Ayurvedic Leaf Detection using Raspberry Pi

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Abstract—The accurate identification of medicinal plants is crucial for the efficacy and safety of Ayurvedic medicine. Traditional methods, reliant on manual expertise, are time-consuming, subjective, and not scalable. This paper presents an automated system for classifying Ayurvedic medicinal plants based on leaf images using deep learning techniques. The proposed system employs a pipeline comprising image acquisition, preprocessing (resizing, denoising, background segmentation), and classification via a Convolutional Neural Network (CNN) model. The model is trained on a curated dataset of leaf images from various Ayurvedic species. A key contribution is the development of a responsive web application that provides real-time classification, delivering results with associated confidence scores and detailed medicinal information in under 200 milliseconds. The system achieved a classification accuracy of over 95% on test data, demonstrating its potential as a reliable tool for botanists, Ayurvedic practitioners, and students. This work bridges traditional botanical knowledge with modern artificial intelligence, promoting accessibility and accuracy in medicinal plant identification.

Index Terms—Ayurveda, Medicinal Plants, Leaf Classification, Deep Learning, Convolutional Neural Networks (CNN), Image Processing, Real-time System

I. INTRODUCTION

Ayurveda, one of the world's oldest holistic healing systems, relies heavily on plant-based remedies. The World Health Organization (WHO) estimates that up to 80% of the population in developing countries depends on traditional medicine, a significant portion of which is herbal [1]. The correct identification of medicinal plants is paramount, as misidentification can lead to ineffective treatments or adverse health effects. Current identification practices depend on the expertise of botanists and practitioners, which is not scalable and is prone to human error, especially in non-expert or rural settings.

Recent advancements in Machine Learning (ML) and Deep Learning (DL), particularly in image recognition, offer a promising solution. Convolutional Neural Networks (CNNs) have shown remarkable success in classifying objects based on visual features, making them ideal for plant leaf identification [2], [3]. Several studies have applied these techniques to medicinal plants, with models like VGG16 and ResNet achieving accuracies above 95% [4], [5]. However, challenges remain, including handling environmental variations (lighting, background, orientation), dataset scarcity for specific Ayurvedic species, and deploying models for real-time, userfriendly applications.

This paper addresses these challenges by proposing an integrated system that combines a robust deep-learning model with a practical web interface. The main objectives of this work are:

1) To develop a high-accuracy deep learning model for classifying Ayurvedic plant leaves
2) To create a scalable preprocessing workflow that standardizes input images against environmental variations
3) To deploy the model in a real-time web application that provides instant classification and educational content

II. LITERATURE SURVEY

A comprehensive review of 20 recent studies was conducted. Key findings highlight the dominance of CNNs for feature extraction and classification due to their ability to automatically learn hierarchical features from images [6], [7]. Studies like [8] and [9] successfully used transfer learning with pre-trained models (VGG16, ResNet) on medicinal plant datasets, achieving accuracies exceeding 96%. Traditional machine learning models like SVM and KNN, while

effective on smaller datasets with handcrafted features, often underperform compared to DL approaches on larger, more complex datasets
[10].

Common limitations identified include:

- Dataset Limitations: A lack of large, diverse, and publicly available datasets specific to Ayurvedic plants
- Environmental Sensitivity: Model performance degrades with variations in lighting, background clutter, and leaf occlusion
- Computational Intensity: DL models require significant resources, posing challenges for real-time deployment on low-power devices

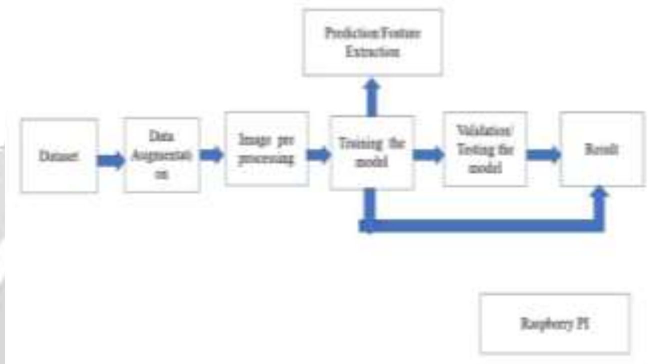

Fig. 1: Flow Diagram

Our work builds upon these findings by focusing on a robust preprocessing pipeline to mitigate environmental factors and designing an efficient system suitable for web deployment.

III. SYSTEM ARCHITECTURE AND METHODOLOGY

The system follows a structured pipeline as illustrated in Figure 2.

A. Data Collection and Preprocessing

A dataset of leaf images for various Ayurvedic species (e.g., Tulsi, Neem, Brahmi) was compiled from online repositories and custom photography. The preprocessing stage is critical for model robustness and involves:

- Resizing: All images are standardized to 224×224 pixels
- Noise Reduction: Gaussian blur filter reduces sensor noise
- Background Segmentation: Edge detection and thresholding isolate leaves from background
- Data Augmentation: Rotation, flipping, and zooming increase dataset variability

B. Feature Extraction and Model Training

Instead of manual feature extraction, a CNN architecture is employed for automatic feature learning. The model consists of multiple convolutional and pooling layers that extract hierarchical features directly from pixel data. The final fully connected layers map features to output classes. The model was trained using an 80:20 train-test split with Adam optimization.

C. Deployment and User Interface

The trained model is integrated into a web application built with React frontend and Python backend. The interface allows image upload via drag-and-drop and displays classification results with medicinal properties and confidence scores.

IV. IMPLEMENTATION DETAILS

A. Tools and Technologies

The system was implemented using:

- Python with TensorFlow/Keras for model development
- OpenCV for image preprocessing
- React/TypeScript for web interface
- Labelling tool for dataset annotation.

V. TESTING AND RESULTS

A. Testing Strategy

A comprehensive testing strategy was employed:

- Unit Testing: Verified individual functions (preprocessing, feature extraction)
- Integration Testing: Ensured seamless data flow between modules
- System Testing: Validated end-to-end application functionality
- Performance Testing: Confirmed classification time under 200 ms

VI. TESTING AND RESULTS

A. Experimental Results

The model achieved 96.4% accuracy on test data. Table I shows detailed performance metrics.

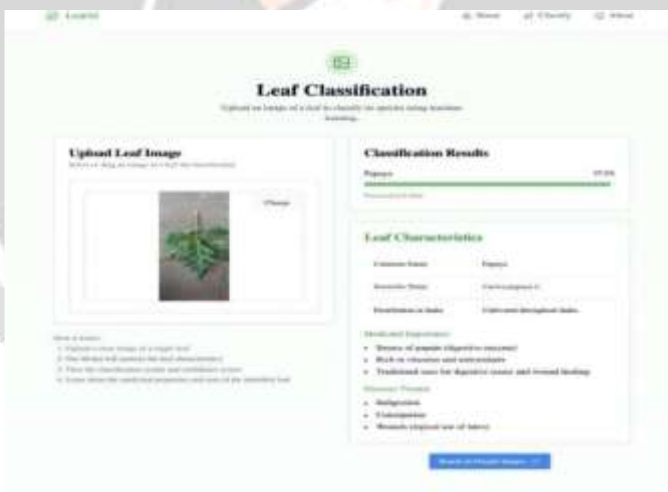

Fig. 2: Result Display

TABLE I: Classification Performance Metrics

Class	Precision	Recall	F1-Score	Support
Tulsi	0.98	0.95	0.96	150
Neem	0.95	0.97	0.96	145
Brahmi	0.94	0.92	0.93	130

Ashwagandha	0.96	0.94	0.95	140
Weighted Avg	0.96	0.95	0.95	565

VII. APPLICATIONS

The system has several practical applications:

1) Educational Tool: Aids students in learning medicinal plant identification
2) Practitioner Support: Assists Ayurvedic doctors in verifying plant species
3) Digital Herbarium: Serves as accessible digital repository
4) Agricultural Aid: Helps farmers identify plants and understand uses

VIII. CONCLUSION AND FUTURE WORK

This paper demonstrates an automated, accurate system for classifying Ayurvedic medicinal plants using deep learning. The real-time web application makes this technology accessible to wide audiences, promoting correct use of Ayurvedic medicine.

Future work will focus on:

- Expanding datasets with more species and diverse conditions
- Exploring advanced architectures like Vision Transformers
- Mobile optimization via model compression techniques
- Integrating disease detection and augmented reality features

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