

# Indian Ayurvedic Medicinal Plant Classification System using Deep Learning

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## ABSTRACT

The accurate identification of medicinal plants is crucial for traditional medicine, research, and conservation. Manual identification is time-consuming and requires expert knowledge. This paper presents an Indian Medicinal Plant Classification System using deep learning to automate identification based on leaf images. The system is trained on 80 classes of Indian medicinal plants using EfficientNet, ResNet50, and a hybrid CNN model. The best-performing model is deployed using a Flask-based web application that allows users to upload images and receive plant classification along with medicinal information.

**Keywords:** Indian medicinal plants, deep learning, leaf image classification, EfficientNet, ResNet50, convolutional neural networks, Flask web application

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## INTRODUCTION

- Indian medicinal plants have played a vital role in traditional healthcare practices for centuries, offering natural remedies for a wide range of diseases and health conditions. With increasing interest in herbal medicine, Ayurveda, and plant-based treatments, there is a growing need for accurate identification and classification of medicinal plants. However, manual identification by botanists can be time-consuming and prone to human error. To address this challenge, we have developed an Indian Medicinal Plant Classification System using Deep Learning, which automates plant identification and provides essential medicinal information.
- Our system is trained on a dataset consisting of 80 different classes of Indian medicinal plant leaves, sourced from Kaggle. The dataset undergoes rigorous preprocessing and augmentation, including feature-wise centering, standardization, rotation, width and height shifts, and horizontal flips. These techniques ensure that our model can generalize well to real-world images, improving its robustness and accuracy in classification.
- To achieve high performance, we implemented EfficientNet to classify medicinal plant leaves. Each model was trained separately to analyze their individual performance, and the best-performing model was selected for deployment. The trained model is capable of recognizing plant species with high precision and is saved for real-time inference on new images uploaded by users.
- Our system is deployed as a web-based application, built using HTML, CSS, JavaScript, and Flask. The application features a simple and intuitive interface, allowing users to upload an image of a medicinal plant leaf for classification. Once the image is processed, the system not only identifies the plant species but also provides crucial information, such as the chemical components present in the plant, the diseases it can cure, any age or gender restrictions, and intake guidelines for pregnant women.
- This project is highly beneficial for researchers, botanists, students, and healthcare professionals who need a quick and reliable method for identifying medicinal plants. By leveraging deep learning, our system reduces dependency on manual classification and enhances accessibility to valuable medicinal plant knowledge. In the future, this system can be expanded by incorporating more plant species, improving model accuracy, and integrating it with mobile applications for on-the-go plant identification.
- Our Indian Medicinal Plant Classification System stands as a significant step towards combining AI with traditional medicine, offering a powerful and efficient tool for the study and application of herbal remedies. With continued advancements in machine learning and data collection, this project has the potential to revolutionize medicinal plant research and make plant-based treatments more accessible to the world.

## METHODOLOGY

- The Indian Medicinal Plant Classification System follows a structured approach that involves data collection, preprocessing, model training, and web application development. The following sections describe each stage in detail.

### 1. DATA Collection

- We used a Kaggle dataset containing 80 different classes of Indian medicinal plant leaves. The dataset consists of images of plant leaves captured under various lighting conditions, angles, and backgrounds. Each class represents a unique medicinal plant species commonly used in Ayurveda and herbal medicine.

### 2. Data Preprocessing and Augmentation

- To ensure high model performance and generalization, we applied image preprocessing and augmentation techniques. These steps help normalize the data and introduce variations that improve model robustness.

#### 2.1 Preprocessing

- Resizing: All images were resized to a fixed dimension (e.g., 224×224 pixels) to maintain uniformity across the dataset.
- Normalization: Pixel values were scaled between 0 and 1 to speed up model convergence.
- Noise Reduction: Gaussian blurring and median filtering were applied to remove unwanted noise and improve feature clarity.

#### 2.2 Data Augmentation

- To prevent overfitting and improve the model's ability to recognize plants under different conditions, we applied various augmentation techniques:
- Feature-wise centering: Centers image pixel values around zero.
- Feature-wise standardization: Normalizes images by scaling based on the dataset's mean and standard deviation.
- Rotation: Images were randomly rotated up to 20 degrees.
- Width and height shifts: Random shifts of up to 20% of the image size were applied.
- Horizontal flip: Images were randomly flipped to introduce more variations.

### 3. Model Development

- For classification, we employed deep learning models based on CNN architectures. We trained three models separately and then analyzed their performance.

#### 3.1 Individual Models

1. EfficientNet: Known for its high accuracy and efficiency, it uses compound scaling to optimize depth, width, and resolution.
2. ResNet50: A widely used deep CNN model with residual learning, allowing deeper networks to avoid vanishing gradient problems.
3. Hybrid Model (EfficientNet + ResNet50): Combines the strengths of both models by using feature fusion techniques.

#### 3.2 Model Training

- Loss Function: Categorical Crossentropy, since this is a multi-class classification problem.
- Optimizer: Adam optimizer was used for faster and efficient convergence.
- Batch Size: Set to 32 for balancing training speed and performance.
- Epochs: Trained for 50–100 epochs, depending on convergence.
- Evaluation Metrics: Accuracy, Precision, Recall, and F1-score were used to assess model performance.
- Early Stopping: Implemented to stop training when validation loss stopped improving.
- Best Model Saving: The model with the highest validation accuracy was saved for deployment.

### 4. Model Deployment

- After training, we deployed the best model using Flask, a lightweight Python web framework.
- Model Serialization: The trained model was saved using TensorFlow's SavedModel format (.h5 or .pb).
- Flask API Development: Created an API for loading the model, processing user-uploaded images, and returning predictions.

#### Inference Pipeline:

1. User uploads an image.
2. The image is preprocessed to match the model's input format.
3. The model predicts the plant species.
4. The system retrieves additional information about the plant, such as:

- Chemical components
  - Diseases it cures
  - Age and gender restrictions
  - Pregnancy intake conditions
5. The results are displayed on the web interface.

## Web Application Development

We built a user-friendly web interface for seamless interaction.

### 5.1 Frontend (User Interface)

- Developed using HTML, CSS, and JavaScript, the website provides:
- Homepage with an introduction to the system.
- Image Upload Page where users can upload medicinal plant images.
- Results Page displaying classification results along with medicinal details.

### 5.2 Backend (Flask API)

- Handles HTTP requests from the frontend.
- Processes uploaded images and feeds them into the model.
- Fetches medicinal plant details based on the classification result.
- Returns predictions to be displayed in the user interface.

## 6. Performance Evaluation

To assess model effectiveness, we conducted quantitative evaluations using multiple metrics:

- Accuracy: The percentage of correctly classified images.
- Precision & Recall: Measures model's ability to correctly classify plant species.
- Confusion Matrix: Visualizes classification results for each class.
- F1-score: Evaluates the balance between precision and recall.
- We also tested the model on new unseen images to ensure real-world applicability.

## 7. Future Enhancements

- To further improve the system, future versions will include:
- A larger dataset with more medicinal plant species.
- Mobile App Integration for on-the-go plant identification.
- OCR-based plant search allowing users to input plant names and retrieve medicinal information.
- Geolocation-based suggestions for finding medicinal plants in specific regions.

## CONCLUSION

This project successfully automates the identification of Indian medicinal plants using **deep learning and a web-based interface**. By integrating **EfficientNet, ResNet50, and a hybrid model**, the system ensures high accuracy in classification while providing **medicinal information** relevant to healthcare and research. The web application makes it accessible to researchers, herbalists, students, and healthcare professionals, promoting AI-driven solutions in traditional medicine.

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