Chapter 10
Hand-Crafted Feature Extraction and Deep Learning Models for Leaf Image Recognition

Angelin Gladston
Anna University, India

Sucithra B.
Anna University, India

ABSTRACT

Plant leaf recognition has been carried out widely using low-level features. Scale invariant feature transform technique has been used to extract the low-level features. Leaves that match based on low-level features but do not do so in semantic perspective cannot be recognized. To address this, global features are extracted and used. Similarly, convolutional neural networks, deep learning networks, and transfer learning-based neural networks have been used for leaf image recognition. Even then there are issues like leaf images in various illuminations, rotations, taken in different angle, and so on. To address such issues, the closeness among low-level features and global features are computed using multiple distance measures, and a leaf recognition framework has been proposed. Two deep network models, namely Densenet and Xception, are used in the experiments. The matched patches are evaluated both quantitatively and qualitatively. Experimental results obtained are promising for the closeness-based leaf recognition framework as well as the Densenet-based leaf recognition.

INTRODUCTION

Since creation, there have been numerous plant species available globally. To categorize the large varieties of plants, development of an efficient plant recognition method is of utmost importance. As trees and plants are very important to ecology, accurate recognition and classification becomes necessary.

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Classification procedure is carried out through number of sub procedures. An identification or classification issue is managed by mapping an input data with one of the unique classes. In this procedure, at first, database of a leaf images is created, that comprises of images of test leaf with their equivalent plant information. Essential features are extracted using image processing techniques. The features have to be stable in order to make the identification system robust. Subsequently the plant/leaf is recognized using machine learning techniques (Pankaja et. al., 2017).

Early works in automatic leaf disease recognition followed the general workflow (Lawrence et al., 2021). Image capture involves collection of photographic information using a suitable camera. Image pre-processing is carried out on the captured images in order to improve image quality. Examples of procedures carried at this stage are image resizing, filtering, color space conversion and histogram equalization. In plant disease recognition applications, segmentation is twofold. Segmentation is first done to isolate the leaf, fruit or flower from the background. A second segmentation is then done to isolate healthy tissue from diseased tissue. Feature extraction involves mining of information from the segmented image which could facilitate accurate classification of the anomaly. Features that could be extracted are texture features namely, energy, contrast, homogeneity, and correlation, along with shape, size and color.

Textural features can be extracted using statistical measures such as Local Binary Patterns (LBP), Grey Level Co-occurrence Matrix (GLCM), Color Co-occurrence Matrix (CCM) and Spatial Grey Level Dependence Matrix (SGLDM). Physical characteristics called morphological features are prominently used for identification. The shape of a leaf is an important feature, and it often varies from species to species (Amala et al., 2017). Textural features can also be extracted using model-based methods such as Auto-Regressive (AR) and Markov Random Field (MRF) models. Machine learning algorithms are supplied with feature vectors and trained to categorize features associated with each disease to be recognized. The trained algorithm can then be used to recognize features from new images captured from the field. Classification deals with matching a given input feature vector with one of the distinct classes learned during training. The designer may use more than one learning algorithm for training and classification and fuse the results from the algorithms.

There are a wide variety of plant species, many of them are useful to humans as food or as medicine (Chithra & Janes, 2018), some are close to extinction and few others are harmful to man. Apart from this, plants are vital in their role they are not only essential for human beings; they are also the base of all food chains, being the producers of food. To protect such plants and sustain biodiversity, we need to acquire in-depth knowledge on how to use and protect these plant species (Guoqing et al., 2019), in spite of the existing challenges (Erick & Jose, 2018) in studying and classifying these plants correctly. First and foremost is identifying the unknown plants which mainly depends on the expertise gained by an expert botanist (Guoqing et al., 2019). Traditionally, the successful method to identify plants easily, is by using the manual-based method based on their morphological characteristics. The success behind using this method for classifying the plant species is mainly rooted on the acquired knowledge and human skills. Plant components such as flowers, fruits, stem, seeds, root and leaves are used in plant identification and classification (Jibi et al., 2018). Predominantly leaf has been used for plant recognition, since leaves stay on the plants for more months. The leaves look completely different from one another exhibiting various characteristics (Neha et al., 2018) such as color, size, kind like maple, and oak, number of points, as well as arrangement of veins. Different plant species contains different leaf characteristics.

Botanists use their knowledge on leaves to identify the plant species and classify them as dangerous species, species having medicinal purposes as well as plant species that are edible. However, this