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# Orchard Tree Segmentation

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**ABSTRACT:** Using various methodologies, this work aimed to provide a method for segmenting orchard trees from aerial photos. In a range of scenarios, including different seasons, tree ages, and weed cover levels, the objective was to automatically identify and distinguish the orchard tree canopy. Included in the implemented dataset were photographs from three different walnut orchards. Photos that meet different use cases were acquired as a result of the dataset's achieved variety. For the best-trained model, the accuracy for testing, validation, and training was 87%, 90%, and 91%, respectively. The trained model was further assessed on previously unseen orthomosaic images of orchards using two methods (oversampling and undersampling) to address issues with out-of-the-field boundary transparent pixels from the image.

**KEYWORDS:** Segment, Orthomosaic, Oversampling and Undersampling.

## I. INTRODUCTION

Precision agriculture (PA) is a modern management concept that aims to effectively control the temporal and spatial variability of field and crop parameters via the use of information and communication technologies. Here, a variety of sensors and technologies are used to record temporal and geographical variability, give a comprehensive data set of field features, and search for the exact causes of their occurrence. Remote sensing (RS) is the non-contact monitoring of crop properties by using the radiation reflected by the plants. It is frequently used for mapping tasks in agricultural systems. It uses photographs taken from the air or on the ground.

To make well-informed crop decisions, farmers can quantify plant volume and canopy size using orchard canopy segmentation. The goal of semantic segmentation is to automatically recognize and locate the orchard tree canopy under various conditions, including varying tree ages, seasons, and weed cover levels. To develop the semantic segmentation database and create the test and train data set, all Unmanned Aerial Vehicle (UAV) photographs are collected. Semantic segmentation helps the farming business by providing a tool for the on-the-spot analysis of orchard ecosystems by automatically separating the tree canopies from aerial photographs. Farmers can evaluate the size, shape, and gaps of the canopy, the age of the trees, and the orchard's potential yield by using UAV photos. Additionally, they have the authority to determine the appropriate dosage of pesticides and water.

The problem of automatically segmenting trees from aerial photographs has been addressed in several ways. But every technique needed a full, sturdy canopy. The aforementioned studies also used object detection or unsupervised learning techniques to address the difficulty. These methods are lacking in two areas: the overall recognition performance and the precise canopy shape neglecting the surrounding environment. Since the results of these methods are required for further activities such as mapping orchards and estimating canopy size, their shortcomings also impact them. To the best of our knowledge, semantic segmentation has not yet been applied to the problem of orchard canopy recognition using UAS-derived pictures. Accurately identifying tree canopies in orchards at various development stages and seasons has also been shown to be lacking.



## II. RELATED WORK

Laura Elena Cué La Rosa, Dário A. B. Oliveira, Maciel Zortea, Bruno Holtz Gemignani, Raul Queiroz Feitosa, “Learning Geometric Features for Improving the Automatic Detection of Citrus Plantation Rows in UAV Images” [1], Unmanned aerial vehicles (UAVs) have made it possible to picture orchards on demand with a level of precision that was previously unattainable. In order to support later analytical stages like recognizing specific fruit trees and planting gaps, producers benefit from the automated identification of plantation rows in the photos, which aids in inventory and planting operations. Strong identification algorithms are required because citrus trees can be grown in curving rows that provide complex geometric patterns in aerial photos. Deep learning techniques are among the most advanced ways to identify photographs with specific geometric patterns, but they lose their efficacy when testing and training data diverge significantly. The study shows how to enhance plantation row detection in UAV photos by utilizing geometric aspects of orchards. The study's main objective is to train a detection encoder-decoder network (DetED) to identify RGB image planting rows. An encoder-decoder correction network (CorrED) is then trained using labeled data, teaching it to transform binary masks with fictitious row segmentation geometries into modified ones. Finally, correct geometric errors in the DetED result using the CorrED network.

Irem Ulku, Erdem Akagündüz, Pedram Ghamisi, “Deep Semantic Segmentation of Trees Using Multispectral Images” [2], The research work aims to investigate the possibility of enhancing the segmentation performance of deep learning models by hand-crafting spectral vegetation indices. The study uses multispectral imaging to address the tree segmentation problem, and it also conducts extensive experiments on multiple deep learning architectures with a range of spectral input combinations. Automatically segmenting trees based on their semantics from satellite and/or aerial photos can be an effective way to monitor forests, but there are still several problems that could make the task difficult, including the spectral signatures of the distinct trees, a lack of labelled data, and geometrical obstacles.

Lihong Chang, Hongchao Fan, Ningning Zhu, Zhen Dong, “A Two-Stage Approach for Individual Tree Segmentation from TLS Point Clouds” [3], Applications such as forest ecosystem modeling and biodiversity evaluation require the segmentation of individual trees in forest panoramas. When trees do not develop in layers, the current methods are effective. If there is a lot of crown overlap and understory plant occlusion, they might not be able to survive. This study demonstrates that there are two phases involved in segmenting individual trees. In this case, a semantic segmentation module and an instance segmentation module are combined. The point clouds are initially divided into tree and nontree points by the semantic segmentation network. In the second step, object detection and post-processing refinement are added using the instance segmentation module.

Yanqi Dong, Zhibin Ma, Fu Xu, Feixiang Chen, “Unsupervised Semantic Segmenting TLS Data of Individual Tree Based on Smoothness Constraint Using Open-Source Datasets” [4], Understanding canopy radiation, photosynthesis, and forest carbon storage requires the unsupervised segmentation of terrestrial laser scanning (TLS) data into wood and leaf. Dust retention and soil heavy metal enrichment provide significant obstacles when further segmenting wood data into the trunk and larger branch (TLB) and the residual branch (RB). The suggested study uses individual tree TLS data to perform automatic and unsupervised semantic segmentation. Using plane fitting residuals and neighborhood normal angle, the method initially uses initial segmentation to recover linked and smooth regions from the point cloud. The geometric qualities of segmented clusters are then measured to mimic leaf or RB features.

Debarun Chakraborty, Bhabesh Deka, “UAV sensing-based semantic image segmentation of litchi tree crown using deep learning” [5], This research explores the potential of UAV sensing and its orthomosaic photogrammetry output by using convolutional neural networks to segment litchi tree tops meaningfully. The UAV-Litchi dataset contains 12 big orthomosaics totaling 3000 256x256 picture patches. The U-Net and smooth bending methods are used to segment the litchi tree's crown. Finally, enormous 3500 x 3500 aerial photos are tested to produce a comprehensive segmentation map of the crop zone.

Seema S. Patil, Yuvraj M. Patil, Suhas B. Patil, “Development of Cost-Effective Precision Spraying Techniques Using Sensor Technology” [6], Spraying operations are a highly helpful tool in the agriculture sector for profitable crop production. The spraying techniques used now are ineffective. The best course of action in this situation is to spray at various speeds. Spraying insecticides at different rates requires a precise estimation of the tree canopy's area. It's challenging because of the varying plant sizes and growing structures. Trees exhibit a range of sizes and shapes over

their growing seasons. When evaluating this change, it's crucial to take into account the tree's height, width, diameter, and overall canopy volume. This study measures the amount of canopy on a tree using ultrasonic sensors, a controller, and a spraying mechanism that is adjusted based on the plant's volume. The system consists of an ultrasonic sensor, controller, and spraying mechanism. The results showed that there was no appreciable difference between the tree canopy volumes estimated by a human and by an ultrasonic sensor. The results of this investigation will aid in the selection and development of the most economical sprayer.

Messina G., Modica G., "Applications of UAV Thermal Imagery in Precision Agriculture: State of the Art and Future Research Outlook" [7], Precision agriculture (PA) uses unmanned aerial vehicles (UAVs) to carry out low-altitude remote sensing (RS), which is a potent instrument. When these conditions are met, thermal RS has several applications. Thermal RS is a great way to detect plant stress situations in real time since plants' surface temperatures change quickly when they are under stress. Among the uses for UAV thermal RS are water stress monitoring, disease detection, and plant phenotyping. However, knowledge of the fundamental characteristics of thermal radiation is necessary for the efficient use and interpretation of thermal data. This work's objective was to evaluate the state of UAV thermal RS in agriculture today, providing an overview of the most recent applications and outlining potential research avenues.

Ofori M., El-Gayar O., "Towards deep learning for weed detection: Deep convolutional neural network architectures for plant seedling classification" [8], Most traditional methods of controlling weeds on farms require a lot of work. Large yield losses are the outcome of this procedure, which is both expensive and time-consuming. The typical method of using chemicals to control weeds, however, contradicts the objective of sustainability. To tackle this, precision agriculture researchers have using computer vision to create remote sensing weed maps. However, because satellite imaging has issues with cloud cover and solar reflection, this has mostly failed to remove weeds in the early season. This study used deep convolutional neural networks' (DCNN) automatic feature extraction capabilities to classify plant seedlings, utilizing recent developments in artificial intelligence. According to a comparison study, DCNNs can correctly classify crops and weeds at various phenological growth phases.

Ronneberger O., Fischer P., Brox T., "U-net: Convolutional networks for biomedical image segmentation" [9], The majority of people concur that thousands of annotated training examples are necessary for effective deep network training. This study suggested a network and training approach that primarily uses data augmentation to make efficient use of the available annotated examples. A symmetric expanding path that enables accurate localization and a contracting path that captures context made up the design. The results of the study demonstrate that such a network can be trained end-to-end from a limited number of images, and it outperforms the previous best technique using u-net architecture, which offers extremely good performance on multiple distinct biomedical segmentation applications.

Schiefer F., Kattenborn T., Frick A., Frey J., Schall P., Koch B., Schmidtlein S., "Mapping Forest tree species in high resolution UAV-based RGB- imagery by means of convolutional neural networks" [10], The study demonstrated how tree species can be accurately mapped throughout heterogeneous temperate forests using RGB imagery from consumer-grade UAVs in conjunction with CNN-based semantic segmentation. A range of tile sizes and spatial resolutions were included in the evaluated CNN-based tree species mapping, which also included height data (nDSM). The tile size had no effect on the model's accuracy when sufficient reference data was available. The study focused on the interaction between CNN-based segmentation techniques and high-resolution UAV data. This study showed how UAVs and CNNs might be used in tandem, creating exciting prospects for forestry applications or extensive, long-term ecological research in the future.

Onishi M., Ise T., "Explainable identification and mapping of trees using UAV RGB image and deep learning" [11], Research is now being done on the use of remotely sensed data for tree mapping and identification in forest management. Using a Red-Green-Blue (RGB) image taken by an unmanned aerial vehicle (UAV) machine vision system, the researchers in this study developed a convolutional neural network (CNN) for mapping and tree recognition. Using color and three-dimensional information, the authors of this study first determined the slope from the three-dimensional model that the UAV had obtained before automatically segmenting the UAV RGB snapshot of the forest into several tree crown objects. Finally, each crown image was classified using CNN based on objects. The guided gradient-weighted class activation mapping (Guided Grad-CAM) showed that the CNN identified trees based on their shapes and leaf contrasts. This improves the system's capacity to recognize distinct trees with comparable colors in a practical and economically feasible manner.

Adhikari A., Kumar M., Agrawal S., Raghavendra S., “An Integrated Object and Machine Learning Approach for Tree Canopy Extraction from UAV Datasets” [12], The research demonstrated how to automatically extract tree canopies and their object-based properties from UAV data while accounting for their proximity. Unlike traditional image processing techniques, unmanned aerial vehicles (UAVs) are able to capture ultra-high-resolution photos. A UAV can now inspect canopies over a wide region to determine their volume. Visual characteristics are frequently extracted using conventional segmentation algorithms. SLIC is a technique that can be used to solve ultra-high resolution UAV datasets. They are inaccurate and need a lot of processing power. A Trimble UX5 fixed-wing UAV captured the data, which was then orthorectified at a spatial resolution of 13 cm. The SLIC method was used to further segment the ortho-image.

Morales G., Kemper G., Sevillano G., Arteaga D., Ortega I., Telles J., “Automatic Segmentation of *Mauritia flexuosa* in Unmanned Aerial Vehicle (UAV) Imagery Using Deep Learning” [13], This study introduced a novel end-to-end trainable deep neural network to address the challenge of segmenting *Mauritia flexuosa* palm trees in aerial photographs captured by unmanned aerial vehicles (UAVs). The suggested model outperformed the convolutional neural networks that were previously used for performance comparison since it is based on Google's Deeplab v3+ network. The segmentation findings show a high degree of similarity to the hand-drawn ground truth mask, with an accuracy of 98.036%. Additionally, our model can recognize and segment *Mauritia flexuosa* palms even when they are partially hidden by higher trees after learning the distinctive characteristics of the palm and its leaves (such as shape, texture, color, etc.).

Zheng Y.-Y., Kong J.-L., Jin X.-B., Wang X.-Y., Zuo M., “CropDeep: The Crop Vision Dataset for Deep-Learning-Based Classification and Detection in Precision Agriculture” [14], This study introduced CropDeep, a domain-specific vision dataset for crops used in precision agriculture. CropDeep is unique because it seeks to set the data standard for creating deep learning-based classification and detection models that consider the realities of agricultural operations in greenhouses. CropDeep has a number of advantages over many other vision datasets. (1) First off, compared to earlier datasets, these are more valuable for providing precision agriculture management services because they are gathered using a variety of cameras and equipment in greenhouses. (2) Compared to earlier studies, the annotation samples for each crop class are larger and more representative, offering a more solid basis for the technical use of deep learning-based models in agricultural activities.

Onishi M., Ise T., “Automatic classification of trees using a UAV onboard camera and deep learning” [15], For many land use managers and scientists, the automated classification of trees based on remotely sensed data has been a fantasy. Unmanned aerial vehicles (UAVs) have recently been anticipated to be a simple and affordable tool for remote sensing of forests, and deep learning has garnered attention due to its machine vision capabilities. In this study, they developed a machine vision system for the autonomous classification of trees using a commercially available UAV and a publically available deep learning program. They divided a UAV-captured forest image into distinct tree tops using object-based deep learning. As a result, the algorithm achieved an accuracy of 89.0% in classifying seven different types of trees. This speed was impressive given that we merely used basic RGB photos from a standard UAV. In contrast, the majority of earlier studies employed costly tools like multispectral imagers to enhance performance. As a result, this technique may be able to identify individual trees effectively and affordably. Many management teams and forest researchers may find this to be a useful tool.

### III. PROBLEM STATEMENT

To develop deep learning based semantic segmentation of tree canopy.

### IV. OBJECTIVE

1. Development of dataset for semantic segmentation.
2. Preprocessing of database images required for semantics segmentation.
3. Development of deep learning algorithm for sematic segmentation of target tree.
4. Evolution of performance parameter of deep learning-based algorithm.



## V. SYSTEM ARCHITECTURE

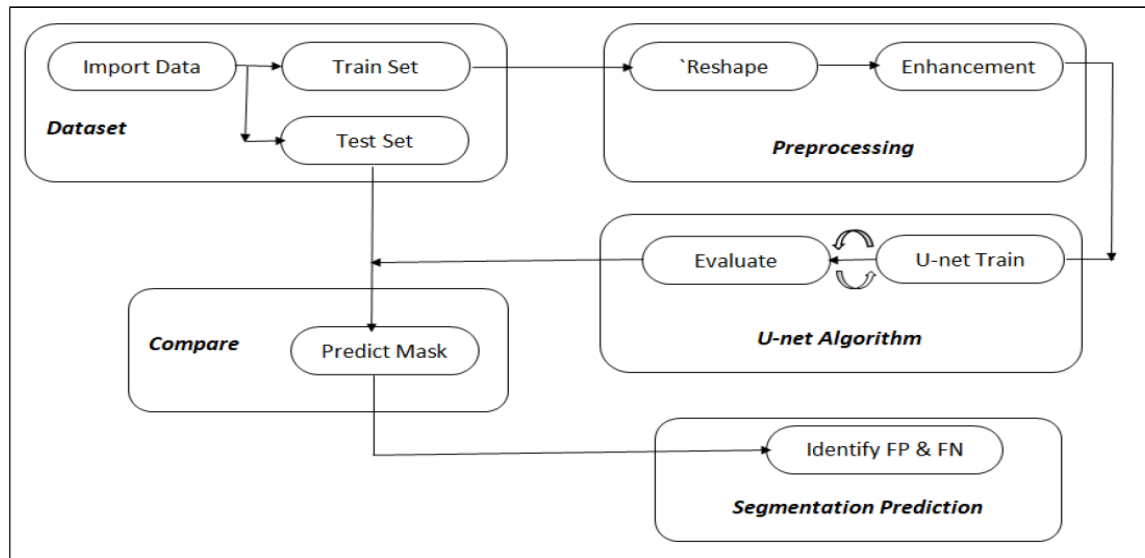


Fig. 1 - System Architecture

The proposed research will build around computer vision methods and data-driven algorithms. By masking the tree canopies in a large number of Unmanned Aerial Vehicle (UAV) captured images, an annotated dataset will be produced, which will then use to create a huge dataset for supervised learning. With the use of this annotated dataset, the model's chosen deep-learning algorithm will be trained so that it can accurately recognize tree canopies and segment them from the surrounding area. As a result, a mask image will be created that will include the shapes of every target tree canopy. After segmentation, each mask's weighted average will be utilized to calculate its centroid. This will serve as a decent approximation of tree trunk.

## VI. METHODOLOGY AND IMPLEMENTATION

### Module 1: Dataset

Imported data will be divided into train and test sets. At least one image from each use case must be included in the test set for the strategy to be implemented. High-resolution aerial photographs of orchards make up the dataset used in this investigation. A drone camera was used to take the pictures. A complete orchard was intended to be covered by each flight in a grid pattern, producing a sequence of overlapping photos. Data was gathered over a period of time to document the orchard's many growths stages.

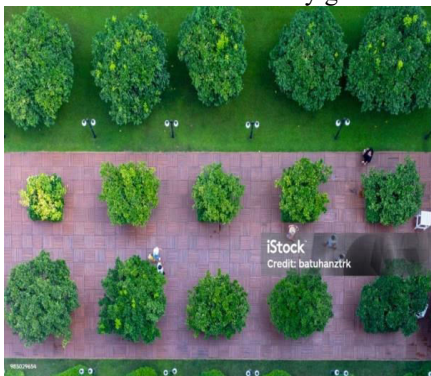


Fig. 2 - Orchard Original Image 1



Fig. 3 - Orchard Original Image 2



Fig. 4 - Orchard Original Image 3

### Module 2: Preprocessing

An essential component of computer vision tasks will be image pre-processing when using self-learning algorithms. For the numerical calculations to be performed, the images must be transformed into the appropriate sizes and forms. The initial process involves shrinking all of the images to 512 x 512 pixels and reducing their size and additionally color enhancement will be done. The steps listed below will be used. • Open the original photos and the annotations that go with them. • For every class, translate annotations into binary masks. • The binary masks should be saved as distinct pictures. These procedures allowed us to produce precise mask images from the original orchard photos, which are necessary for deep learning models to be trained for orchard mapping semantic segmentation. By ensuring that the model has access to high-quality, labeled data for learning, this preprocessing improves performance and accuracy in the segmentation tasks that follow.

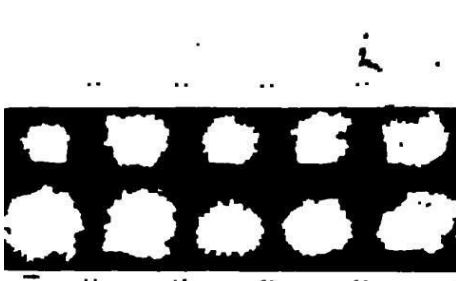


Fig. 5 - Orchard Mask Image 1



Fig. 6 - Orchard Mask Image 2

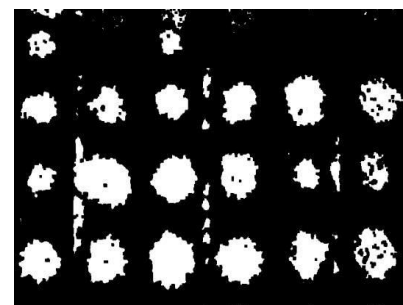


Fig. 7 - Orchard Mask Image 3

### Module 3: U-net algorithm

The training data will fed into the U-net and the model learns to create proper segmentations for each image. An evaluation metric is used across a randomly selected validation set comprising 10% of the training set, so that the trained model can learn to create better segmentation masks. The trained model produces segmentation masks for the test images and the evaluation metric is applied.

### Module 4: Compare & Predict

False Positive (FP): Incorrect identification of trees at locations.

False Negatives (FN): Failing to identify trees.

In order to manually check for false positive or false negative segmentations, the segmentation masks will be compared to the real masks produced during annotation. The performance of overall model will be defined by accuracy of trained model on test data set and also ratio of false positive over false negative.

## VII. RESULT

The following outcomes are obtained after complete processing and the UNET algorithm. A number of metrics are used to assess the following deep learning semantic segmentation model's performance. A dataset of high-resolution aerial photos of several orchards is used to train and evaluate the model. Examples of the original photos, mask images, and anticipated segmentations are displayed in Figures 8 and 9.

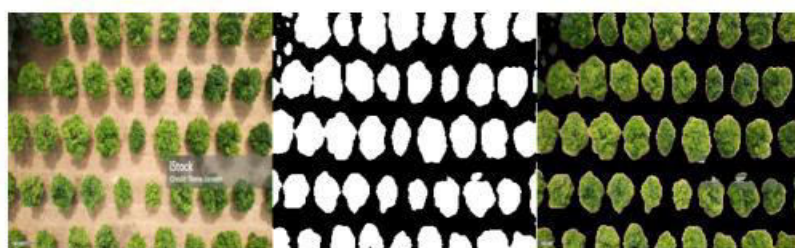


Fig. 8

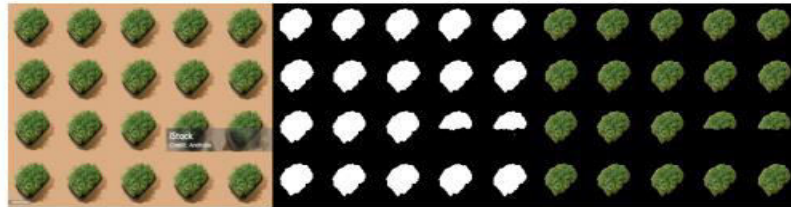


Fig. 9

### VIII. CONCLUSION

This study aimed to propose, develop, and validate an approach for orchard trees segmentation using aerial images based on a custom variant of a deep learning convolutional neural network, namely the U-net network. The purpose was the automated detection and localization of the canopy of orchard trees under various conditions (i.e., different Sensors seasons, different tree ages, different levels of weed coverage). The results of this study contribute to the farming community by providing a robust tool for instant scouting of orchard environments by automatically segmenting the tree canopies from aerial images.

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