Automated Recognition of Medicinal Plants in the Wild: A Leaf-centric Approach

Muhammad Ammar Ahmad Zaki[1], Mohd Zhafri Mohd Zukhi[2], Mazura Mat Din[3]

[1,2,3]College of Computing, Informatics and Mathematics, Universiti Teknologi MARA Sungai Petani, Malaysia

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Correspondence Email:
ammarzaki1608@gmail.com

Abstract

This study explores the use of technology to simplify the identification of medicinal plants in the wild by focusing on leaf characteristics. Using convolutional neural networks (CNNs), the research aims to develop a mobile-friendly system tailored to Malaysia's rich biodiversity and traditional medicine heritage. Key steps include collecting a diverse range of plant data, enhancing image quality through pre-processing, and testing various CNN models to determine the most effective one. Designed for use by both experts and non-experts, such as rural communities and herbalists, the tool integrates advanced AI with traditional knowledge to preserve cultural practices, promote safe natural remedies, and raise awareness about medicinal plants' role in healthcare and conservation. By addressing the decline in herbal knowledge, this project aims to deliver a practical and accessible solution that supports public health and environmental sustainability.

1. Introduction

Medicinal plants have always been a cornerstone of healthcare, traditional medicine, and biodiversity. Despite their importance, identifying these plants can often be a slow, error-prone process that requires expert knowledge(Pushpanathan et al., 2022). With advancements in technology, particularly in machine learning and computer vision, there's an exciting opportunity to make this process faster, more accurate, and accessible to everyone. This study aims to create a practical tool for identifying medicinal plants using images of their leaves. By focusing on characteristics like shape, texture, and vein patterns, the system leverages convolutional neural networks (CNNs) and advanced image processing techniques to provide real-time, reliable recognition. Ultimately, the goal is to develop a mobile-friendly application that can benefit not only researchers and conservationists but also rural communities and herbalists who rely on these plants (Saleem et al., 2019).

The need for such a system is evident. Research shows that while herbal remedies are widely used, many people lack the knowledge to use them safely and effectively (Arumugam, 2019). This lack of awareness not only limits the potential health benefits of these plants but also puts their conservation at risk. Without proper identification, there's a danger of misusing or even losing these valuable resources. Additionally, traditional practices, which often blend cultural rituals with medicinal formulations, highlight the importance of accurate plant identification to preserve both health and heritage (Sahanudin & Abdullah, 2023). A system that helps

people easily recognize medicinal plants could promote better health practices and protect these natural treasures for future generations.

This research is especially meaningful in Malaysia, a country with a rich diversity of medicinal plants and a deep cultural connection to traditional remedies. The project begins by selecting a variety of common herbal plants found across Malaysia, focusing on their medicinal properties and cultural significance. From there, it identifies key leaf characteristics, like shape and color, to train the system using machine learning and image analysis. The aim is to ensure that the tool works reliably in different conditions, such as varying lighting or image quality. Beyond plant identification, the project also seeks to raise public awareness, encourage the use of natural remedies, and support conservation efforts by engaging with communities and experts.

By combining modern technology with traditional knowledge, this research hopes to bridge the gap between the past and the future. The result will be a user-friendly, accurate tool that empowers people—from rural herbalists to researchers—to identify medicinal plants with confidence. This not only promotes sustainable health practices but also helps preserve biodiversity and cultural heritage for generations to come.

2. Related works

Medicinal plants have been a cornerstone of traditional medicine and agriculture for centuries. With advances in technology, innovative methods now make it easier to identify and classify these plants with higher precision and efficiency. Among the most promising developments is the use of Artificial Intelligence (AI), particularly deep learning, to revolutionize this field. However, while technology progresses, a notable gap in generational knowledge about medicinal plants raises concerns about preserving cultural heritage.

One study, An AI-Based Approach for Medicinal Plant Identification and Classification Using Deep CNN, explored the potential of Convolutional Neural Networks (CNN) in addressing the challenges of identifying medicinal plants. The researchers built a detailed dataset of medicinal leaves and applied the ResNet-50 model, achieving a remarkable accuracy of 94.2%. Their process involved steps such as data preprocessing, feature extraction, and model training. Beyond technical achievements, the study highlighted the practical benefits of these methods, including improving healthcare accessibility, supporting conservation efforts, and safeguarding traditional knowledge(Sangeetha et al., 2024).

Another study, Automated Plant Leaf Classification using Ensemble Transfer Learning in CNN Model, focused on classifying diseases in potato leaves but offered insights applicable to medicinal plants. By combining multiple pre-trained models like MobileNetV2, ResNet, and DenseNet into an ensemble framework, the approach achieved 94.8% accuracy. The study emphasized the importance of data augmentation and preprocessing for enhancing performance while demonstrating how transfer learning reduces computational demands. The findings suggest that this approach could be adapted to other contexts, including medicinal plant classification(Yuvalatha et al., 2022).

While technology continues to advance, cultural knowledge about medicinal plants is declining, particularly among younger generations. The study Herbs in Malay Traditional Medicine: Analysis of Perception, Knowledge and Practice Among Generation Z examined this issue within Malay communities. It found that while older generations maintain strong ties to herbal traditions, Generation Z shows limited understanding and interest. Factors like globalization, modern lifestyles, and the popularity of fast food contribute to this trend. The study stressed the importance of educational efforts to reconnect younger generations with the cultural and practical value of herbs like turmeric, ginger, and lemongrass.(Johari & Rosly, 2024)

Together, these studies highlight how technology and traditional knowledge can complement each other. AI-powered tools like CNNs and ensemble learning models are redefining plant identification, making the process more accurate and accessible. However, the diminishing cultural knowledge of medicinal plants reminds us that technology alone isn't enough. Efforts must also focus on education and cultural preservation to ensure that the wisdom surrounding medicinal plants is not lost. Combining the strengths of modern technology with traditional practices offers a path forward, blending innovation with respect for heritage.

3. Research Methodology

This study employs a systematic methodology divided into five phases to ensure the development of an efficient automated medicinal plant recognition system using a leaf-centric approach.

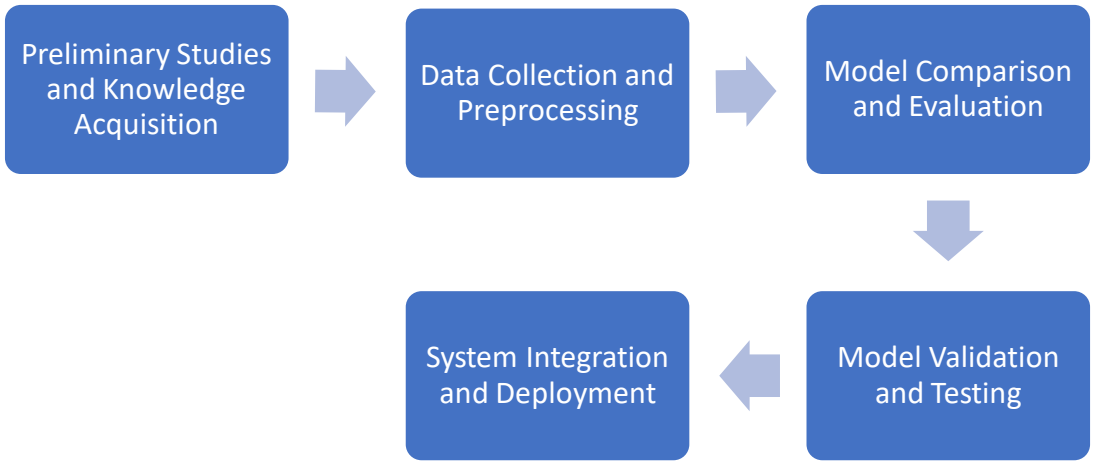

Fig. 1 Research Methodology Flowchart

Phase 1: Preliminary Studies and Knowledge Acquisition

The research begins with an in-depth review of existing literature and consultations with botanical experts to understand medicinal plant characteristics and their identification criteria. This phase establishes the theoretical foundation, identifies challenges in automated plant recognition and defines the project's scope.

Phase 2: Data Collection and Preprocessing

High-quality images of medicinal plant leaves are collected from diverse environments to ensure the inclusion of various species, leaf shapes, colours and textures. Preprocessing involves standardizing image sizes, removing noise, and enhancing quality. Advanced techniques such as image normalization and augmentation are applied to expand the dataset and enhance the model's robustness to variations in lighting, orientation, and environmental conditions.

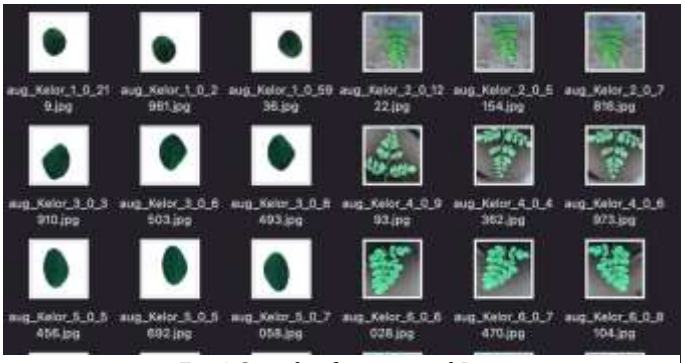

Fig. 2 Sample of augmented Data

Phase 3: Model Comparison and Evaluation

Several pretrained CNN models, such as VGG19, ResNet-50, InceptionV3, and MobileNet, are tested on the dataset to identify the most suitable architecture for this specific application. These models are fine-tuned using transfer learning to adapt to the dataset. Performance metrics such as accuracy, precision, recall, and F1-score are compared across models. Additionally, the computational efficiency and inference speed of each model are evaluated to select the optimal balance between accuracy and practicality.

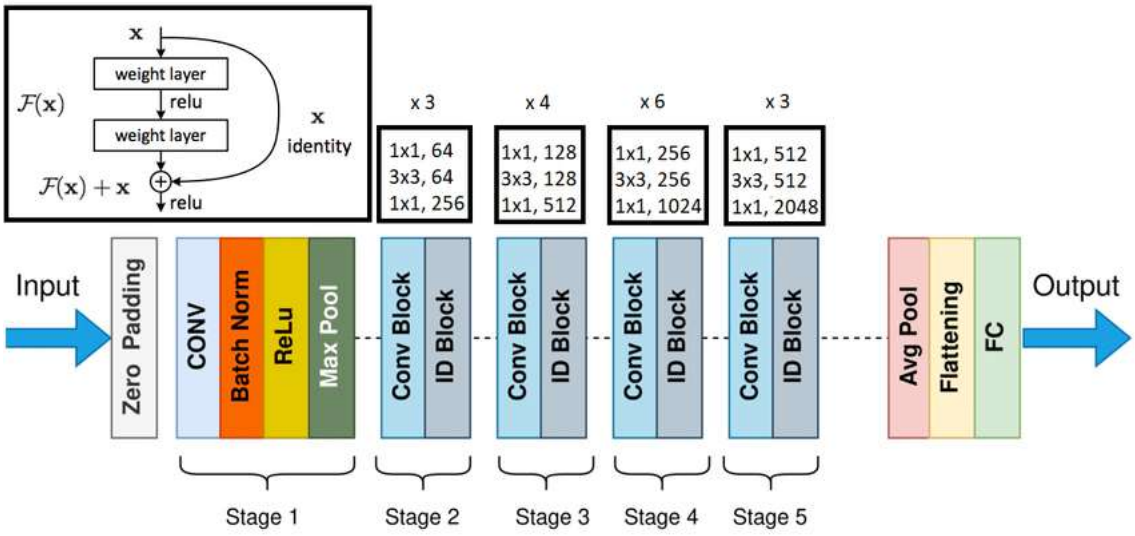

Fig. 3 Resnet-50 Model Architecture

Phase 4: Model Validation and Testing

The selected model from Phase 3 undergoes detailed validation and testing using separate datasets. Validation is used to fine-tune hyperparameters and prevent overfitting, while testing evaluates the model's performance on unseen data. Metrics like accuracy, precision, recall, and F1-score are analyzed to measure the model's effectiveness. Error analysis is conducted to identify and address limitations, and k-fold cross-validation is performed to ensure reliability across different data subsets.

Phase 5: System Integration and Deployment

The final trained model is integrated into a mobile-friendly application to enable real-time leaf recognition in field conditions. The system is tested in practical scenarios to evaluate usability and effectiveness. Feedback from end-users, such as herbalists and conservationists, is collected to guide final adjustments before full deployment.

This methodology ensures a comprehensive approach to developing a reliable, practical, and efficient tool for the automated recognition of medicinal plants in the wild.

4. Conclussion

This study highlights how combining modern technology with traditional knowledge can solve challenges in identifying medicinal plants. By using convolutional neural networks (CNNs), it aims to create a simple, accessible system to help people recognize herbal plants in Malaysia more accurately and efficiently. This tool

is designed for everyone, from rural communities and herbalists to researchers, making plant identification easier and more reliable.

Beyond its practical uses, the project also plays a key role in preserving cultural heritage, promoting the safe use of natural remedies, and protecting biodiversity. By addressing the declining awareness of medicinal plants, especially among younger generations, this work bridges the gap between innovation and tradition. The result is a mobile-friendly solution that supports sustainable health practices, encourages conservation, and fosters a deeper appreciation for the critical role medicinal plants play in our lives and the environment.

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