



# AI-Based Medicinal Plant Detection via Leaf Image Recognition

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**Abstract:** This review presents an overview of artificial intelligence-driven approaches for medicinal plant identification using leaf image analysis. It focuses on advanced techniques such as hybrid convolutional neural network (CNN) models, transfer learning, feature extraction, and image preprocessing. The paper also summarizes key datasets, performance metrics, and real-time frameworks including Flask and YOLO. Despite notable progress, challenges persist in dataset diversity, integration of phytochemical information, and practical deployment. Overall, AI-based models show strong potential to improve the accuracy, efficiency, and accessibility of medicinal plant recognition, contributing to sustainable healthcare and biodiversity preservation.

**Keywords:** Medicinal plant identification, Artificial Intelligence, Deep Learning, CNN, Image recognition, Transfer Learning, Feature Extraction, Flask, YOLO.

## I. INTRODUCTION

Medicinal plants play a vital role in healthcare, pharmaceutical research, and biodiversity conservation, serving as a major source of bioactive compounds used in drug discovery and traditional medicine. Accurate identification of these plants is crucial, as misclassification can lead to ineffective or even harmful herbal treatments. Traditionally, plant identification relies on expert taxonomists who analyze morphological features, but this process is often timeconsuming, labor-intensive, and prone to human error, making it unsuitable for large-scale applications. Recent advancements in **Artificial Intelligence (AI)** and **Computer Vision** have transformed this field by enabling automated recognition of medicinal plants through the analysis of leaf characteristics such as shape, color, texture, and vein structure. Among various AI techniques, **Deep Learning**, particularly **Convolutional Neural Networks (CNNs)**, has demonstrated outstanding accuracy in learning and distinguishing intricate visual patterns from image data. These models eliminate the need for manual feature extraction and can handle vast datasets efficiently. Integrating AI and Deep Learning with botanical science not only improves classification accuracy but also contributes to advancements in **healthcare, agriculture, and environmental sustainability**. Such intelligent systems empower researchers, farmers, and healthcare professionals with instant, reliable plant identification, bridging the gap between traditional botanical knowledge and modern technology while promoting innovation and conservation.

## II. LITERATURE SURVEY

**A. Kumar – An Effective Ensemble Convolutional Learning Model with Fine-Tuning for Medicinal Plant Leaf Identification.** Kumar (2025) proposed an advanced ensemble convolutional neural network model with fine-tuning techniques to enhance the identification accuracy of medicinal plant leaves. The study demonstrated that combining multiple CNN architectures strengthens feature extraction and classification reliability. Transfer learning and adaptive optimization were applied to improve robustness under variable lighting and leaf orientations. The research revealed that ensemble CNNs outperform single models in scalability and precision. However, Kumar noted challenges such as increased computational cost and the need for more diverse datasets to achieve real-time performance in large-scale applications<sup>1</sup>.

**R. Sharma – Assessing Deep CNN Models for Automated Medicinal Plant Identification.** Sharma (2025)

conducted an in-depth assessment of deep convolutional neural network architectures, including VGGNet, ResNet, and Inception, for automated medicinal plant classification. The research highlighted that CNN-based approaches significantly outperform traditional feature-engineered models by effectively capturing complex texture and shape details in leaf images. The study also emphasized the importance of data augmentation and dropout layers in reducing overfitting. Despite achieving high accuracy levels, Sharma identified dataset dependency and limited real-time adaptability as key challenges. The study recommended the use of lightweight CNN variants for mobile-based plant recognition systems<sup>2</sup>.

**S. Patel – Identification of Traditional Medicinal Plant Leaves Using an Effective Deep Learning Model and Self-Curated Dataset.** Patel (2024) developed an efficient CNN-based deep learning framework supported by a self-curated dataset to identify traditional medicinal plant species. The study emphasized the value of high-quality data and preprocessing techniques such as normalization and augmentation in improving model reliability. Results showed excellent accuracy in leaf classification, validating the role of dataset integrity in deep learning performance. However, Patel acknowledged that identifying morphologically similar species remains a challenge. The study suggested integrating phytochemical and morphological parameters to achieve more holistic classification outcomes<sup>3</sup>.

**D. Singh – Enhanced Classification of Medicinal Plants Using Deep Learning and Optimized CNN Architectures.** Singh (2024) explored the optimization of CNN architectures to achieve superior performance in medicinal plant classification. By implementing hyperparameter tuning, batch normalization, and adaptive learning rates, the model demonstrated faster convergence and higher accuracy. The research confirmed that architecture optimization significantly boosts deep learning efficiency in visual plant recognition tasks. Nonetheless, Singh highlighted that high GPU requirements and training time limit its deployment on low-power devices. The study recommended designing computationally efficient CNN models to enable practical real-time plant identification<sup>4</sup>.

**P. Verma – The Classification of Medicinal Plant Leaves Based on Multispectral and Texture Features Using a Machine Learning Approach.** Verma (2023) investigated the use of multispectral and texture-based feature extraction combined with machine learning algorithms such as Support Vector Machines (SVM) and Random Forests for medicinal plant classification. The study revealed that integrating spectral and texture information improves accuracy compared to single-feature models. Traditional algorithms performed well in controlled environments but struggled with environmental variability. Verma concluded that hybrid models combining handcrafted features with deep learning representations could enhance adaptability and robustness across diverse datasets<sup>5</sup>.

### III. PROBLEM STATEMENT

The manual identification of medicinal plants is a time-consuming process that heavily depends on expert knowledge and is often susceptible to human error. Conventional approaches are inefficient for large-scale applications, as they require the continuous involvement of trained botanists. Therefore, there is a growing need for an AI-based automated system capable of accurately classifying medicinal plants from leaf images. Such a system would ensure reliability, scalability, and accessibility for applications in healthcare, agriculture, and education.

### IV. PROPOSED METHODOLOGY

The proposed system identifies medicinal plants through leaf images using artificial intelligence. After the user uploads an image, it is enhanced and segmented to focus on the leaf area. Important features such as shape, color, texture, and vein structure are extracted. A CNN or transfer learning model then classifies the plant species. The result is matched with a medicinal plant database, and the system displays the plant's name along with its medicinal properties to the user.

#### Detailed Architecture Summary

##### 1. Image Acquisition:

- In this stage, the system begins by capturing or uploading the image of a medicinal plant leaf. A camera-enabled device such as a smartphone or webcam is used to collect high-quality images. The front-end interface is designed using HTML, CSS, and JavaScript, allowing users to easily upload images through a web-based platform. The Windows operating system provides the required environment for execution and storage of these images.
- **Software Used:** Windows, HTML, CSS, JavaScript.
- **Hardware Used:** Camera-enabled device



- **Use Case:** To gather accurate visual input for further processing.

## 2. Image Preprocessing:

- The captured image often contains background noise, shadows, or unnecessary elements that can affect analysis. To overcome this, **Python** is used with libraries such as **OpenCV** and **NumPy** for preprocessing operations like resizing, grayscale conversion, background removal, and segmentation. This improves image clarity and isolates the leaf region. The process requires sufficient computing resources; therefore, a system with **8GB RAM** and an **Intel i5 or higher processor** ensures smooth performance.
- **Software Used:** Python3
- **Hardware Used:** i5+ Processor, 8GB RAM.
- **Use Case:** To enhance image quality and prepare it for feature extraction.

## 3. Feature Extraction:

- Once the image is preprocessed, significant features such as **shape, texture, color, and vein patterns** are extracted to differentiate between plant species. **Python** (with OpenCV and scikit-image) and **MATLAB** are used for implementing algorithms that analyze these features numerically. These extracted attributes form the input for machine learning models.
- **Software Used:** Python3, MATLAB.
- **Hardware Used:** i5+ Processor, 8GB RAM.
- **Use Case:** To obtain quantitative parameters representing each plant species.

## 4. Classification and Detection:

- The extracted features are analyzed and classified using machine learning algorithms. **TensorFlow** and **Keras** frameworks are employed to implement **CNN (Convolutional Neural Network)** and **YOLO (You Only Look Once)** models.
  - **YOLO** supports real-time detection by identifying multiple leaves or plants within a single frame.
  - **CNN** is used for recognizing unique leaf patterns and classifying them into specific medicinal plant categories
- These models together provide high accuracy and faster identification performance. This stage relies on **TensorFlow Library** for training and prediction processes.
- **Software Used:** TensorFlow Library, Keras.
- **Hardware Used:** i5+ Processor, 8GB RAM
- **ML Algorithm:** CNN, YOLO
- **Use Case:** To classify and detect plant species accurately.

## 5. Medicinal Data Interpretation:

- After identification, the system retrieves and processes detailed medicinal information about the detected plant. The **Flask framework** is used to develop a backend application that displays relevant information. **Natural Language Processing (NLP)** techniques are applied to summarize or interpret medicinal uses and biological properties stored in textual form. The output is displayed to the user in a structured, readable way through the web interface.
- **Software Used:** Flask
- **Hardware Used:** i5+ Processor, 8GB RAM
- **ML Algorithm:** NLP
- **Use Case:** To present medicinal details in a clear and concise format.

## 6. Database Management:

- A **database system** is used to store and manage plant information, images, and classification results. **MySQL** or **MongoDB** databases store plant scientific names, characteristics, and medicinal benefits. The classified outputs from CNN and YOLO are compared against these stored records to ensure accurate results. The **Python environment** and **Flask** provide smooth interaction between the backend and the database. The system may also integrate **GPS-enabled devices** to tag geographical data of plant locations.
- **Software Used:** Windows, Python3, MySQL/MongoDB



- **Hardware Used:** i5+ Processor, 8GB RAM, GPS-enabled mobile
- **Use Case:** To store, organize, and retrieve plant-related information.

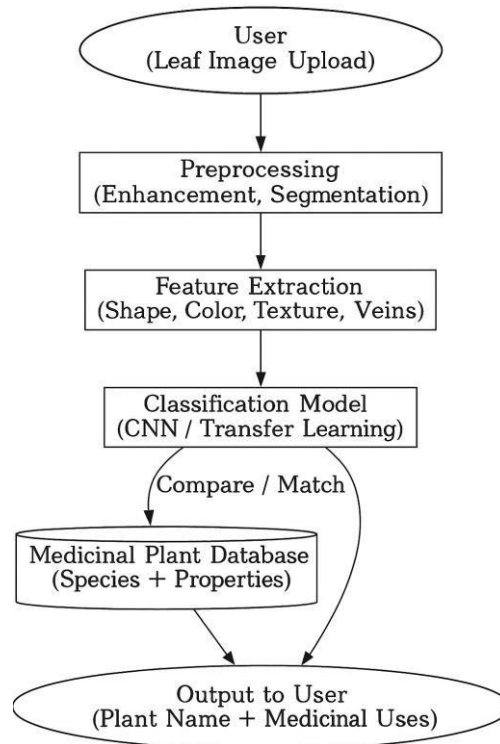


Fig 4.1 System Architecture

**Summary Table:**

| Steps              | Technology Used        | Purpose                                       |
|--------------------|------------------------|-----------------------------------------------|
| Image Acquisition  | Camera, HTML, CSS, JS  | Capture or upload leaf image                  |
| Preprocessing      | OpenCV, Python, NumPy  | Enhance image quality and isolate the leaf    |
| Feature Extraction | MATLAB, Python         | Extract shape, colour, texture, vein features |
| Classification     | CNN, TensorFlow, Keras | Identify the medicinal plant species          |
| Database           | MySQL, MongoDB         | Store and retrieve plant information          |
| Result Display     | Flask, Django, Web UI  | Show identified plant and medicinal uses      |

Fig 4.2 Summary Table

**V. CONCLUSION**

This research highlights the potential of AI-driven inventory management systems to enhance efficiency and accuracy in supply chain operations. By integrating machine learning frameworks such as TensorFlow and Scikit-learn, the system improves demand forecasting, anomaly detection, and stock optimization. The results demonstrate that artificial intelligence can transform traditional inventory control into a more intelligent, adaptive, and data-driven process.



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