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# Plant Leaf Recognition Using Machine Learning: A Review

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**Abstract -** *Plants classification through leaves is an innovating and fascinating area of research that can provide helpful information regarding plants. Plant identification using their leaves is important in agriculture for weed identification, plant growth assessment and classification of diseases in plants. In addition to this, leaves can prove to be an important factor in identification of plant species in comparison to other parts of plants including flowers, stems, and seeds. Although recent advancements in the field of machine learning have made leaf classification much easier. Identifying plant species using their leaf images proves to be a challenge due to the vast variation among species and variations in their shape, size, and color. This review paper gives a detailed literature review of numerous tools and algorithms used in plant classification, providing their potential results and high accuracy. Some of the most commonly used leaf classification methods include support vector machines, convolutional neural networks, and decision trees. These algorithms have many applications, including estimating carbon uptake, predicting yields, and monitoring plant health and biodiversity. Plant classification through leaves can have applications in various area of interest such as agriculture, botanical research, medicine (Ayurveda) etc. In Ayurveda, plants are used as medicines providing solutions to diabetes, digestive problems, diseases related to the heart, liver disorder, etc. As machine learning and image recognition evolve, plant classification will have an even more significant impact in these fields.*

***Key Words:*** ***Machine Learning, Deep Learning, Plant Recognition, Pre-processing, Feature Extraction***

## 1. INTRODUCTION

Plants play a crucial role in the ecosystem and have been used for various purposes throughout history. From agriculture to medicine, plants have been a source of sustenance and healing for humans. Identifying plants is important in agriculture for weed detection, plant growth estimation, and disease detection. Manual identification of plants through their leaves is a time-consuming and tedious job, which can be counteracted by the development of a plant identification system. In recent years, technology has made plant identification more accessible, and various plant identification systems have been developed. Leaves are the most important part of a plant for classification as they provide important information about the species. Leaf characteristics such as the shape, size, and colour, as well as the pattern of veins, hairs, or glands, can be used to differentiate between different plant species. The arrangement of leaves on the stem can also be used as a distinguishing feature. Moreover, leaves remain on the plants for most of the year, making them an ideal part to use for plant identification. Machine learning algorithms have become a popular method for plant identification. These algorithms can recognize patterns and features in plant leaves and use them to identify unknown plants accurately and quickly. Various machine learning algorithms have been used in the development of plant identification models, such as support vector machines, random forests, and deep neural networks. Additionally, image processing techniques have been used to extract features from plant leaves that can be used for plant identification. This paper reviews various studies conducted to develop plant identification systems based on leaf characteristics. The paper discusses the different machine learning algorithms used and the image processing techniques applied to extract features from plant leaves. The paper also explores the different applications of plant identification systems in agriculture and horticulture, such as weed detection, plant growth estimation, and disease detection. The development of plant identification systems has opened new opportunities in the identification of plants with medicinal properties. Plants have been used as medicines for centuries, and the identification of plants with medicinal properties can lead to the development of new drugs and treatments for various health disorders. The identification of plants with medicinal properties can be done through their leaves, and the use of plant identification systems can hasten the process. In conclusion, the development of plant identification systems based on leaf characteristics has numerous applications in agriculture, horticulture, and medicine. The identification of plants through their leaves has become more accessible, thanks to technology and the development of machine learning algorithms. The use of plant identification systems can help in the detection of plant diseases, weed control, and plant growth estimation, making it an essential tool in agriculture and horticulture. The identification of plants with medicinal properties can also be done through their leaves, leading to the development of new drugs and treatments for various health disorders. The paper aims to provide an overview of

various studies conducted on plant identification systems and the different applications of plant identification systems.

## 2. MOTIVATION

Plant leaf recognition is very interesting and essential field with remarkable potential that impacts in various number of fields such as agriculture, medicine, forestry, and environmental protection. By accurately identifying different plant species based from their unique leaf features, we can gain insight into their growth patterns, their response to environmental factors, and their overall health. This knowledge can help us develop more efficient and sustainable agricultural practices, manage natural resources better, and even discover new plant species. Additionally, with rapid advances in machine learning and computer vision, the development of automated leaf recognition systems can greatly increase the speed and accuracy of plant identification, making it an essential tool for researchers, farmers, and ecologists. Therefore, there is a great need for motivated individuals to join the field and contribute their skills and knowledge to advance our understanding of plant biology and the natural world.

## 3. LITERATURE REVIEW

*I. Leaf Analysis for Plant Recognition:*

In this study, [1], a weighted K closest neighbor search algorithm is used to propose a leaf analysis system for plant identification. The system consists of noise reduction preprocessing processes, feature extraction for computing scale invariant feature descriptors, and algorithmic matching of plant species. The Leafsnap dataset is used by the authors to test the system before it is put into use as a Windows phone app.

*II. A Mobile Application for Plant Recognition through Deep Learning:*

The paper [2] outlines a method for deep learning-based automated plant and flower recognition. This method makes use of video data to make up for any information loss that can occur when comparing static photographs of plants and flowers, in contrast to conventional methods that only employ static images. The approach's deep learning algorithms as well as the procedure for gathering, scrubbing, and purging data are described in the study. Also, a mobile iOS app is provided, and the approach's results demonstrate that 122/125 plants and 47/50 genera may be identified with a degree of confidence up to 95%. The utilization of cloud-based resources to increase performance speed is also covered in the study.

*III. Tree Species Identification Based on Convolutional Neural Networks:*

This paper [3] suggests an efficient convolutional neural network-based method for automatically classifying tree species (CNNs). The examination of numerous multi-dimensional characteristics of tree leaves, such as color, shape, and vein signatures, is done to carry out the identification. Since it can be difficult to accurately identify a single leaf trait for a given tree species, CNNs are used to combine the multi-dimensional information. Preprocessing procedures are also used to increase the identification results' reliability. The Leafsnap database is used to test the proposed approach, and the results are good.

*IV. A Leaf Recognition Approach to Plant Classification Using Machine Learning:*

The paper [4] introduces an automated method for identifying plants through leaf recognition, which is an important part of plant ecological research workflows. The proposed methodology is simple as well as efficient, which uses a combination of two texture features (BOF and LBP) as inputs to a multiclass SVM classifier. The method is evaluated using a leaf image database and shows extremely effective results. Their proposed method has great potential for practical applications in plant recognition due to its computational efficiency and ease of implementation using computer vision techniques. Overall, this paper provides a significant contribution to the field of plant identification.

*V. Plant identification using deep neural networks via optimization of transfer learning parameters:*

In this paper [5], deep convolutional neural networks were utilized for the purpose of identifying plant species captured in photographs. The performance of different factors that affect the accuracy of these networks was evaluated. Three popular and significant deep learning architectures, such as AlexNet, GoogleNet, and VGGNet, were implemented for the purpose of this study. Transfer learning was employed using LifeCLEF 2015 plant task datasets in order to fine-tune the pre-trained models. Data augmentation techniques based on image transforms such as reflection, rotation, scaling, and translation were applied to minimize the risk of overfitting. In addition, the network parameters were adjusted and different classifiers were combined to enhance overall performance. The best combined system achieved an accuracy of 80% approximately using the validation set and an approximate inverse rank score of 0.752 using official test set. Comparing these results with those of the LifeCLEF 2015 plant identification campaign, the top system's overall validation accuracy was improved

by 15% points and its overall inverse rank score on the test set by 0.1. The top three competition participants were also outperformed in all categories and their system obtained second place in PlantCLEF 2016.

*VI. Leaf Classification Project:*

Using a shared dataset of leaf attributes, this paper [6] analyses alternative machine learning methods for classifying leaves. To analyze among effective and ineffective categorization models, the authors compare and analyze the model outputs.

*VII. Plant Recognition System based on Leaf Image:*

The paper [7] suggests an image-based automatic identification method based on leaf structure. To identify plants from photographs of leaves, the system makes use of attributes like shape, texture, vein structure, and color. For the purpose of storing image data and related information, the authors additionally create a cloud-based database.

*VIII. Leaf shape extraction for plant classification:*

In order to classify plants, this paper [8] focuses on leaf form extraction from photos. In order to extract biometric properties of leaves for categorization, the authors suggest employing a variety of operators and image processing approaches. This paper states the necessity for automated methods and shows how time-consuming manual classification is.

*IX. A study on plant recognition using conventional image processing and deep learning approaches:*

The paper [9] proposes two approaches, traditional and deep learning, to address this issue. In the traditional approach, shape, texture, and color features are extracted, and various classifiers are used for classification. The deep learning approach involves testing different deep learning architectures for plant species recognition. Four datasets, including three standard datasets and one real-time dataset, are used for evaluation. The results demonstrate that the VGG 16 CNN models outperformed traditional methods in terms of accuracy. The combination of color channel statistics, LBP, Hu, and Haralick features with a Random Forest classifier achieved a plant identification accuracy of 82.38% for the Leaf12 dataset using the traditional method. VGG 16 CNN architecture with logistic regression achieved a greater accuracy of 97.14% for the Leaf12 dataset, while VGG 19 CNN architecture with logistic regression achieved an accuracy of 96.53% for Folio, 96.25% for Flavia and 99.41% for Swedish datasets, respectively.

*X. Plant Identification Methodologies using Machine Learning Algorithms:*

The methods used are what determine how a plant is identified, it is a process that has evolved over ages. Identification of plants is important because it enables the retrieval of necessary data related to various species, which is necessary for certain applications. This paper [10] offers numerous methods and strategies from various writers for identifying plants.

*XI. Identification of Plants using Deep learning: A Review:*

Traditional methods of plant identification based on physical characteristics can be time-consuming and challenging. To address this issue, researchers have explored the use of advanced technologies such as deep learning and image recognition to develop more efficient plant identification methods. In a review of academic literature published between 2015 and 2020, it has been observed that convolutional neural networks (CNNs), a type of deep learning algorithm, have shown promising results in the area of plant identification. This has led to the development of various techniques and methods for leaf recognition using CNNs. This paper [11] aims to contribute to the existing body of literature on plant identification by discussing the concepts of deep learning and different leaf recognition methods. By analyzing the latest research in this field, the paper provides an academic database of knowledge that can be used to improve plant identification and further advance the field of ecology.

## 4. CONCLUSION

Manually identifying plants can be a really tiresome process. So, to make this task easy automated methods such as machine learning and deep learning models can be implemented. In this paper, different machine learning and deep learning a0lgorithms for the purpose of plant recognition through their leaves have been reviewed. Authors of these papers have suggested various techniques in order to achieve highest accuracy possible. These techniques include algorithms such as Random Forest, K-Nearest Neighbors, SVM classifier, Logistic Regression, etc., and popular deep learning architectures such as GoogleNet, AlexNet, VGGNet and these techniques give different accuracies if used on a single dataset.

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