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An Effective Ensemble Convolutional Learning Model with Fine-Tuning for Medicinal Plant Leaf Identification

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Abstract

Accurate and efficient medicinal plant image classification is of utmost importance as these plants produce a wide variety of bioactive compounds that offer therapeutic benefits. With a long history of medicinal plant usage, different parts of plants, such as flowers, leaves, and roots, have been recognized for their medicinal properties and are used for plant identification. However, leaf images are extensively used due to their convenient accessibility and are a major source of information. In recent years, transfer learning and fine-tuning, which use pre-trained deep convolutional networks to extract pertinent features, have emerged as an extremely effective approach for image-identification problems. This study leveraged the power by three-component deep convolutional neural networks, namely VGG16, VGG19, and DenseNet201, to derive features from the input images of the medicinal plant dataset, containing leaf images of 30 classes. The models were compared and ensembled to make four hybrid models to enhance the predictive performance by utilizing the averaging and weighted averaging strategies. Quantitative experiments were carried out to evaluate the models on the Mendeley Medicinal Leaf Dataset. The resultant ensemble of VGG19+DensNet201 with fine-tuning showcased an enhanced capability in identifying medicinal plant images with an improvement of 7.43% and 5.8% compared with VGG19 and VGG16. Furthermore, VGG19+DensNet201 can outperform its standalone counterparts by achieving an accuracy of 99.12% on the test set. A thorough assessment with metrics such as accuracy, recall, precision, and the F1-score firmly established the effectiveness of the ensemble strategy.

Keywords: ensemble convolutional learning; transfer learning; fine-tuning; multiclass classification; medicinal plant identification