Dual-Stage Deep Learning System for Automated Freshness Classification of Fruits

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Introduction

- Ensuring the quality of fruits is crucial for health and taste.
- An automated system can minimize human errors, save time, and reduce labor costs in food quality control processes.
- This study aims to create a smart system that automatically checks if fruits are fresh or rotten using machine learning techniques.

Dataset

- 1200 Images of fresh and rotten fruits were collected from Kaggle to train the model.
- These images were labeled, organised, and split into training (768 images), validation (192 images), and test (240 images) sets.

Table 1: Data Statistics

Fruits	Fresh	Rotten
Apple	200	200
Banana	200	200
Orange	200	200

- To enhance the model's reliability, data augmentation techniques were applied.

Samples:

Figure 1: Sample images of dataset

- https://data.mendeley.com/datasets/bdd69gyhv8/1

Table 2: Related Works

Authors	Method	Dataset	Performance
Palakodati *et al.* (2020)	Customised CNN	Fruits fresh and rotten for classification [7]	Acc. 97.82%
Fahad *et al.* (2022)	YOLOv5, VGG16	Fruit Veg Freshness [2]	Acc. 82.2%
Kumar *et al.* (2022)	Customised CNN	Fruits fresh and rotten for classification [7]	Acc. 97.14%
Mukhiddinov *et al.* (2022)	YOLOv4	Fruits and Vegetables dataset [8]	Prec. 73.5%
Akter *et al.* (2022)	DenseNet201	Customised Dataset [5]	Acc. 98.56%
Ahmed *et al.* (2023)	Customised CNN	Combined Dataset [7, 9, 10, 11, 12, 13, 14]	Acc. 97.64%

Methodology

The proposed approach combines two powerful machine learning models:

- YOLOv8: Detecting fruits
- VGG16: Classifying them as fresh or rotten
  - YOLO quickly spots the fruits in the image and draws boxes
  - These bounding boxes are then cropped and sent to VGG16, which decides if the fruit is fresh or not
  - This combined approach makes the system both fast and highly accurate in checking fruit quality

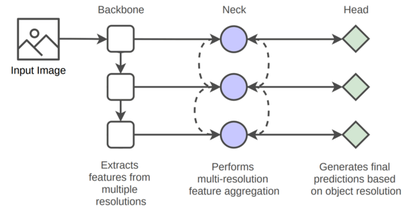


Figure 2: YOLO

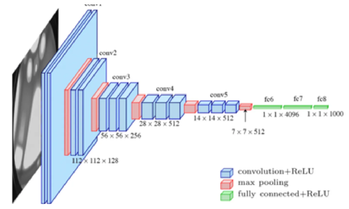


Figure 3: VGG16

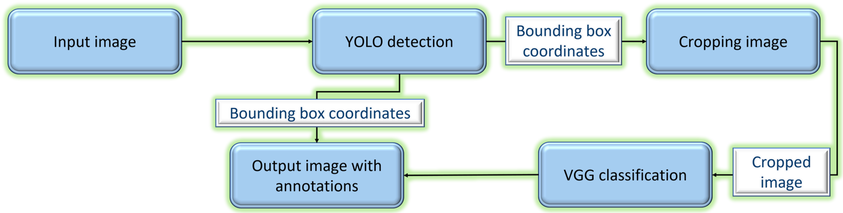


Figure 4: Overall Framework of Proposed Method

Table 3: Why YOLO & VGG16?

YOLO	VGG16
• Real-time object detection capability	• Strong feature extraction and classification ability
• Requires fewer memory, GPU, and computational resources compared to other detection models	• Excellent for transfer learning and fine-tuning on smaller datasets
• High accuracy in detecting multiple objects within a single image	• Simple architecture with lower computational cost

The existing approaches use different datasets focused on multiple freshness levels, making direct comparison difficult. However, the proposed system, successfully classifies fresh and rotten fruits.

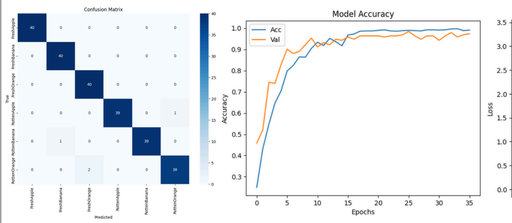
Experimental Setup

Experiments were done by several structures based on:

- Model1: YOLOv8x and Model2: VGG16
- optimizer: RMSprop
- learning rate: 0.0001
- dropout: 0.5
- batch size: 32
- epochs: 100
- loss: Categorical cross entropy
- activation: ReLU & SoftMax

Discussion and Conclusion

- The system achieved an impressive 98.2% accuracy, reliably identifying fresh and rotten fruits across various types and conditions. These results show that the approach is fast, accurate, and practical for real-world use in the food industry.



Class Name	Precision
Fresh apple	1.00
Fresh banana	0.98
Fresh orange	0.95
Rotten apple	1.00
Rotten banana	1.00
Rotten orange	0.97

Figure 5: Performance of the Proposed Method

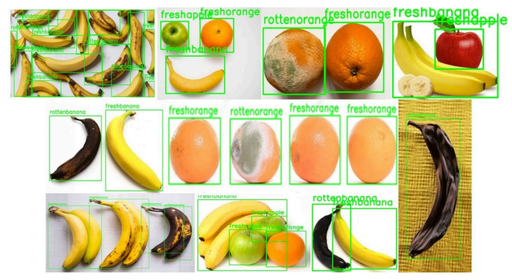


Figure 6: Correct Predictions

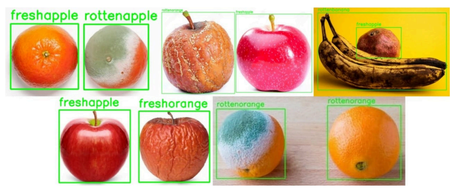


Figure 7: Incorrect Predictions

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