Project Title: OmniShelf AI — YOLOv11-Based Shelf Intelligence & Smart Shopping Assistant

Student Name: Sukriti Sehgal

Email: sukriti.sehgal@colorado.edu

1. Project Description

OmniShelf AI is an end-to-end applied computer vision system designed to detect grocery products, compute stock levels, evaluate shelf compliance, and assist customers in locating products. The project uses **YOLOv11** for product detection, combined with a database and dashboard layer to form a complete intelligent retail solution.

The project follows a **train-on-clean, test-on-real** methodology.
YOLOv11 will be **trained on the Grozi-120 dataset**, which contains clean, isolated grocery product images with annotated bounding boxes. The model will then be **evaluated on 10–15 real supermarket shelf images** from the "Supermarket Shelves Dataset (Humans in the Loop)" to measure real-world generalization—an approach commonly used in industry.

OmniShelf AI includes two modules:

- **Store Intelligence Module:** Detects products, counts stock, flags low-stock/out-of-stock items, and checks planogram compliance.

- **SmartCart Assistant (Customer Module):** Allows customers to enter a shopping list and instantly see shelf location and stock status for each product.

Results are stored in **PostgreSQL**, served via **FastAPI**, and visualized through **Streamlit** dashboards for both store staff and customers.

2. Research Question

How effectively can a YOLOv11 model trained on clean product images (Grozi-120) generalize to real supermarket shelves, and can its detections reliably power automated stock analytics and a customer-facing product lookup assistant?

3. Dataset

Training Dataset (Primary)

Grozi-120 — Roboflow Version

- 120 grocery product categories
- Clean product images
- YOLO-ready annotations
- Ideal for fine-tuning YOLOv11

Evaluation Dataset (Real Shelf Testing)

Supermarket Shelves Dataset — Humans in the Loop (Kaggle)

- Only 10–15 real shelf images
- Includes clutter, occlusion, mixed lighting
- Used purely to test generalization

This combination reflects real retail AI pipelines: training on standardized product images and evaluating on real store shelf photos.

4. Methodology

4.1. Model Training

1. Install YOLOv11 locally (ultralytics library)
2. Load pretrained YOLOv11 weights
3. Train on Grozi-120 with:
    - augmentation (blur, jitter, rotation, synthetic scenes)
    - 50–100 epochs

    - hyperparameter tuning
4. Track mAP, precision, recall, and per-class performance

4.2. Real-Shelf Generalization Testing

1. Run inference on 10–15 real shelf images
2. Compute:
    - mAP drop
    - counting error
    - misclassification patterns
    - qualitative error analysis

4.3. Stock Intelligence Module

1. Count detected product instances
2. Compute **Shelf Stock Health Score**
3. Flag:
    - low stock
    - out-of-stock
    - misplacements
4. Store all detections + metadata in PostgreSQL

4.4. SmartCart Assistant

1. Customer enters a shopping list (e.g., “cornflakes, pasta, coke”)
2. System maps products to shelves using a planogram table

3. Queries PostgreSQL for latest stock levels
4. Returns:
    - shelf number
    - stock status (High/Medium/Low/Out)
    - alternatives if unavailable

4.5. System Integration

- **FastAPI** for serving detection + lookup endpoints
- **PostgreSQL** for detections + planogram storage
- **Streamlit Dashboard** for:
    - Store View: stock health, counts, OOS alerts
    - Customer View: find product locations, availability

5. Success Metrics

Model Metrics

- mAP@50 ≥ **85%** on Grozi-120 validation
- Precision ≥ **88%**, Recall ≥ **85%**
- Generalization accuracy ≥ **70%** on real shelf images

Shelf Analytics Metrics

- Counting error ≤ **10%**
- Stock Health Score accuracy ≥ **90%**

SmartCart Metrics

- Product-location lookup accuracy ≥ **95%**
- Response time ≤ **2 seconds/query**
    - YOLOv11 detections
    - stock analytics dashboard
    - SmartCart Assistant workflow