Automated Medicinal Plant Identification Using Deep Learning for Improved Healthcare

Kanchan N[1], Dhananjayan V[2], Jaiwin francis[3], Xavier Mary A[4]

[1,2,3,4]Adhiyamaan College of Engineering, Hosur, India.

ABSTRACT
The identification of medicinal plants is crucial for healthcare, drug manufacturing, and environmental management. Traditional manual identification methods are often time-consuming and prone to errors, potentially leading to adverse health effects. To address this challenge, this project proposes an automated system for medicinal plant classification using deep learning. Leveraging convolutional neural networks (CNNs) with Xception-based feature extraction, the system ensures high accuracy and classification of medicinal plants. Additionally, it incorporates a symptom-based recommendation module, enabling users to input symptoms and receive suggestions for the appropriate medicinal plant. By automating plant identification and providing targeted recommendations, this system enhances efficiency, reduces errors, and facilitates safer and more effective use of medicinal plants in healthcare.

Keywords: Medicinal Plant Classification, Deep Learning, Symptom-Based Recommendation, Feature Extraction, Convolutional Neural Networks, Machine Learning.

1. INTRODUCTION

Medicinal plants have been an integral part of traditional and modern healthcare due to their therapeutic properties. With thousands of plant species possessing medicinal benefits, accurate identification is crucial for safe and effective usage in medicine, drug development, and environmental management. However, traditional identification methods depend on expert knowledge, which can be time-consuming, error-prone, and challenging for non-specialists. Misidentification may lead to ineffective treatments or adverse health effects, highlighting the need for a more efficient and reliable approach.

Recent advancements in computational techniques have enabled the development of automated methods for plant classification. Image-based identification systems provide an efficient way to recognize plant species with high accuracy. This project introduces an automated medicinal plant classification system that utilizes image-processing techniques with convolutional neural networks (CNNs) for feature extraction and classification. By employing the Xception model, the system enhances accuracy and ensures faster identification of medicinal plants.

Additionally, the system includes a symptom-based recommendation module, allowing users to input medical symptoms and receive suggestions for suitable medicinal plants. This approach enhances accessibility to traditional plant-based remedies, supports healthcare professionals, and promotes the safe and effective use of medicinal plants.

2. LITERATURE SURVEY

S. Roopashree et al. [1] proposed DeepHerb, a vision-based medicinal plant classification system using

Xception-based feature extraction. Previous research in medicinal plant identification relied on traditional CNNs, but this study demonstrated that Xception improves classification accuracy due to its depthwise separable convolutions. The authors validated their model on a diverse medicinal plant dataset, achieving superior performance compared to conventional CNN-based approaches.

P. Shekonya Kanda et al. [2] introduced a deep learning-based plant leaf classification technique using CNNs. While prior works applied deep networks directly to raw images, this study employed transfer learning and data augmentation to enhance model generalization, reducing errors in plant species classification. The study also highlighted the importance of dataset diversity in ensuring robust classification performance across different environmental conditions.

L. Cao et al. [3] developed a GAN-based semantic segmentation approach for plant leaf classification. Unlike previous studies that applied CNNs for plant segmentation, this research incorporated attention mechanisms to refine leaf structure recognition, improving classification accuracy in complex backgrounds. The authors demonstrated that GAN-based segmentation significantly enhances feature extraction, reducing classification errors caused by noisy or occluded images.

V. Gajjar et al. [4] focused on plant identification in imbalanced datasets, addressing the challenge of class imbalance in leaf classification. This study applied data balancing techniques and a hybrid CNN model, reducing misclassification rates in real-world plant identification. By introducing an adaptive resampling strategy, the model effectively handled underrepresented plant species, ensuring higher classification reliability.

F. Twum et al. [5] proposed a textural analysis technique using Log Gabor filters for medicinal plant identification. While conventional CNN-based classification relies on shape and color, this work emphasized texture features, leading to more accurate classification of medicinal plants. The study also explored the impact of different filter scales and orientations on feature extraction, demonstrating improved classification accuracy for plants with similar leaf structures.

T. Chompookham et al. [6] introduced an evolutionary ant colony optimization model for plant leaf recognition. Unlike prior works that used fixed learning rates, this study implemented learning rate scheduling with evolutionary optimization, significantly improving the model selection process. The results showed that incorporating adaptive learning rates reduced overfitting and enhanced classification robustness in diverse plant species.

T. Le et al. [7] proposed a hybrid plant identification model combining multiple images with taxonomic information. Unlike traditional CNN-based classification, this work integrated botanical taxonomy and image analysis, yielding higher accuracy in species identification. The study demonstrated that supplementing image-based features with taxonomic data enhances model interpretability and reduces confusion between morphologically similar plants.

M. T. Islam et al. [8] introduced a Particle Swarm Optimized Cascaded Network for medicinal plant classification. Prior studies primarily relied on CNNs, but this research combined cascaded networks with swarm optimization, improving feature selection for enhanced classification accuracy. The authors demonstrated that optimizing hyperparameters using swarm intelligence techniques significantly improved the model's efficiency and reduced computation time.

S. Mumtaz et al. [9] focused on leaf classification for sustainable agriculture, exploring deep learning techniques for species-level classification. Unlike general plant classification models, this study emphasized species-specific characteristics, contributing to precision agriculture. The research also discussed how automated leaf classification can support environmental conservation efforts and biodiversity monitoring.

P. Sharma et al. [10] proposed a VGG-16-based medicinal plant classification system. Unlike prior research using general CNN models, this work fine-tuned pre-trained networks on medicinal plant datasets, improving classification efficiency. The authors demonstrated that leveraging VGG-16's deep hierarchical features resulted in more accurate plant species identification compared to shallow architectures.

V. Rao et al. [11] introduced an attention-enhanced deep learning model for medicinal plant detection. Unlike conventional CNN architectures, this study integrated self-attention mechanisms, refining feature selection for better classification results. The model effectively captured long-range dependencies in plant leaf structures, reducing misclassification in visually similar species.

D. Liu et al. [12] developed a deep learning-based plant disease recognition system using medicinal plant images. Unlike previous models that focused solely on classification, this work incorporated disease detection capabilities, making it useful for agriculture and healthcare. The study highlighted the potential of AI-driven plant monitoring systems in detecting early signs of diseases and improving crop health.

A. Mishra et al. [13] explored a hybrid ResNet-DenseNet model for medicinal plant species identification. The study demonstrated that combining two deep architectures enhanced accuracy by leveraging multi-scale feature extraction techniques. The authors compared their approach to standalone CNN models and found that hybrid architectures significantly improved classification performance while maintaining computational efficiency.

H. Nguyen et al. [14] presented a graph neural network (GNN)-based approach for plant classification, addressing the spatial relationship between plant features. Unlike CNN-based models, this research modeled plant structures as graph representations, enhancing recognition accuracy. The study showed that GNNs effectively captured complex relationships between plant morphology and taxonomy, leading to more accurate classifications.

S.A. Shehab et al. [15] proposed a mobile-friendly lightweight CNN model for real-time medicinal plant classification. Unlike prior works requiring heavy computational resources, this study optimized model size and inference speed, making it suitable for mobile applications. The research demonstrated the feasibility of deploying deep learning models on edge devices, enabling on-the-go plant identification for researchers and the general public.

3. METHODOLOGIES USED

1. Convolutional Neural Networks (CNNs) for Image-Based Classification – CNNs are widely used for extracting features from medicinal plant images. By leveraging deep layers and convolutional filters, CNNs capture intricate spatial patterns, improving classification accuracy. The proposed system utilizes the Xception model for feature extraction, as its depthwise separable convolutions enhance computational efficiency while maintaining high accuracy.
2. Pre-Trained Models for Feature Learning – Transfer learning with pre-trained models such as Xception improves classification performance by leveraging knowledge from large-scale datasets. These models reduce training time and enhance feature extraction, ensuring better generalization for real-world plant images. However, fine-tuning pre-trained models requires careful optimization to avoid overfitting.
3. Image Preprocessing and Augmentation – To improve model robustness, image preprocessing techniques such as resizing, normalization, and background noise reduction are applied. Data augmentation techniques, including rotation, flipping, and brightness adjustments, enhance model

generalization by preventing overfitting and improving classification accuracy under varying conditions.

4. Feature Extraction and Classification – The Xception-based CNN extracts essential features from plant images, distinguishing between different medicinal species. A fully connected neural network layer then classifies the extracted features into corresponding medicinal plant categories, ensuring precise identification.
5. Symptom-Based Recommendation System – A symptom-based module is integrated into the system, allowing users to input symptoms and receive recommendations for suitable medicinal plants. This module is built using a knowledge-based approach, mapping predefined symptoms to medicinal plants known for their therapeutic effects. This ensures an accurate and efficient retrieval of medicinal information for healthcare applications.

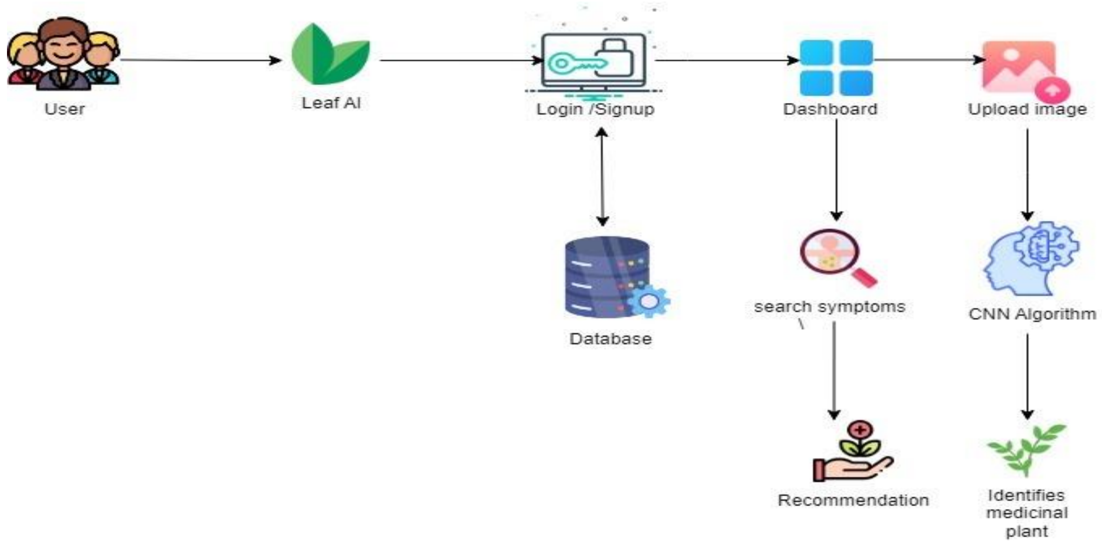

Fig 1: SYSTEM ARCHITECTURE

Proposed Work

This study aims to develop a web-based medicinal plant classification and symptom-based recommendation system using deep learning techniques. The proposed approach employs convolutional neural networks (CNNs), specifically utilizing the Xception model for feature extraction and classification of medicinal plant images. Additionally, a symptom-based recommendation module is integrated to provide users with suitable medicinal plants based on their health conditions.

The workflow consists of several key stages. First, data acquisition involves collecting a diverse dataset of medicinal plant images from botanical databases and online sources. The preprocessing phase includes image normalization, resizing, noise reduction, and data augmentation techniques such as rotation, flipping, and contrast adjustments to enhance model robustness. The feature extraction and classification stage utilizes the Xception model, which captures intricate plant characteristics for accurate identification. A CNN-based classifier then categorizes plant species, with performance evaluated using accuracy, precision, recall, and F1-score.

The system is developed as a web-based application, where users can upload plant images for classification. The model processes the image and provides immediate identification results along with relevant medicinal properties. Additionally, a symptom-based recommendation module allows users to input symptoms, retrieving medicinal plants known for treating those conditions. This module is built using a knowledge-based mapping system, where predefined symptom-plant relationships are stored in a structured database.

The application is designed to run on a local server or standalone system, eliminating the need for cloud-based infrastructure. The web interface is developed using HTML, CSS, and JavaScript for the frontend, while Python (Flask/Django) and TensorFlow/Keras are used for backend processing and model inference. Future improvements include expanding the dataset, optimizing classification accuracy, and refining the user interface for better accessibility and ease of use.

4. IMPLEMENTATION

Dataset Selection

For this project, a diverse dataset containing high-quality images of medicinal plants is essential to ensure accurate classification. The dataset consists of images collected from publicly available botanical databases, research institutions, and online plant repositories. The dataset includes images of various plant species commonly used in traditional medicine, covering different environmental conditions, angles, and lighting variations to improve model generalization.

Each image in the dataset is labeled with the corresponding plant species name, ensuring a well-structured dataset for supervised learning. The dataset is carefully curated to include multiple plant parts, such as leaves, flowers, and stems, to enhance the model's ability to recognize medicinal plants accurately.

Preprocessing

Before using the dataset for model training, several preprocessing steps are applied to enhance image quality and improve classification performance. Image resizing ensures uniform input dimensions, while color normalization standardizes image brightness and contrast. Noise reduction techniques are used to remove background clutter, making it easier for the model to focus on relevant plant features.

Data augmentation techniques such as rotation, flipping, scaling, and brightness adjustments are applied to artificially expand the dataset and improve model robustness. This step helps prevent overfitting and ensures that the model can recognize plant species under different conditions.

Feature Extraction and Classification

The Xception model, a deep convolutional neural network (CNN), is employed for feature extraction and classification. The model extracts essential features such as leaf shape, texture, and vein patterns, distinguishing between different medicinal plant species. The classification process involves:

1. Feature extraction – The Xception model captures unique characteristics of each plant image using depthwise separable convolutions.
2. Classification layer – A fully connected neural network classifies the extracted features into corresponding medicinal plant categories.

Symptom-Based Recommendation System

In addition to plant classification, the system includes a symptom-based recommendation module that provides users with medicinal plant suggestions based on their health conditions. This module is built using a knowledge-based mapping system, where predefined symptom-plant relationships are stored in a structured database. When users input specific symptoms, the system retrieves relevant medicinal plants known for treating those ailments, ensuring reliable and quick recommendations.

Web-Based Application Development

The entire system is integrated into a web-based application, allowing users to upload plant images for identification and input symptoms for medicinal plant recommendations. The web interface is developed using HTML, CSS, and JavaScript for the frontend, while Python (Flask/Django) and TensorFlow/Keras handle backend processing and deep learning model inference. The system runs on a local server, making it accessible without requiring cloud infrastructure.

Future improvements will focus on expanding the dataset, fine-tuning model performance, and enhancing the web interface for better user experience and accessibility.

5. CONCLUSION

Medicinal plant classification and symptom-based recommendation using deep learning offer a significant advancement in healthcare by enabling accurate, efficient, and automated identification of medicinal plants. By leveraging convolutional neural networks (CNNs) with Xception-based feature extraction, the system ensures precise classification of plant species, reducing the risks associated with manual misidentification. Image preprocessing techniques, including noise reduction and data augmentation, enhance model robustness, ensuring reliable recognition under various environmental conditions.The integration of a symptom-based recommendation module further enhances the system's utility by providing users with suitable medicinal plant suggestions based on health conditions. This feature bridges the gap between traditional herbal knowledge and modern technology, making plant-based remedies more accessible. The development of a web-based application ensures ease of use for researchers, healthcare practitioners, and the general public. Future improvements may focus on expanding the plant database, refining classification accuracy, and incorporating multilingual support to enhance accessibility. This study lays the foundation for an intelligent, user-friendly medicinal plant identification and recommendation system, promoting the safe and effective use of plant-based treatments in healthcare.

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