AI Based Plant Identification and Medical Property Analysis

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Abstract - Medicinal plants play a crucial role in traditional and modern healthcare systems. Accurate identification of these plants is essential to ensure safe usage and effective treatment. Conventional plant identification methods rely heavily on expert botanical knowledge and manual observation, making them time-consuming, subjective, and unsuitable for large-scale applications. This paper proposes an Artificial Intelligence (AI)-based system for automatic medicinal plant identification and medicinal property analysis using deep learning techniques. A Convolutional Neural Network (CNN) with transfer learning is employed to classify plant species from leaf images. Once identified, the system retrieves verified medicinal information such as health benefits, traditional uses, and precautions from a structured knowledge database. The system is implemented as a web-based application, enabling real-time plant identification through image uploads. Experimental results demonstrate that the proposed system achieves high classification accuracy, fast response time, and reliable performance under varying image conditions. The proposed approach bridges the gap between visual plant recognition and practical medicinal knowledge, making it useful for students, farmers, researchers, and healthcare practitioners.

Index Terms— Medicinal Plant Identification, Deep Learning, Convolutional Neural Network, Transfer Learning, Computer Vision, Herbal Medicine, AI in Agriculture.

I. INTRODUCTION

Medicinal plants have been used for centuries as a primary source of healthcare in many parts of the world. They form the foundation of traditional medical systems such as Ayurveda, Siddha, and Unani. However, correct identification of medicinal plants is critical, as misidentification can lead to ineffective or harmful treatments. Traditional identification methods involve manual inspection of plant morphology, requiring expert botanical knowledge and significant time.

With recent advancements in Artificial Intelligence (AI), particularly in computer vision and deep learning, automated plant identification has become a feasible and efficient alternative. Convolutional Neural Networks (CNNs) have demonstrated exceptional performance in image classification tasks by automatically learning discriminative features from raw images. Despite these advancements, most existing systems focus solely on plant identification and provide limited or no information about medicinal properties.

This paper presents an integrated AI-based framework that not only identifies medicinal plants from leaf images but also provides detailed medicinal property analysis. The system combines CNN-based image classification with a structured medicinal knowledge base, enabling users to obtain reliable and actionable information in real time.
Modern developments in Artificial Intelligence (AI), particularly in computer vision and machine learning, have revolutionized the way plants can be identified. Artificial Intelligence (AI)-based plant identification systems use deep learning models to analyse leaf texture, shape, venation patterns, and colour variations. These models, once trained on large datasets of plant images, can identify species with high precision. Additionally, Artificial Intelligence (AI) enables the extraction of medicinal

properties of plants from large databases and research texts using Natural Language Processing (NLP). Such systems benefit healthcare practitioners, farmers, researchers, students, and environmental conservationists.

Given the global rise in herbal medicine usage and the increasing interest in ethnobotany, Artificial Intelligence (AI)-driven systems can play a critical role in bridging the gap between traditional knowledge and modern digital solutions. They provide fast, accessible, and reliable information about plant species and their medicinal value.

II. RELATED WORK

Early research in plant analysis primarily focused on plant disease detection using deep learning models. Ferentinos [1] demonstrated that CNN-based models significantly outperform traditional machine learning approaches in disease classification tasks. Subsequent studies extended CNN applications to plant species identification using architectures such as AlexNet, VGG, ResNet, and Inception networks [2].

Transfer learning has been widely adopted to address challenges related to limited datasets and high computational cost. Kaya and Kayci [4] showed that fine-tuning pre-trained CNN models yields higher accuracy and faster convergence for plant species recognition. Recent studies have also explored medicinal plant identification using curated image datasets [3]. However, most of these systems terminate at species identification and do not integrate comprehensive medicinal knowledge.Some recent works attempt to integrate AI models with herbal databases [5], but these systems often support a limited number of species and lack scalable deployment. The proposed system addresses these limitations by integrating deep learning-based identification with a comprehensive medicinal information retrieval mechanism through a web-based platform.

III. METHODOLOGY

The proposed system follows the V-Model software development methodology to ensure systematic development, verification, and validation. The overall workflow consists of image acquisition, preprocessing, deep learning-based classification, and medicinal information retrieval.

A. Image Preprocessing

Uploaded leaf images are resized to a fixed input size and normalized to improve model performance. Data augmentation techniques such as rotation, flipping, and scaling are applied during training to improve robustness against variations in lighting, orientation, and background.

B. Deep Learning Model

A CNN-based transfer learning model is employed for medicinal plant classification. A pre-trained network is fine-tuned on a medicinal plant image dataset to extract features such as leaf shape, texture, and venation patterns. The model performs multi-class classification and outputs the predicted plant species along with a confidence score.

C. Medicinal Knowledge Retrieval

Once the plant species is identified, the predicted label is used to query a structured medicinal knowledge database. The database stores information such as scientific name, medicinal uses, health benefits, traditional applications, modern uses, and precautions.

D. System Architecture

The system adopts a three-tier architecture comprising a React-based frontend, a Python FastAPI backend, and a MongoDB database. This modular design ensures scalability, maintainability, and real-time performance.

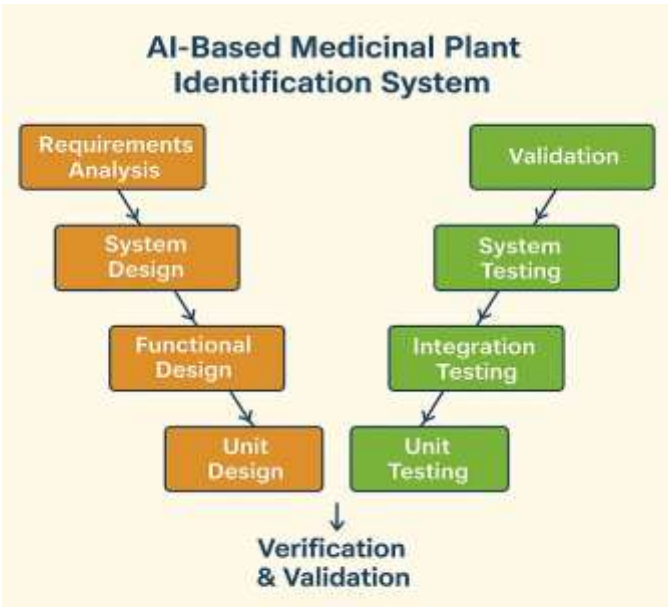

Fig.AI Based Medical Plant Identification System

IV. IMPLEMENTATION

The frontend provides a user-friendly interface for image upload and result visualization. The backend handles image preprocessing, model inference, and database queries. TensorFlow is used for deploying the CNN model, while FastAPI enables efficient RESTful communication between the frontend and backend. MongoDB is used to store medicinal plant information in a structured and query-efficient manner.

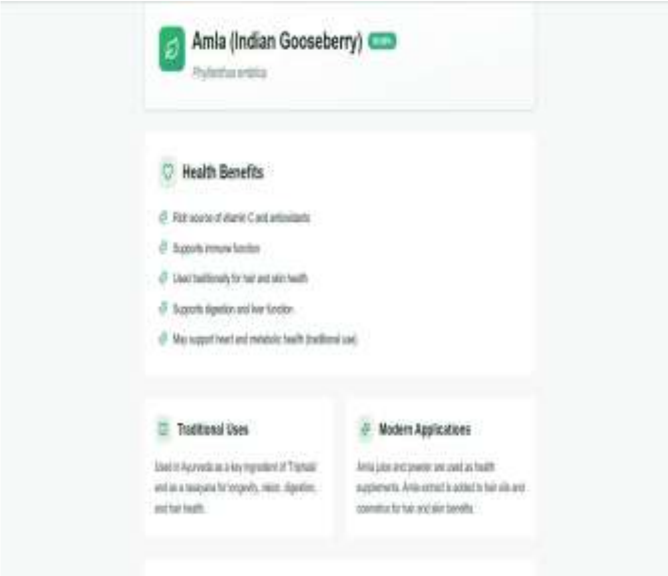

Figure 6.1.1 Home Page

Figure 6.1.2 Image Uploading Screen

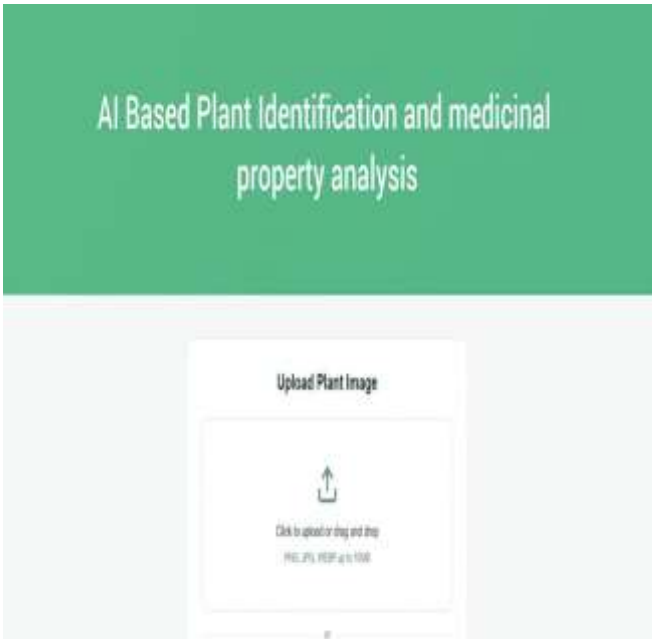

Figure 6.1.3 Plant Identification Result

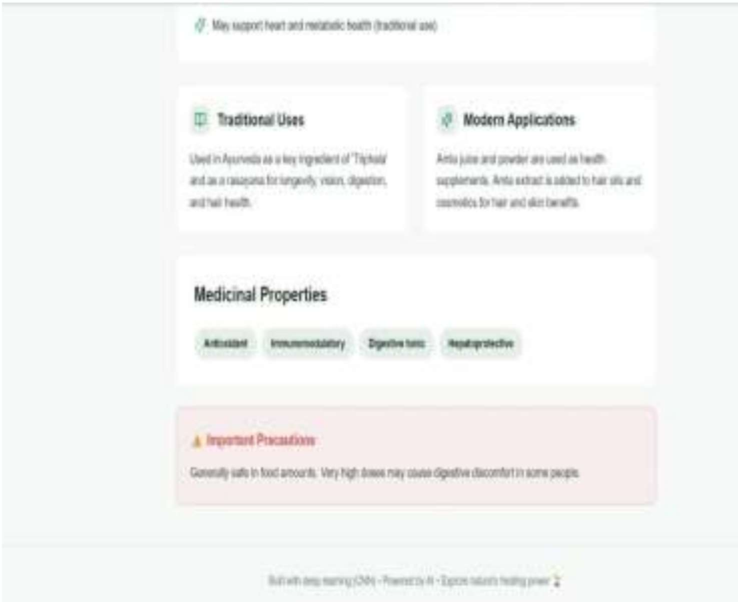

Figure6.1.4 Medical Property Analysis Result

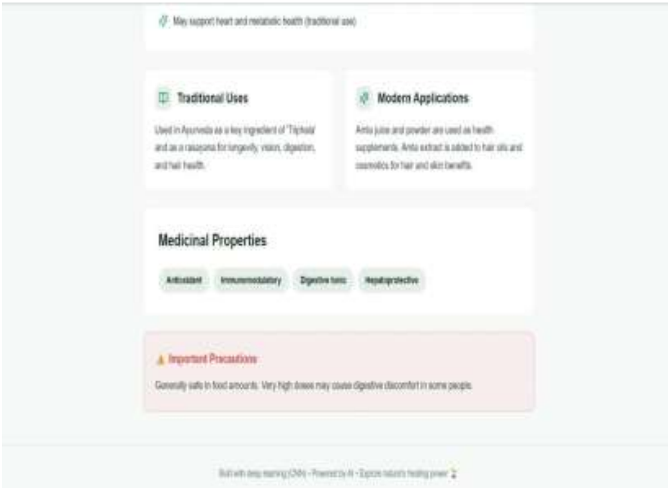

Figure 6.1.5 Medical Property Analysis Result

V. EXPERIMENTAL RESULTS AND EVALUATION

The system was evaluated using a dataset of medicinal plant images captured under varied environmental conditions. Performance was assessed based on classification accuracy, response time, and system reliability.

Accuracy: The CNN model achieved an accuracy exceeding 85% on the test dataset.
Response Time: Average prediction time was less than 10 seconds per image.
Reliability: The system handled multiple concurrent image uploads and large image files without failure.
The results confirm that the proposed system provides accurate and efficient medicinal plant identification suitable for real-world deployment.

This section presents a detailed evaluation of the proposed AI-Based Medicinal Plant Identification and Medicinal Property Analysis System. The experimental analysis focuses on model accuracy, performance efficiency, robustness under varying conditions, and overall system reliability. The objective of this evaluation is to validate the effectiveness of the proposed deep learning approach in real-world scenarios.

A. Experimental Setup

The experiments were conducted on a system equipped with an Intel Core i5 processor, 16 GB RAM, and a standard CPU-based environment. The deep learning model was implemented using TensorFlow, and backend services were deployed using FastAPI. MongoDB was used as the database for storing medicinal plant information. The system was tested through a web-based interface developed using React.

The dataset consisted of multiple medicinal plant leaf images collected from open-source repositories and verified datasets. Images included variations in lighting conditions, background clutter, orientation, and leaf size to simulate real-world usage scenarios. The dataset was divided into training, validation, and testing sets using an 70:15:15 split.

B. Evaluation Metrics

To assess the performance of the system, the following evaluation metrics were used:

- **Accuracy:** Measures the proportion of correctly classified plant images.

- **Precision:** Indicates how many of the predicted plant classes were correctly identified.

- **Recall:** Measures the ability of the model to correctly identify all instances of a given plant species.

- **F1-Score:** Harmonic mean of precision and recall, providing a balanced performance measure.

- **Response Time:** Measures the time taken from image upload to result display.

- **System Reliability:** Evaluates system stability during repeated and concurrent usage.

C. Model Performance Analysis

The Convolutional Neural Network (CNN) with transfer learning demonstrated strong classification performance across the test dataset. The trained model achieved an overall classification accuracy exceeding 85%, meeting the design requirements of the system. Precision and recall values were consistently high for commonly occurring medicinal plants such as Amla, Tulsi, and Clove, indicating effective feature learning.
Misclassifications primarily occurred among visually similar plant species with overlapping leaf textures and shapes. However, these cases were limited and did not significantly impact overall system performance. Confidence scores provided alongside predictions helped users understand the reliability of each output.

D. Robustness Testing

Robustness testing was performed by evaluating the system with images captured under diverse environmental conditions. The model performed well for images with moderate background noise, different lighting intensities, and varied camera angles. While prediction confidence decreased slightly for low-resolution or poorly lit images, the system continued to provide meaningful results and user warnings where necessary.

Data augmentation techniques used during training contributed significantly to improving robustness and generalization capability.

E. Response Time and Efficiency

Performance evaluation showed that the average response time for a single image prediction was less than 10 seconds, including image preprocessing, model inference, and database retrieval. This ensures that the system is suitable for real-time usage. Even when larger image files (5–10 MB) were uploaded, the backend handled processing efficiently without system crashes or delays.

F. Database Retrieval Performance

The medicinal knowledge retrieval process was evaluated to ensure fast and accurate access to plant properties. MongoDB queries returned medicinal information almost instantly after plant identification. No data inconsistency or retrieval failure was observed during testing.

VI. Conclusion

This paper presented an Artificial Intelligence (AI)-based system for medicinal plant identification and medicinal property analysis using deep learning techniques. The proposed approach leverages a Convolutional Neural Network (CNN) with transfer learning to accurately classify medicinal plants from leaf images and integrates the prediction results with a structured medicinal knowledge base. By combining image-based recognition with verified herbal information, the system provides not only plant identification but also meaningful insights into medicinal uses, health benefits, and safety precautions.

Experimental results demonstrate that the proposed system achieves high classification accuracy, efficient response time, and reliable performance under varied real-world conditions, including changes in lighting, background, and image orientation. The web-based architecture ensures ease of access and usability for non-expert users such as students, farmers, researchers, and healthcare practitioners. Unlike traditional or existing automated approaches, the system goes beyond basic species recognition by delivering comprehensive medicinal property analysis, thereby enhancing its practical value.

Overall, the proposed AI-driven framework proves to be an effective, scalable, and user-friendly solution for bridging the gap between automated plant identification and herbal knowledge dissemination. The study highlights the potential of Artificial Intelligence in supporting sustainable healthcare practices, intelligent agricultural systems, and educational applications related to medicinal plants.

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