ABSTRAK

Deteksi objek merupakan salah satu tugas fundamental dalam bidang *computer vision* yang bertujuan untuk mengidentifikasi serta menentukan lokasi objek di dalam citra. Performa model deteksi objek berbasis *deep learning* sangat bergantung pada ketersediaan data berlabel dalam jumlah besar, sementara proses anotasi manual pada deteksi objek memerlukan waktu, biaya, dan ketelitian yang tinggi. Kondisi ini menjadi tantangan utama dalam pengembangan sistem deteksi objek yang optimal, khususnya pada domain dengan keterbatasan data berlabel. Penelitian ini bertujuan untuk merancang model deteksi objek berbasis YOLOv8 dengan pendekatan *Semi-Supervised Learning* serta membuktikan bahwa pendekatan tersebut efektif dalam meningkatkan performa deteksi objek makanan pada kondisi data berlabel terbatas.Pendekatan yang digunakan mengombinasikan data berlabel untuk melatih *teacher model* dengan data tidak berlabel yang dimanfaatkan dalam pelatihan *student model* melalui mekanisme *pseudo-labeling*. Evaluasi kinerja dilakukan dengan membandingkan model supervised murni dan model SSL menggunakan metrik *precision*, *recall*, *F1-score*, *mAP50*, dan *mAP50–95*. Hasil pengujian menunjukkan bahwa pendekatan SSL memberikan peningkatan performa yang signifikan. Pada data validasi, model SSL mencapai nilai *precision* 0,94, *recall* 0,79, *F1-score* 0,86, *mAP50* 0,89, dan *mAP50–95* 0,61, sedangkan model supervised hanya mencapai *precision* 0,52, *recall* 0,48, dan *F1-score* 0,50. Pada data uji, model SSL memperoleh *precision* 0,86, *recall* 0,73, *F1-score* 0,79, *mAP50* 0,83, dan *mAP50–95* 0,58, yang menunjukkan kemampuan generalisasi yang baik. Hasil penelitian ini membuktikan bahwa pemanfaatan data tidak berlabel melalui pendekatan SSL efektif dalam meningkatkan akurasi dan kualitas lokalisasi objek pada sistem deteksi objek berbasis YOLOv8 dalam kondisi keterbatasan data berlabel.

Kata Kunci: citra makanan, deteksi objek, *pseudo-labeling*, *semi-supervised learning*, YOLOv8

ABSTRACT

Object detection is a fundamental task in computer vision that aims to identify and localize objects within images. The performance of deep learning–based object detection models heavily depends on the availability of large-scale labeled datasets, while manual annotation for object detection requires substantial time, cost, and accuracy. This limitation poses a significant challenge in developing robust detection systems, particularly in domains with limited labeled data. This study aims to design a YOLOv8-based object detection model using a Semi-Supervised Learning approach and to demonstrate that this approach is effective in improving food object detection performance under limited labeled data conditions. The proposed method combines a limited amount of labeled data to train a teacher model with unlabeled data that are utilized to train a student model through a pseudo-labeling mechanism. Model performance is evaluated by comparing a fully supervised model and the SSL-based model using precision, recall, F1-score, mAP50, and mAP50–95 metrics. Experimental results demonstrate that the SSL approach significantly improves detection performance. On the validation dataset, the SSL model achieved a precision of 0.94, recall of 0.79, F1-score of 0.86, mAP50 of 0.89, and mAP50–95 of 0.61, while the supervised model only obtained a precision of 0.52, recall of 0.48, and F1-score of 0.50. On the test dataset, the SSL model achieved a precision of 0.86, recall of 0.73, F1-score of 0.79, mAP50 of 0.83, and mAP50–95 of 0.58, indicating strong generalization capability. These results confirm that leveraging unlabeled data through a semi-supervised learning approach is effective in enhancing both detection accuracy and localization quality of YOLOv8-based object detection systems under limited labeled data conditions.

Keywords: *food image, object detection, pseudo-labeling, semi-supervised learning, YOLOv8*