FRESHNESS ASSESSMENT OF AGRI-PRODUCTS VIA MULTI-TASK COMPUTER VISION

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What ?
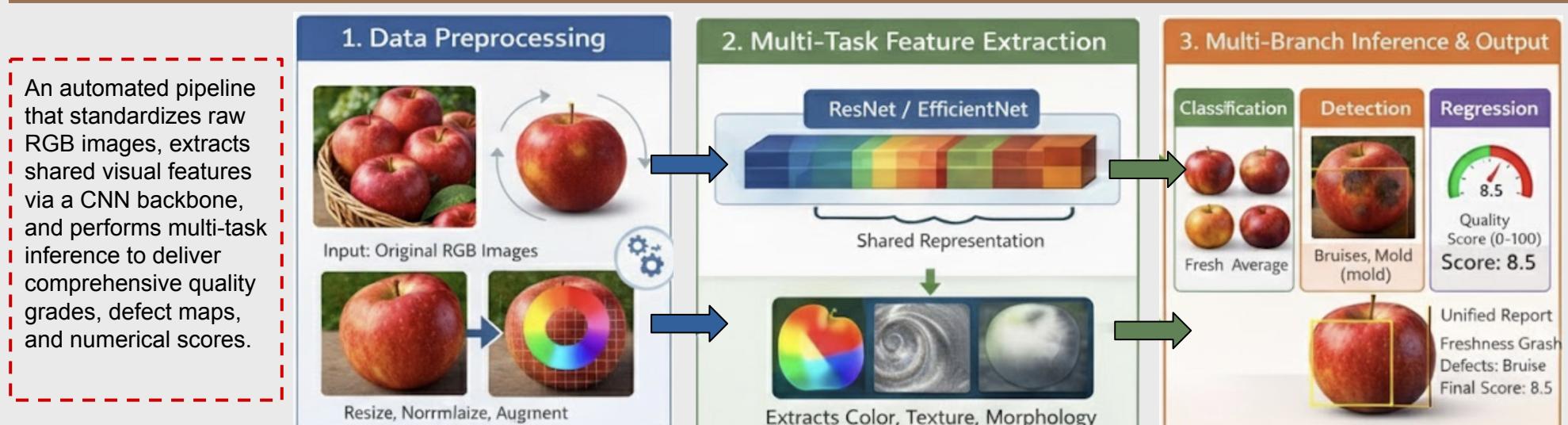
We propose an automated Multi-task Learning framework for comprehensive agri-product quality assessment:
- Freshness Grading: Classifies quality into discrete levels (e.g., Fresh, Average, Poor).
- Defect Detection: Identifies and locates surface issues like bruises, rot, or mold.
- Quality Scoring: Predicts a continuous numerical score for objective valuation.

Why ?

- Objective Standards: Replaces inconsistent manual inspection with quantitative, data-driven results for export markets.
- Operational Efficiency: A single MTL model is more resource-efficient and stable than three separate single-task models.
- Economic Value: Enhances transparency in pricing and quality control for both farmers and exporters.

Overview

An automated pipeline that standardizes raw RGB images, extracts shared visual features via a CNN backbone, and performs multi-task inference to deliver comprehensive quality grades, defect maps, and numerical scores.

1. Data Preprocessing — Input: Original RGB Images — Resize, Norrmlaize, Augment

2. Multi-Task Feature Extraction — ResNet / EfficientNet — Shared Representation — Extracts Color, Texture, Morphology

3. Multi-Branch Inference & Output — Classification: Fresh, Average — Detection: Bruises, Mold (mold) — Regression: Quality Score (0-100) Score: 8.5 — Unified Report: Freshness Grash, Defects: Bruise, Final Score: 8.5

Description

1. Data Preprocessing

- Normalization: Standardizes RGB input to 224x224 resolution for consistent processing.
- Augmentation: Applies rotation, flipping, and scaling to improve model robustness.
- Denoising: Filters noise to ensure high-quality feature extraction.
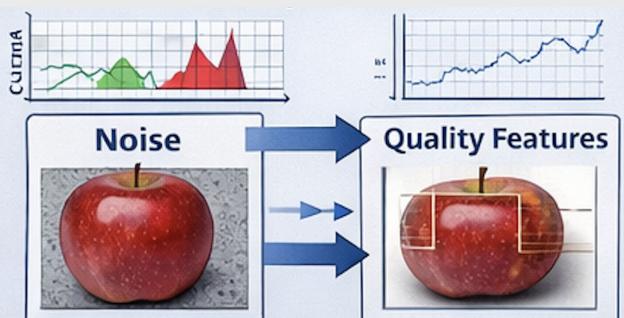
Figure 1. Data Standardization & Noise Reduction

2. Multi-Task Feature Extraction

- Backbone: Utilizes a shared ResNet/EfficientNet architecture for efficient encoding.
- Core Features: Extracts color (ripeness), texture (smoothness), and morphology (shape).
- Shared Representation: Reduces computation by reusing features for multiple tasks.

Color (Ripeness) — Texture (Smoothness) — Shape (Morphology)

Figure 2. Shared Feature Representation

3. Multi-Branch Inference & Output

- Classification: Categorizes fruit quality into grades: Fresh, Average, or Poor.
- Defect Detection: Pinpoints surface anomalies like bruises or mold using bounding boxes.
- Regression: Calculates a quantitative Quality Score (e.g., 8.5/10) for valuation.
- The X–Y plot illustrates the relationship between sample index and predicted quality score, reflecting overall freshness degradation.

Classification — Fresh, Average — Defect Detection: Bruise, Mold — Regression: 8.5 / 10

$$L_{det} = L_{box} + \lambda_1 L_{cls} + \lambda_{Dex} + \lambda_{Reg}$$
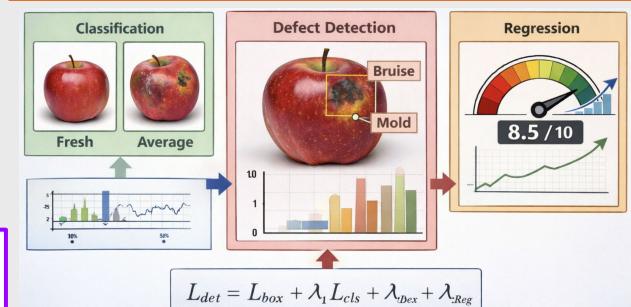
Figure 3. Multi-task inference outputs and joint loss optimization.

Evaluation Metrics: Accuracy, F1-score, mAP, MAE.

Advantages of Multi-Task Learning Framework

The proposed framework jointly optimizes classification, defect detection, and quality regression using shared visual representations. This joint learning captures correlations between surface defects and overall freshness, improves generalization and robustness under real-world variations. The unified architecture enables efficient deployment for practical agricultural quality inspection.

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