PENGEMBANGAN SISTEM PENGHITUNG OTOMATIS TANAMAN PEPAYA (*Carica papaya* L.) BERBASIS *CONVOLUTIONAL NEURAL NETWORK* (CNN) DARI CITRA UDARA UAV VTOL

INTISARI

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Penghitungan populasi dan klasifikasi kesehatan tanaman pepaya (*Carica papaya L.*) merupakan sebuah aspek dalam mendukung pertanian presisi karena informasi tersebut dapat digunakan untuk estimasi kebutuhan pupuk, pemantauan produktivitas, serta deteksi dini stres tanaman. Praktik manual masih sering digunakan tetapi cara ini tidak efisien ketika diterapkan pada areal luas dan cenderung menghasilkan bias. Penelitian ini mengembangkan sistem penghitung otomatis berbasis *computer vision* dengan algoritma *deep learning* YOLOv11x yang dilatih menggunakan citra udara beresolusi tinggi dari drone VTOL Trinity Pro dengan kamera Sony RX1R II. Tahapan pengembangan ini meliputi akuisisi data citra, pembuatan *orthomosaic*, segmentasi *region of interest* (ROI), *tiling*, anotasi manual ke dalam tiga kelas kesehatan (Normal, Moderate, Abnormal), serta augmentasi untuk memperbesar variasi dataset hingga berjumlah 541 citra. Proses pelatihan dilakukan dengan tiga variasi *epoch* (50, 100, 150) dan hasilnya dievaluasi menggunakan *precision*, *recall*, *F1-score*, serta *mean Average Precision* (mAP). Secara kuantitatif, Model A (*epoch* 50) mencapai *precision* 0,804, *recall* 0,816, *F1-score* 0,810, dan mAP50 0,863 (mAP50 hingga mAP95 0,555), sedangkan Model C (*epoch* 150) memberikan *recall* tertinggi 0,840. Pada implementasi, dibanding perhitungan manual 1.918 pohon normal, 304 moderate, dan 258 abnormal, Model C mendeteksi 1.634 normal, 568 moderate, dan 174 abnormal dengan *error* total 4,19%, sementara Model A dan Model B menghasilkan *error* total 1,53% dan 3,87%. Meskipun pada kelas moderate sistem masih sulit mendeteksi dengan baik, sistem ini terbukti mampu memvisualisasikan pola spasial kesehatan tanaman secara lebih komprehensif.

Kata kunci: Computer vision, UAV, Tree Counting, Pertanian Presisi, YOLOv11

DEVELOPMENT OF AN AUTOMATIC COUNTING SYSTEM FOR PAPAYA TREES (*CARICA PAPAYA* L.) BASED ON *CONVOLUTIONAL NEURAL NETWORK* (CNN) USING UAV VTOL AERIAL IMAGERY

ABSTRACT

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Population counting and health classification of papaya (*Carica papaya L.*) plants is an essential component of precision agriculture because this information can be used to estimate fertilizer requirements, monitor productivity, and detect early plant stress. Manual practices are still often used, but they are inefficient for large areas and tend to introduce bias. This study developed an automatic counting system based on computer vision using the YOLOv11x deep learning algorithm trained on high-resolution aerial imagery captured by a Trinity Pro VTOL drone equipped with a Sony RX1R II camera. The development stages included image acquisition, orthomosaic generation, region-of-interest (ROI) segmentation, tiling, manual annotation into three health classes (Normal, Moderate, Abnormal), and augmentation to increase dataset diversity to 541 images. Training was conducted with three epoch settings (50, 100, 150) and evaluated using precision, recall, F1-score, and mean Average Precision (mAP). Quantitatively, Model A (50 epochs) achieved a precision of 0.804, recall of 0.816, F1-score of 0.810, and mAP50 of 0.863 (mAP50–95 of 0.555), while Model C (150 epochs) yielded the highest recall of 0.840. In implementation, compared with manual counts of 1,918 normal trees, 304 moderate, and 258 abnormal, Model C detected 1,634 normal, 568 moderate, and 174 abnormal with a total error of 4.19%, whereas Model A and Model B produced total errors of 1.53% and 3.87%, respectively. Although the system still struggles to accurately detect the Moderate class due to visual ambiguity, it effectively visualizes the spatial patterns of papaya plant health in a more comprehensive manner.

***Keywords**:*Computer vision, UAV, Tree Counting, Presision Agriculture, YOLOv11