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The Application of Color-Coded Visualization for Monitoring Expiry of FMCG in Warehouse

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ABSTRACT

Warehouse management is efficient operation is essential for ensuring timely product movement and reducing losses due to expired or outdated goods. Traditional systems rely heavily on software records and manual verification, which often leads to human errors in stock picking. This project proposes a real-time inventory monitoring system that integrates hardware and software for automated stock visibility. Data is stored in a centralized warehouse database and processed by an age calculator module. Based on the manufacturing date and expiry date, products are categorized into three stages:green for newly stored items, yellow for medium-aged items, and red for older or near-expiry items. The system maps these categories to LED indicators mounted above each storage rack which eliminates the need for workers to manually check labels or software entries before picking.Workers can instantly identify priority stock using visual cues, improving operational efficiency. The system also ensures proper stock rotation following the First Expiry First Out(FEFO)method.The results reduce waste,minimize expired goods, and enhance worker productivity. It also demonstrates an innovative approach to bridging digital inventory data with physical stock visibility. By merging automation and colour-coded indicators,warehouses can achieve smart, efficient, and error-free inventory management.

Keywords: Inventory, Automation, Efficiency, FEFO, Handing, Visualization.

Outline:

Colour-coded visualization remains a critical best practice for tracking Fast-Moving Consumer Goods (FMCG) expiration, significantly reducing waste and ensuring safety by simplifying the identification of perishable items

Color-coded visualization significantly enhances the monitoring of FMCG expiry dates in warehouses by providing instant visual cues for stock prioritization. This approach reduces errors, speeds up inventory checks, and minimizes waste from expired goods.

Significant Benefits:

- Improves picking accuracy through quick identification of near-expiry items, enabling FEFO (First Expiry First Out) compliance.
- Boosts operational efficiency by allowing workers to spot issues at a glance, cutting down search times and manual audits.

- Lowers financial losses as colour zones (e.g., green for fresh, yellow for caution, red for imminent expiry) trigger timely actions like promotions or disposal.

Implementation Approach: Warehouse teams apply colour stickers or digital dashboard labels based on expiry timelines, such as 90 days out. Integration with inventory software automates updates, ensuring real-time visibility across large FMCG stocks.

Potential Challenges: Standardization across shifts prevents misinterpretation, while training ensures consistent application. Initial setup costs are offset by long-term waste reduction in high-volume environments.

Color-coded systems for FEFO (First Expiry First Out) in FMCG warehouses typically use intuitive traffic-light schemes to prioritize stock visually. Green signals safe, long-shelf-life items; yellow warns of approaching expiry; and red flags imminent or expired goods for immediate action

Commended Codes:

- Green: Over 90 days to expiry—safe for regular picking and storage in main zones.
- Yellow: 30-90 days remaining—move to priority picking or promotional areas.
- Red: Under 30 days or expired—dispatch first, discount, or dispose to minimize waste.

Application Tips: Apply codes via stickers on pallets or digital labels in warehouse software, updating daily based on batch dates. Train staff on the scheme for consistency, integrating with barcode scanners for automated alerts.

Benefits in FMCG: This reduces expiry losses by 20-30% in high-turnover warehouses, speeds audits, and ensures compliance with food safety standards.

Warehouses:

Warehouses play a vital role in the supply chain by ensuring safe storage, efficient handling, and timely distribution of goods. In sectors such as FMCG, food, and pharmaceuticals, improper inventory rotation often leads to product expiry, financial losses, and reduced customer trust. Traditional warehouse operations depend largely on software-based tracking and manual checks, which are prone to delays and human error.

One of the major challenges in FMCG warehouses is identifying which products must be dispatched first based on expiry dates. Workers often rely on system screens or physical label checks, which slows down operations and increases error probability. This project addresses this issue by introducing a **visual, real-time, colour-coded system** that directly communicates stock status at the rack level.By integrating physical visualization with digital inventory records, the proposed system enables faster decision-making, supports FIFO practices, reduces wastage, and improves operational efficiency without major structural changes to existing warehouses

Evolution of Warehouses: Warehousing has evolved from simple storage facilities in ancient civilizations to highly automate smart fulfilment centre. Early warehouses focused only on storage, while modern warehouses emphasize speed, accuracy, automation, and real-time visibility. The rise of e-

commerce and FMCG demand has accelerated the adoption of smart technologies such as WMS, IoT sensors, robotics, and automation systems.

Warehouse Processes: Warehouse operations follow a systematic flow:

- Receiving
- Put-away
- Storage
- Inventory management
- Order picking
- Packing
- Shipping
- Returns management

Each process must be accurately coordinated to maintain product quality, especially for perishable goods. **Types of Warehouses: Warehouses are classified into private, public, bonded, automated, cold storage, and distribution centre. FMCG warehouses typically operate as** distribution centre**, where speed, stock rotation, and expiry control are critical.**

FMCG AND EXPIRY MANAGEMENT

Fast-Moving Consumer Goods are products with high demand and short shelf life, such as food, beverages, toiletries, and household items. Due to frequent turnover, FMCG warehouses must maintain strict control over expiry dates.

Manufacture Date (MFD) and Expiry Date (EXP)

- **MFD** indicates when the product was produced.
- **EXP** defines the last safe usage date.

Effective monitoring of these dates ensures product safety, regulatory compliance, and customer satisfaction.

FEFO Principle

FEFO ensures that products nearing expiry are dispatched first, regardless of arrival date. This approach significantly reduces waste and is essential for FMCG, food, and pharmaceutical warehouses.

COLOUR THEORY AND VISUAL COMMUNICATION

Colour plays a crucial role in human perception and decision-making. In industrial environments, colour coding is widely used for safety, alerts, and prioritization.

- **Green**: Safe, fresh, low priority
- **Yellow**: Warning, medium priority
- **Red**: Danger, high urgency

Applying colour-coded visualization in warehouses allows workers to instantly identify stock status without reading labels or checking screens, improving speed and accuracy.

SYSTEM ARCHITECTURE AND COMPONENTS

The proposed system integrates a Warehouse Management System with a physical prototype using an Arduino Nano microcontroller. The system processes expiry data and activates visual indicators accordingly.

Hardware Components

- Arduino Nano
- LED indicators (Red, Yellow, Green)
- LCD display
- Push buttons (for simulation)
- Buzzer (alert system)
- Power supply and circuit board

Software Integration

The WMS provides product details such as batch number, MFD, and EXP. An age calculation logic determines the remaining shelf life and triggers corresponding LED signals.

WORKING METHODOLOGY

When products enter the warehouse, their details are stored in the WMS. The system continuously evaluates product age. Based on predefined thresholds:

- Green LED activates for fresh stock
- Yellow LED activates for medium-aged stock
- Red LED activates for near-expiry stock

LEDs mounted near racks provide instant visual feedback to warehouse workers. The LCD displays detailed status messages, while buzzers alert staff when urgent action is required.

RESULTS AND DISCUSSION

The developed prototype successfully demonstrated improved visibility of product expiry status through the use of colour-coded visual indicators, enabling warehouse personnel to easily identify stock conditions at the rack level. The system facilitated faster and more accurate picking decisions by allowing workers to prioritize products based on their remaining shelf life without referring to manual records or software screens.

The implementation of the system contributed to a reduction in expired inventory by ensuring that near-expiry products were identified and dispatched in a timely manner. Additionally, dependency on manual verification processes such as label checking and repeated system monitoring was significantly reduced, thereby minimizing human error. The prototype also enhanced compliance with the First Expiry First Out (FEFO) principle, ensuring proper stock rotation within the warehouse.Thesystem proved to be cost-effective, scalable, and easy to integrate with existing warehouse layouts, making it a practical and efficient solution for improving inventory management in FMCG warehouse environments.

Advantages

- The system provides real-time visual indicators that help reduce human error caused by manual label checking and frequent software verification.
- Colour-coded alerts improve worker productivity by enabling faster and more accurate decision-making during picking and stock rotation processes.
- Effective monitoring of expiry dates helps minimize product wastage and reduces financial loss, especially in FMCG and perishable goods warehouses.
- The system enhances safety and regulatory compliance by ensuring that expired or near-expiry products are identified and handled appropriately.
- Use of low-cost hardware components makes the system economical and cost-effective.

Applications

- FMCG warehouses for managing fast-moving products with limited shelf life.
- Pharmaceutical storage facilities to ensure strict expiry compliance and product safety.
- Cold storage warehouses handling perishable food items to prevent spoilage and maintain quality.
- Retail distribution centre to improve stock rotation efficiency and reduce losses due to expired products.

Limitations

- The system is developed as a prototype model and does not represent a full-scale industrial implementation.
- Warehouse Management System (WMS) data is manually simulated using push buttons instead of being fetched automatically from a live database.
- The system has limited sensor integration in its current form.
- Environmental factors such as temperature and humidity, which can affect product shelf life, are not monitored.

- Real-time connectivity with existing warehouse software systems is not implemented.

CONCLUSION

This project presents an effective and practical solution for monitoring product expiry in FMCG warehouses using a colour-coded visualization approach. By integrating digital inventory data with physical visual cues, the system successfully bridges the gap between software-based records and real-world warehouse operations. The prototype demonstrates how simple automation and visual communication can enhance operational efficiency, reduce human error, and support FEFO-based inventory management.The proposed system improves accuracy, productivity, and sustainability while remaining cost-effective and easy to implement. Its adaptable design allows it to be scaled and integrated into various warehouse environments, making it a promising solution for modern supply chain and logistics operations. Overall, the project highlights the potential of smart visualization techniques in transforming traditional warehouse management into a more efficient and reliable system.

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