ABSTRACT

The ripeness level of coffee beans is a crucial factor that determines the final quality of coffee products. However, the assessment process, which is typically performed manually, remains subjective, time-consuming, and inefficient for industrial-scale applications. This study develops a digital image–based classification model for coffee bean ripeness using deep learning with the InceptionV3 architecture through transfer learning and fine-tuning on several layers, along with a customized head model adapted to four ripeness classes: Green, Light, Medium, and Dark. The dataset consists of 1.600 images that underwent preprocessing, including resizing and normalization. A total of 27 training scenarios were evaluated using a Grid Search method to explore combinations of learning rate, batch size, and dropout. The results indicate that the best configuration learning rate of 1e-4, dropout of 0,5, and batch size of 32 achieved a validation accuracy of 98,33% and a testing accuracy of 99,25%, with precision, recall, and F1-score values above 97%, demonstrating excellent model generalization. Inference optimization using TensorRT produced an average prediction time of 9,98 ms per image, enabling real-time implementation. The developed model is expected to contribute to the automation of sorting and quality inspection processes for coffee beans, thereby improving accuracy, efficiency, and consistency in the coffee processing industry.

Keywords: Coffee bean classification, Convolutional Neural Network, InceptionV3, TensorRT, transfer learning, hyperparameter tuning, web application.