ABSTRAK

Meningkatnya budaya konsumsi kopi di masyarakat menjadikan kualitas biji kopi sebagai faktor penting dalam industri kopi. Salah satu aspek kualitas tersebut ditentukan oleh kondisi fisik biji kopi. Namun, proses penyortiran biji kopi di industri kecil dan menengah umumnya masih dilakukan secara manual, sehingga rentan menghasilkan ketidakkonsistenan akibat kelelahan dan subjektivitas manusia. Cacat fisik seperti biji pecah, terpotong, berjamur, dan keriput harus dapat dikenali secara akurat untuk menjaga mutu kopi. Seiring berkembangnya teknologi, diperlukan solusi otomatis yang mampu mendeteksi cacat fisik pada biji kopi secara akurat. Penelitian ini bertujuan untuk mengembangkan sistem deteksi objek berbasis YOLOv8 guna mengidentifikasi cacat fisik pada biji kopi Arabika dalam satu citra digital.

Penelitian ini menggunakan metode deteksi objek dengan algoritma YOLOv8 versi ringan (YOLOv8n) karena efisien dan cocok untuk dataset berukuran kecil. Data yang digunakan berasal dari dataset biji kopi hijau Arabika dengan tujuh kelas cacat fisik. Tahapan penelitian meliputi pengumpulan data, pembersihan data, anotasi menggunakan Roboflow, augmentasi, pelatihan model, evaluasi performa, dan pengujian sistem. Model dikembangkan dan dilatih menggunakan Python dan pustaka Ultralytics, sedangkan sistem deteksi diimplementasikan dalam bentuk antarmuka lokal berbasis web. Evaluasi performa dilakukan menggunakan metrik precision, recall, dan mean Average Precision (mAP). Selain itu, pengujian tambahan dilakukan dengan citra multiobjek hasil kolase semi-real melalui sistem untuk melihat kemampuan model mendeteksi lebih dari satu objek dalam satu gambar.

Hasil penelitian menunjukkan bahwa model terbaik diperoleh pada pelatihan 30 epoch dengan nilai precision sebesar 83,2%, recall sebesar 89,4%, mAP50 dan mAP50-95 yang sama-sama mencapai 97,1%. Model mampu mendeteksi objek cacat fisik dengan cukup akurat, meskipun masih ditemukan kesalahan deteksi pada objek cacat berukuran kecil atau tampak kabur. Pengujian sistem menggunakan citra multiobjek pada berbagai jarak menunjukkan bahwa deteksi berjalan optimal pada jarak 10–15 cm, namun gagal mendeteksi objek pada jarak 30 cm akibat berkurangnya kejelasan visual fitur cacat.

Berdasarkan hasil pengujian pada dua kelas cacat fisik, yaitu Insect Damage dan Fungus Damage, model YOLOv8n menunjukkan kinerja yang cukup baik dengan rata-rata akurasi sebesar 69,49%, presisi 89,02%, dan recall 75,93%. Kelas Fungus Damage memiliki performa terbaik dengan presisi 91,67% dan recall 81,48%, sedangkan Insect Damage memperoleh presisi 86,36% dan recall 70,37%. Hasil ini menunjukkan bahwa model mampu mendeteksi objek cacat dengan tingkat kesalahan yang relatif rendah, meskipun masih terdapat objek yang tidak terdeteksi terutama pada kelas dengan bentuk cacat yang lebih samar.

Penelitian ini memberikan kontribusi dalam pengembangan solusi deteksi otomatis cacat fisik biji kopi dan membuka peluang penerapan lebih lanjut dalam proses penyortiran biji kopi secara efisien di lingkungan industri.

Kata Kunci: YOLOv8, deteksi objek, cacat fisik, biji kopi Arabika, sistem otomatis

ABSTRACT

The growing coffee consumption culture in society has made coffee bean quality an important factor in the coffee industry. One aspect of this quality is determined by the physical condition of the coffee beans. However, the coffee bean sorting process in small and medium-sized industries is generally still done manually, making it prone to inconsistencies due to human fatigue and subjectivity. Physical defects such as cracked, cut, moldy, and wrinkled beans must be accurately identified to maintain coffee quality. With the advancement of technology, an automated solution is needed that can accurately detect physical defects in coffee beans. This study aims to develop a YOLOv8-based object detection system to identify physical defects in Arabica coffee beans in a single digital image.

This study uses the object detection method with the lightweight YOLOv8 algorithm (YOLOv8n) because it is efficient and suitable for small datasets. The data used comes from a dataset of Arabica green coffee beans with seven physical defect classes. The research stages include data collection, data cleaning, annotation using Roboflow, augmentation, model training, performance evaluation, and system testing. The model was developed and trained using Python and the Ultralytics library, while the detection system was implemented as a local web-based interface. Performance evaluation was conducted using precision, recall, and mean Average Precision (mAP) metrics. Additionally, further testing was performed using multi-object images from semi-real collages through the system to assess the model's ability to detect more than one object in a single image.

The results show that the best model was obtained after 30 epochs of training, with a precision value of 83.2%, a recall value of 89.4%, and mAP50 and mAP50-95 values of 97.1%. The model was able to detect physically defective objects with sufficient accuracy, although detection errors were still found in small or blurry defective objects. System testing using multi-object images at various distances showed that detection performed optimally at distances of 10–15 cm, but failed to detect objects at 30 cm due to reduced visual clarity of defect features.

Based on testing results for two physical defect classes, namely Insect Damage and Fungus Damage, the YOLOv8n model demonstrated satisfactory performance with an average accuracy of 69.49%, precision of 89.02%, and recall of 75.93%. The Fungus Damage class had the best performance with a precision of 91.67% and a recall of 81.48%, while Insect Damage obtained a precision of 86.36% and a recall of 70.37%. These results indicate that the model is capable of detecting defective objects with a relatively low error rate, although there are still objects that are not detected, especially in classes with more subtle defect shapes.

This research contributes to the development of automated detection solutions for physical defects in coffee beans and opens opportunities for further application in efficient coffee bean sorting processes in industrial settings.

Keywords: YOLOv8, *object detection*, *physical defects*, *Arabica coffee beans*, *automated system*