Chapter 13
Machine Learning and Convolution Neural Network Approaches to Plant Leaf Recognition

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ABSTRACT

Plants are very important for the existence of human life. The total number of plant species is nearing 400 thousand as of date. With such a huge number of plant species, there is a need for intelligent systems for plant species recognition. The leaf is one of the most important and prominent parts of a plant and is available throughout the year. Leaf plays a major role in the identification of plants. Plant leaf recognition (PLR) is the process of automatically recognizing the plant species based on the image of the plant leaf. Many researchers have worked in this area of PLR using image processing, feature extraction, machine learning, and convolution neural network techniques. As a part of this chapter, the authors review several such latest methods of PLR and present the work done by various authors in the past five years in this area. The authors propose a generalized architecture for PLR based on this study and describe the major steps in PLR in detail. The authors then present a brief summary of the work that they are doing in this area of PLR for Ayurvedic plants.

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INTRODUCTION

Plants constitute the most important part of the earth's ecology. Many plants and their products are the primary sources of food for other living species including Humans. Many plant extracts and products are being used as medicines. The ancient Indian system of medicine is known as Ayurveda and makes extensive use of Indian medicinal plant products for curing various diseases. Plants help in preventing global warming by consuming carbon dioxide for photosynthesis. Forest and thick vegetation result in rains. Recognition of plant species is important to be able to take full advantage of the benefits provided by the respective species. Given the huge number of plant species, the recognition of plant species requires knowledge and expertise. An expert botanist has the skill to recognize plant species based on morphological characteristics. Manual techniques to recognize plants are time-consuming and demands expert knowledge. Each plant can be identified using leaves, stem, petals, flowers, and seeds. Leaves of the plant play a dominant role in the identification of plants because of their availability in all seasons. Also, leaves of one plant species are discriminable from the leaves of other plant species. Classification of the plant species based on leaf images has become an active area of research. Due to advances in image processing and artificial intelligence techniques, it is possible to solve the complex problem of PLR. PLR is a multiclass classification problem that can be solved using digital image processing, machine learning and convolution neural network techniques.

BACKGROUND

This section reviews some of the PLR literature published between the year 2016 and the year 2020. The summary of the reviews is presented in Table I.

(Kala, J. R. et al., 2016) presented an approach for plant leaf recognition and classification using leaf shape feature called the sinuosity coefficients. Sinuosity coefficient is a new feature proposed by the authors and is a vector of sinuosity measures. Sinuosity measure represents the degree of meandering of a curve and characterizes a particular shape. The authors have used a subset of leaf images from the Flavia leaf images database for the purpose of experimentation. They have used 25 leaves each per four different species of plants. Multilayer Perceptron (MLP) classifier, K-Nearest Neighbor (KNN), and Naive Bayes classifiers were used to classify the images. A classification rate of 92%, 91%, and 94% was achieved respectively using MLP, KNN, and Naive Bayes classifier.

(Chaki, J., 2017, pp. 1992-2002) proposed a plant species recognition system using shape features of digital images of leaves. The author developed Shape Feature Selection Template (SFST) for the collection of shape features of the leaf. The aspect ratio of leaf images was taken into consideration for shape feature selection. Six combinations of aspect ratios were developed for the classification of leaf image into six types (Square, Very Wide, Wide, Medium, Narrow, and Very Narrow). The modules involved in this implementation are Pre-processing Module (PP), Simple Shape Module (SS), and classification. Visual features of a leaf are represented from the feature vectors generated from the shape module. Neuro-fuzzy controller (NFC) and Neural Network (NN) were used for the purpose of classification. A dataset of 1160 leaf images belonging to 58 classes was created from plantscan dataset and Flavia leaf dataset. This custom dataset was used for experimentation. An accuracy of 94% was achieved using this approach.

(Salve, P. et al., 2018) developed a multimodal plant identification system. The authors used five features (Vein features, HOG features, Geometric features, Spectral Signatures and the fusion of all