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Automated Medicinal Plant Identification Using Deep Learning for Improved Healthcare

Janakiraman S[1], Nandhini S[2]
[1]*Assistant Professor,* [2]*MCA, Department of Master of Computer Applications, Er.Perumal Manimekalai College of Engineering, Hosur,*

Abstract: ***With thousands of plant species present in the world, many of them possessing medicinal properties, the identification of these plants plays a crucial role in healthcare, drug manufacturing, and environmental management. Proper identification benefits various sectors, including the forest department, life scientists, physicians, medication laboratories, and the public. While manual identification by skilled practitioners has been the traditional method, it is often time-consuming and prone to misidentification, which could lead to side effects or serious health risks. To address these challenges, this project proposes an automated system for medicinal plant classification using deep learning algorithms. In recent years, the use of deep learning techniques, particularly in computer vision, has gained traction for solving complex identification problems. The proposed system employs convolutional neural networks (CNNs), which are highly effective in feature extraction and classification tasks. The model utilizes Xception-based feature extraction, followed by classification with a CNN classifier, demonstrating high accuracy and faster prediction times with real-time images. By automating the identification process, the system aims to enable faster and more reliable recognition of medicinal plant species. This advancement could significantly reduce errors, increase efficiency, and provide immediate access to valuable plant-based medicinal data for various stakeholders, ensuring safer and more effective use of medicinal plants in healthcare.***

Keywords: Convolutional NeuralNetwork,ImageClassification,Healthcare,Artificial Intelligence ,Webapplication ,Herbal Medicine

I. INTRODUCTION

Plants are multicellular organisms in the kingdom Plantae that use photosynthesis to make their own food. There are over 300,000 species of plants; common examples of plants include grasses, trees, and shrubs. Plants have an important role in the world's ecosystems. They produce most of the world's oxygen, and are important in the food chain, as many organisms eat plants or eat organisms which eat plants. The study of plants is called botany.A medicinal plant is any plant which, in one or more of its organs, contains substances that can be used for therapeutic purposes or which are precursors for the synthesis of useful drugs. The term "medicinal plant" includes various types of plants used in herbalism ("herbology" or "herbal medicine"). It is the use of plants for medicinal purposes, and the study of such uses. The word "herb" has been derived from the Latin word, "herba" and an old French word "herbes". Now a day, herb refers to any part of the plant like fruit, seed, stem, bark, flower, leaf, stigma or a root, as well as a non-woody plant. Earlier, the term "herb" was only applied to non-woody plants, including those that come from trees and shrubs. These medicinal plants are also used as food, flavonoid, medicine or perfume and also in certain spiritual activities. Plants have been used for medicinal purposes long before prehistoric period. Ancient Unani manuscripts Egyptian papyrus and Chinese writings described the use of herbs. Evidence exists that Unani Hakims, Indian vaids and European and Mediterranean cultures were using herbs for over 4000 years as medicine. Indigenous cultures such as Rome, Egypt, Iran, Africa and America used herbs in their healing rituals, while other developed traditional medical systems such as Unani, Ayurveda and Chinese Medicine in which herbal therapies were used systematically. Treatment with medicinal plants is considered very safe as there is no or minimal side effects.

II. EXISTING ALGORITHM

In traditional botanical practices, plant identification based on leaves is a meticulous process carried out by skilled practitioners and botanists. This method relies on a deep understanding of plant morphology, emphasizing the intricate details of leaves. The following paragraphs delve into the key components of the traditional system of plant identification using leaves.

A. Field Observation and Collection

Botanists typically begin by observing plants in their natural habitat. The skilled practitioner takes note of various characteristics such as leaf shape, size, color, and the arrangement of leaves on the stem. Representative leaves are then carefully collected for further examination.

B. Botanical Keys and Manuals

The collected leaves are compared to botanical keys and manuals, which serve as comprehensive guides containing descriptions and illustrations of plant species. Botanical keys present a series of choices based on observable characteristics, guiding the practitioner toward the accurate identification of the plant.

C. Morphological Features

Detailed attention is given to morphological features of leaves, including leaf shape, margins, venation pattern, and the presence of any distinctive structures such as hairs or glands. These features contribute to the unique fingerprint of each plant species.

D. Herbarium Specimens

Collected leaves are often pressed, dried, and preserved on herbarium sheets. These herbarium specimens serve as a reference collection, allowing for comparisons and validations of identifications over time.

E. Dichotomous Keys

Dichotomous keys, a common tool in traditional plant identification, present a series of choices leading to the identification of a plant. Each choice consists of a pair of contrasting characteristics, helping to narrow down possibilities.

F. Disadvantages

- Limited availability of skilled practitioners.
- Extensive time required for manual identification.
- Identification decisions influenced by practitioner expertise.
- Challenges in distinguishing closely related species.
- Restricted access to reference specimens.
- Algorithms sensitive to variations in lighting and resolution.
- Risk of inaccurate generalization without proper training.
- High implementation complexity, requiring specialized knowledge.
- demanding powerful hardware.

III. PROPOSED SYSTEM

The proposed system aims to revolutionize the identification and utilization of medicinal plants through the following key components:

A. Automated Plant Identification

Implementing a robust system capable of automatically identifying medicinal plant species based on leaf images. This system will leverage advanced image processing techniques and machine learning algorithms to achieve accurate and reliable plant classification.

B. Feature Extraction and Classification

Utilizing state-of-the-art feature extraction techniques, including the utilization of Xception features, to enhance the discriminative power of the classification model. The system will employ Convolutional Neural Network (CNN) architecture for efficient feature extraction and classification tasks relevant to plant leaf images.

C. Real-time Identification Capability

Ensuring that the proposed system can perform rapid and accurate identifications, even when presented with real-time leaf images. This capability will enable users to quickly obtain information about medicinal plant species directly from the field.

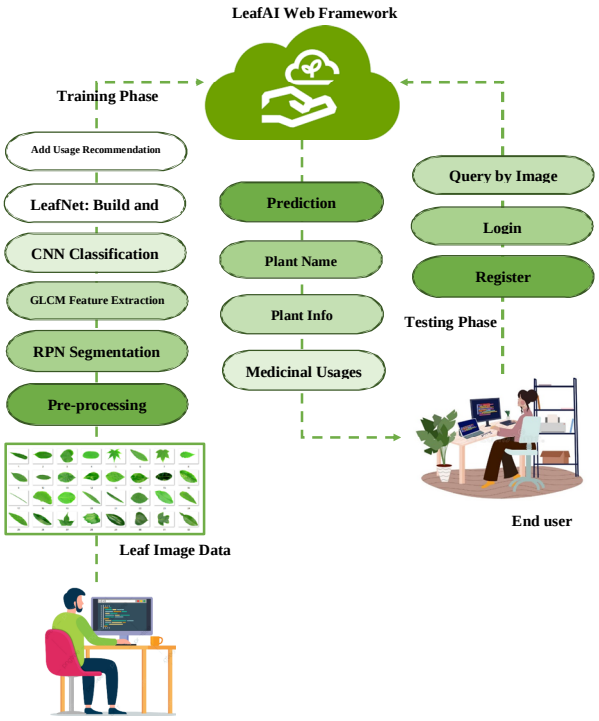
D. Usage Recommendation Component

Integrating a usage recommendation component within the system to provide practical recommendations for the identified medicinal plant species. These recommendations will draw from established knowledge and research in the field, helping users understand the medicinal properties and potential applications of identified plants.

E. Advantages

- Automated medicinal plant identification, reducing reliance on manual methods.
- Efficient feature extraction through advanced image processing and deep learning algorithms.
- Inclusion of a usage recommendation module for practical insights into plant benefits.
- Minimization of misidentification risks, ensuring safer medicinal plant usage.
- Significant time savings through the automated identification process.
- User-friendly web interface for enhanced accessibility.
- Web-based accessibility, allowing plant identification from any location with internet access.
- Contribution to education and awareness about medicinal plants.

IV. SYSTEM ARCHITECTURE



V. MODULES DESCRIPTION

A. Plant Finder Web App

The Plant Finder web app is built on a robust foundation using Python, Flask, MySQL, and Bootstrap technologies, integrating seamlessly to provide a holistic user experience. Python, with its versatility, serves as the core programming language, while Flask, a lightweight web framework, facilitates the creation of dynamic and scalable web applications. MySQL is employed for efficient data management and storage, ensuring seamless retrieval and manipulation of datasets. The utilization of Bootstrap enhances the user interface, delivering a responsive and visually appealing design. The Plant Finder web app has been designed and developed with a suite of interconnected modules to ensure a seamless and comprehensive user experience. The User Authentication Module provides a secure registration and login process, while the Admin Dashboard Module empowers administrators with tools for dataset management, LeafNet model construction, continuous improvement, and user administration.

The Dataset Management Module facilitates the collection and importation of datasets crucial for model training, while the LeafNet Model Construction Module oversees the construction, training, and deployment of the model. Continuous Improvement Module enables ongoing enhancements to the model, adapting to new datasets and deep learning advancements. User-centric modules include Registration and Identification, allowing users to register, upload plant images, visualize predictions, and access detailed information about identified plants. The Usage Recommendation Module provides valuable insights into the applications and benefits of identified medicinal plant species. Security measures are embedded within the Security Module, implementing encryption, secure connections, and user authentication. The Responsive UI/UX Module ensures a user-friendly interface for both administrators and users. Additional functionalities, such as notifications, logging and analytics, deployment and hosting, and testing and quality assurance, collectively contribute to the robustness, reliability, and effectiveness of the Plant Finder web app.

B. End User Interface

1) Admin Interface

1) Login: Allows administrators to securely authenticate and access the admin functionalities.
2) Upload Dataset: Enables admins to upload the dataset containing leaf images and corresponding labels. This dataset is used for training the model.
3) Train the Model: Provides functionality for admins to initiate the training process of the LeafNet model using the uploaded dataset. Admins can monitor the training progress and performance metrics.
4) User Management: Allows admins to manage user accounts, including creating new accounts, updating user information, and deleting accounts.

2) User Interface

5) Register: Allows new users to create an account by providing necessary details such as username, email, and password.
6) Login: Provides a login interface for registered users to authenticate themselves and access the system.
7) Input Leaf Image: Enables users to upload images of plant leaves they want to identify. Users can select image from their device or capture one using their device's camera.
8) View Predicted Result: Displays the predicted plant species based on the uploaded leaf image. Users can view the predicted class label along with confidence scores or probabilities.
9) Receive Usage Recommendation of the Predicted Plant: Provides usage recommendations for the predicted plant species. This feature may include information on medicinal properties, culinary uses, cultivation tips, and potential side effects.

C. LeafNet Model: Build and Train

1) Image acquisition

The first step in the process of identification is to acquire the image of the plant. The image taken can be of the entire plant, leaf, flower, stem or even the fruits. Authors in suggest that there are three categories of images based on how the image is acquired, viz. ‘scans’, ‘pseudo-scans’, and ‘photos. In scan and pseudo-scan categories, the leaf images are taken by the method of scanning and photography respectively i.e. the images are captured in front of a plain background indoors. For the third category, the images are of plants are captured in natural environment. Scans and pseudo-scans images are largely used by researchers as they are easy to examine. Typically, the leaves selected are simple, fully grown and not tampered. These are then imaged in the lab under proper lighting conditions. The scans and pseudo-scans simplify the classification task as the image is taken against a plain background. Some of the available standard datasets are Swedish dataset (15 species of leaves), Flavia dataset (32 species of leaves), ICL dataset (220 plant species), etc. Majority studied have worked on images from these three datasets (refer table 1). In our study we have used Swedish dataset which contains 75 images each of 15 species of plants, which makes a total of 1,125 images. The dataset is available in public domain and can be downloaded from the official website (http://www.cvl.isy.liu.se/en/research/datasets/swedishleaf/). It contains images of plant leaves which are in .tiff format. Table 2 gives the names of the 15 species and one image each from all the species.

2) Leaf Image Pre-processing

Image pre-processing is an important step as it helps to enhance the quality of image for further processing. This step is necessary as an image inherently contains noise and this may result in lower classification accuracy. It is performed to remove the noise that hampers the identification process and handle the degraded data.

A series of operations are followed to improve the image of the leaf which include, converting the RGB image to grayscale, then from grayscale to binary, followed by smoothing, filtering etc . Pre-processing mechanism used in this paper contains noise handling along with resizing operation and image enhancement.

D. Plant Identifier

1) Input Image

Users interact with the Plant Identifier module by uploading images of plants they wish to identify. This user-friendly feature allows individuals to seamlessly submit images directly through the interface, simplifying the process of plant identification.

2) Plant Identification

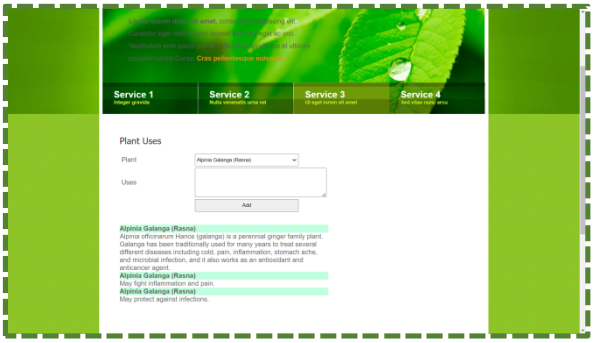
Upon image submission, the Plant Identifier module employs the trained LeafNet CNN model to accurately identify the plant species depicted in the uploaded image. Leveraging deep learning techniques, the system analyzes the unique characteristics present in the image, such as leaf shape, texture, and color patterns, to make informed predictions regarding the plant's species. Utilizing convolutional neural networks (CNNs), the LeafNet model has been meticulously trained on a diverse dataset of plant images, enabling it to recognize a wide array of plant species with remarkable accuracy. Through the intricate layers of the CNN architecture, the model effectively extracts relevant features from the input image, allowing for precise classification of the depicted plant. Upon completion of the identification process, users are presented with the predicted plant species, accompanied by relevant information and details. This seamless integration of image upload and plant identification functionalities within the Plant Identifier module enhances user accessibility and provides a valuable resource for individuals seeking to identify plants with confidence.

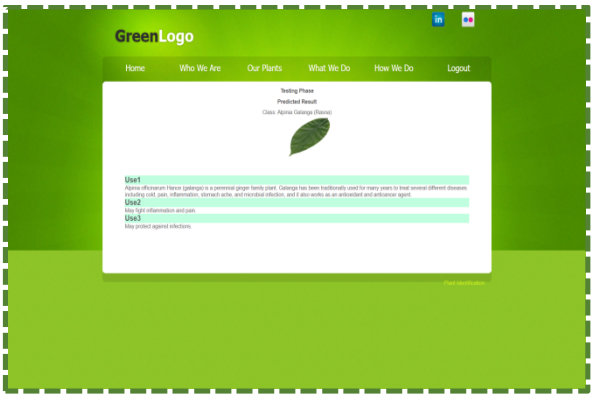
E. Usage Recommendation

The Usage Recommendation Module is an integral component of the Plant Finder web app, offering valuable insights into the practical applications and benefits of identified medicinal plant species. This module enhances the user experience by providing detailed recommendations on how the identified plant can be utilized for various purposes, including medicinal, culinary, or ornamental uses. Upon successful identification of a plant through the Plant Identifier module, the Usage Recommendation Module accesses a comprehensive database that contains information on the properties, traditional uses, and potential benefits of the identified plant. This database is curated to offer users reliable and relevant information about the applications of medicinal plants. The module presents users with a clear and user-friendly display of usage recommendations based on the identified plant species. This information can include medicinal properties, preparation methods, dosage guidelines, and any known cultural or historical uses of the plant. Additionally, the module may provide insights into other practical applications, such as culinary uses or ornamental features. The Usage Recommendation Module contributes not only to the user's understanding of the identified plant but also to broader initiatives in healthcare traditions, education, and collaborative research.

VI. RESULTS

The accuracy, reliability, and usability of the system were verified through various test cases, and the system's performance was found to meet acceptable industry standards. Overall, project is a reliable and accurate system that can effectively identify and classify medicinal plants and provide appropriate usage recommendations based on historical data and scientific research.





VII. CONCLUSION

Classifying the plants species with their leaf using the algorithms of computer vision show concern on categorizing the plant images into its distinct groups. The classification of plants using digital leaf images are challenging due to their similarities in inter-class and intra-class, the possibility of complex background and variations in many parameters such as illumination and color. Thus, developing tools and solutions to analyze and interpret the patterns in the leaf images with significant results are essential. This project proposes an automated plant identification system, for identifying the plants species through their leaf. This task is accomplished using deep convolutional neural network to achieve higher accuracy. Image pre-processing, feature extraction and recognition are three main identification steps which are taken under consideration. Proposed CNN classifier learns the features of plants such as classification of leafs by using hidden layers like convolutional layer, max pooling layer, dropout layers and fully connected layers. The model acquires a knowledge related to features of Swedish leaf dataset in which 30 plant classes are available, that helps to predict the correct category of unknown plant with accuracy of 97% and minimum losses. Result is slightly better than the previous work that analyzes 93.75% of accuracy.

VIII. ACKNOWLEDGMENT

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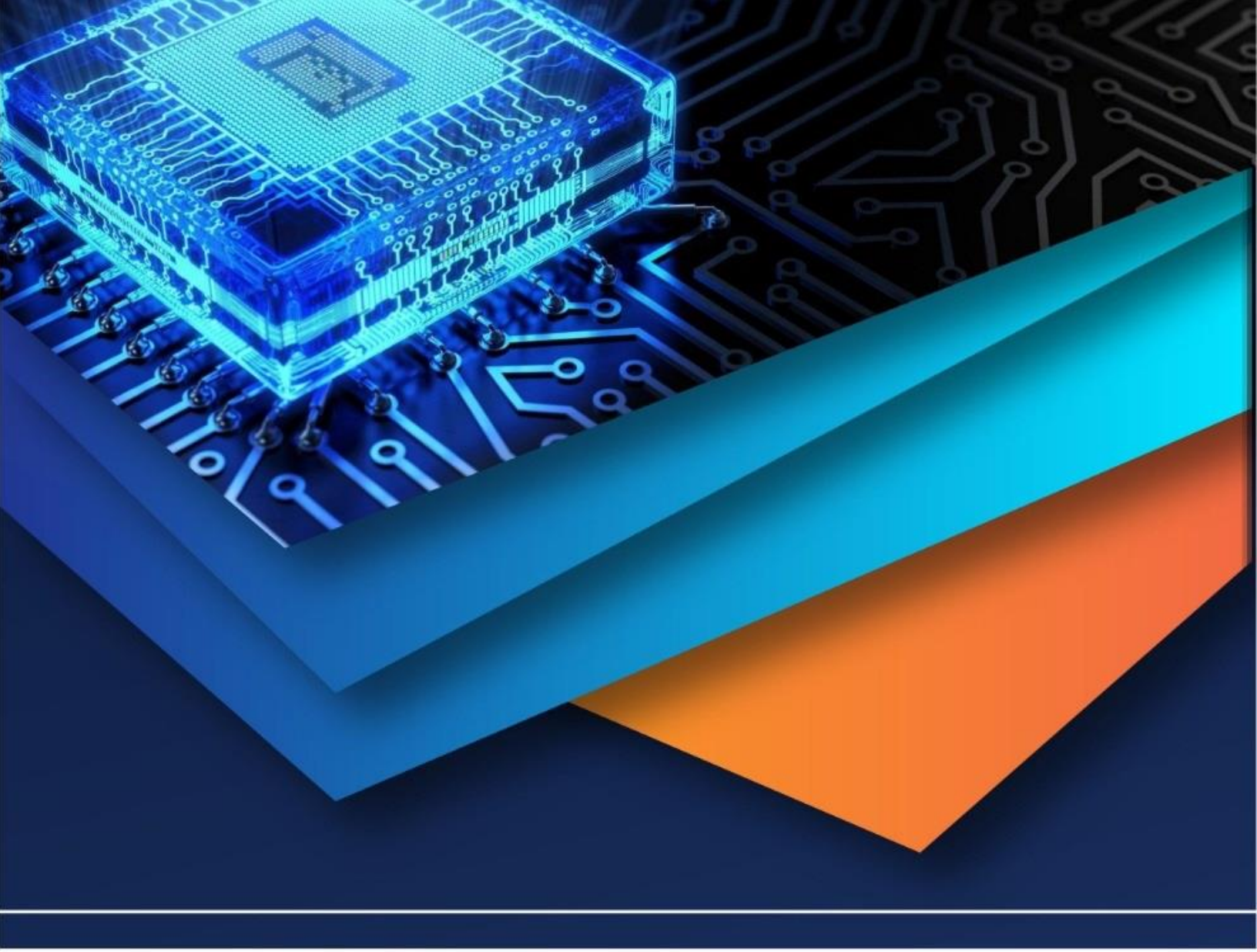

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