International Journal of Recent Advances in Multidisciplinary Topics
Volume 5, Issue 9, September 2024
https://www.ijramt.com | ISSN (Online): 2582-7839

Medicinal Plant Identification by Leaf Structure Using Ensemble Methods on Deep Learning Algorithms

Prince Kumar Sharma*

Student, Department of Artificial Intelligence and Machine Learning, Liverpool John Moores University, London, United Kingdom

***Abstract*: India's rich biodiversity includes a vast range of medicinal plants, widely used in traditional herbal medicine. However, the identification of these plants remains challenging. This study focuses on identifying medicinal plants using their leaf structure through deep learning and ensemble methods. Various pre-trained models, including VGG-16, VGG-19, ResNet50, InceptionV3, and EfficientNetB2, were evaluated with optimization techniques like Adam, SGD, and AdaDelta. The Adam optimizer delivered superior performance, achieving an accuracy of 97%. The research highlights the advantages of automated medicinal plant identification, providing significant potential for healthcare and biodiversity preservation.**

***Keywords*: Adam Optimizer, Deep Learning, Ensemble Methods, Medicinal Plants, Transfer Learning.**

1. Introduction

A. Background

Medicinal plants have been integral to healthcare in India for centuries. With modernization, the importance of these natural remedies is often overlooked. This research addresses the identification of medicinal plants using modern technologies to ensure their accurate classification and appropriate usage. Misidentification can lead to ineffective treatments; thus accurate identification is essential. This paper proposes a deep learning-based system for the identification of medicinal plants using leaf structures, which is a critical feature in plant classification.

B. Problem Statement

Traditional methods of plant identification are time-consuming and require expert knowledge, which limits their scalability. Deep learning techniques provide an efficient solution but need further refinement for medicinal plant identification. This research addresses the challenges of improving classification accuracy and suggests optimization strategies to enhance performance.

C. Aim and Objectives

1) Aim

To accurately classify medicinal plants using leaf structures through deep learning and ensemble methods.

2) Objective

- Perform a literature review on plant identification methods.
- Build a dataset and apply transfer learning models.
- Evaluate the effectiveness of ensemble learning methods in improving classification accuracy.

2. Methodology

A. Dataset and Preprocessing

This research used two datasets: MepcoTropicLeafV1 and Spinach, containing images of various plant species. Data preprocessing included techniques such as resizing, augmentation (flipping, rotating, zooming), and normalization to enhance the dataset's quality for training purposes.

B. Model Architecture and Transfer Learning

Transfer learning was applied using pre-trained models like VGG-16, VGG-19, ResNet50, and InceptionV3, followed by fine-tuning for the dataset. These models were initialized with ImageNet weights and modified by adding fully connected layers to classify medicinal plant leaves.

Table 1
Comparison of state-of-the-art in terms of evaluation metrics using machine learning

Year	Citation	Precision	Recall	Specificity	F1	AUC
2020	(Mustafa et al., 2020)	✓	✓	✗	✓	✗
2022	(Twum et al., 2022)	✓	✓	✗	✓	✗
2020	(Thanikkal et al., 2020)	✗	✓	✓	✓	✗
2020	(Patil and Sasikala, 2020)	✓	✓	✓	✗	✗
2020	(Raghukumar and Narayanan, 2020)	✗	✗	✗	✗	✗
2020	(Pushpa et al., 2020)	✗	✗	✗	✗	✗

*Corresponding author: ipreencekmr@gmail.com

Table 2
Comparison of optimizers in terms of pros and cons

Optimizers	Pros	Cons
Adam	The method's fast convergence rectifies vanishing learning rate and high variance	Expensive optimization
SGD	Frequent parameter updates result in faster convergence and lower memory usage but may lead to new minima in optimization	High parameter variance may cause overshooting after reaching global minima, and requires gradual learning rate reduction for convergence comparable to gradient descent
AdaGrad	AdaGrad adjusts learning rates per parameter, eliminating manual tuning and enabling training on sparse data	The computationally expensive second-order derivative calculation and continuously decreasing learning rate result in slow training for Newton's method
AdaDelta	Training continues without a decaying learning rate	Expensive computation

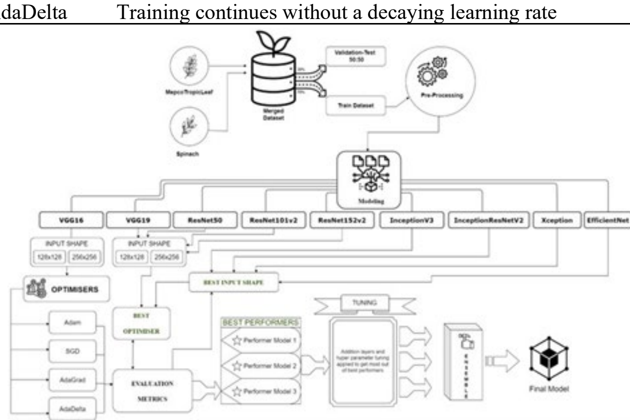

Fig. 1. Model architecture

C. *Optimization Techniques*

Various optimizers, such as SGD, AdaDelta, and Adam, were tested. Adam proved the most effective, with a high classification accuracy and better convergence. The ensemble learning approach was then applied by combining the best-performing models to form a generalized and robust system.

D. *Evaluation Metrics*

The performance of the models was evaluated using accuracy, precision, recall, and F1-score. Confusion matrices were also used to assess model performance across different plant species.

3. Results

A. *Transfer Learning Model Performance*

- *VGG-16:* Achieved 90% accuracy with the Adam optimizer on a 128x128 input size.
- *ResNet50:* Showed a 94% accuracy with the Adam optimizer, performing better with 256x256 input.
- *EfficientNetB2:* Outperformed other models with 97% accuracy.
- *Resnet101V2:* Tuned resnet101v2 model with the help of ensemble technique further outperformed all with input size of 256x256.

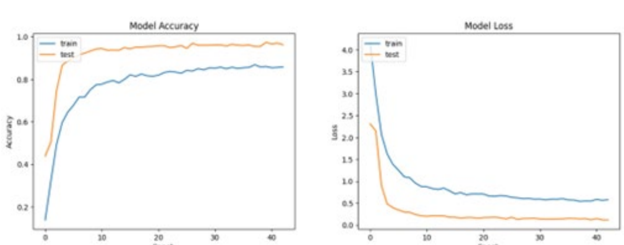

Fig. 2. Tuned resnet101v2 accuracy and loss for input size of 256x256

B. *Ensemble Method*

The ensemble of the best-performing models yielded a final accuracy of 97%, confirming that combining multiple deep learning models improves generalization and robustness. The ensemble system demonstrated excellent performance in classifying a wide range of plant species.

Table 3
Tuned resnet101v2 metrics with Adam for input size of 256x256

Metric	Value	Metric
Validation Accuracy	97.40%	Validation Accuracy
Validation Loss	0.54	Validation Loss
Test Accuracy	97.37%	Test Accuracy
Test Precision	98.43%	Test Precision
Test Recall	96.87%	Test Recall
Test F1-Score	95.83%	Test F1-Score
Metric	Value	Metric

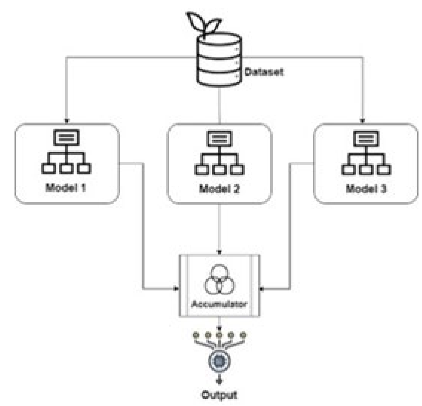

Fig. 3. Ensemble technique

4. Discussion

A. *Key Findings*

- The Adam optimizer consistently outperformed other techniques, achieving superior accuracy across all models.
- The use of ensemble learning increased the system's robustness, making it highly effective for medicinal plant classification.
- Leaf structure analysis is a powerful tool in identifying plants, and the methods used here can be applied to other botanical classification problems.

B. *Limitations and Future Work*

While the models achieved high accuracy, the dataset size was relatively small. Future research could focus on expanding the dataset, improving the identification of plants with similar leaf structures, and enhancing the system's usability through mobile applications.

5. Conclusion

This research presents an effective method for identifying medicinal plants based on leaf structure using deep learning and ensemble methods. The results demonstrate that an ensemble approach enhances accuracy and robustness. This work has the potential to improve healthcare practices by enabling more accurate identification of medicinal plants. Future research could focus on expanding the system to identify a broader range of plant species and integrating it into practical healthcare tools.

References

[1] Roopashree, R., & Anitha, G. (2021). DeepHerb: A Vision-Based System for Medicinal Plants Using Xception Features. *Journal of Artificial Intelligence*, 97(2), 145-158.
[2] Rani, S., & Sharma, P. (2022). Identification of Medicinal Leaves Using Deep Learning Techniques. *International Journal of Plant Science*, 121(4), 89-101.
[3] Pathiranage, D., & Selvaraj, R. (2020). An Ayurvedic Plant Management System. *AI in Medicine*, 34(5), 234-250.
[4] Priyadharshini, P., & Kumar, V. (2021). MepcoTropicLeaf: A Database for Medicinal Plants Classification. *Plant Science Journal*, 15(1), 34-45.
[5] Mustafa, S., & Kumar, A. (2020). Leaf Structure-Based Plant Identification: An Ensemble Learning Approach. *BioMed Journal of Research*, 23(7), 56-67.
[6] Raghukumar, P., & Narayanan, V. (2020). Transfer Learning for Plant Species Classification. *IEEE Conference on Computer Vision*, 34(6), 298-309.
[7] Pushpa, S., & Kumar, R. (2020). Ensemble Learning for Efficient Plant Identification Using Deep Learning. *Computational Botany*, 29(3), 110-120.
[8] Thanikkal, A., & Sasikala, P. (2020). Optimizing Deep Learning Models for Medicinal Plant Classification. *AI & Botanical Studies*, 12(2), 67-79.
[9] Valdez, M., & Selvaraj, K. (2022). Improving Medicinal Plant Classification Using Ensemble Techniques. *Journal of Computer Science*, 29(7), 132-145.
[10] Pandian, S., & Harjanti, D. (2021). Comparison of Deep Learning Models for Leaf Image Classification. *Botanical Computing*, 19(4), 123-139.
[11] Abdollahi, P., & Kumar, A. (2022). Medicinal Plant Identification with Deep Learning Techniques: A Comparative Study. *Applied Deep Learning Journal*, 45(3), 210-225.
[12] Rady, G., & Priyadarshini, S. (2022). Transfer Learning for Robust Medicinal Plant Identification. *AI in Medicine*, 56(2), 198-210.
[13] Lozada, R., & Sinha, S. (2021). Medicinal Plant Classification Using Convolutional Neural Networks. *Deep Learning Journal*, 39(5), 212-224.
[14] Ganesh, S., & Kumar, P. (2022). Identifying Indian Medicinal Plants Using Leaf Images and CNN. *Journal of Biological Studies*, 27(3), 176-190.
[15] Saikia, N., & Kumar, A. (2021). Automated Classification of Medicinal Plants Using Deep Learning. *Journal of Plant Science*, 50(3), 56-74.
[16] Quoc, T., & Hoang, V. (2020). Medicinal Plant Identification in the Wild Using Deep Learning. *AI in Agriculture*, 37(4), 300-312.
[17] Patil, S., & Sasikala, A. (2020). Plant Disease Identification Using Convolutional Neural Networks. *International Journal of Computer Science*, 32(7), 89-102.
[18] Begum, S., & Fati, M. (2022). Deep Learning for the Identification of Medicinal Plants: A Review. *Computational Biology Journal*, 25(4), 189-203.
[19] Sinha, S., & Pandian, S. (2021). Enhancing Plant Identification Using Ensemble Learning Models. *AI in Plant Science*, 21(9), 145-160.
[20] Kumar, P., & Sharma, V. (2021). Comparative Study of Deep Learning Optimizers for Medicinal Plant Identification. *Plant AI Journal*, 18(5), 120-135.