taken out before it expires, the RFID tag is scanned again to update the database accordingly.

IV. HARDWARE AND SOFTWARE COMPONENTS

Hardware Components

- ESP32 Microcontroller
- RFID Reader
- RFID Tags
- OLED Display
- Power Supply

Software Components

- Arduino IDE
- Embedded C Programming
- Blynk Mobile Application

V. HARDWARE COMPONENTS DESCRIPTION

ESP32 Microcontroller

The ESP32 is an affordable and robust microcontroller created by Espressif Systems, commonly utilized in Internet of Things (IoT) projects. It incorporates both Wi-Fi and Bluetooth modules, making it ideal for connecting smart devices. In the described system, the ESP32 serves as the main processing unit. It collects RFID data, saves information about food items and their expiration dates in its internal memory, interacts with the Blynk mobile app, and manages the OLED display. The ESP32 continuously checks the expiration dates and sends notifications when an item is nearing its expiration.

RFID Reader Module

The RFID reader module is designed to detect RFID tags attached to food products. It operates using radio frequency communication to read the unique ID number that is embedded in the RFID tag. When a food item is either placed into or taken out of the refrigerator, the RFID reader obtains the tag ID and relays it to the ESP32 for further processing. This enables the system to monitor the addition or removal of food items precisely without requiring manual entry.

OLED Display

The OLED (Organic Light Emitting Diode) display serves to present system notifications and expiration alerts. It ensures good visibility while consuming minimal power, making it ideal for ongoing use. In the suggested system, the OLED display indicates warnings like “Food Item Expiring Tomorrow” along with the related RFID tag details. This guarantees that users obtain visual alerts directly on the refrigerator.

Power Supply Unit

A regulated power supply is utilized to deliver consistent voltage to the ESP32, RFID reader, and OLED display. The ESP32 generally functions at 3.3V, whereas other components might need 5V. Adequate voltage regulation guarantees dependable system performance and safeguards against hardware damage.

Mobile Device with Blynk Application

A smartphone running the Blynk mobile application is used as the user interface. The user enters the expiry date of each food item through the app after scanning the RFID tag. The app communicates with the ESP32 over Wi-Fi, enabling real- time data input and system monitoring.

VI. WORKING METHODOLOGY

The proposed methodology for the Smart Refrigerator featuring an RFID-based expiry alert system is crafted to guarantee precise identification, storage, monitoring, and notification of food items stored inside the refrigerator. This system incorporates RFID technology, an IoT-enabled microcontroller, a mobile application interface, and a display module to deliver an automated and user-friendly solution for food management.

At the outset, each food item designated for storage within the refrigerator is allocated a unique RFID tag. These RFID tags hold a distinct identification number that sets each food item apart. Prior to placing a food item inside the refrigerator, the user scans the RFID tag with the RFID reader module connected to the ESP32 microcontroller. The RFID reader captures the

unique ID of the tag and relays it to the ESP32 for additional processing.

Once the RFID tag has been accurately scanned, the user inputs the associated food item's expiry date via the Blynk mobile application. The Blynk app acts as the user interface, communicating with the ESP32 through a Wi-Fi connection. This design choice negates the necessity for physical input devices like keypads, streamlining the overall system design. The expiry date entered by the user gets linked to the scanned RFID tag ID and is committed to the internal memory of the ESP32. This internal memory serves as a local database, enabling the system to function autonomously without dependence on external cloud storage.

Following the storage of the food item details, the ESP32 consistently runs a background task to keep track of all recorded expiry dates. It periodically compares the current date with the expiry dates stored in the memory to ensure prompt identification of approaching expiration items. When the system recognizes that a food item is exactly one day away from its expiry date, it activates an alert mechanism.

The alert mechanism consists of presenting a warning message on the OLED display attached to the refrigerator. The display conveys information such as the RFID tag identifier and an alert message that indicates the corresponding food item is nearing its expiration. This visual alert empowers users to take necessary actions, such as consuming the food item or removing it from the refrigerator, thus minimizing food waste and mitigating health risks associated with expired products.

Alongside expiry monitoring, the system also manages the removal of food items. If a food item is removed from the refrigerator before reaching its expiry date, the user scans the RFID tag once more using the RFID reader. Upon recognizing a repeated scan of an existing RFID tag, the ESP32 interprets this as the removal of the item. The relevant entry is then deleted from the internal memory, ensuring that outdated or unnecessary data is cleared from the system. This update process upholds the accuracy of the stored database and prevents erroneous expiry alerts.

The entire system functions in real time and maintains synchronization between the RFID reader, ESP32, OLED display, and the Blynk application. Since the database is contained locally within the ESP32, the system continues to operate even during short-term network outages. The use of energy-efficient components guarantees ongoing operation with minimal power consumption, making the system ideal for prolonged use in both residential and commercial settings.

In summary, the working methodology guarantees smooth interaction between hardware and software components, facilitating effective tracking of food items, accurate expiry monitoring, and prompt alert generation. The modular design of the system allows for future enhancements such as cloud integration, mobile notifications, and advanced analytics without necessitating significant modifications to the existing architecture.

VII. RESULTS AND OBSERVATIONS

The system successfully tracked multiple food items and their expiry dates. Alerts were displayed accurately one day before the expiry date. The system also correctly updated the database when food items were removed before expiry. The use of local memory ensured reliable operation even without continuous internet connectivity.

VIII. ADVANTAGES

- Reduces food wastage
- Low-cost implementation
- Easy to use and maintain
- Provides real-time expiry alerts
- No dependency on cloud storage

IX. APPLICATIONS

- Household refrigerators
- Restaurants and hotels
- Hostels and mess facilities
- Medical cold storage

- Supermarkets

X. CONCLUSION

The Intelligent Refrigerator featuring an RFID-based expiration alert system presents a practical method for overseeing food supplies through IoT technology. By delivering prompt expiry notifications, this system aids in minimizing food waste and enhancing food safety. The system proposed is cost-effective, expandable, and applicable to real- world scenarios. Potential future improvements could involve mobile alerts, cloud connectivity, and sophisticated analytics.

XI. FUTURE SCOPE AND UPGRADATIONS

The proposed smart refrigerator system could be improved with several advanced features to enhance its functionality, scalability, and user experience. One potential upgrade is to incorporate cloud-based storage, enabling food item data and expiration details to be stored and retrieved remotely. This capability would allow users to receive real-time alerts on their smartphones even when they are not at home.

Another significant enhancement is the inclusion of mobile push notifications or SMS alerts, making sure that users are informed about approaching food expiry dates without having to check the refrigerator screen. Additionally, integrating with voice assistants could be an option, permitting users to inquire about food status through voice commands.

The system could also be upgraded to facilitate automatic expiry detection by implementing barcode scanning or image recognition methods, thereby decreasing the necessity for manual entry of expiration dates. Advanced analytics could be introduced to evaluate food consumption trends and offer recommendations for optimal purchasing or storage methods to reduce waste.

From a hardware standpoint, larger displays or touchscreens could be added to create a more engaging user interface. The system may also be expanded to accommodate multiple compartments and large-scale storage environments, including supermarkets, cold storage facilities, and medical refrigeration units.

In summary, these upgrades could evolve the proposed system into a fully automated, intelligent food management solution appropriate for smart homes and commercial uses.

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