OCR-Based Inventory Detection & Alert Architecture

System Objective

The objective of this module is to design and implement a computer vision–assisted inventory monitoring system for a smart freezer using OCR-based text extraction. The system autonomously identifies ice-cream flavour labels from captured images, converts unstructured visual data into structured inventory information, evaluates stock levels in real time, and generates intelligent alerts when inventory falls below predefined thresholds.

This approach eliminates manual stock inspection and enables continuous, automated inventory awareness within smart refrigeration systems.

Overall Architectural Philosophy

The system follows a **pipeline-based, modular architecture**, where each stage performs a clearly defined responsibility. This separation ensures:

- High interpretability
- Easy debugging
- Future extensibility (YOLO, cloud, sensors)
- Hardware independence

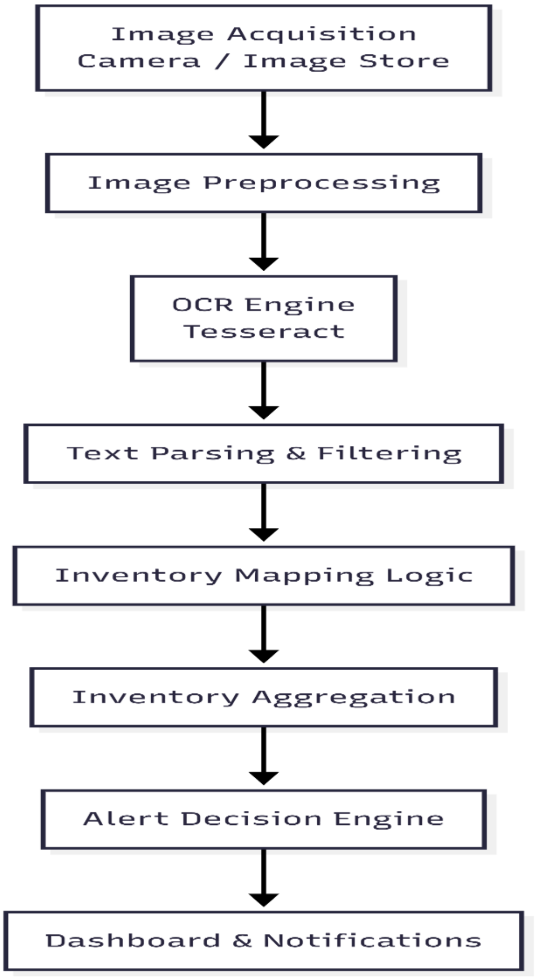


Image Acquisition Layer

This layer captures images of freezer contents containing visible flavour labels. The design is hardware-agnostic, supporting:

- Laptop camera (development/testing)
- USB cameras
- Embedded camera modules (ESP32-CAM in future phases)

The captured images act as the primary unstructured data source for inventory detection.

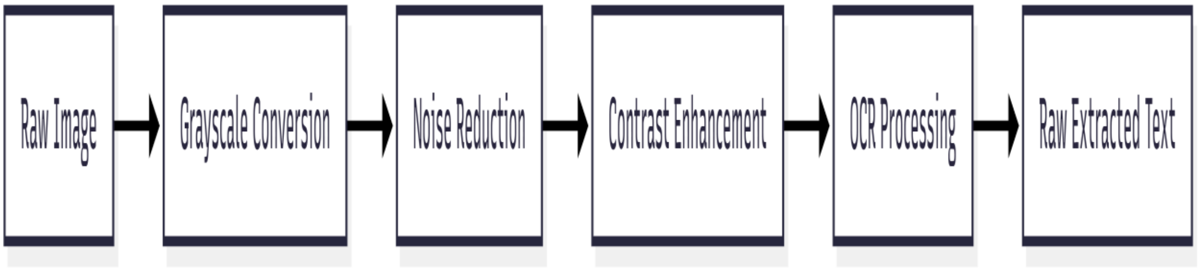
4. Image Preprocessing Stage (Enhanced)

Captured images undergo preprocessing to improve OCR accuracy under challenging freezer conditions such as low lighting and reflections.

Key preprocessing steps include:

- RGB → Grayscale conversion
- Noise reduction using thresholding
- Contrast enhancement for label clarity

Purpose:
Improve OCR reliability and reduce misclassification caused by environmental noise.



OCR Engine Integration

The system integrates Tesseract OCR as the text recognition engine.

Configuration Highlights:

- Language: English
- Page Segmentation Mode (PSM): Optimized for block text
- Output: Raw extracted textual data

This stage converts visual pixel data into machine-readable text, enabling downstream logical analysis.

6Text Parsing & Semantic Filtering

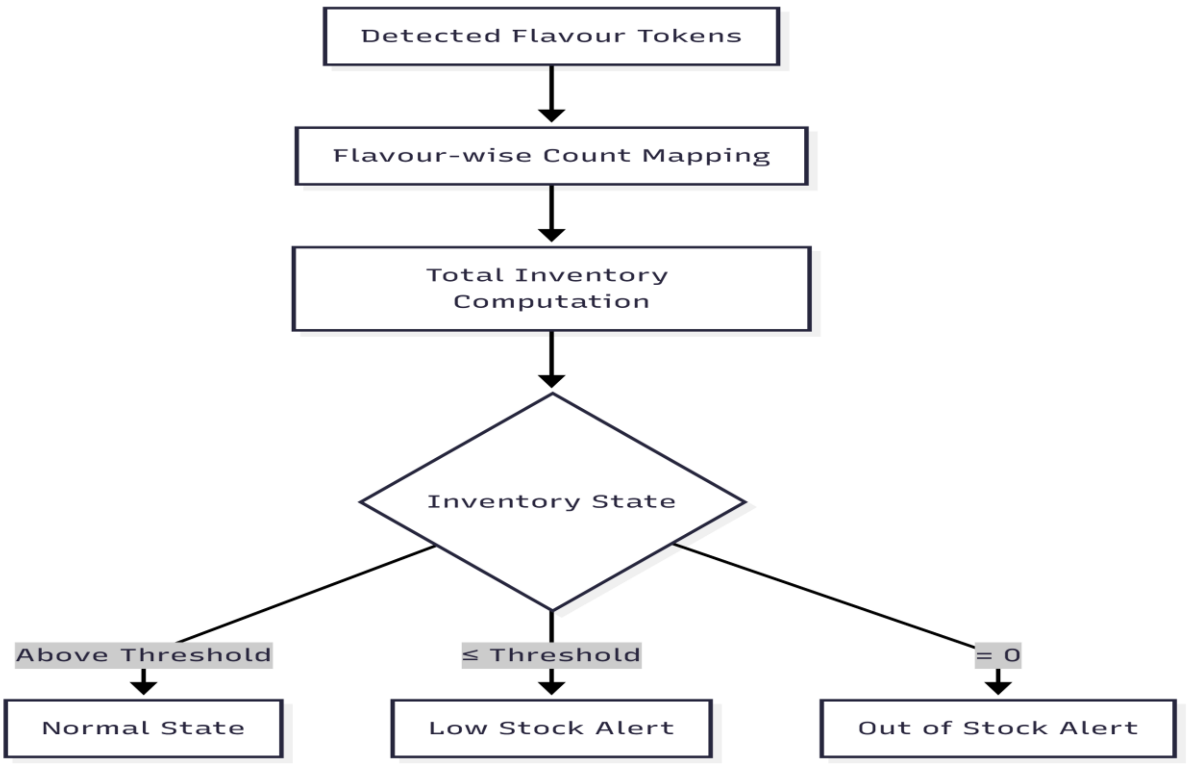
OCR output may contain noise, incomplete words, or irrelevant characters. A semantic filtering module processes this output by:

- Normalizing text (lowercase conversion)
- Tokenizing words
- Matching tokens against a predefined flavour vocabulary

Valid flavour vocabulary example:

["vanilla", "chocolate", "strawberry", "mango", "pista", "coffee"]

Only valid semantic tokens are retained for inventory computation.



Inventory Mapping Logic

Each detected flavour keyword is mapped to an independent inventory counter. Repeated detections increment the corresponding count.

This logic ensures:

- Scalability to multiple flavours
- Independence from image order or count
- Easy addition of new product categories

Inventory Aggregation & State Computation

The system computes:

- Flavour-wise inventory
- Total inventory count
- Inventory state based on thresholds

Inventory States:

- **Normal:** Stock above threshold
- **Low Stock:** Stock ≤ threshold
- **Out of Stock:** Stock = 0

These states serve as **inputs for alert generation and system intelligence**.

Alert Decision Engine

A rule-based alert engine ensures timely stock notifications.

Alert Logic:

- Total inventory = 0 → Critical alert
- Inventory ≤ threshold → Warning alert
- Else → Normal state

This prevents sudden stock depletion and supports proactive restocking.

Data Output & Visualization Layer

Structured inventory data is forwarded to visualization components.

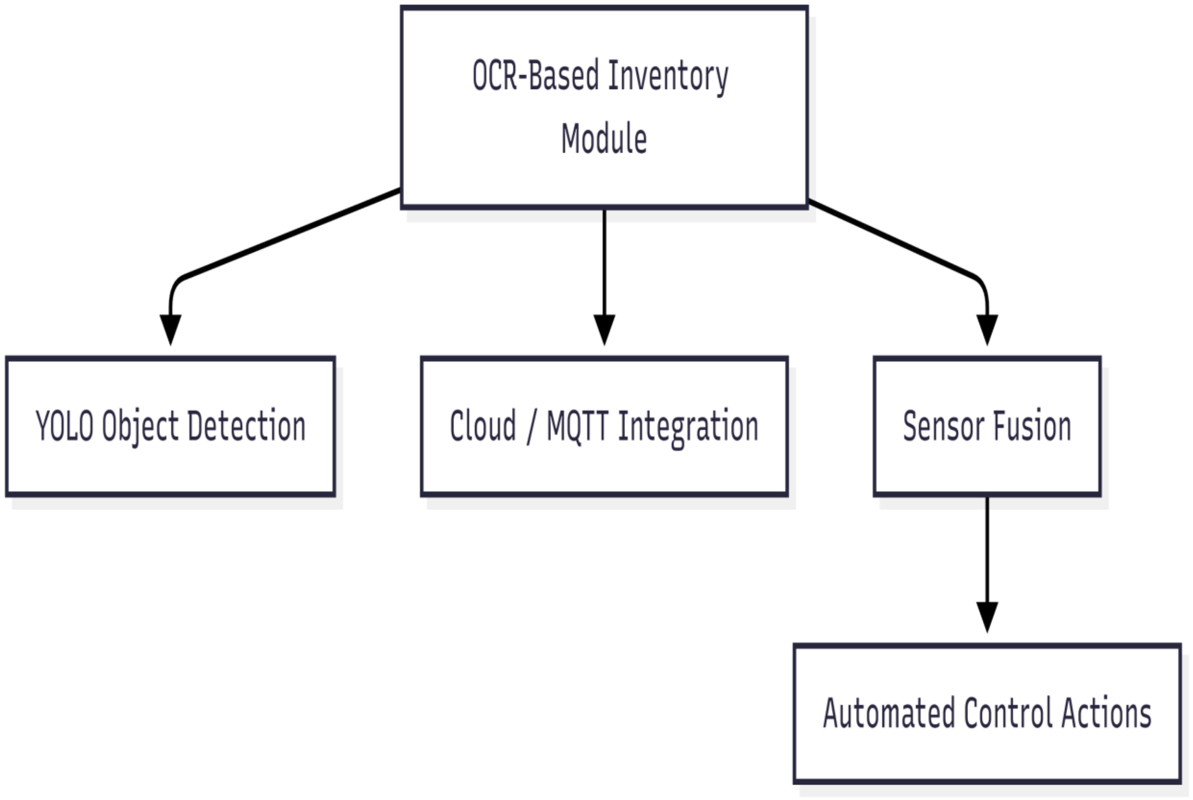
Displayed Parameters:

- Flavour-wise counts
- Total inventory
- Inventory status
- Alert messages

Visualization methods include:

- Dashboard text widgets
- Inventory gauges
- Pop-up alerts

This enables **real-time operator awareness**.



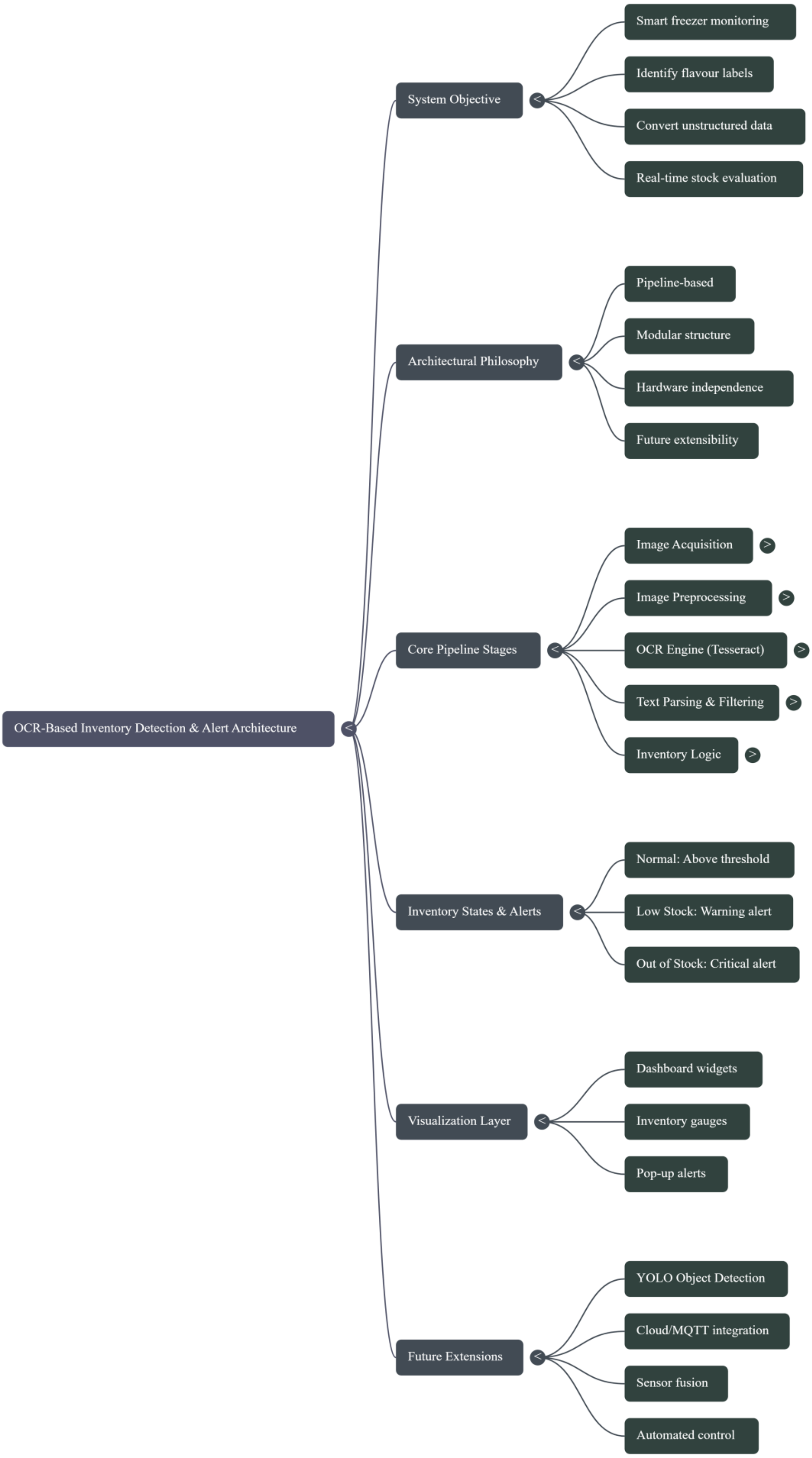
System Modularity & Extensibility

The architecture is modular, enabling seamless future upgrades such as:

- Replacing OCR with YOLO-based object detection
- Cloud-based inventory analytics using MQTT
- Fusion with temperature and door sensors
- Automated freezer control decisions based on inventory

Conclusion

The OCR-based inventory detection system provides a **cost-effective, scalable, and intelligent solution** for automated freezer inventory monitoring. By transforming unstructured visual label data into structured inventory intelligence, the system bridges computer vision with decision-making logic and lays the foundation for advanced smart freezer automation.


OCR-Based Inventory Detection & Alert Architecture
System Objective
Smart freezer monitoring
Identify flavour labels
Convert unstructured data
Real-time stock evaluation
Architectural Philosophy
Pipeline-based
Modular structure
Hardware independence
Future extensibility
Core Pipeline Stages
Image Acquisition
Image Preprocessing
OCR Engine (Tesseract)
Text Parsing & Filtering
Inventory Logic
Inventory States & Alerts
Normal: Above threshold
Low Stock: Warning alert
Out of Stock: Critical alert
Visualization Layer
Dashboard widgets
Inventory gauges
Pop-up alerts
Future Extensions
YOLO Object Detection
Cloud/MQTT integration
Sensor fusion
Automated control