ABSTRAK

Proses sortasi tandan buah segar (TBS) sawit di pabrik yang dilakukan secara manual rentan terhadap subjektivitas dan kelalaian manusia (*human error*), sehingga berimplikasi pada inkonsistensi mutu rendemen *crude palm oil* (CPO). Penelitian ini bertujuan untuk merancang sistem sortasi cerdas dan objektif melalui implementasi algoritma *deep learning* berarsitektur *convolutional neural network* (CNN) model ResNet-50. Model dikembangkan menggunakan strategi *transfer learning* pada 1.380 citra latih untuk mengklasifikasikan TBS ke dalam kategori belum masak, masak, dan terlalu masak. Model klasifikasi tersebut kemudian diintegrasikan ke dalam antarmuka aplikasi web responsif menggunakan *framework Flask* dan *proxy tunneling* Ngrok agar dapat diakses oleh penyortir secara *real-time* di PKS. Berdasarkan pengujian sistem secara langsung terhadap 90 sampel data primer di PKS PTPN IV Tanjung Seumantoh, sistem mencatatkan kinerja yang luar biasa dengan akurasi klasifikasi sebesar 96,67% dan *F1-Score* 98,29%. Analisis reliabilitas Cohen's Kappa menghasilkan skor 0,951 yang membuktikan tingkat kesepakatan hampir sempurna (*almost perfect agreement*) antara hasil deteksi sistem kecerdasan buatan dengan justifikasi visual petugas sortir. Hasil penelitian membuktikan bahwa sistem deteksi ini andal, efisien, serta efektif mampu mensubstitusi subjektivitas sortasi manual untuk mengoptimalkan standar mutu rendemen CPO di industri sawit.

Kata kunci: *deep learning*, *Flask*, kematangan sawit, ResNet-50, Sortasi TBS.

ABSTRACT

The manual sorting of fresh fruit bunches (FFB) at palm oil mills is prone to subjectivity and human error, which leads to inconsistencies in the quality and yield of crude palm oil (CPO). This study aims to design an intelligent and objective sorting system through the implementation of a deep learning algorithm based on the ResNet-50 convolutional neural network (CNN) model. The model was developed using a transfer learning strategy on 1,380 training images to classify FFB into the categories of unripe, ripe, and overripe. The classification model was then integrated into a responsive web application interface using the Flask framework and Ngrok proxy tunneling so that it could be accessed in real-time by sorters at the palm oil mill. Based on direct system testing on 90 primary data samples at the PTPN IV Tanjung Seumantoh palm oil mill, the system demonstrated exceptional performance with a classification accuracy of 96.67% and an F1-Score of 98.29%. Cohen's Kappa reliability analysis yielded a score of 0.951, demonstrating an almost perfect agreement between the AI system's detection results and the visual justifications provided by the sorters. The research findings confirm that this detection system is reliable, efficient, and effective in replacing the subjectivity of manual sorting to optimize CPO yield quality standards in the palm oil industry.

***Keywords**: deep learning, Flask, oil palm maturity, ResNet-50, TBS sorting.*