ABSTRAK

Kelapa sawit merupakan komoditas penting bagi perekonomian Indonesia. Untuk menghasilkan minyak dengan mutu tinggi, buah sawit harus dipanen pada tingkat kematangan yang tepat. Namun, proses klasifikasi kematangan masih mengandalkan pengamatan manual yang rentan kesalahan. Seiring berkembangnya teknologi, metode deep learning seperti *Convolutional Neural Networks* (CNN) dan *You Only Look Once* (YOLO) mulai diterapkan dalam deteksi kematangan buah. Raspberry Pi 5 sebagai komputer mini berbiaya rendah menawarkan solusi portabel dan hemat energi untuk integrasi sistem deteksi berbasis YOLOv11.

Penelitian ini bertujuan mengimplementasikan dan menguji kinerja model YOLOv11 pada Raspberry Pi 5 dalam mendeteksi tingkat kematangan buah sawit. Dataset yang digunakan dibagi menjadi data pelatihan dan pengujian dengan augmentasi berupa rotasi, perubahan kecerahan, *flip*, serta *Gaussian blur* untuk meningkatkan generalisasi model. Evaluasi dilakukan dengan mengukur *confusion matrix*, *precision*, *recall*, *F1-score*, mAP50, mAP50-95, konsumsi sumber daya perangkat, kecepatan *frame per second* (FPS), serta jarak deteksi.

Hasil pengujian menunjukkan model YOLOv11 mampu mencapai nilai *precision* sebesar 0.98 *recall* 0.875, dan *F1-score* 0,851906. Nilai mAP50 diperoleh sebesar 0.885 sedangkan mAP50-95 sebesar 0.623. Berdasarkan pemantauan task manager Raspberry Pi 5, rata-rata penggunaan CPU mencapai 71% dan RAM 1764 selama proses deteksi berlangsung. Perhitungan kecepatan deteksi menghasilkan rata-rata 19,84 FPS dengan rata-rata 15,53 objek terdeteksi setiap 5 detik. Selain itu, sistem mampu melakukan deteksi secara optimal pada jarak 45–50 cm.

Dengan demikian, implementasi YOLOv11 pada Raspberry Pi 5 terbukti dapat bekerja secara efisien untuk deteksi kematangan buah sawit dengan akurasi yang baik dan performa yang stabil. Sistem ini berpotensi dikembangkan lebih lanjut sebagai solusi portabel yang mampu meningkatkan efisiensi panen dan kualitas produksi minyak sawit secara berkelanjutan.

Kata Kunci: YOLOv11, Raspberry Pi 5, Kelapa sawit, Deteksi Kematangan.

ABSTRACT

Palm oil is a vital commodity for the Indonesian economy. To produce high-quality oil, palm fruits must be harvested at the correct ripeness level. However, the classification process is still largely dependent on manual observation, which is prone to errors. With the advancement of technology, deep learning methods such as Convolutional Neural Networks (CNN) and You Only Look Once (YOLO) have been increasingly applied in fruit ripeness detection. Raspberry Pi 5, as a low-cost mini computer, offers a portable and energy-efficient solution for integrating a detection system based on YOLOv11.

This study aims to implement and evaluate the performance of the YOLOv11 model on Raspberry Pi 5 in detecting palm fruit ripeness. The dataset was divided into training and testing data, with augmentation techniques including rotation, brightness adjustment, flipping, and Gaussian blur to improve model generalization. Evaluation was conducted using the confusion matrix, precision, recall, F1-score, mAP50, mAP50-95, device resource consumption, frame per second (FPS), and detection distance.

The experimental results show that YOLOv11 achieved a precision of 0.98, recall of 0.875, and F1-score of 0.851906. The model obtained a mAP50 of 0.885 and mAP50-95 of 0.623. Task manager monitoring on Raspberry Pi 5 indicated an average CPU usage of 71% and RAM usage of 1764 MB during detection. The detection speed reached an average of 19.84 FPS with 15.53 objects detected every 5 seconds. Furthermore, the system was able to detect optimally within a distance of 45–50 cm.

In conclusion, the implementation of YOLOv11 on Raspberry Pi 5 demonstrates efficient performance for palm fruit ripeness detection, with high accuracy and stable operation. This system holds potential for further development as a portable solution to improve harvesting efficiency and sustainable palm oil production quality.

Keywords: YOLOv11, Raspberry Pi 5, *Palm oil*, *Ripeness Detection*.