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MedLeaf: Smart Medicinal Plant Identifier

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Abstract: The increasing reliance on artificial intelligence (AI) for groundbreaking medical advancements has led to innovative solutions in botanical medicine. “MedLeaf : Smart Medicinal Plant Identifier” represents a pioneering approach to identifying and analysing medicinal properties in leaves using AI technologies. This study harnesses machine learning algorithms to extract, classify, and evaluate bioactive compounds within various plant leaves, aiming to streamline the discovery of new medicinal agents and enhance therapeutic efficacy. By integrating AI with traditional botanic practices, this research demonstrates significant potential in revolutionizing pharmaceutical development, providing an efficient pathway for discovering novel treatments for a wide array of diseases. Key findings reveal the accuracy and speed of AI in medicinal leaf analysis, promising substantial contributions to the field of herbal medicine and pharmacognosy.

Keywords: Leaf identification, Medicinal properties, Plant species, Herbal medicine, Image recognition, Plant database, Xcept

INTRODUCTION

The integration of artificial intelligence (AI) into scientific fields has led to significant advancements, particularly in botanical medicine. MedLeaf : Smart Medicinal Plant Identifier is an innovative initiative that harnesses AI to revolutionize the discovery and analysis of medicinal properties in plant leaves. This project utilizes advanced machine learning algorithms to extract, classify, and evaluate bioactive compounds in various plant species. By doing so, it accelerates the identification of novel medicinal agents that can be used for developing treatments for numerous diseases. The combination of AI with traditional botanical knowledge enhances the therapeutic efficacy of natural remedies and contributes to pharmacognosy.

Beyond efficiency and accuracy, MedLeaf highlights the importance of interdisciplinary collaboration in pharmaceutical development. The project offers a streamlined approach to discovering new treatments, ultimately improving healthcare outcomes and broadening the scope of herbal medicine. AI-driven analysis enables a more systematic study of medicinal plants, reducing the time and resources needed for research while increasing reliability. Additionally, this initiative opens new avenues for research and could lead to groundbreaking treatments for diseases that have eluded conventional medicine. It also emphasizes sustainable and eco-friendly practices, as medicinal plants are renewable resources that can be cultivated with minimal environmental impact.

In summary, MedLeaf leverages AI to transform botanical medicine, bridging technology with traditional knowledge to uncover new medicinal compounds.

MATERIALS AND METHODS

Paper [1] examines deep learning for medicinal plant identification employing pre-trained models such as Xception, ResNet, and InceptionV3. A system trained on an Indian medicinal leaves dataset using the Xception model reaches 93% accuracy. One can recognize plants through its user-friendly interface, which will help researchers, herbal medicine users, and conservation efforts by providing automated classification of plants.

Paper [2] proposes, for medicinal plants identification and classification, a method using the Vision Transformer and overcomes the inefficiencies of the traditional and CNN-based methods. Employing self-attention mechanisms, data augmentation, and high-resolution datasets, the model achieves accuracy of more than 95%, thus outperforming the conventional CNN. The research applications cover herbal medicine and biodiversity conservation.

Paper [3] surveys deep learning approaches for medicinal plant identification, highlighting CNN- based models reaching accuracy as high as 99%. Various applications including those in the real world are discussed, and it aims at drawing attention towards the benefits of automation, adaptability on mobile platforms, and limitations of the models. The study underlines the need for a standardization of data sets and improved adaptability for different environmental conditions.

Paper [4] proposes a deep learning-based method for the identification of medicinal plants using image processing and feature extraction. It employs ResNet50V2 and MobileNet SSD models, and it achieves accuracy of 85%. A Web platform integrated with real-time identification provides immense assistance to botany and pharmacology while enabling traditional medicine through automation in plant recognition.

Paper [5] proposed a deep learning-based medicinal plant identification and the growth of therapeutic use by using transfer learning. VGG16, InceptionV3, and Xception are employed. From these, the InceptionV3 model with the SVM classifier yielded an accuracy of 99.34%. The study will also help in sustaining traditional medicinal knowledge and automated plant recognition for healthcare applications.

Paper [6] is on the identification of medicinal plants deep learning-based approaches using ResNet50V2 and MobileNet SSD models. A developed system, thereby applying image processing along with automatic feature extraction, efficiently identifies medicinal plants with an accuracy of 85%. This will bring botanical and pharmacological applications into practice with an easy web interface for real-time plant identification.

Paper [7] proposes an Xception deep learning-based system for high-accuracy identification of medicinal plants. The CNN model has been trained on a large dataset of images of leaves to learn fine-grained features related to texture, venation, and shape. The results show that the proposed approach gives 88% accuracy, hence showing its strength in classifying various plant species. In this work, the contribution of deep learning is portrayed in supporting the applications of botanical research, natural conservation, and medicine.

Paper [8] presents the state-of-the-art deep learning-based herbal species identification using leaf images scanned from various types of flora and some of the advanced CNN architectures. Various models, such as MobileNet, DCNN, ResNet50, and an optimized Advanced Xception, were trained on a dataset of Indian medicinal leaves. The advanced Xception model produced the best accuracy of 99.25%, showcasing superior feature extraction and classification. Further, in this work, the developed model has been integrated into a web application for real-time plant leaf identification and accessing their medicinal and nutritional values.

Paper [9] The paper proposed a modified Xception architecture for the recognition of medicinal herbs based on deep learning. It compares several CNN models, namely VGG16, ResNet50, standard Xception, and the proposed modified Xception model, which attains the best architecture. Experimental results have concluded that the modified Xception performs the best with the lowest loss and highest accuracy of 96.79% outperforming all other baseline models. The study has indicated that tailored model design substantially enhances accuracy in the identification of medicinal plants and promotes new progress in healthcare and folk medicine.

Paper [10] presents a deep learning system for the detection of Indian medicinal plant species using leaf images and superior computer vision techniques. In order to identify the most accurate model, several CNN architectures have been evaluated: MobileNet, ResNet50, DenseNet121, Xception, and Inception v3. Experimental results indicate the highest accuracy of 95.16% achieved by Inception v3, outperforming all other architectures. The paper provides evidence that deep learning can be successfully applied for medicinal plant recognition, automating this process and reducing dependence on human experts.

Paper [11] proposes an overall machine learning framework for the identification and classification of medicinal plants based on images of their leaves. Several models, such as Random Forest, SVM, KNN, MLP, and CNN, are trained and compared; Random Forest achieved the highest accuracy of 98%. These systems extracted features related to shape and texture in order to enhance the reliability of the classification performance for various species of plants. The study stated that automatic plant recognition can contribute towards the applications of traditional medicine, sustainable harvest, and botanical education.

Paper [12] presents a CNN-based medicinal leaf recognition system that identifies plant species from images and gives, as output, traditional medical information like its uses, dosage, and restrictions. Trained on a dataset of Indian medicinal leaves, their model achieves an overall mean average precision of 80%. High accuracy was recorded for species like amla and aloe vera. Implementation involves real-time classification on a user-friendly Gradio interface. This hereby marries traditional herbal knowledge to modern machine learning in the development of an accessible and practical tool for the identification of medicinal plants.

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Paper [13] proposes a real-time medicinal plant identification system using deep learning, comparing CNN and MobileNet architectures. A diverse image dataset is preprocessed using resizing, normalization, and augmentation to improve model robustness. Experimental results indicate that the proposed architecture achieved an accuracy of 96.8% with better inference speed and generalization for MobileNet compared with CNN, thus making it more suitable for deployment on resource-constrained devices. The overall performance of the proposed system is very promising for real-world applications regarding healthcare, agriculture, and environmental monitoring.

Paper [14] proposes an advanced AI-based identification system for medicinal plants using an efficient model based on the combination of EfficientNet for powerful features extraction and XGBoost for highly accurate classification. For user convenience, a RASA-powered NLP module is incorporated that gives comprehensive medicinal information using natural language queries. Experimental results are showing accuracy in the training-91%, and strong recognition performance across 87 classes of plants has been observed. Generally, the modern deep learning is integrated with traditional medicinal knowledge as a scalable, user-friendly tool to perform the plants identification and the retrieval of information.

Paper [15] proposes a CNN-based herbal plant leaf detection system trained and tested on a dataset of 75 species (6,000 images in total) to present the effectiveness of the model. It shows a good learning ability with a high training accuracy of 77.88% and a reasonably high validation accuracy of 69.84%, but with some overfitting. Detailed discussions on the accuracy, loss, precision, and recall graphs provide a clear view of weaknesses that need further strengthening by improving the dataset size and regularization. This research shows the potential CNNs have for trusted herbal plant identification and also mentions the scope for enhancement before real-world implementation.

Paper [16] proposes the deep learning-based system comprising two advanced models, namely U-Net for segmentation and F-Net for classification, for medicinal plant identification and fungal disease detection. A curated dataset of medicinal leaves was preprocessed, segmented, and analyzed for disease-specific feature extraction with high accuracy of up to 99.9%. The study integrates a Kivy-based mobile application for real-time plant and disease identification. In general, the proposed system provides an effective and highly accurate method for automated medicinal plant identification along with early disease diagnosis.

METHODOLOGY

Xception Based Model

Artificial intelligence has proved to be a valuable asset in plant science, particularly in medicinal plant identification by using leaves. Here, pre-trained deep neural models, in this instance, the Xception model, which is famous for its fine-grained visual feature extraction ability, are relied upon. Through transfer learning, in fact, such models can be quickly tweaked to work in the specialized task of correctly distinguishing medicinal plants.

The workflow is triggered by image preparation. Each plant image is first turned into a standard size so that there's a similar structure in all inputs. Normalization follows, whereby pixels are converted to a standard scale so that discernible patterns are understood by the model more intuitively. Data augmentation strategies, such as rotation, flipping, and scaling, are then employed to further robustify the model. The alterations mimic real-world conditions such as varying lighting, angles, or camera settings. The model therefore becomes more robust and more versatile as it receives different inputs.

Once developed, such images are then subjected to the Xception network. What makes Xception more superior is that it applies depthwise separable convolutions, making it feasible for the model to detect fine details—like that fine venation of a leaf, texture, or accurate curvature of its margins. Unlike earlier convolutional neural networks, Xception does this in a more effective way, extracting rich features while incurring low cost computationally.

While propagating through more layers of the network, residual connections also help in retaining important facts and data loss avoidance. In this final step, fine-tuned features are input into a softmax classifier that provides the best possible plant species estimation. In addition to estimation output, more information—in terms of botanical name of the plant, medicinal value, as well as general uses in health—is also output by the system. In cases where this species does not appear in the database, it returns a default output, necessitating enriching more data. Through integration of speed, precision, and scale, it is possible to reliably identify medicinal plants using Xception. This makes it a viable solution not only for practitioners of herbal medicine, but also researchers, conservationists, and educators who require a reliable AI-based approach to cataloging and researching plants.

Dataset Description

Dataset Preparation In order to ensure that the system will be able to correctly detect and classify plants, we developed a specialized dataset particular to this work. The dataset focused on four of the best-known medicinal plants with roots in traditional and folk medicine:

- Curry Leaves (Murraya koenigii)
- Aloe Vera (Aloe barbadensis)
- Hibiscus (Hibiscus rosa-sinensis)
- Neem (Azadirachta indica)

The species were selected intentionally due to the therapeutic importance, prevalence of use, and historical relevance in traditional herbal medicine. The data set was also hand-curated such that there was a roughly equal number of pictures per plant, thus avoiding classification bias.

Data Collection The data set was developed by taking high-quality pictures of plant leaves under diverse conditions. Pictures were taken using smartphone cameras as well as DSLR cameras, so there could be variation in resolution and quality. In order to increase the model's robustness, pictures were taken under varying conditions of lighting, angles, and backgrounds so that prominent leaf features—like texture, venation, and margins continued to remain distinguishable at all times.By placing emphasis on quality, diversity, and balancing data, the dataset was made a robust platform upon which to train and test the AI system, such that it could predict fairly and accurately in all four plant species.

Working Procedure of MedLeaf

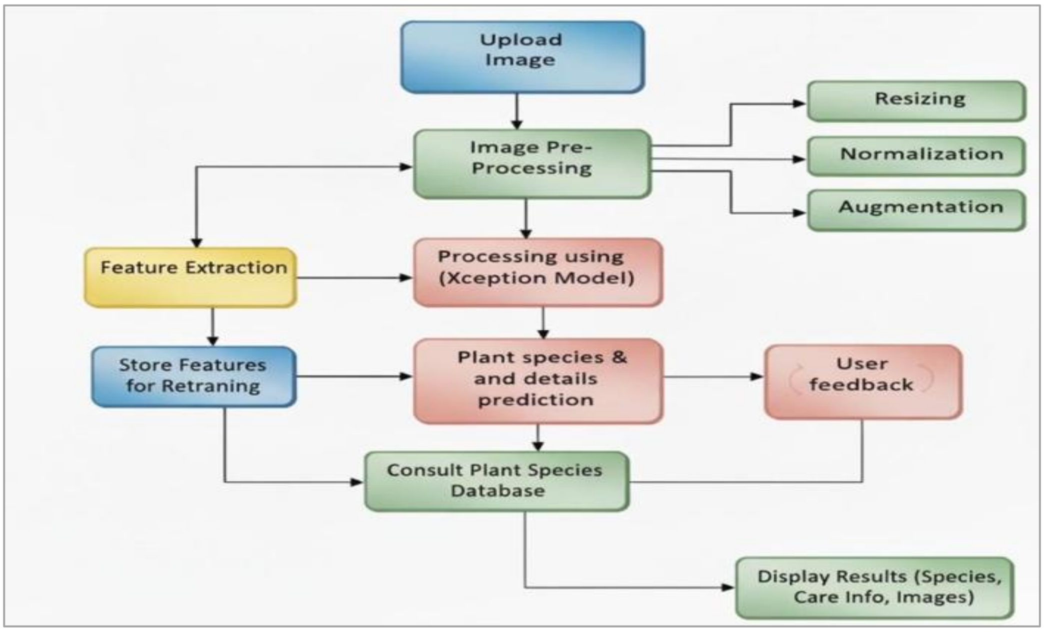

Fig. 1: Working Flow of MedLeaf

The working of MedLeaf, illustrated in Fig. 1, has been designed to take a simple leaf image and transform it into meaningful medicinal knowledge through a deep learning–driven process. The journey begins when a user uploads an image of a plant leaf. This step is intentionally kept simple and flexible—whether captured using a smartphone, a DSLR, or any other device, the system accepts it with ease. By lowering the entry barrier, MedLeaf ensures accessibility not only to researchers and botanists but also to farmers, students, and everyday users curious about medicinal plants. Once the image is uploaded, it enters a critical stage of pre-processing. Here, the photo is prepared so that the model can interpret it clearly. Resizing standardizes all images into a uniform dimension, normalization ensures pixel values are scaled appropriately, and augmentation creates additional variations by rotating, flipping, or scaling the image. These steps simulate real-world conditions, helping the system remain robust when faced with differences in lighting, angles, or backgrounds.

Image is then processed by the Xception deep learning model, a state-of-the-art architecture that excels at capturing fine details. Unlike older approaches, Xception leverages depthwise separable convolutions, allowing it to focus on intricate features such as the vein structure, surface texture, and overall leaf shape. This not only boosts accuracy but also reduces computational demands, making the system both efficient and powerful.

At this stage, the system performs feature extraction, identifying unique fingerprints of the leaf in the form of shapes, textures, and patterns. These features serve as the foundation for classification and are also stored for retraining. This ability makes MedLeaf dynamic—it can continue learning and improving with every new input, rather than remaining static.

Using the extracted features, the system generates predictions and consults a curated plant species

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database, which acts as its knowledge hub. The database enriches the results by providing the botanical and common names of the plant, along with detailed medicinal properties, therapeutic uses, nutritional benefits, and the geographical regions where the species is commonly found. Instead of simply labeling the plant, the system delivers a complete knowledge package.

The results are then presented to the user in a clear, accessible, and visually guided format. Along with the species name, users receive information on medicinal and healing properties, care instructions, cultivation details, cultural significance, folk medicine references, and reference images for comparison. The goal is not just to deliver a technical report, but to offer a practical, user-friendly guide that bridges scientific accuracy with real-world application.

Finally, MedLeaf incorporates a feedback mechanism where users can confirm the accuracy of predictions or suggest corrections. This feedback loop is invaluable, as it turns the system into a collaborative learning tool. Each correction strengthens the model by contributing to retraining, ensuring that its accuracy and reliability improve over time. Through this continuous cycle of learning and adaptation, MedLeaf evolves into a smarter, more trustworthy, and future-ready medicinal plant identification system.

RESULTS

Result and Analysis

Since MedLeaf's work remains in development, its potential value lies primarily in its ability to accurately pinpoint medicinal plant species and provide rich, readily available data about them. The computer program was taught to classify four of the most prominent plants - Neem (Azadirachta indica), Aloe Vera (Aloe barbadensis), Hibiscus (Hibiscus rosa-sinensis), and Curry Leaves (Murraya koenigii)—using deep learning techniques that work on images of leaves.

When someone uploads a photo of a leaf, it analyzes it and makes a guess about what plant species it is. Not only does it tell what species it is, but that output is educational and informative. For every known plant, it provides:

- Botanical name, common names,
- Medicinal properties and therapeutic uses,
- Health benefits and nutritional values.

This makes MedLeaf more than simply a tool of identification, it also makes it a knowledge source, bridging centuries of past wisdom regarding herbs with up-to-date AI-driven analysis.

In the case of an untrained species (i.e., a plant that is not in this current data set), there is a default output by the system, indicating that it does not support that species yet. Notice that this strategy has two advantages:

- It provides clear feedback to the user without misidentifying.
- This facilitates enhancing of datasets in subsequent releases, as unrecognized input can be flagged, collected, and included in model's retraining.

DISCUSSION

Analysis of Performance and Comparison

We anticipate that MedLeaf will outperform previous plant identification systems in terms of accuracy and efficiency. The scalability and adaptability of traditional approaches to a variety of input conditions were limited by their heavy reliance on manual feature extraction and simple image processing techniques. Our system overcomes these drawbacks by: utilising the depthwise separable convolutions in the Xception deep learning architecture, which effectively captures minute details. By using transfer learning, the previously trained model can quickly adjust to the classification task of medicinal plants. utilising a meticulously selected dataset that is concentrated on plants with substantial therapeutic value, guaranteeing high precision and relevance. incorporating a user feedback loop, which gradually improves and refines accuracy.

Previous systems based on ResNet, InceptionV3, or MobileNet frequently needed ensemble methods or computationally intensive vision transformers, despite its notable accuracy. MedLeaf, on the other hand, is made to attain accuracy within or above this range while preserving computational efficiency and enabling the system to be used in the real world, even on low-end devices like smartphones.

Table 1. Expected Output

Test Case ID	Description	Input	Expected Output	Result
01	Valid image upload	Clear leaf image	Correct plant identification	Passed
02	Blurry/unclear image	Blurred leaf	Default "Plant Not Found"	Passed
04	Missing file input	No image	Prompt to upload image	Passed
05	Identify leaf	Leaf images (Curry, Neem, Hibiscus, Aloe Vera)	Displays Aloe Vera medicinal details	Passed

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SNAPSHOTS

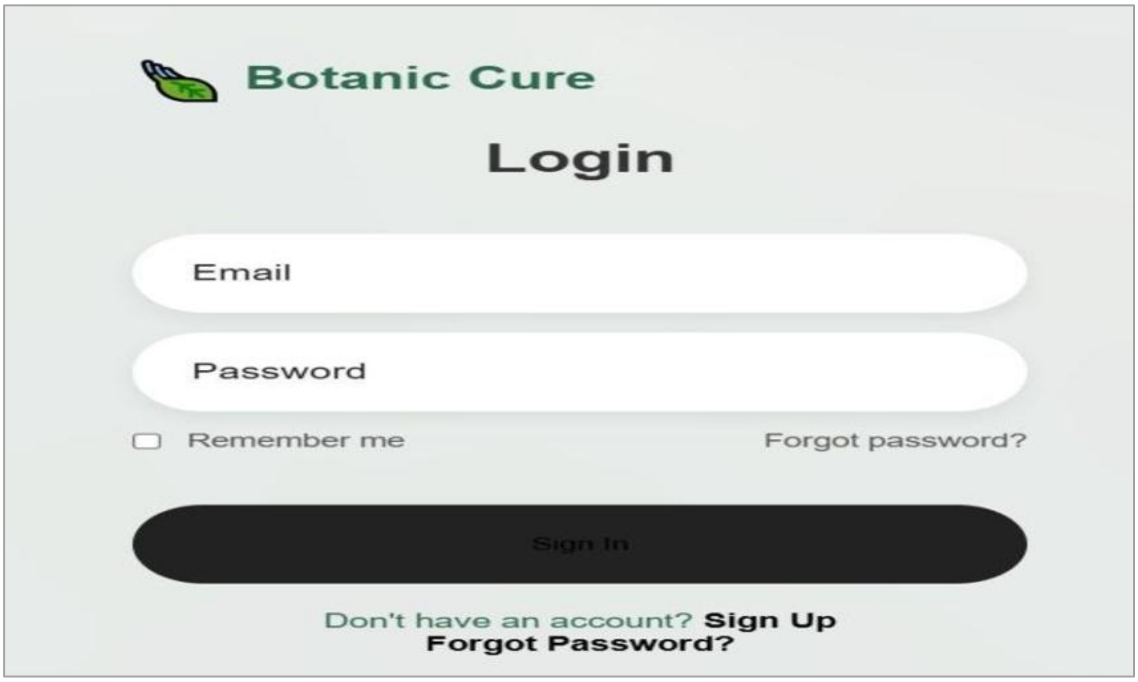

Fig. 2: MedLeaf Login Page

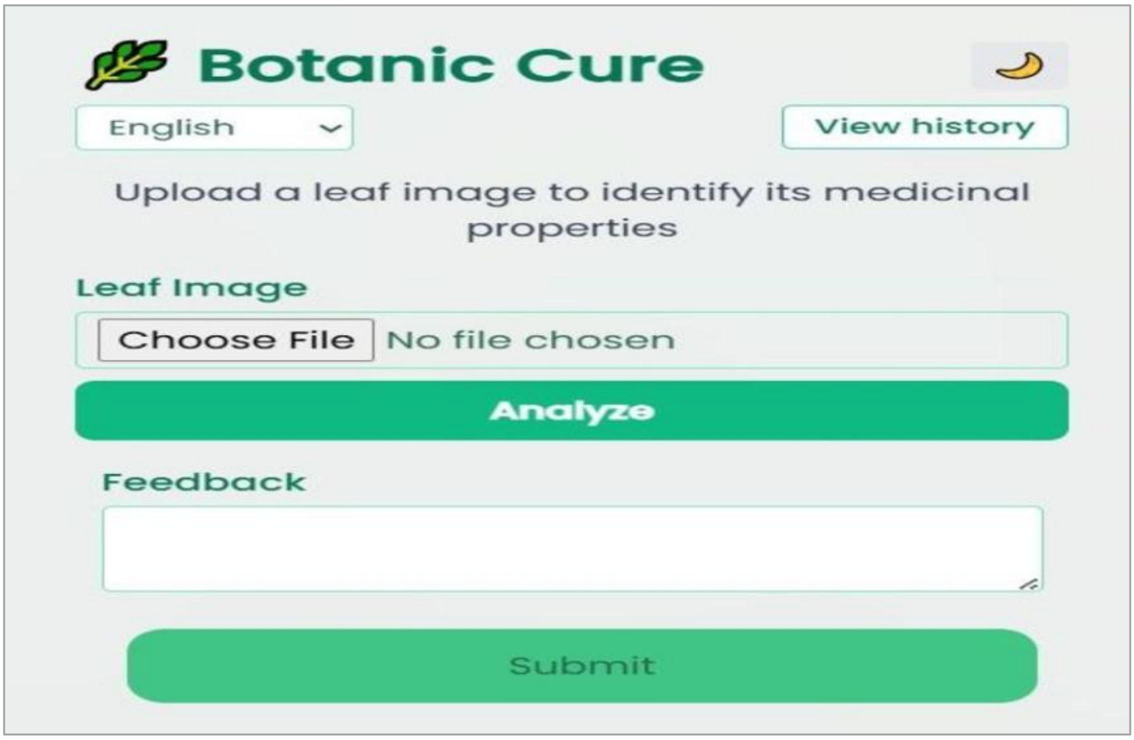

Fig. 3: MedLeaf Image Upload Page

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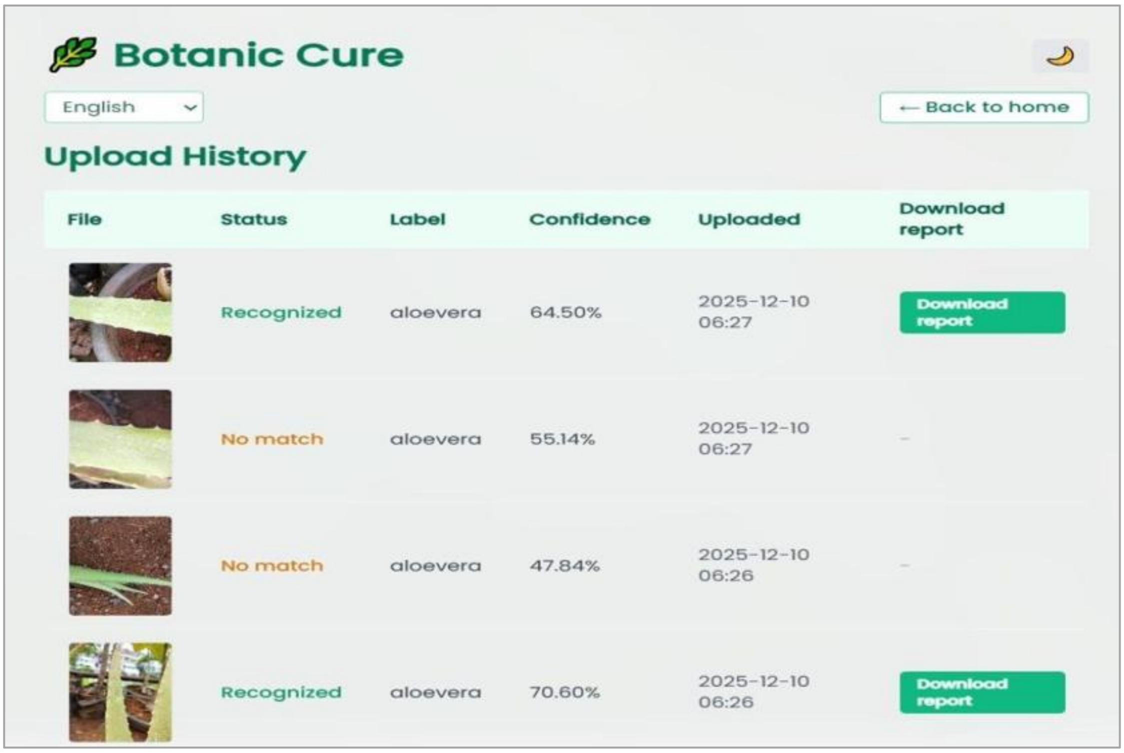

Fig. 4: History Page of MedLeaf

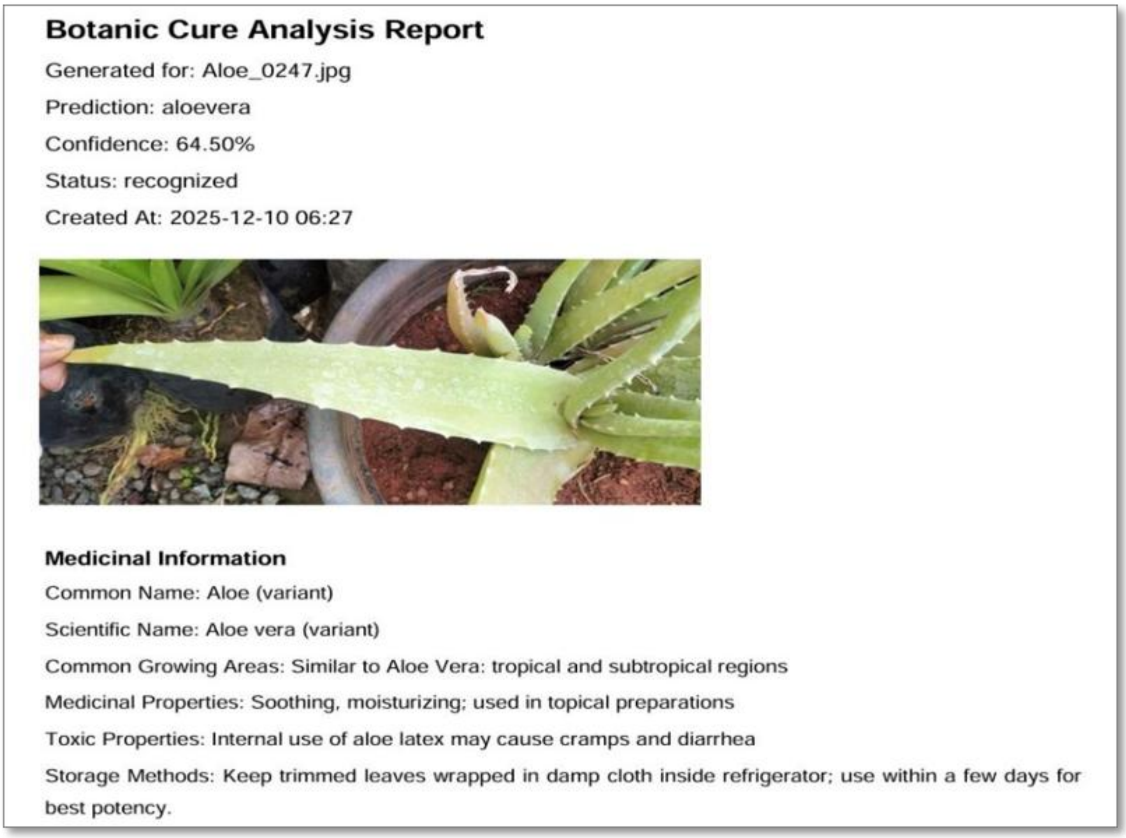

Fig. 5: MedLeaf analyzed leaf report sample

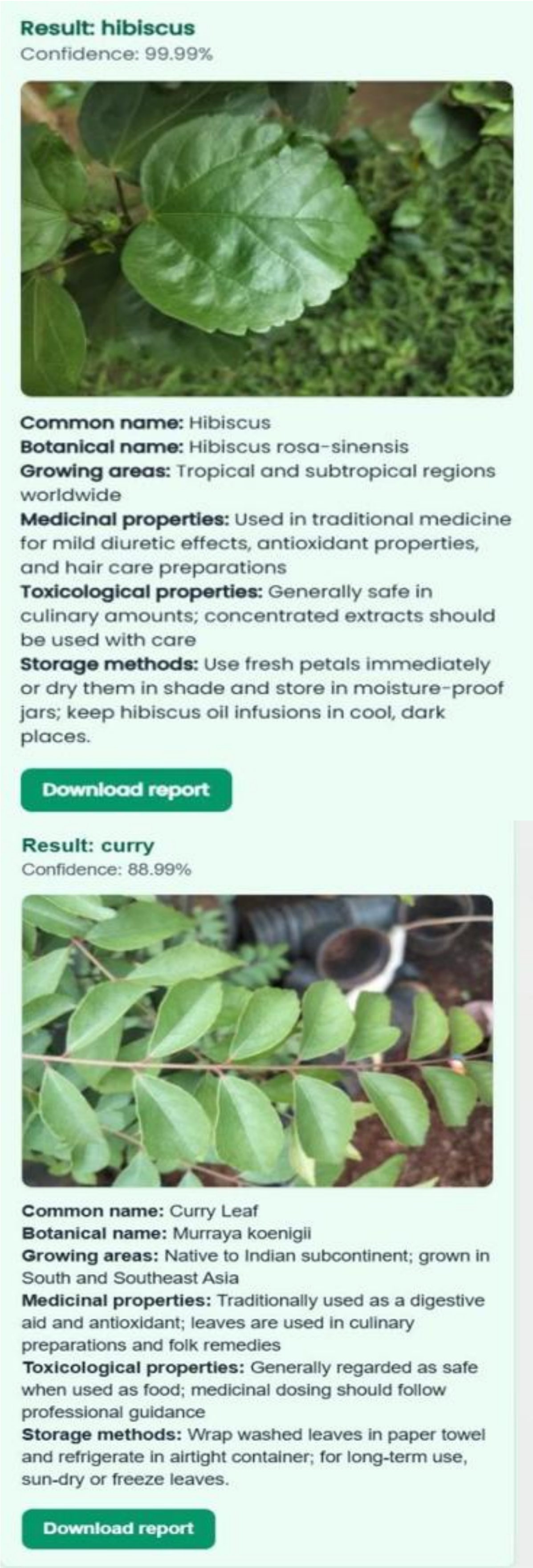

Fig. 6: Result Page of Hibiscus and Curry Leaves

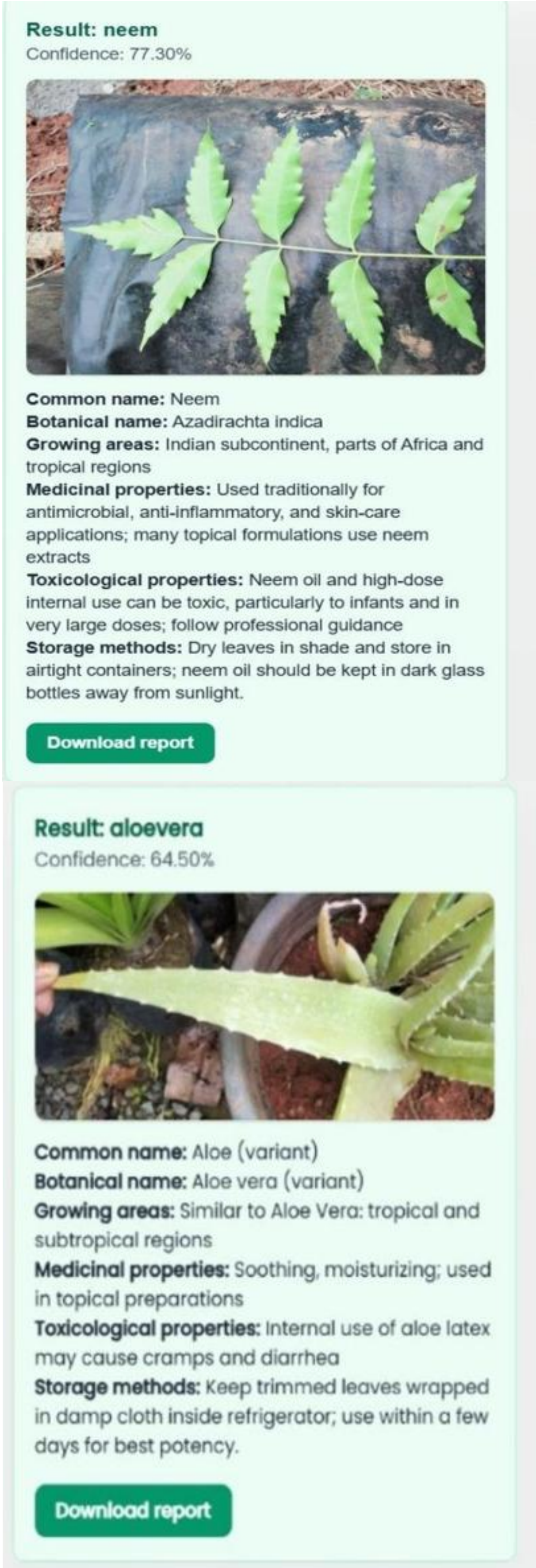

Fig.7: Result Pages of Neem and Aloe vera Leaves

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CONCLUSION

Plant identification through Artificial Intelligence is especially coded to offer crisp, clear, and easily understandable details of the medicinal values of Neem, Aloe Vera, Hibiscus, and Curry Leaves. Through advanced image detection, it shall provide details of each plant's botanical classification, therapeutic use, and regions where it is known to inhabit. If the system doesn't succeed in identifying a plant, clear instructions and prompts shall reach the users in an endeavor to maximize the identification procedure, hence allowing for a more efficient and helpful experience.

This project stands out for its integration of advanced AI technology with traditional plant-based medicinal knowledge. It effectively brings the therapeutic value of medicinal plants into practical, everyday use while respectfully preserving the deep cultural roots associated with these remedies. This work aims not only to ensure accurate documentation of medicinal plants but also to provide scientific validation and promote their safe, effective application in healthcare and wellness practices.

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