

ABSTRAK

Peningkatan volume dan keberagaman jenis sampah menuntut adanya sistem klasifikasi yang akurat dan efisien untuk mendukung pengelolaan limbah berbasis teknologi. Klasifikasi citra sampah merupakan salah satu permasalahan *computer vision* yang memiliki tingkat kompleksitas tinggi akibat kemiripan tekstur antar kelas, bentuk objek yang beragam, serta variasi pencahayaan dan latar belakang. Salah satu pendekatan yang banyak digunakan untuk mengatasi permasalahan tersebut adalah *Convolutional Neural Network* (CNN) yang mampu mengekstraksi fitur visual secara otomatis. Penelitian ini bertujuan mengimplementasikan model CNN berbasis *EfficientNet-B0* menggunakan metode *transfer learning* untuk mengklasifikasikan citra sampah ke dalam lima kelas, yaitu organik, kertas, plastik, logam dan B3. Metodologi penelitian yang digunakan adalah *Cross-Industry Standard Process for Data Mining* (CRISP-DM) yang terdiri atas tahapan *Business Understanding*, *data understanding*, *data preparation*, *modeling*, *Evaluation*, dan *Deployment*. Model dikembangkan menggunakan bobot pra-latih (*pre-trained weights*) dari *ImageNet* melalui proses *Feature Extraction* dan *Fine-Tuning*. Evaluasi model dilakukan menggunakan metrik *Accuracy*, *Precision*, *Recall*, dan *F1-Score*, serta dianalisis menggunakan *confusion matrix*. Hasil penelitian menunjukkan bahwa model *EfficientNet-B0* pada skenario *Fine-Tuning* menghasilkan performa terbaik dengan nilai *Accuracy* sebesar 90,50%, serta mampu memberikan nilai *Precision*, *Recall*, dan *F1-Score* yang baik pada proses klasifikasi. Model yang telah dikembangkan kemudian berhasil diimplementasikan ke dalam aplikasi berbasis *Streamlit* sehingga pengguna dapat melakukan klasifikasi citra sampah secara interaktif disertai informasi jenis sampah, nilai *confidence*, probabilitas setiap kelas, dan tips pengelolaan sampah. Hasil penelitian menunjukkan bahwa pendekatan *EfficientNet-B0* berbasis *transfer learning* efektif untuk mendukung proses klasifikasi citra sampah secara otomatis.

Kata kunci: Klasifikasi Citra Sampah, *Convolutional Neural Network*, *EfficientNet-B0*, *Transfer learning*, CRISP-DM, *Deep Learning*.

ABSTRACT

The increasing volume and diversity of waste require an accurate and efficient classification system to support technology-based waste management. Waste image classification is one of the challenging problems in computer vision due to the high visual complexity caused by similarities in texture between classes, irregular object shapes, and variations in lighting conditions and backgrounds. One of the most widely used approaches to address this problem is the Convolutional Neural Network (CNN), which is capable of automatically extracting visual features from images. This study aims to implement a CNN model based on EfficientNet-B0 using the transfer learning approach to classify waste images into five categories: organic, paper, plastic metal, and hazardous waste. The research employed the Cross-Industry Standard Process for Data Mining (CRISP-DM) methodology, which consists of six stages: Business Understanding, data understanding, data preparation, modeling, Evaluation, and Deployment. The model was developed using ImageNet pre-trained weights through Feature Extraction and Fine-Tuning processes. Model performance was evaluated using Accuracy, Precision, Recall, and F1-Score, and further analyzed using a confusion matrix. The experimental results show that the EfficientNet-B0 model with the Fine-Tuning approach achieved the best performance, obtaining an Accuracy of 90.50%, along with high Precision, Recall, and F1-Score values in waste image classification. Furthermore, the trained model was successfully deployed into a Streamlit-based web application, enabling users to classify waste images interactively while displaying prediction confidence, class probabilities, waste information, and waste management recommendations. These findings demonstrate that the EfficientNet-B0 model with the transfer learning approach is effective for supporting automatic waste image classification.

Keywords: *Waste Image Classification, Convolutional Neural Network, EfficientNet-B0, Transfer learning, CRISP-DM, Deep learning.*