

农业蘑菇收割识别系统实验报告

1. 实验环境

1.1 硬件环境

- 运行平台: ARM架构(香橙派或类似设备)
- 内存要求: ≥ 2 GB RAM
- 操作系统: Linux(推荐)

1.2 软件环境

- Python 3.8.20+
- PyTorch (CPU版本)
- ultralytics
- OpenCV
- augmentations(用于数据增强)

2. 实验方法

2.1 数据集处理

1. 原始数据预处理

- 使用 `scripts/tools/json2label.py` 将JSON标注转换为YOLO的标签格式
- 生成标准化的边界框坐标(归一化到0-1范围)

2. 数据增强(`scripts/data_augmentation/data_augmentation.py`):

- 随机旋转(-30° ~ 30°)
- 水平/垂直翻转
- 颜色调整(亮度、对比度、饱和度)
- 高斯噪声

○ 高斯模糊

```
(mushroom-augmentation) rc@rc:~/桌面/2025/test$ python ./scripts/data_augmentation/data_augmentation.py
=====
蘑菇识别数据增强脚本
=====

生成训练集（100轮增强）：
成功加载 30 个有效图像和标注
增强图像（train模式）：100%|██████████████████████████████████████████████████████████████████████████████| 30/30 [00:35<00:00, 1.19s/it]
完成！成功生成 3000 个增强样本
原始图像：30 张，增强倍数：100，总样本数：3000
有效增强率：100.00%

生成验证集（20轮增强）：
成功加载 30 个有效图像和标注
增强图像（val模式）：100%|██████████████████████████████████████████████████████████████████████████████| 30/30 [00:07<00:00, 4.09it/s]
完成！成功生成 600 个增强样本
原始图像：30 张，增强倍数：20，总样本数：600
有效增强率：100.00%

准备测试集（原始数据）：
测试集准备完成：30 张图像

训练集：3000 张增强图像
验证集：600 张增强图像
测试集：5 张原始图像
=====
```

2.2 模型训练

- 基础模型: YOLOv8系列(v8n, v8s)和YOLO11系列(11n, 11s)
- 训练策略:
 - 批次大小: 根据模型配置自适应
 - 图像尺寸: 可配置(默认640x480)
 - 训练轮次: 根据模型类型调整

```

[yolo11] robot@robot-NUC11PHi7--/桌面/2025/Lh/yolo$ ./train.sh
=====
Training yolo11n...
=====
Ultralytics 8.3.111 Python-3.12.0 torch-2.6.0+cu124 CUDA:0 (NVIDIA GeForce RTX 2060, 5918MiB)
engine/trainer: task=detect, mode=train, model=/home/robot/桌面/2025/Lh/yolo/weights/yolo11n.pt, data=/home/robot/桌面/2025/Lh/yolo/datas/mushroom_data/data.yaml, epochs=120, time=No
ne, patience=20, batch=16, imgs=640, save=True, save_period=1, cache=False, device=None, workers=8, project=None, name=mushroom2.0_yolo11n_custom_train, exist_ok=False, pretrained=
True, optimizer=auto, verbose=True, seed=0, deterministic=True, single_cls=False, rect=False, cos_lr=False, close_mosaic=10, resume=False, amp=True, fraction=1.0, profile=False, free
ze=None, multi_scale=False, overlap_mask=True, mask_ratio=4, dropout=0.0, val=True, split=val, save_json=False, conf=None, iou=0.7, max_det=300, half=False, dnn=False, plots=True, so
urce=None, vid_stride=1, stream_buffer=False, visualize=False, augment=False, agnostic_nms=False, classes=None, retina_masks=False, embed=None, show=False, save_frames=False, save_tx
t=False, save_conf=False, save_crop=False, show_labels=True, show_conf=True, show_boxes=True, line_width=None, format=torchscript, keras=False, optimize=False, int8=False, dynamic=Fa
lse, simplify=True, opset=None, workspace=None, nms=False, lr=0.01, lrf=0.01, momentum=0.937, weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8, warmup_bias_lr=0.1, box=7.
5, cls=0.5, dfl=1.5, pose=12.0, kobj=1.0, nbs=64, hsv_h=0.015, hsv_s=0.7, hsv_v=0.4, degrees=0.1, scale=0.5, shear=0.0, perspective=0.0, flipud=0.0, fliplr=0.5, bgr=0.
0, mosaic=1.0, mixup=0.0, copy_paste=0.0, copy_paste_mode=flip, auto_augment=randaugmt, erasing=0.4, cfg=None, tracker=botsort.yaml, save_dir=runs/detect/mushroom2.0_yolo11n_custom
_train
Overriding model.yaml nc=80 with nc=1

   from n  params  module  arguments
  0   -1  1   464  ultralytics.nn.modules.conv.Conv  [3, 16, 3, 2]
  1   -1  1  4672  ultralytics.nn.modules.conv.Conv  [16, 32, 3, 2]
  2   -1  1  6640  ultralytics.nn.modules.block.C3k2  [32, 64, 1, False, 0.25]
  3   -1  1  36992  ultralytics.nn.modules.conv.Conv  [64, 64, 3, 2]
  4   -1  1  26880  ultralytics.nn.modules.block.C3k2  [64, 128, 1, False, 0.25]
  5   -1  1  147712  ultralytics.nn.modules.conv.Conv  [128, 128, 3, 2]
  6   -1  1  87840  ultralytics.nn.modules.block.C3k2  [128, 128, 1, True]
  7   -1  1  295424  ultralytics.nn.modules.conv.Conv  [128, 256, 3, 2]
  8   -1  1  346112  ultralytics.nn.modules.block.C3k2  [256, 256, 1, True]
  9   -1  1  164608  ultralytics.nn.modules.block.SPPF  [256, 256, 5]
 10  -1  1  249728  ultralytics.nn.modules.block.C2PSA  [256, 256, 1]
 11  -1  1    0  torch.nn.modules.upsampling.Upsample  [None, 2, 'nearest']

```

3. 算法实现

3.1 目标检测实现

核心检测逻辑(src/process.py):

```
def process_img(img_path):  
    model_path = 'weights/mushroom2.0 v8n.pt'
```

```
if not hasattr(process_img, "model"):
    process_img.model = YOLO(model_path)
results = process_img.model(img_path, device="cpu")
boxes = results[0].boxes.xywh.cpu().numpy()
# 转换为所需格式...
```

3.2 性能优化

1. 模型优化:

- 图像尺寸优化(416-640可选)
- 轻量级模型架构

2. 推理优化:

- 批处理推理
- CPU优化部署

4. 实验结果

4.1 检测结果

```

(mushroom) rc@rc:~/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition$ bash run.sh data/raw/images/
正在运行蘑菇识别系统 (CPU模式) ...
-----
image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333757793.jpg: 480x640 6 mushrooms, 36.5ms
Speed: 1.2ms preprocess, 36.5ms inference, 0.7ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333757793.jpg -> 检测到 6 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333881430.jpg: 480x640 4 mushrooms, 27.6ms
Speed: 0.7ms preprocess, 27.6ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333881430.jpg -> 检测到 4 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333762621.jpg: 480x640 6 mushrooms, 27.5ms
Speed: 0.8ms preprocess, 27.5ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333762621.jpg -> 检测到 6 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333109104.jpg: 480x640 1 mushroom, 26.3ms
Speed: 0.7ms preprocess, 26.3ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333109104.jpg -> 检测到 1 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/174833377316.jpg: 480x640 2 mushrooms, 29.7ms
Speed: 0.8ms preprocess, 29.7ms inference, 0.6ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 174833377316.jpg -> 检测到 2 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1749456936944.png: 480x640 4 mushrooms, 26.8ms
Speed: 1.0ms preprocess, 26.8ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1749456936944.png -> 检测到 4 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333311333.jpg: 480x640 2 mushrooms, 28.5ms
Speed: 0.8ms preprocess, 28.5ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333311333.jpg -> 检测到 2 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333381141.jpg: 480x640 2 mushrooms, 28.7ms
Speed: 0.8ms preprocess, 28.7ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333381141.jpg -> 检测到 2 个目标

```

```

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1749458081000.png: 480x640 3 mushrooms, 29.6ms
Speed: 1.2ms preprocess, 29.6ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1749458081000.png -> 检测到 3 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333847823.jpg: 480x640 3 mushrooms, 29.9ms
Speed: 0.8ms preprocess, 29.9ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333847823.jpg -> 检测到 3 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333920330.jpg: 480x640 5 mushrooms, 28.4ms
Speed: 0.8ms preprocess, 28.4ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333920330.jpg -> 检测到 5 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1749457542790.png: 480x640 8 mushrooms, 26.4ms
Speed: 1.0ms preprocess, 26.4ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1749457542790.png -> 检测到 8 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333302462.jpg: 480x640 2 mushrooms, 28.6ms
Speed: 0.8ms preprocess, 28.6ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333302462.jpg -> 检测到 2 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333576305.jpg: 480x640 5 mushrooms, 30.8ms
Speed: 0.7ms preprocess, 30.8ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333576305.jpg -> 检测到 5 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333703799.jpg: 480x640 6 mushrooms, 26.3ms
Speed: 0.8ms preprocess, 26.3ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333703799.jpg -> 检测到 6 个目标

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333539975.jpg: 480x640 4 mushrooms, 28.7ms
Speed: 0.8ms preprocess, 28.7ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
处理完成: 1748333539975.jpg -> 检测到 4 个目标
检测完成, 结果已保存至: output.txt
-----
识别完成! 结果保存在 output.txt 文件中

```

4.2 检测性能

使用 `scripts/tools/evaluate_models.py` 进行评估:

- 评估指标:
 - 精确率(Precision)
 - 召回率(Recall)
 - F1分数
 - 平均IoU
 - 综合评分(IoU 60% + F1 40%)

```

(mushroom) rc@rc:~/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition$ python scripts/tools/evaluate_models.py --gt data/raw/图片对应输出结果.txt --models output_v8n.txt output_11n.txt output_v8s.txt output_11s.txt output_v8n2.txt output_11n2.txt --names v8n 11n v8s 11s v8n2 11n2
正在评估模型: v8n...
正在评估模型: 11n...
正在评估模型: v8s...
正在评估模型: 11s...
正在评估模型: v8n2...
正在评估模型: 11n2...

=====
蘑菇识别模型评估报告
=====
官方标注文件: data/raw/图片对应输出结果.txt
评估模型数量: 6
-----
模型名称      综合评分      平均IoU      精确率      召回率      F1分数
-----
v8n            0.9598        0.9453        0.9708        0.9925        0.9815
11n            0.9465        0.9398        0.9296        0.9851        0.9565
v8s            0.9625        0.9450        0.9852        0.9925        0.9888
11s            0.9625        0.9450        0.9925        0.9851        0.9888
v8n2           0.9810        0.9684        1.0000        1.0000        1.0000
11n2           0.9802        0.9671        1.0000        1.0000        1.0000

详细指标说明:
- 综合评分: 平均IoU(60%) + F1分数(40%)
- 平均IoU: 所有图片检测框的平均交并比
- 精确率: 正确检测框数 / 总检测框数
- 召回率: 正确检测框数 / 总标注框数
- F1分数: 精确率和召回率的调和平均数

```

4.3 运行效率

src/process.py中的性能测试结果:

- 平均处理时间
- 最大/最小处理时间
- 总体吞吐量

```

(mushroom) rc@rc:~/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition$ python src/process.py --input_dir data/raw/images/
处理图片：data/raw/images/1748333757793.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333757793.jpg: 480x640 6 mushrooms, 38.3ms
Speed: 1.2ms preprocess, 38.3ms inference, 0.7ms postprocess per image at shape (1, 3, 480, 640)
检测到 6 个蘑菇，耗时：831 ms

处理图片：data/raw/images/1748333881430.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333881430.jpg: 480x640 4 mushrooms, 28.7ms
Speed: 0.7ms preprocess, 28.7ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
检测到 4 个蘑菇，耗时：31 ms

处理图片：data/raw/images/1748333762621.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333762621.jpg: 480x640 6 mushrooms, 28.0ms
Speed: 0.8ms preprocess, 28.0ms inference, 1.2ms postprocess per image at shape (1, 3, 480, 640)
检测到 6 个蘑菇，耗时：31 ms

处理图片：data/raw/images/1748333109104.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333109104.jpg: 480x640 1 mushroom, 28.0ms
Speed: 1.1ms preprocess, 28.0ms inference, 0.4ms postprocess per image at shape (1, 3, 480, 640)
检测到 1 个蘑菇，耗时：33 ms

处理图片：data/raw/images/174833377316.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/174833377316.jpg: 480x640 2 mushrooms, 27.4ms
Speed: 0.8ms preprocess, 27.4ms inference, 1.2ms postprocess per image at shape (1, 3, 480, 640)
检测到 2 个蘑菇，耗时：31 ms

```

```

处理图片：data/raw/images/1748333847823.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333847823.jpg: 480x640 3 mushrooms, 33.9ms
Speed: 0.9ms preprocess, 33.9ms inference, 1.4ms postprocess per image at shape (1, 3, 480, 640)
检测到 3 个蘑菇，耗时：38 ms

处理图片：data/raw/images/1748333920330.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333920330.jpg: 480x640 5 mushrooms, 34.0ms
Speed: 0.9ms preprocess, 34.0ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
检测到 5 个蘑菇，耗时：39 ms

处理图片：data/raw/images/1749457542790.png

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1749457542790.png: 480x640 8 mushrooms, 29.7ms
Speed: 7.6ms preprocess, 29.7ms inference, 1.2ms postprocess per image at shape (1, 3, 480, 640)
检测到 8 个蘑菇，耗时：45 ms

处理图片：data/raw/images/1748333302462.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333302462.jpg: 480x640 2 mushrooms, 33.6ms
Speed: 0.8ms preprocess, 33.6ms inference, 1.2ms postprocess per image at shape (1, 3, 480, 640)
检测到 2 个蘑菇，耗时：38 ms

处理图片：data/raw/images/1748333576305.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333576305.jpg: 480x640 5 mushrooms, 32.5ms
Speed: 0.7ms preprocess, 32.5ms inference, 0.7ms postprocess per image at shape (1, 3, 480, 640)
检测到 5 个蘑菇，耗时：35 ms

处理图片：data/raw/images/1748333703799.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333703799.jpg: 480x640 6 mushrooms, 37.5ms
Speed: 0.8ms preprocess, 37.5ms inference, 0.5ms postprocess per image at shape (1, 3, 480, 640)
检测到 6 个蘑菇，耗时：41 ms

处理图片：data/raw/images/1748333539975.jpg

image 1/1 /home/rc/桌面/2025/Agricultural-Mushroom-Harvesting-Recognition/data/raw/images/1748333539975.jpg: 480x640 4 mushrooms, 31.0ms
Speed: 0.8ms preprocess, 31.0ms inference, 0.8ms postprocess per image at shape (1, 3, 480, 640)
检测到 4 个蘑菇，耗时：34 ms

性能统计：
平均处理时间：57 ms
最大处理时间：831 ms
最小处理时间：31 ms
总处理时间：2023 ms
处理图片数量：35

```

5. 结果分析

5.1 模型对比分析

- YOLOv8n vs YOLOv8s:
 - v8n: 更快速度，较轻量级
 - v8s: 更高精度，较大模型
- YOLO11n vs YOLO11s:
 - v11n: 更快速度，较轻量级
 - v11s: 更高精度，较大模型

- YOLOV8 vs YOLO11:
 - YOLOv8: 更快速度, 精度略低
 - YOLOv11: 更高精度, 速度略慢

无论是YOLOv8n、YOLOv8s还是YOLO11n、YOLO11s, 在测试集上的精准率在98%左右, 但是速度方面, YOLOv8n、YOLO11n的速度更快, 且更轻量级。

5.2 算法优缺点

优点:

1. 实时性能好
2. 部署简单
3. 精度可靠
4. 资源占用低

缺点:

1. 受相似目标影响较大
2. 对光照敏感
3. CPU推理速度受限

6. 改进方向

1. 模型优化:

- 探索更多轻量级架构
- 模型量化与压缩
- 针对性能瓶颈优化

2. 数据增强:

- 增加更多场景数据
- 优化数据增强策略
- 引入更多真实场景数据

3. 针对硬件平台优化:

- 针对ARM架构进行优化

- 。针对香橙派等含NPU芯片的设备进行优化，如NPU推理加速

7. 结论

本项目成功实现了面向ARM设备的蘑菇检测系统，在保证检测精度的同时实现了较好的实时性。通过数据增强、模型优化等手段，系统展现出良好的实用性和可扩展性。未来可进一步优化模型性能和系统适应性。