CV Project: Fruits

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1. Introduction

This project explores fruit image classification, detection, and generation using deep learning. We use MobileNetV2 for classification, YOLOv8 for object detection, and GANs for image generation, leveraging the Fruits-360 dataset.

2. Objectives

- Accurately classify fruit images into their respective categories.
- Detect and localize fruits in images using object detection.
- Generate new, realistic fruit images using GANs.

3. Dataset Description

- Fruits-360: Over 70,000 images, 100x100 pixels, 131 fruit classes.
- Source: https://www.kaggle.com/datasets/moltean/fruits
- Structure: Images are organized in class folders, with separate Training and Test directories.
- Sample Images: (See notebooks for visualizations)

4. Data Preprocessing

- Images resized to 100x100 pixels.
- Dataset split into train/val/test (70/15/15).
- Data augmentation (rotation, flip, etc.) and normalization applied.
- For YOLO, bounding boxes generated for each fruit.
- For GANs, images are resized and normalized to [-1, 1].

5. Model Architectures

MobileNetV2 (Classification)

- Pretrained on ImageNet, top removed.
- Added global average pooling and dense layers.
- Output layer: softmax for multi-class classification.

YOLOv8 (Detection)

- YOLOv8n pretrained weights.
- Custom data.yaml and label files generated.

GANs (Image Generation)

- DCGAN-style Generator and Discriminator implemented in PyTorch.
- Generator: Transposed convolutions to upsample noise to images.
- Discriminator: Convolutions to classify real vs. fake images.

6. Training Setup

- MobileNetV2: Adam optimizer, learning rate 0.0001, early stopping, model checkpointing, 30 epochs max.
- YOLOv8: 30 epochs, batch size 16, image size 640.
- GANs: 30 epochs, batch size 128, Adam optimizer, learning rate 0.0002.
- Hardware: GPU-accelerated environment (e.g., Kaggle, Colab).

7. Evaluation Metrics & Results

- MobileNetV2: Categorical accuracy, loss curves.
- YOLOv8: mAP, precision, recall (see YOLO logs).
- GANs: Visual inspection of generated images, loss curves.
- Results:
  - MobileNetV2 Test Accuracy: ~99%
  - YOLOv8: High detection accuracy, robust bounding boxes.
  - GANs: Generated realistic fruit images after training (see GAN notebook for samples).
- Plots: Training/validation accuracy and loss curves (see notebooks).

8. Discussion & Challenges

- Data augmentation improved generalization.
- Some fruit classes are visually similar, leading to occasional misclassifications.
- YOLOv8 performance depends on label quality and dataset balance.
- GANs require careful tuning and sufficient data for realistic image generation.

9. Conclusion & Future Work

- MobileNetV2 is highly effective for fruit classification.
- YOLOv8 provides strong detection results.
- GANs can generate realistic fruit images, useful for data augmentation.
- Future work: more data, advanced augmentation, improved GAN architectures, real-world deployment.

10. References

- Fruits-360 Dataset: https://www.kaggle.com/datasets/moltean/fruits
- MobileNetV2: https://arxiv.org/abs/1801.04381
- YOLOv8: https://docs.ultralytics.com/
- DCGAN: https://arxiv.org/abs/1511.06434