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Edge AI Based Expiry Detection and Email Alert System Using OCR Cloud Integration and Raspberry Pi

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Abstract: The increasing consumption of packaged food products, medicines, and household consumables make user difficult to remember each and every product's expiry dates and has created a growing need for efficient expiry-date monitoring systems. Traditional methods of manually checking product expiry dates are time-consuming, prone to human error, and often result in unnecessary product wastage or safety risks. This paper proposes an Edge AI Based Expiry Detection and Email Alert System that utilizes Optical Character Recognition (OCR), cloud storage, and automated email notification services including computer vision to monitor product expiry information. The proposed system employs a Raspberry Pi zero 2w and a camera module to capture product information, extract name, manufacturing and expiry dates, and store the data in a cloud-based Google Sheets database. The system further integrates a Real-Time Clock (RTC) module for date comparison, an OLED display for local notifications, a PIR motion sensor for user-triggered alerts, and email notification services for remote monitoring. For products containing "Best Before" durations instead of explicit expiry dates, the system calculates expiry dates automatically using the manufacturing date. The complete system is designed as a battery-powered portable solution utilizing rechargeable 18650 lithium-ion cells with charging and power management circuitry. The proposed architecture aims to reduce manual effort, improve inventory monitoring efficiency, and provide a low-cost intelligent solution suitable for households, retail stores, pharmacies, and inventory management applications.

Keywords: *Edge-AI, Google Sheets,Optical Character Recognition, Cloud Storage, Power Management Circuitry,Computer Vision,Raspberry Pi zero 2w.*

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I. INTRODUCTION

➢ *General Overview*

Health is one of the most important aspects of the human life, and it is highly dependent on the quality and safety of the food and medicines consumed. Consumption of expired food products, expired ingredients, or expired medicines can lead to serious health issues and safety risks.

➢ *Problem Statement*

In many households, food ingredients and medicines are often transferred from their original packaging into storage containers after purchase. During this process, important information such as manufacturing date and expiry date printed on the product packaging may be discarded along with the cover. As a result, users may lose track of the expiry status of the stored products.

Due to the lack of an effective monitoring system, people may unknowingly use expired products in daily life. This can lead to health complications, food wastages, and reduced consumer safety.

➢ *Objectives*

- Automate product expiry monitoring.
- Reduce manual effort.
- Provide cloud-based record management.
- Generate OLED and email notifications.
- Calculate expiry dates from shelf-life information.
- Enable battery-powered portable operation.

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II. EASE OF USE

A. User Convenience

The proposed system is designed to minimize user effort by automating product information extraction, expiry date calculation, cloud synchronization, and notification generation. Users only need to place the product in front of the camera, while all subsequent operations are preformed automatically.

B. Automation Benefits

The integration of OCR, cloud storage, and automated date processing eliminates manual record keeping and expiry verification. This improves operational efficiency, reduces human intervention, and minimizes the possibility of errors.

C. Accessibility

The system provides both local and remote notifications through OLED display and email alerts. Its battery-powered design enables portable deployment, making it suitable for households, pharmacies, retail stores, and inventory management applications.

III. LITERATURE REVIEW

Several researchers have explored automated inventory monitoring and product management systems using computer vision, cloud computing, and embedded system technologies.

- *Optical Character Recognition*

Optical Character Recognition(OCR) has emerged as an effective solution for extracting textual information from the images and printed labels. *Ray Smith[1]* presented the ICDAR proceedings on *"An overview of the Tesseract OCR Engine"* demonstrated its capability to recognize and extract text from digital images with high accuracy. This technology has since been widely adopted in document analysis, product identification, and inventory management applications.

- *Edge Computing*

The emergence of Edge Computing has enabled real-time data processing at the source of data generation, reducing dependence on cloud infrastructure and minimizing communication latency. Satyanarayanan. M[2] (*The emergence of Edge Computing)* highlighted the advantages of edge computing in supporting intelligent IoT applications by performing computational tasks closer to end devices. Edge computing platforms are particularly beneficial for applications requiring immediate decision-making and local data processing.

- *Raspberry Pi Zero 2w Documentation*

Embedded computing platforms such as the Raspberry Pi have gained significant popularity in IoT and automation systems due to their low cost, compact size, wireless connectivity, and sufficient processing capabilities. The Raspberry Pi Foundation provides comprehensive documentation demonstrating the suitability of Raspberry Pi devices for image processing, sensor interfacing, cloud communication, and embedded artificial intelligence applications. These features make Raspberry Pi an ideal platform for implementing smart monitoring systems.

- *Google Sheets API Documentation*

Cloud-based storage and synchronization services have further enhanced the functionality of modern IoT systems. The Google Sheets API enables secure storage, retrieval, and management of structured data through cloud-based spreadsheets. Such cloud integration facilitates centralized monitoring, remote accessibility, and efficient data management without requiring dedicated database infrastructure.

- *Smart Expiry Date Detection Using AI and Cloud Deployment*

Farzana and Arun Kumar[5] proposed a smart expiry detection system integrating OCR, barcode scanning, cloud architecture, and automated notification mechanisms for product expiry monitoring. Their work highlighted the importance of automated expiry recognition and real-time alert generation in reducing manual monitoring efforts. The study demonstrated the potential of combining computer vision and cloud technologies for inventory management applications. However, the system primarily focused on cloud-based monitoring and barcode integration.

Although these technologies have been successfully applied in various inventory management and monitoring applications, most existing systems primarily focus on inventory tracking and product identification. Limited attention has been given to automated expiry date monitoring and notification systems. Furthermore, many existing solutions require significant manual intervention or additional hardware infrastructure. The proposed Edge AI Based Expiry Detection and Email Alert System addresses these limitations by integrating OCR-based text extraction, edge computing, cloud storage, automated expiry date calculation, motion-triggered notifications, and email alert services within a low-cost battery-powered embedded platform.

IV. SYSTEM OVERVIEW

The proposed Edge AI Based Expiry Detection and Email Alert System is designed to automate the process of monitoring product expiry dates using Optical Character Recognition, cloud integration, and embedded computing technologies. The system combines image acquisition, text extraction, cloud storage, date comparison, and notification mechanisms within a single intelligent platform.

The overall system consists of a Raspberry Pi Zero 2 W, Raspberry Pi Camera Module V2, DS3231 Real Time Clock module, PIR motion sensor, OLED display, cloud based Google Sheets database, and a rechargeable battery powered subsystem. The Raspberry Pi zero 2w serves as the central processing unit responsible for image processing, OCR execution, cloud communication, expiry date calculation, and notification management.

Initially, the camera captures product images containing product names, manufacturing dates, expiry dates, or shelf life information. OCR algorithms extract the relevant textual information from the captured images. The extracted data is then stored in a Google Sheets database through a wireless internet connection.

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The Real Time Clock module continuously provides current date and time information. The system compares the stored expiry date with the current date to identify expired products. For products containing only shelf life information such as "Best Before 24 Months," the expiry date is automatically calculated using the manufacturing date.

Expired product information is displayed on an OLED display whenever user presence is detected by the PIR motion sensor. Additionally, email notifications are automatically generated and sent to users at predefined intervals. The entire system is powered using rechargeable 18650 lithium ion batteries with charging and power management circuitry, enabling portable operation.

The proposed architecture aims to provide an efficient, low cost, and intelligent solution for product expiry monitoring in households, pharmacies, retail stores, and inventory management environments.

V. PROPOSED METHODOLOGY

The proposed system operates through six major stages.

- *Stage-1:Product Image Acquisition*

The user places a product in front of camera module. The system captures two images. The first image is used for extracting the product name while the second image is used for extracting manufacturing and expiry date information. Everything extracted from the image is shown in the OLED display for user acknowledgement.

- *Stage-2:Cloud synchronization*

After extracting the product name, the information is uploaded to a Google Sheets database through a wireless internet connection. The second image is captured only after successful cloud synchronization of name of the product. After the cloud synchronization of manufacture and expiry dates OLED display the details for user acknowledgement and confirmation.

- *Stage-3:RTC Based Expiry Monitoring*

The extracted expiry date is compared with the current date obtained from a Real Time Clock module. If the product has expired or reaches its expiry date, the system generates notifications.

- *Stage-4: Motion Triggered Notification and Email Alerts*

A PIR motion sensor continuously monitors user activity. When motion is detected, expired product details are displayed on an OLED display.

Everyday at 9:00 AM IST, the system sends email notification if expired products exist. Sender's email credentials and the receiver email address is given in the code itself.

- *Stage-5:Automatic Expiry Date calculation*

Certain products specify shelf life using "*Best Before*" durations instead of explicit expiry dates. In such cases, the system extracts the manufacturing date and calculates the expiry date automatically by adding the specified duration.

- *Stage-6:Power Management*

The complete system is powered using rechargeable 18650 lithium ion batteries. A battery charging module, battery protection circuit, and voltage regulation circuitry ensure reliable and portable operation.

Two Switches are used:

- Main Power Switch
- Camera Power Switch

The camera remains Off until required to save power. Buck/Boost convertors regulate stable voltage for Raspberry Pi zero 2w operation.

VI. HARDWARE MODULE

The proposed system consists of the following hardware components:

A. *Raspberry Pi zero 2w(1 GHz Quad-Core CPU)*

The Raspberry Pi Zero 2 W serves as the central processing unit. It performs image acquisition, OCR processing, cloud communication, date calculations, notification generation, and sensor interfacing.

B. *Raspberry Pi Camera Module(5MP)*

The camera module captures images of product labels and date information. The captured images are processed by OCR algorithms for text extraction.

C. *OLED Display*

A 0.96 inch OLED display is used to provide local notifications regarding expired products. Product names and expiry dates are displayed to users.

D. *DS3231 Real Time Clock Module*

The RTC module maintains accurate date and time information required for expiry date comparison.

E. *PIR Motion Sensor*

The PIR sensor detects human movement and activates notification display functionality when user presence is detected.

F. *Battery Management System*

The power subsystem includes rechargeable 18650 batteries, charging circuitry, battery protection circuitry, and voltage regulation modules to ensure stable system operation.

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VII. SOFTWARE MODULES

The software architecture is developed using Python and consists of multiple modules.

A. Image Processing Module

The OpenCV library is used to preprocess captured images. Noise reduction, grayscale conversion, and thresholding operations improve OCR accuracy.

B. OCR Module

Tesseract OCR extracts textual information including product names, manufacturing dates, expiry dates, and shelf life durations.

C. Cloud Storage Module

Google Sheets API is used as a cloud database for storing product information and expiry records.

D. Date Processing Module

Python datetime libraries are utilized to compare dates and calculate expiry dates from manufacturing dates and shelf life durations.

E. Notification Module

OLED display notifications and email alert services are implemented to provide local and remote expiry alerts.

F. Scheduling Module

The scheduling module automates periodic checks, daily notifications, and cloud synchronization tasks.

VIII. EXISTING SYSTEMS

A. A Cloud-Based Smart Expiry System Using QR Code[3]

➢ *Summary:*
- Uses QR codes and cloud storage.
- Customers scan a QR code to receive expiry reminders.
- Automatically downloads expiry information from the cloud.

➢ *Limitations:*
- Requires QR codes to be available on the products.
- No OCR capability.
- Limited edge processing.

B. Automatic Expiry Date Notification System Interfaced with Smart Speaker[4]

➢ *Summary:*
- Provides expiry reminders using a smart speaker.
- Focuses on automated notifications.

➢ *Limitations:*
- Primarily a reminder system.
- Does not automatically extract expiry dates from product labels.
- Requires prior data entry.

C. Smart Expiry Date Detection System Using AI and Cloud Deployment[5]

➢ *Summary:*
- Scans barcode and uses OCR techniques to retrieve the expiry date.
- Focuses on automated notifications.

➢ *Limitations:*
- Certain products do not contain expiry information in the barcode
- Lack of expiry date calculation.
- Motion triggered notifications.

Table 1 Identified Research Gap

Research Gap	Existing System	Proposed System
Expiry Date Calculation	Most systems cannot calculate expiry dates when only shelf-life information (e.g., "Best Before 24 Months") is available.	Automatically computes expiry dates using manufacturing dates and shelf-life duration.
Intelligent User Notification	Many systems provide only SMS or basic dashboard notifications.	Provides OLED notifications, PIR-triggered alerts, and scheduled email notifications.
Portable Deployment	Most inventory monitoring systems require continuous mains power.	Battery-powered architecture using rechargeable 18650 lithium-ion cells enables portability.
Multi-Domain Applicability	Existing solutions are often designed specifically for food products or medicines.	Supports food products, medicines, cosmetics, and household consumables.
Cloud-Based Record Management	Some systems rely on local storage, limiting accessibility and scalability.	Uses Google Sheets cloud integration for centralized and remotely accessible records.
Low-Cost Implementation	Many Systems use Raspberry Pi as a central processing unit which is high cost.	Uses Raspberry Pi zero 2w as central processing unit which is cost effective and reliable.

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IX. LIST OF FIGURES

- *Power Architecture*

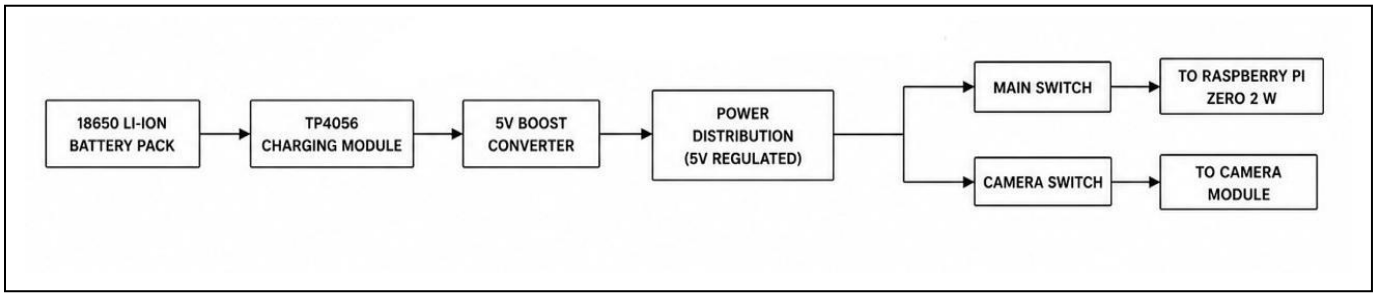

Fig 1 Power Architecture of the Proposed System

- *System Architecture*

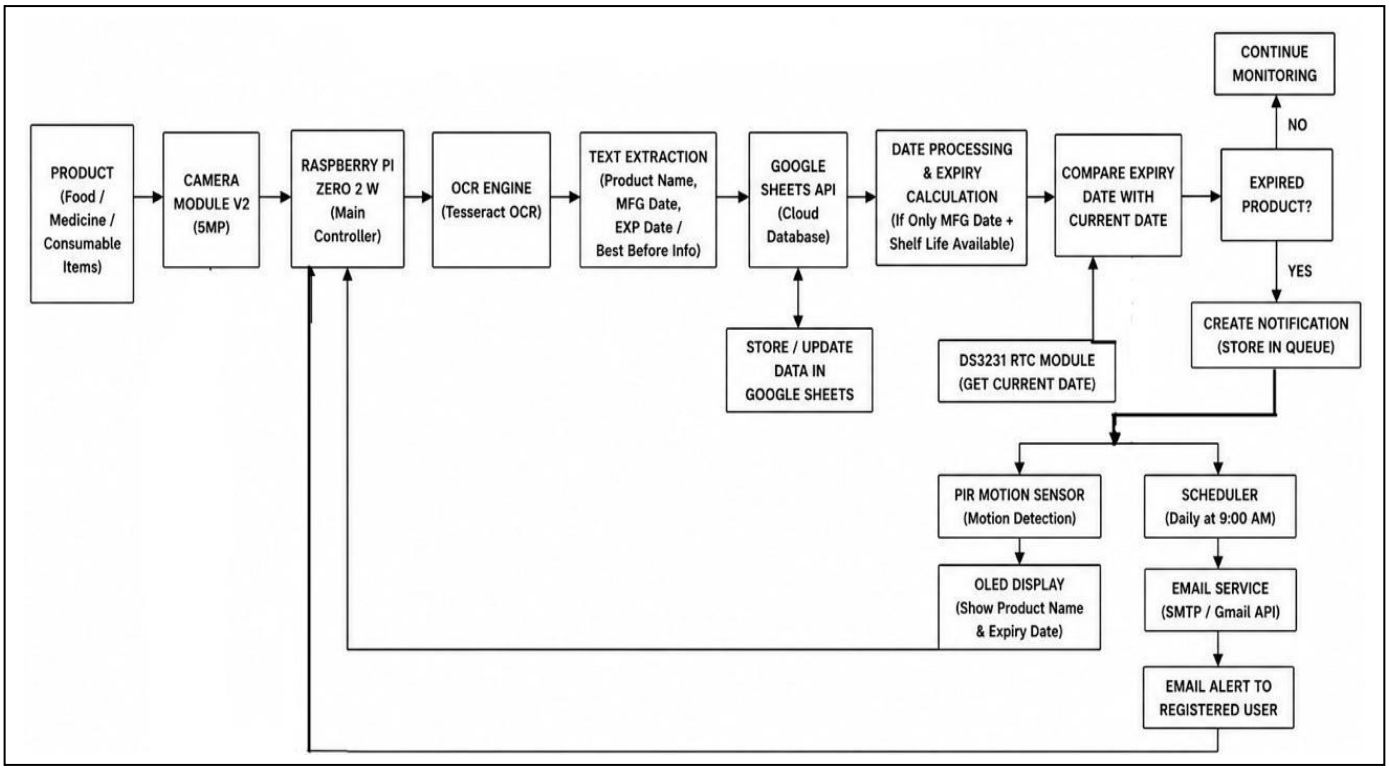

Fig 2 System Architecture

Table 2 List of Abbreviations

Abbreviations	Meaning
OCR	Optical Character Recognition
OLED	Organic Light Emitting Diode
MFG	Manufacture
EXP	Expiry
RTC	Real Time Clock
PIR	Passive Infrared
API	Application Programming Interface
QR	Quick Response code

X. EXPECTED RESULTS

The proposed system is expected to:

- Extract product information accurately using OCR.
- Detect expired products automatically.
- Calculate expiry dates from manufacturing dates.
- Display notifications on OLED.
- Send daily email alerts.
- Reduce manual monitoring effort.

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XI. CONCLUSION

This paper presented a proposed Edge AI Based Expiry Detection and Email Alert System Using Raspberry Pi. The system integrates OCR technology, cloud storage, automated date processing, motion based notifications, and email alert services to address challenges associated with manual expiry monitoring.

The proposed architecture provides a low cost, portable, and intelligent solution capable of reducing product wastage and improving consumer safety. The integration of embedded computing and cloud technologies demonstrates the potential for developing smart inventory management systems suitable for domestic and commercial applications. Future implementation and experimental evaluation will further validate the effectiveness and practical applicability of the proposed system.

FUTURE SCOPE

- Mobile application integration can provide real time notifications and inventory management.
- Advanced machine learning algorithms can enhance OCR performance under challenging lighting conditions.
- Voice based notifications and multilingual support can further improve accessibility.
- Integration with cloud databases and enterprise inventory systems can support large scale deployment in retail and pharmaceutical industries.

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