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Medicinal Plant Recognition

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Abstract: This paper introduces the concept of an "Medicinal Plant Recognition" has historically relied on expert knowledge and manual classification, often leading to errors and inefficiencies. This work presents an automated medicinal plant recognition system using deep learning techniques, specifically a fine-tuned ResNet50 model, coupled with a web-based user interface built with Flask. The system enhances classification accuracy by applying a series of preprocessing steps including grayscale conversion, edge detection, thresholding, and sharpening. Users can interact with the application by uploading leaf images or using real-time camera input for immediate predictions. Upon classification, the system provides the plant's name, the confidence score, and detailed medicinal information such as benefits and potential side effects. Designed for scalability, the platform bridges traditional medicinal knowledge with modern artificial intelligence approaches, offering applications in healthcare, agriculture, education, and biodiversity conservation.

Keywords: Medicinal plant recognition, Deep learning, ResNet50, Image preprocessing, Flask web application, Convolutional Neural Networks (CNN).

I. INTRODUCTION

Medicinal plants have been integral to human healthcare for centuries, serving as natural remedies and contributing significantly to pharmaceutical advancements. However, accurate identification remains a major challenge due to the morphological similarities among plant species and the variations induced by environmental conditions. Traditional methods, which often depend on expert botanists, are not only time-consuming but also susceptible to errors, posing risks in fields such as herbal medicine production and biodiversity conservation. The advent of artificial intelligence (AI) and computer vision technologies offers a promising alternative for automated plant recognition. In this project, we introduce a deep learning-based system employing the ResNet50 convolutional neural network (CNN) architecture to classify medicinal plants based on leaf images. By integrating advanced image preprocessing techniques, the model achieves high classification accuracy, enhancing its ability to distinguish subtle differences between species. A user-friendly web interface built with the Flask framework enables seamless interaction, allowing users to upload leaf images or utilize real-time camera functionality. Additionally, the system retrieves comprehensive medicinal information for each recognized plant, making it a valuable tool for researchers, healthcare professionals, farmers, and educators.

II. RELATED WORKS

Several approaches have been proposed to automate the identification of medicinal plants, focusing largely on image processing, machine learning, and deep learning techniques.

Surya C. M. and Varun P. [1] developed a method based on morphological, color, and texture feature extraction from green and dry leaf samples, achieving high accuracy using Multilayer Perceptron (MLP) and Support Vector Machine (SVM) classifiers. However, the system's reliance on a limited custom dataset restricts its generalizability.

Rohan Kumar Verma [2] explored the use of pre-trained deep learning models such as Xception, ResNet, VGG, and Inception on a Kaggle dataset of medicinal leaves, achieving a test accuracy of 93% with the Xception model. Despite promising results, the approach demands significant computational resources.

A CNN-based classification system using AlexNet architecture was proposed by Sameer A. Kyalkond et al. [3], demonstrating high accuracy for Ayurvedic medicinal plants. However, the dataset was geographically limited to Karnataka, affecting the model's scalability.

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Sivaranjani C. [4] presented a real-time medicinal plant identification system using ExG-ExR vegetation indices for segmentation and logistic regression for classification, achieving an accuracy of 93.3%. Yet, its performance was constrained by a limited number of plant classes.

LeafYogi, a mobile framework developed by Chalmers J. et al. [5], utilized YOLOv5, YOLOv8, and ResNet-50 architectures trained on the DIMPSAR dataset, achieving real-time detection with 99.2% accuracy. Although robust, its deployment on low-end devices remains challenging.

Sharanya M. D. [6] conducted a comparative analysis between machine learning and deep learning algorithms for medicinal leaf classification, finding VGG16 to outperform other models with 96.73% accuracy. Nonetheless, overfitting remained a concern due to the dataset size.

III. PROPOSED METHODOLOGY

The proposed medicinal plant recognition system integrates deep learning and image processing techniques within a user-accessible web application. The workflow is organized into four main phases: image acquisition, preprocessing, classification, and information retrieval.

A. System Overview

The system accepts an input image of a medicinal plant leaf, either uploaded manually or captured via a live camera. Prior to classification, the image undergoes several preprocessing operations to enhance feature visibility. A fine-tuned ResNet50 convolutional neural network (CNN) then predicts the plant species based on extracted features. Upon classification, medicinal information corresponding to the predicted species is retrieved and displayed through a Flask-based web interface.

B. Image Preprocessing

To improve model performance, uploaded images are subjected to a series of preprocessing techniques:

Grayscale Conversion: Simplifies the input by removing color information, reducing computational complexity.

Noise Removal: Median filtering is applied to suppress image noise while preserving important edges.

Edge Detection: Highlights structural leaf patterns such as veins and margins, aiding in feature extraction.

Thresholding and Sharpening: Enhances critical boundaries and texture details for more accurate feature learning.

C. Deep Learning Model

The system employs a ResNet50 model pre-trained on ImageNet and fine-tuned on a medicinal plant dataset. ResNet50, known for its residual learning framework, addresses the vanishing gradient problem and enables deeper architectures with superior feature extraction capabilities. The modified final layers output the predicted plant class along with a confidence score.

D. Web Interface and Database

A lightweight web application is developed using the Flask framework, providing the following functionalities:

User Authentication: Secure login and registration using SQLite database integration.

Image Upload and Prediction: Users can upload leaf images and receive classification results along with medicinal benefits, advantages, and possible side effects.

Medicinal Information Retrieval: A structured database maps plant species to curated medicinal information for easy access upon prediction. This modular design ensures scalability, allowing the future integration of additional plant species, enhanced feature sets, and potential mobile application deployment.

IV. IMPLEMENTATION DETAILS

A. Tools and Technologies

The system development utilized open-source tools and frameworks to ensure cost-effectiveness and flexibility:

Programming Language: Python

Deep Learning Framework: TensorFlow with Keras API

Image Processing Libraries: OpenCV and Pillow

Web Development: Flask microframework

Database Management: SQLite

Model Training Platform: Google Colab with GPU acceleration

These tools collectively enabled efficient development, training, deployment, and user interaction.

B. Dataset Preparation

Medicinal leaf images were collected from publicly available sources, including Kaggle and PlantVillage datasets, supplemented by additional curated samples. The dataset was preprocessed to standardize image sizes (150×150 pixels) and augment data through rotation, flipping, and brightness adjustments to enhance model generalization.

The final dataset was divided into training (80%) and testing (20%) sets to evaluate model performance effectively.

C. Model Training and Fine-Tuning

The ResNet50 model was initialized with ImageNet weights and fine-tuned for medicinal plant classification:

The top layers of the network were replaced with new fully connected layers suitable for the number of classes in the dataset.

A softmax activation function was used for multiclass classification.

The Adam optimizer was selected with an initial learning rate of 0.0001.

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Training was conducted over 30 epochs with a batch size of 32.
Early stopping and learning rate reduction callbacks were incorporated to avoid overfitting and improve convergence.

D. Flask-Based Web Application

A lightweight web interface was developed using Flask to make the model accessible to users. Key functionalities include:
User Authentication: New users can register securely, and existing users can log in to access the prediction service.
Image Upload and Real-Time Prediction: Users can either upload leaf images or activate a camera for live plant detection.
Medicinal Information Display: Upon prediction, the system fetches detailed information about the medicinal properties, benefits, and cautions associated with the identified plant.
HTML templates, styled with Bootstrap, were employed for the front-end, while server-side logic was handled through Flask routes and Python scripts.

E. Challenges and Solutions

During the development process, several challenges emerged:
Data Scarcity: Limited availability of high-quality medicinal leaf datasets was mitigated through extensive data augmentation techniques.
Hardware Constraints: The computational demands of deep learning training were managed by leveraging free cloud-based GPUs offered by Google Colab.
Model Deployment: Integration of the trained model with Flask required careful serialization using TensorFlow's .h5 model format and handling preprocessing consistency between training and inference phases.

V. RESULTS AND DISCUSSION

A. Model Performance

The fine-tuned ResNet50 model demonstrated robust classification capabilities across various medicinal plant species. On the test dataset, the model achieved a classification accuracy of 94.8%, highlighting its effectiveness in differentiating between similar leaf patterns. The confusion matrix further indicated that most misclassifications occurred among species with visually similar morphological traits, suggesting areas for future refinement.
The performance metrics of the model are summarized below:
Test Accuracy: 94.8%
Precision: 94.5%
Recall: 94.3%
F1-Score: 94.4%
These results validate the suitability of deep convolutional neural networks, particularly residual architectures like ResNet50, for fine-grained plant species classification tasks.

B. User Interface Functionality

The developed Flask-based web application offers a streamlined and intuitive user experience. Major functionalities observed include:
User Authentication: Secure login and registration processes.
Image Upload and Real-Time Capture: Users can either upload pre-captured images or activate a live camera for direct classification.
Medicinal Information Display: Upon successful identification, detailed medicinal properties, benefits, and potential side effects associated with the plant are presented.
Screenshots of key application interfaces are shown in Fig. 1 to Fig. 4.
<p align="center">
Fig. 1. User Login Interface.
Fig. 2. Home Page for Image Upload.
Fig. 3. Leaf Classification Result.
Fig. 4. Medicinal Information Display.
</p>

C. Discussion

The system successfully bridges traditional botanical knowledge with modern deep learning techniques, offering a practical and accessible tool for users across domains such as healthcare, agriculture, and education. While the system demonstrates high classification accuracy, future improvements could involve expanding the dataset to include more species, integrating multilingual support, and optimizing real-time recognition speed for mobile platforms.

VI. CONCLUSION

This paper presents a deep learning-based system for the automated recognition of medicinal plants using leaf images. By leveraging the ResNet50 convolutional neural network along with image preprocessing techniques, the system achieved a high classification accuracy of 94.8%. The integration of a Flask-based web application provides a user-friendly platform for both image-based prediction and retrieval of detailed medicinal information. The proposed approach effectively addresses the limitations associated with manual plant identification, including time inefficiency and the risk of misclassification.

Through real-time or uploaded image inputs, users can easily access critical information regarding various medicinal plants, thereby bridging traditional knowledge with modern artificial intelligence solutions.
In the future, the system can be extended in several directions:
Dataset Expansion: Incorporating a larger and more diverse collection of medicinal plant species to improve model generalization.
Mobile Application Deployment: Developing a lightweight mobile version to facilitate field usage by farmers, researchers, and healthcare workers.
Multilingual Support: Integrating regional languages to improve accessibility for users from different linguistic backgrounds.
Real-Time Optimization: Enhancing real-time processing speed and accuracy for seamless live plant recognition.

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