

## Identification of Medical Plants Using Deep Learning Techniques

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### ABSTRACT

Medical plant identification is an important activity in the health care system, pharmacology and in traditional medicine systems where correct identification is crucial to effective and safe usage. Traditional forms of identification are very dependent on the expertise of a botanist and manual inspection, which makes it a time-intensive process that is prone to error. This paper proposes a deep learning-based automated system of medical plants identification to mitigate these constraints. The suggested model compares three models, one of them Convolutional neural Network (CNN), one is MobileNet, and the last model is a hybrid network which is composed of MobileNet and Recurrent Neural Network (RNN). The models are trained and evaluated using Indian Medical Leaves Dataset which comprises of about 3,800 pictures symbolizing 40 different medical plant species. The methods of image preprocessing and data augmentation are utilized to boost the resistance to changes in lighting, background and morphology of leaves. The CNN model has shown through experimentation a precision of 83% and MobileNet shows a better figure of 92% with less computation complexity. MobileNet+RNN model is the most accurate model with the highest accuracy of 94% which shows that the model is effective in deriving spatial and contextual features. The findings confirm that the hybrid deep learning architectures remarkably boost accuracy and reliability of classification. The proposed system offers a scalable and efficient service of automated medical plants identification and can find applications in the healthcare industry, botanical studies, and plant recognition systems on mobile devices.

**Keywords:** Medical plant identification, Deep learning, Convolutional neural network, MobileNet, Recurrent neural network, Image classification

### I. INTRODUCTION

Medical plants are important in health care systems throughout the globe, especially in the traditional medicine practices like Ayurveda, Siddha, Unani, and folk medicine. These plants have therapeutic values that have been extensively applied in treating and preventing different diseases. Medical plants that are being used must be correctly identified to guarantee there. Proper usage, because it can be misdiagnosed and cause both ineffectiveness and serious health problems. Conventionally, identification of plants has been based on the expertise of botanists who examine morphological characteristics including shape and color of leaves, leaf texture and venation. Nonetheless, it is a slow, subjective, and in most cases inaccessible method, particularly in the rural and resource-constrained areas, as computer vision and artificial intelligence develop and become more popular. Early methods of computation relied on features that were a combination of human crafts with classical machine learning classifiers. Despite achieving moderate performance with the use of these methods, they were very sensitive to feature engineering

and did not perform well in different environmental settings including change in illumination, cluttered backgrounds, and leaf deformations. Deep learning, especially Convolutional Neural Networks (CNNs) has become a viable substitute in that it automatically derives hierarchical feature representations directly out of image data.

Although these CNN-based models have shown impressive performance in image classification, such as the plant and leaf recognition, the traditional CNN architectures tend to need an enormous amount of computational power which restricts its usage in real-time and in mobile settings. Lightweight architectures like MobileNet have been brought to overcome this challenge. MobileNet applies depth wise separable convolutions to greatly minimize the model size and computational burden without affecting competition with accuracy. This makes it appropriate to be deployed on embedded and mobile platforms. Moreover, hybrid deep learning models, which combine CNNs with Recurrent Neural Networks (RNNs), have demonstrated the possibility of identifying contextual and sequential relationships between extracted features, and their three suggested models of CNN, MobileNet, and hybrid MobileNet+RNN have higher classification performance. In this paper, an automated system based on medical plants identification is presented within a combination of CNNs, Recurrent Neural Networks (RNNs). Indian Medical Leaves Dataset with 40 medical plant species of varying image conditions are used to test the system. The main goal of the work is to compare the results of the tasks of these models regarding the quality of accuracy and reliability and to find an effective and scalable approach to the classification of medical plants. The proposed method will be useful in assisting researchers, healthcare practitioners, and herbalists in identifying medical plants through a rapid and efficient tool.

## II. LITERATURE SURVEY

Beikmohammadi and Faez [1] introduced a deep transfer learning-based plant leaf classification. They used pre-trained convolutional neural networks to gain the discriminative features of leaf images which greatly enhanced the classification accuracy of the images as compared to the traditional handcrafted features. The findings revealed the transfer learning capability in performing on small plant datasets. Kavitha et al. [2], suggested a real-world medicinal plant detection system based on deep learning. Their model showed good results in the recognition of medicinal plants in practice, which highlights the relevance of deep learning models in the practice of healthcare and botany. Beghin et al. [3] proposed a leaf classification method of plants based on textures and shape characteristics. They were based on morphological measures and traditional classifiers and offered a baseline method of plant recognition but had a reputation of being sensitive to lighting changes and noise in the background.

He et al. [4] suggested the deep residual learning architecture, the ResNet, that dealt with the issue of degradation in deep learning networks. This architecture facilitated training of very deep networks and greatly enhanced the accuracy of image classification which has impacted many studies related to plant recognition. Tan and Le [5] proposed EfficientNet A scaling CNN that trades network depth, width, and resolution. Their method was able to perform state-of-the-art both with fewer parameters and hence can be used in high-accuracy image classification problems, such as plant recognition. MobileNet is a lightweight CNN architecture that was introduced by Howard et al. [6], and it is based on depthwise separable convolutions. MobileNet is highly accurate and consumes very little computing power, which makes it the best choice in mobile and embedded-based plant identification devices. In a study by Ullah et al. [7], deep learning-based techniques of leaf classification were used to identify plant species in Bangladesh. Their experiment has shown that they are more accurate than the old machine learning algorithms and prove the suitability of CNNs to regional plants.

The convolutional neural networks were applied in plant leaf recognition by Jeon and Rhee [8]. Their work demonstrated that CNNs are capable of automatic learning robust leaf feature which is superior to the handcrafted feature-based learning methods. In their publication, Kadir et al. [9] suggested a system of leaf classification based on shape, color, and texture with the help of classical classifiers. The method was also extensive in terms of feature engineering and not scalable unlike in small datasets. Phani Praveen [10] came up with a CNN-based medicinal plant recognition model and showed better classification level than traditional machine learning approaches. The paper has emphasized the appropriateness of deep learning in identifying medicinal plants. Datta et al. [11] examined deep learning methods of the plant leaf classification and identification. They proved their hypothesis by experimental findings that CNN-based models can manage more complicated changes of leaf structure and texture.

Rakib et al. [12] suggested a multispectral and texture-based deep-learned automatic system to identify medicinal plants. Their methodology gave a better representation of features and stronger classification. Taslim et al. [13] developed a CNN-based system of identifying plant leaves and tested it on various data sets. Their experiment focused on the significance of rich architectures in the development of discriminative leaf patterns. Beikmohammadi et al. [14] proposed a multistage deep CNN architecture (SWP-LeafNET) that uses leaf identification on plants. Their model had a high rate of classification accuracy by sequentially refining the feature extraction at different stages. Turkoglu [15] suggested a multi-division CNN-based system of identification of plants. The model enhanced learning by separating images into various areas, which enhanced the discrimination of features and general classification accuracy. Amin and Hossain [16] introduced a deep learning-based method of leaf shape classification. As shown in their work, CNNs are appropriate to extract geometric patterns in plant leaves.

Sandeep Kumar et al. [17] examined the application of traditional machine learning algorithms to identify medicinal plants. Even though reasonable accuracy was obtained, the research concluded that deep learning techniques are more effective compared to traditional ones. Saleem et al. [18] have used deep learning to detect and classify plant diseases. Their study has demonstrated the strength of CNNs in the agricultural analysis of images and confirmed their relevance in plant-related classification problems. According to Siddharth et al. [19], morphological features based on half-regions of the leaf were used as a leaf recognition method. Although efficient, the technique needed a high degree of segmentation and was also vulnerable to changes in image quality.

### III. EXISTING SYSTEM

The current system of medical identification of plants is mainly based on the traditional methodologies and previous computational systems. Traditional identification is conducted by herbalists and botanists who lay their eyes on the morphology of the plant (such as leaf shape and size, color, texture, and venation pattern). Despite its precision, this manual process is cumbersome, qualitative and very reliant on the subjective knowledge of the experts, thus unsuitable when dealing with large-scale or real-time operations. Due to the shortage of trained professionals in rural and remote locations, the access to reliable plant identification is further restricted by the lack of automated feature extraction methods, while classical machine learning algorithms, i.e. k-Nearest Neighbors, Support Vector Machines, and Decision Trees were used in early automated systems. The shape descriptors, color histograms and texture metrics were features that were manually constructed to display leaf features. Although these systems attained moderate accuracy on small and controlled datasets, they failed to work well when there were variations in lighting, background clutter, the orientation, and damage to the leaves.

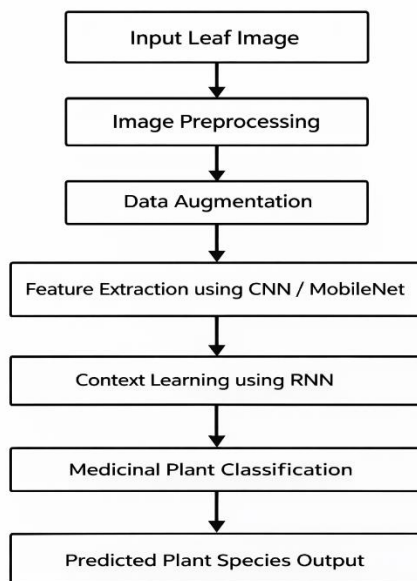
Also, domain expertise and extensive tuning were needed in the manual feature engineering process. Convolutional Neural Networks were introduced with the advent of the deep learning system and applied in the classification of plants. The current CNN-based systems proved to be more accurate since it automatically learned hierarchical features of images. Nevertheless, a lot of such models are computationally expensive, which means that they demand lots of processing power and memory. This restricts their operation on mobile gadgets and embedded systems that are usually needed in plant identification in the field. Moreover, most of the current systems aim at independent CNN structures without considering the contextual or sequential Correlated features. Consequently, they have difficulties in differentiating the plant species of visual similarity but with slight differences. In general, the current medicinal plant identification systems possess issues concerning scalability, computational performance, resistance to real-life variations, and availability, which implies the necessity to develop more effective and correct deep learning-based tools. Such restrictions encourage the creation of hybrid, lightweight architecture designs with a potential of providing high accuracy at lower computational complexity in real-life applications.

#### IV. PROPOSED SYSTEM

To eliminate the drawbacks of the current methods, the proposed system presents an automated medicinal plant identification system based on advanced deep learning methods. The system is expected to be able to classify medical plants accurately using images of the leaves and be computationally efficient and strong in real world conditions. The system first takes images of the leaves as taken by cameras or mobile phones. The steps of preprocessing of these images include resizing, normalization, and data augmentation that minimize the noise and enhance a generalization process.

Three deep-learning models are used to extract features and classify them based on rotation, flipping, and brightness manipulation to make the model adapt to changes in lighting, orientation, and appearances of the leaves. Convolutional Neural Network is used as a baseline model to train spatial features like edges, textures and vein patterns. The lightweight alternative used is MobileNet, which uses depth wise separable convolutions as it results in better performance and reduced computing expenses, suitable in mobile and embedded environments. To further improve performance, a MobileNet and Recurrent Neural Network hybrid model is suggested. MobileNet in this architecture is used to extract high-level spatial features of leaf images and then passed through an RNN layer, where the relationships between contextual features in the sequences are encoded. This is to enhance discrimination of visual resembling plant species.

The system is trained and tested on the Indian Medical Leaves Dataset that comprises forty plant species. Accuracy, precision, recall and F1-score are used to measure the performance. The suggested system offers a solution that is more accurate than the conventional CNN based methods and at the same time is efficient and is scalable and user-friendly to use in the identification of medical plants. It can assist botanists, health practitioners and researchers since it would allow them to recognize plants quickly and accurately and could be expanded into real time mobile applications in the future. The strategy will increase the quality of decision making, usefulness, flexibilities on deployment, sustainability, and intelligent agricultural systems of the future (Fig. 1).



**Figure 1:** Proposed system architecture for medical plant identification

### V. DATASET

The dataset that will be utilized in this research is the Indian Medical Leaves Dataset that was attained through Kaggle, and this dataset is dedicated to the identification of medical plants using image-based deep learning methods. The data set includes the images of forty different medical plant species that are frequently used in India which encompass a broad spectrum of therapeutic plants that are used in traditional medicine systems. Overall, the dataset includes about 3,800 images of leaves and each class is represented by nearly one hundred samples (Fig. 2). Each image in the dataset is the image of a single plant leaf in different environmental conditions. The visuals have varying lighting conditions, complexity of the background, orientation, scale, and morphology of leaves, and as such, the data is applicable in assessing the strength of classification models. The image resolution per sample is diverse, thus allowing the effective generalization of models. All samples are properly labeled with the names of corresponding plant species, which makes them supervised. Preprocessing processes before the model training include resizing, normalization and augmentation, to enhance the quality of data and class balance. The dataset is highly diverse and correctly labeled, which implies that it can be used to train, test, and validate deep learning models in medical plant classification. The given dataset is the empirical basis of automated identification system evaluation and can be used to create reliable and scalable plant recognition solutions.



**Figure 2:** Sample medical plant leaf images from the dataset

## VI. METHODOLOGY

The project Identification of Medical Plants Using Deep Learning Techniques methodology is aimed at processing, analyzing, and classifying medical plant leaf images with the help of deep learning models in a systematized way. The workflow can be divided into several steps that are clearly defined such as dataset acquisition, image preprocessing, data augmentation, formulating target variables, model development, training, evaluating, predicting, and deploying. The main goal is to come up with the precise and functional automated tool that will recognize the medicinal plant species based on the leaf photographs in real-world conditions.

### 6.1 Data Collection

The dataset made available in this research is derived out of a publicly accessible Kaggle repository referred to as Indian Medical Leaves Dataset. It has a dataset of about 3,800 leaf images of 40 different medical plant species that are common in India. Every picture is associated with one leaf and is named with the name of the corresponding plant species, which constitutes the ground truth of supervised learning. The pictures are very diverse regarding their lighting conditions, background complexity, orientation, resolution, and morphology of leaves, which refers to the situation of acquiring images.

### 6.2 Image Preprocessing

Preprocessing of images is done to improve the quality of the data and compatibility to deep learning structures. Preprocessing involves the step of resizing all the images to a fixed size of input, the normalization of the pixel intensity levels to an accepted range, noise reduction to eliminate background artifacts, contrast adjustment to enhance the texture of the leaf and patterns of veins, conversion of images to three-channel format where necessary by pretrained CNN models and removal of corrupted or low-quality samples. Such measures make the models concentrate in the pertinent leaf characteristics and not disparities in the images.

### 6.3 Data Augmentation

Data augmentation methods are used to enhance generalization and minimize overfitting of the training process. Augmentation algorithms may involve rotation, horizontal flipping, zoom, translation, change in brightness, change in contrast and random cropping. These methods enhance the diversity of the dataset and enhance the strong performance of models in unseen variability of data, which is reliable in practical situations.

### 6.4 Target Variable Formation:

The classification problem is expressed as a multi-class problem of classification having forty classes of outputs, where each one of the classes represents a distinct medical plant species. The input images are individually matched to their respective plant labels allowing the correct identification of the species. In this type of supervised learning, the models have an opportunity to learn discriminative features to be used to classify medicinal plants reliably.

## 6.5 Model Training

Three deep learning models have been applied and tested:

- Convolutional Neural Network (CNN) - A standard model that has been used as a baseline of spatial features extraction of leaf images.
- The mobile net is used in its lightweight structure and depthwise separable convolution, which can be implemented in real-time and mobile environments.
- Hybrid MobileNet-RNN Model - Integrates the features extraction ability of MobileNet with a Recurrent Neural Network to encompass contextual dependencies among the extracted features.
- Learning of transfer is utilized with the ImageNet pretrained weights. The data is separated into training and testing data (usually 80:20). Learning rate, batch size, optimizer, and dropout are hyperparameters that are optimized to get maximum performance.

## 6.6 Model Evaluation

The trained models are measured by standard classification measures:

- Precision in the general classification performance.
- Precision, recall and F1-score by class-wise analysis.
- Confusion to study misclassification trends.
- Validation curves and convergence and overfitting monitoring and training. Such metrics apply to the reliability and efficacy of the suggested system.

## 6.7 Severity Prediction and Interpretation

The prediction is done through optimized models and used to predict the medical plant species of unknown leaf images. The images are grouped into forty categories of known plant images depending on the acquired visual patterns including the shape of the leaf, the texture and the venation. The predictions help practitioners, herbalists and researchers to identify plants correctly.

## 6.8 System Deployment

The resulting trained model can be deployed by way of a web-based or mobile application. People can post images of leaves and get an instant location of medicinal plants. With this deployment, real-time use is possible, access is enhanced, and useful applications to medical care, agriculture and botanical studies are possible.

# VII. RESULTS AND DISCUSSIONS

After applying the deep learning models on the medical plant leaf image dataset, they were tested on the metrics of standard classification such as accuracy, precision, recall, and F1-score. Some of the models that will be applied to this research are a Convolutional Neural Network (CNN), MobileNet and a hybrid MobileNet-RNN model, since they are best suited in classifying plants through images; they can extract features well and they learn effectively. The data was split into training (80) and test (20) sets and the model hyperparas were optimized to achieve the highest possible performance.

### 7.1 Model Performance Comparison

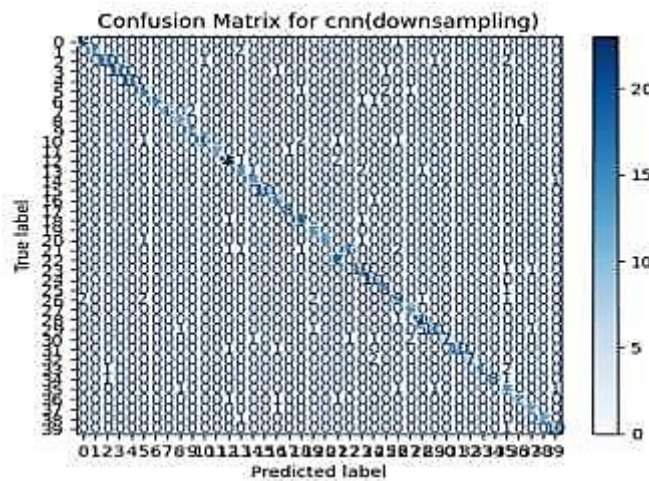
**TABLE 1:** PERFORMANCE COMPARISON OF DEEP LEARNING MODELS FOR MEDICAL PLANT IDENTIFICATION.

Algorithm	Accuracy (%)	Precision	Recall	F1- Score
EfficientNet	83	0.83	0.82	0.82
InceptionV3	92	0.93	0.92	0.92
Hybrid	94	0.94	0.94	0.94

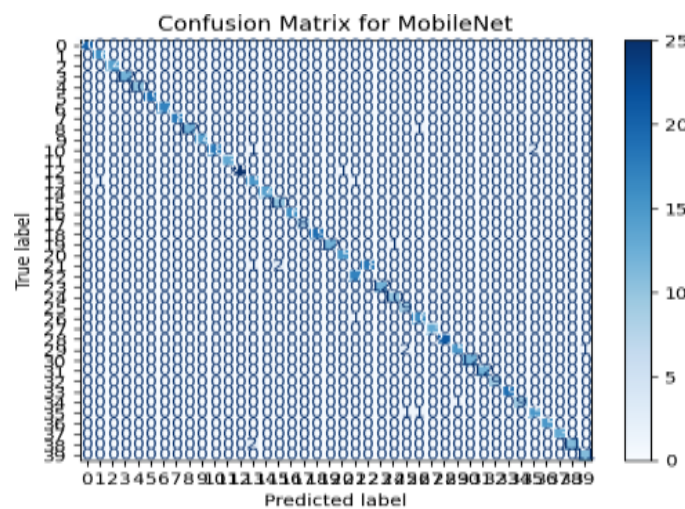
The (Table 1) findings show that the hybrid MobileNet-RNN model has the best overall accuracy of 94 percent than MobileNet with 92 percent and finally CNN model with a relatively lower accuracy of 83 percent. The above performance pattern indicates how effective the combination of contextual learning with efficient feature extraction can be used in enhancing the accuracy of classification of various plant species.

### 7.2 Confusion Matrix Analysis

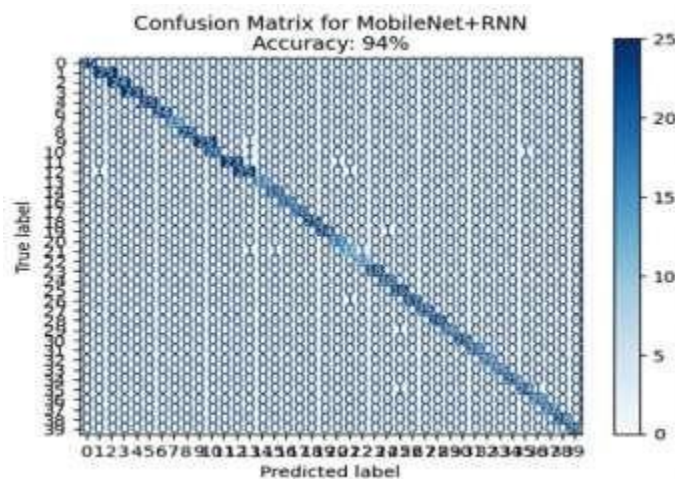
The confusion matrices are given as a visual indication on the actual and predicted medicinal plant classes in forty species.



**Figure 3:** CNN Confusion Matrix



**Figure 4:** MobileNet Confusion Matrix



**Figure 5:** Hybrid MobileNet–RNN Confusion Matrix

In the CNN model, the confusion matrix (Figures 3, 4 and 5) indicates clear cases of misclassified plant species that have visual similarity, especially those having the same leaf shape and texture. This implies that there will be restriction on the ability to capture fine discriminative features leading to lower recall of some classes. MobileNet model, on the contrary, has a better diagonal dominance, showing better classification and fewer misclassifications in most plant species. The lightweight architecture is an efficient approach to trade-off accuracy and computational efficiency. MobileNet-RNN hybrid model has a high diagonal dominance with small off-diagonal errors, which means that there are high-accuracy predictions in all classes. The classification report demonstrates that in terms of precision and recall the values are consistently high, which proves the reliability of the model. Learning contextual features is aided by the incorporation of RNN, and thus enhances distinguishing similar species based on their visual appearances. Overall, the findings of the experiment indicate that the suggested hybrid model offers a valid, scalable and effective solution to the problem of automated medical plant identification.

## VIII. CONCLUSION

This paper was a successful deep learning-based method of identifying medical plants with the help of leaf images. A variety of models (a traditional Convolutional Neural Network, MobileNet, and a hybrid MobileNet-RNN architecture) were deployed and tested on a wide range of datasets of medical plants. The experimental outcomes indicate that deep learning models can effectively extract discriminative visual features that include the leaf shape, texture, and vein patterns, which are the essential features of effective plant classification. The hybrid MobileNet-RNN model was found to perform better with an accuracy of 94 and a high value of precision, recall, and F1- score. The fact that the hybrid model performed better shows that a combination of effective feature extraction and sequential learning will be beneficial in capturing subtle inter-class differences in plant species. The system is a proposed solution to problems of medical plants identification, which is scalable, automated, and reliable, which helps not rely on the human knowledge base and eliminates the risk of errors during classification. Moreover, the light nature of the chosen architecture allows them to be applied practically to resources- constrained devices like mobile platforms. Overall, this piece of work shows that deep learning techniques can be useful in botanical research, practices of traditional medicine, and digital healthcare. Enhancements in the future can involve increasing the number of data, adding multi-modal input, and developing sophisticated attention-based models to enhance the accuracy of classification.

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