Olive Tree Pruning Detection

in Drone Images with YOLOv7-tiny

Introduction

Agriculture plays a vital role in feeding the global population and contributing to the economy

Precision agriculture has gained attention for its potential to optimize crop production

Monitoring the health and growth of trees in orchards is a key aspect of precision agriculture

Tree pruning is crucial for maintaining tree health and productivity

Accurately detecting pruned and unpruned trees can provide valuable insights for tree management

This project explores the use of YOLOv7-tiny model for detecting and classifying pruned and unpruned trees in drone images of olive tree fields

Related work

Jiménez-Brenes et al. combined UAV technology and a custom object-based image analysis algorithm for 3D modeling of olive tree pruning

2017

De Castro et al. developed an adaptable OBIA procedure using UAV imagery and Digital Surface Model for 3D grapevine modeling

2018

Di Gennaro et al. assessed the use of UAV imagery and unsupervised segmentation to estimate pruning biomass in chestnut orchards

2020

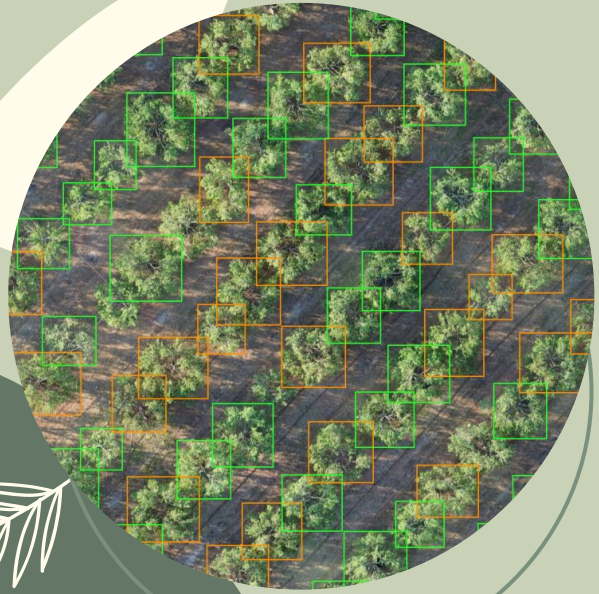
Materials and Methods

01 Image Labeling

02 Image Processing and Dataset Preparation

03 Model Selection and Training

Image Labeling



- Two high-resolution TIF images of olive tree fields in Apulia, Italy, captured using a drone
- Images contained both pruned and unpruned trees
- Trees labeled manually using the Computer Vision Annotation Tool (CVAT)
- Pruned trees were assigned the label 0, and unpruned trees were given the label 1
- Annotated images exported in PASCAL VOC format

Dataset Preparation

Original images divided into 768x768 pixel squares, each containing at most 5-6 trees

Associated XML file containing tree bounding boxes and respective labels

Offline data augmentation to balance the dataset

Model Selection

Considered Models

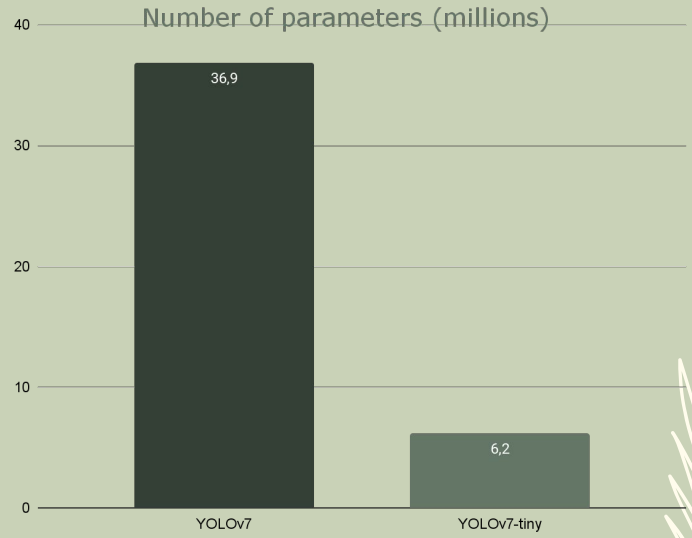
- YOLOv7
- InternImage-H

Chosen Model

YOLOv7-tiny

Motivations

- fewer parameters
- faster training and inference times
- suitable for drone vision applications (edge computing)



Hyperparameter Comparison

Three different experiments were conducted by varying the hyperparameters of the model to improve performance.

Experiment	Epochs	Initial LR	Final LR	Optimizer	Weight decay
1	50	0.01	0.01	SGD	0.0005
2	100	0.001	0.0001	Adam	0.0005
3	200	0.001	0.0001	Adam	0

Experimental Results

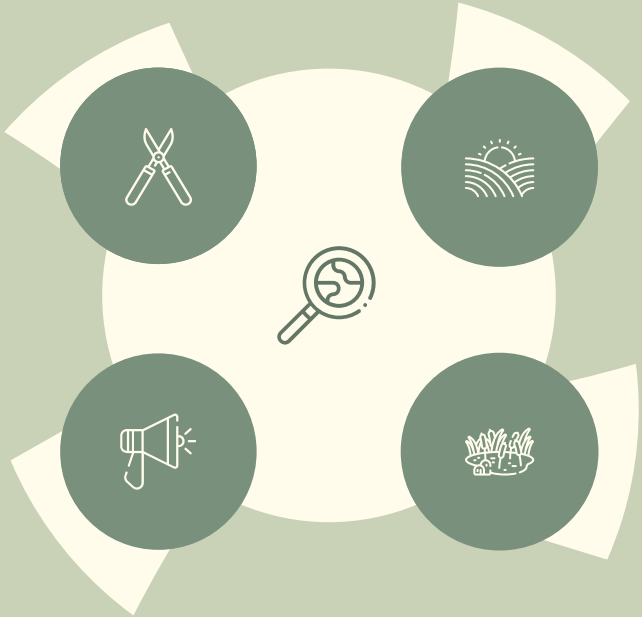
Experiment	Precision	Recall	mAP@.5	mAP@.5:.95
1	0.348	0.542	0.308	0.174
2	0.395	0.711	0.53	0.335
3	0.47	0.66	0.527	0.349

- Increasing the number of epochs improved performance metrics
- Reducing the initial learning rate and applying final learning rate reduction enhanced convergence
- Switching from SGD to Adam optimizer improved performance
- Weight decay might have led to underfitting in the specific tree pruning detection problem

Challenges in Binarizing Tree Pruning Detection

Tree pruning is a continuous process

Drone vision challenges: image quality, perspective, lighting conditions, tree density, and occlusions



Difficult to definitively label a tree as "pruned" or "unpruned"

Estimating pruning degree could provide more valuable insights

Impact of YOLOv7-tiny Architecture

Performance

However, lower complexity might reduce the model's ability to capture fine details of tree pruning

Tiny

Fewer parameters, less computational resources required, faster training and inference times

Trade-off

Potential trade-off between performance and computational efficiency

Dataset Quality

Imbalanced dataset

More pruned trees
than unpruned trees

Labeling

Difficulty distinguishing between pruned and unpruned trees

Augmentation

Helped balance the dataset, but it might introduce artificial patterns

Size

Limited number of available images

Conclusion and Future Work

1. YOLOv7-tiny demonstrates potential for detecting and classifying pruned and unpruned olive trees in drone images
2. Hyperparameters play an essential role in model performance
3. Challenges remain in binary classification for tree pruning detection
4. Future work could explore:
    - Estimating pruning degree instead of binary classification
    - Comparing YOLOv7-tiny to other models
    - Expanding the dataset with images from different locations and times of the year
    - Investigating the model's performance on other types of tree crops