Individual Detection of Olive Trees Under Different Olive Planting Distributions

Advancing Agricultural Analysis by Remote Sensing – GEOProcessing 2025

Nice, France May 18 - 22, 2025

Pablo Latorre Hortelano
Francisco García del Castillo
David Jurado Rodríguez
Lidia M. Ortega Alvarado
Juan Manuel Jurado Rodríguez

Introduction

This work in progress focuses on the **individual detection** of olive trees using computer vision and 3D analysis, adaptable to different **plantation distributions** —traditional, intensive, and super-intensive.

Accurate tree identification supports precise management and optimized **agricultural practices.**

Project motivation

The main challenge lies in the complexity of individual tree detection across diverse **planting patterns**, due to varying tree density, geometric distribution, and spacing.

High-resolution RGB imagery captured by UAVs, combined with advanced **computer vision** and **3D spatial analysis**, offers a robust and adaptable solution.

This approach supports individual tree identification across different planting systems enabling better **crop management and decision-making**.

IARIA

Methodology

1) **Vegetation segmentation**

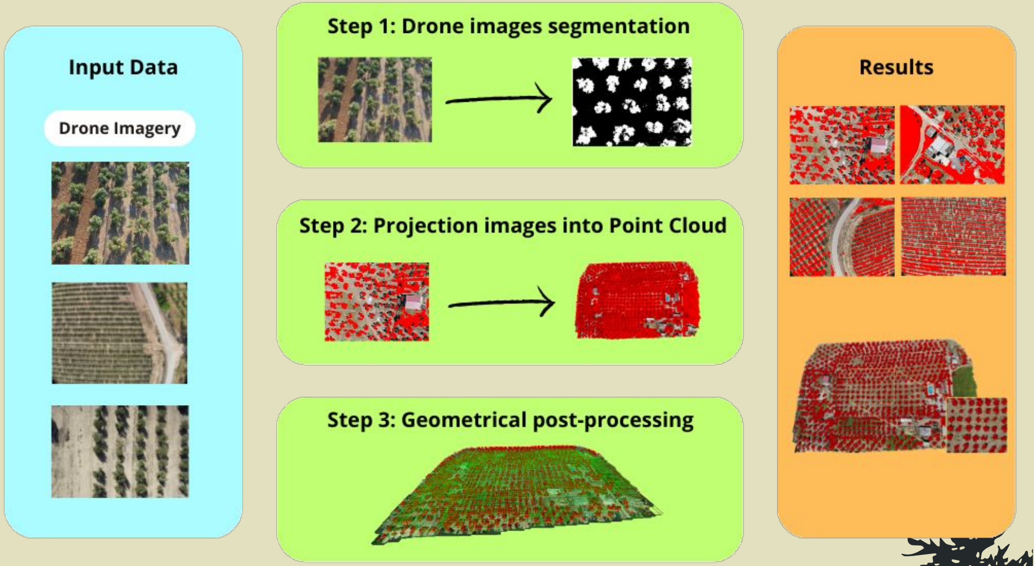
    Comparison between classical computer vision methods and deep-learning methods.

2) **Projection into 3D model**

    Segmented 2D images projected onto precise 3D photogrammetric point clouds

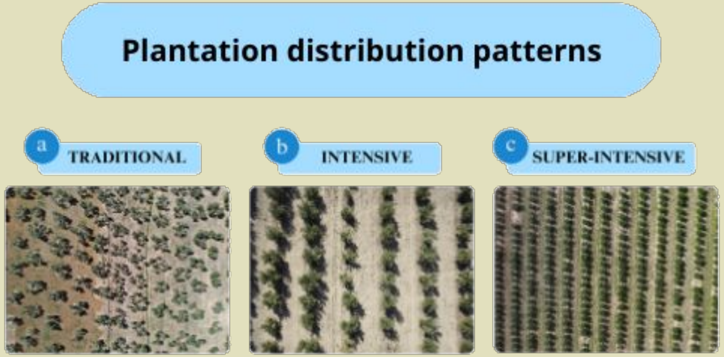
3) **Geometrical filtering**

    Height-based geometric filtering to remove low vegetation



Work Data

- The study includes three olive plantation types:
    - Traditional: widely spaced trees, irregular layout.
    - Intensive: trees planted in well-defined rows, closer spacing.
    - Super-intensive: very dense planting, high uniformity and defined rows.



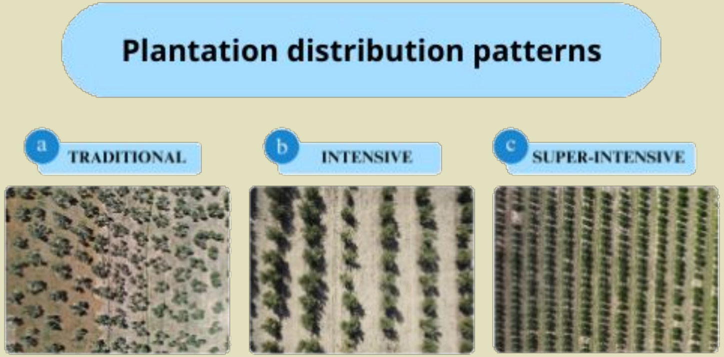
Work Data

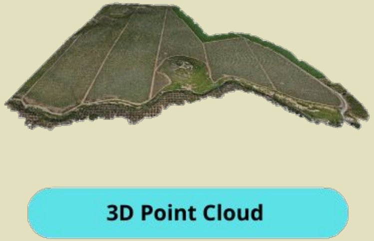
Data acquisition using UAVs equipped with RGB sensors

- Also multispectral, hyperspectral or LiDAR sensors could be used.

After the UAV flight we obtain:

- 3D models reconstructed using Structure from Motion (SfM) photogrammetry.
- RGB image dataset.

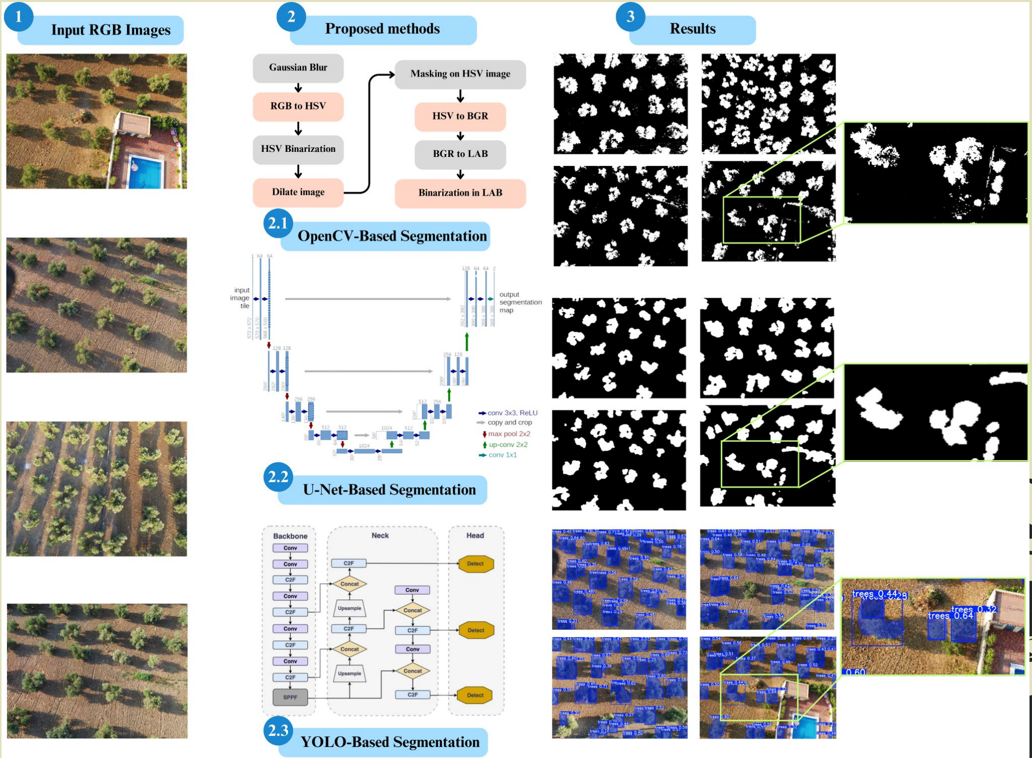




Step 1 → Images Segmentation

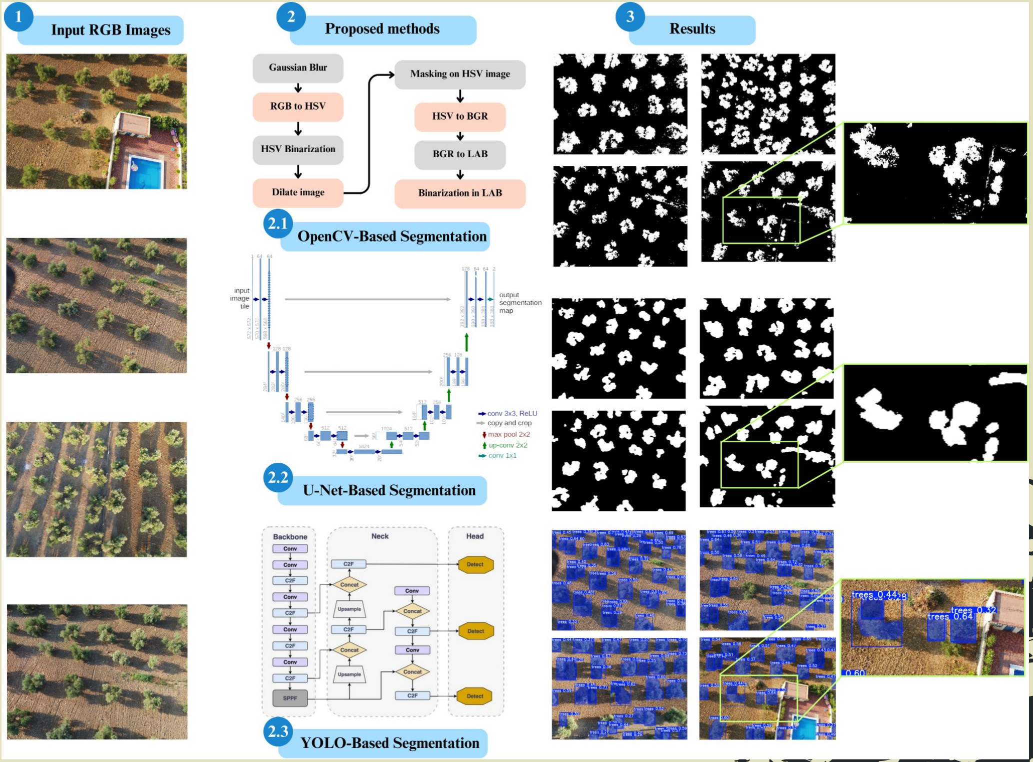
Three main approaches were evaluated for olive tree segmentation:

- **Traditional computer vision techniques** based on color thresholds, which do not require labeled datasets.
- **Deep learning models:**
    - **U-Net**: Convolutional neural network designed for semantic segmentation.
    - **YOLOv8-seg**: object detection model adapted for segmentation.



Step 1 → Images Segmentation

- Models were trained and tested on datasets representative of different plantation types (traditional, intensive, super-intensive).
- Due to lack of manually validated ground truth, results were visually assessed by experts.



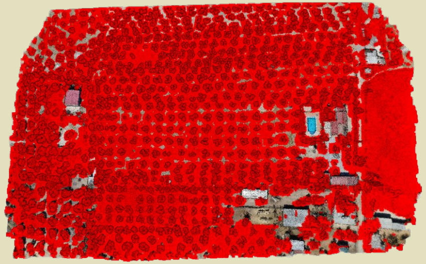
Comparison: Traditional vs Deep learning

Features	Traditional Techniques	Deep Learning Techniques
Processing Speed	High	Moderate / High
Data Requirements	No labeled data required	Labeled data required
Generalization	Good Generalization	Depends on training data
Segmentation Accuracy	Moderate	High in simple scenarios
Adaptability to changes	Limited	High after proper training

Step 2 → Projection images into Point Cloud

- After segmenting individual trees in RGB images, the labeled masks are projected onto the 3D point clouds obtained via photogrammetry.
- Projection is based on the **pinhole camera model**, using intrinsic and extrinsic camera parameters to map image coordinates to 3D spatial coordinates.

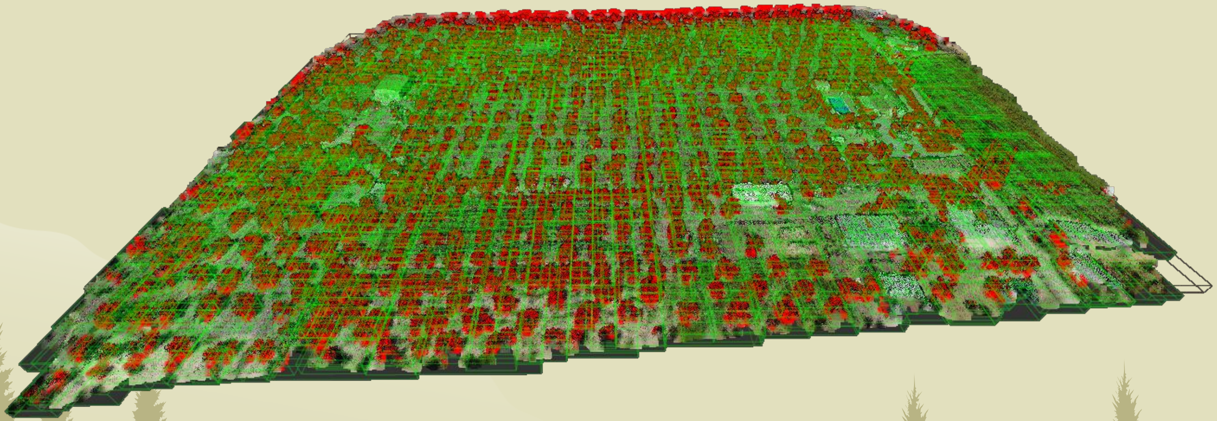
$$s \begin{bmatrix} v \\ v \\ 1 \end{bmatrix} = K \, [R \mid t] \begin{bmatrix} X \\ V \\ Z \end{bmatrix}$$



a VEGETATION POINTS PROJECTED

Step 3 → Geometrical filtering

- After projecting segmented masks onto the 3D point cloud, a height-based filter is applied to remove points corresponding to **low vegetation**.
- The height filtering is implemented through **voxelization** of the point cloud, which allows efficient division of the cloud into volumetric cells to analyze point heights.
- This process cleans the 3D representation, isolating olive tree canopies more effectively



IARIA

Results

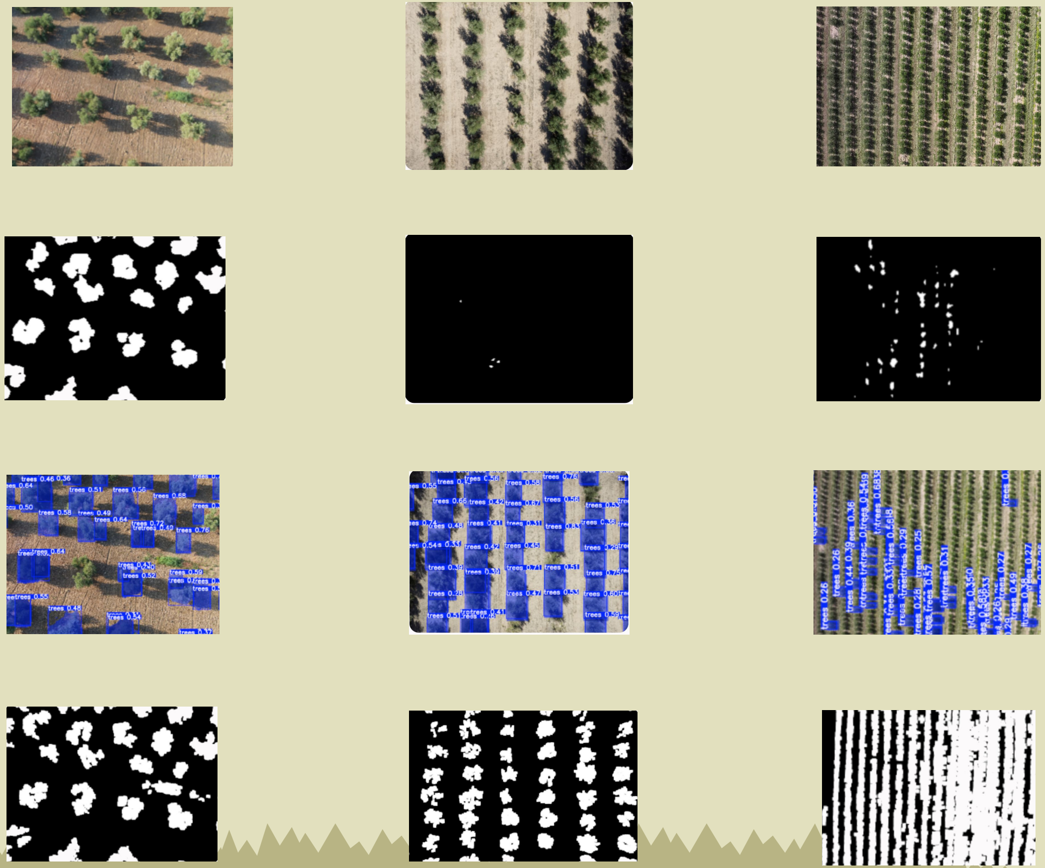
TRADITIONAL | INTENSIVE | SUPER-INTENSIVE

A) INPUT

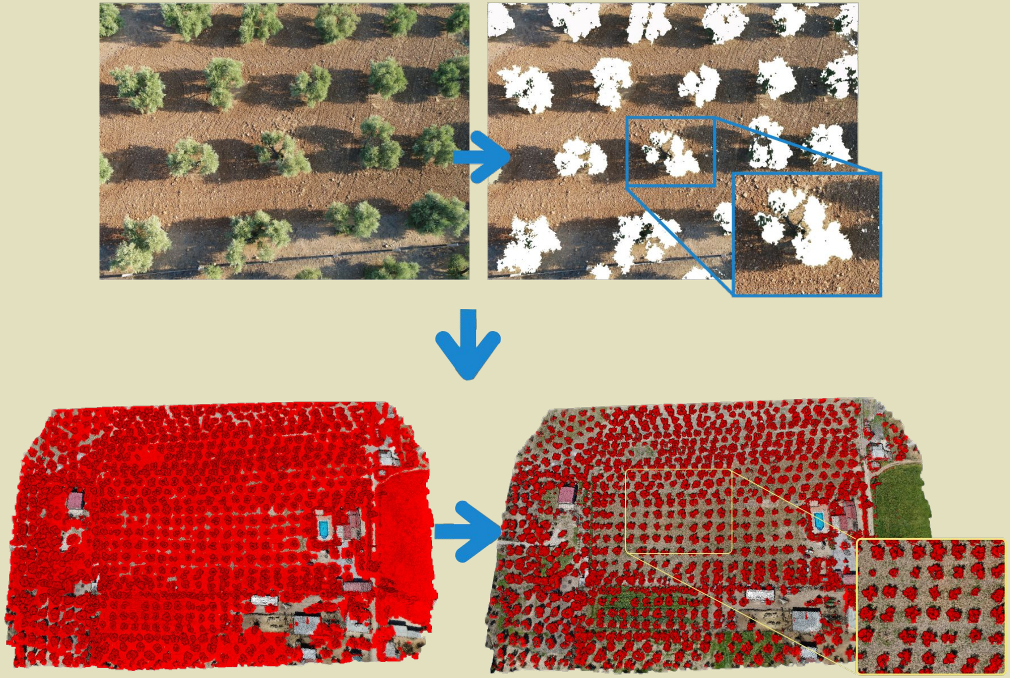
B) UNET

C) YOLO

D) CV



Results



Practical Applications in precision agriculture

- Individualized pruning strategies based on tree distributions
- Customized irrigation and fertilization management strategies
- Enhances integration with digital agricultural platforms for real-time farm management
- Provides detailed, tree-level data, supporting accurate predictions of crop yield and facilitating better planning and market decisions

Conclusions

- A traditional image segmentation approach combined with 3D height filtering proves **effective and fast** for isolating olive trees across different plantation types.
- Preliminary **deep learning models** (U-Net, YOLOv8-seg) show promising results in simpler scenarios but require more training data for generalization.
- The method provides a solid foundation for precise and automated olive tree identification to support precision agriculture in both 2 or 3 dimensional data.

Future Works

- Improve segmentation accuracy by refining and expanding deep learning models with **larger and diverse datasets**.
- Develop advanced clustering algorithms to automatically encapsulate individual trees in 3D point clouds and segmented images.
- Integrate data fusion with sensors such as multispectral or hyperspectral for improving the filtering method and tree characterization.

IARIA

IARIA

Thank you for your attention!! Questions?

Grupo de Gráficos y Geomática de Jaén

Universidad de Jaén