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Short Paper

Development of HerbaLens: A Medicinal Plant Image Capture Application

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Abstract

Purpose – This study introduces HerbaLens, an Android application developed to assist users in capturing images of medicinal plants in Calauan, Laguna, and retrieving relevant information for identification and educational purposes. The app aims to prevent the misuse and destruction of endangered species while promoting education, conservation, and the preservation of traditional knowledge.

Method – The study employs a developmental and descriptive research design. The developmental aspect focuses on refining the app's functionality, user interface, and database to enhance its ability to identify and provide relevant information about medicinal plants accurately. The descriptive aspect collects data on the characteristics and uses of these plants.

Results – The application was evaluated using ISO 25010 standards—functionality, usability, reliability, and performance efficiency—and was rated as "Satisfied" by experts. Limited to 23 verified plants and 2,455 datasets, HerbaLens demonstrated strong functionality, high usability, consistent reliability, and commendable performance efficiency.

Conclusion - The HerbaLens application has significantly contributed to the community, public health, and plant conservation by aiding in the identification of medicinal plants. Its well-designed interface and frequent updates have helped achieve high accuracy and user satisfaction.

Recommendations – The plant database should be updated continuously, and the image recognition algorithms should be improved. Future work may involve increasing user engagement through gamification and the creation of social groups, expanding the application's compatibility with iOS devices, and improving its performance under various conditions.

Research Implications – The application is highly useful to the community, students, botanists, and researchers as it provides accurate information that can support further research endeavors.

Practical Implications – The offline mode of the application is useful in areas with limited or no internet connection.

Social Implications – Through the encouragement of the preservation of traditional knowledge and supporting the conservation causes, HerbaLens benefits the local communities as well as the global conservation causes.

Keywords – medicinal plants, image capture, image recognition, ethnopharmacology, mobile application, community health, sustainable healthcare

INTRODUCTION

Automatic plant identification through image recognition is increasingly recognized as a key method for addressing gaps in botanical taxonomy. With advancements in machine learning, complex models for plant identification have been developed. The widespread use of smartphones and apps has led to the collection of millions of plant images. Mobile-based plant identification is crucial for various real-world applications, including ecological monitoring, managing invasive species, and promoting ecological science. Consequently, enhancing the accuracy of these mobile identification systems has become a focal point for researchers and engineers (Sun, Liu, Wang, & Zhang, 2017).

The appearance of medicinal plants can vary depending on several characteristics, including development phases, age, and environmental circumstances. It may be challenging to correctly identify them due to these variances. Furthermore, the misidentification of medicinal plants raises concerns frequently since it might result in the use of the incorrect plant for medical purposes, which may have negative health effects.

The development of a medicinal plant image capture application, complemented by a comprehensive database, educational resources, conservation tools, and traditional knowledge preservation features, is efficient and effective. This integrated solution addresses the crucial issue of accurate plant identification, providing a reliable tool for diverse users. The application's extensive database enhances educational outreach, supporting users in deepening their understanding of medicinal plants.

Accurate identification of medicinal plants is crucial for various purposes, including herbal medicine preparation, research, and conservation. However, traditional methods of plant identification often rely on expert knowledge, making them inaccessible to many communities. In response to this challenge, we introduce HerbaLens, a mobile application designed to empower users to identify medicinal plants with ease. This paper outlines the development process of HerbaLens and discusses its potential contributions to plant identification in communities like Makati Homeville, Calauan, Laguna. The inspiration and foundational data for this project are grounded in the study by Aguil et al. (2023), which documented the ethnopharmacological practices and medicinal plant diversity in Makati Homeville, highlighting the importance of accessible plant knowledge for underserved communities.

LITERATURE REVIEW

Android Operating System

Android is a mobile operating system (OS) that was created by a Silicon Valley startup called Android Inc. A 2007 collaboration sponsored by Google through the Open Handset Alliance (OHA) offered Android an advantage in delivering a complete software set, which includes the main operating system, middleware, and specific mobile application, or app (Rouse, 2023).

Android is an open-source operating system that serves as the digital heart for a wide range of devices, including smartphones, tablets, smartwatches, TVs, and even cars. With a user base of 2.5 billion active devices. Android is renowned for its transformative impact on people's daily lives, powering features such as GPS navigation, messaging capabilities, and virtual assistants. Its open platform allows developers, designers, and device manufacturers to experiment and create innovative solutions, contributing to the platform's diversity and adaptability in this ever-evolving world. While convenience is a significant factor, security is also taken into account by Android, whereby security features are integrated into the operating system with components such as Google Play Protect and regular software updates offering continuous security. The privacy of users' data means a lot to us. The application has a location request notification system and centralized settings for privacy.

The tool of Digital Wellbeing sets the tone of Android's determination to help users explore and control their time spent on devices, showing the details of the screens they have been on and their alerts. Also, it is a design that is to be accessible to all users without paying regard to their disabilities and includes features like a screen reader and AR walking directions that help users as they approach all the technology-related obstacles from the perspective of the different ways people use technology. Overall, Android stands as a dynamic and user-centric platform that balances innovation, security, user control, and accessibility across continuously evolving devices.

Competition and Comparative Studies

When developing an application, there is always existing competition in the market. The researchers can compare and contrast existing studies to provide a comparison between those existing studies and the researcher's study. Firstly, LeafByte, according to Pickering (2019) LeafByte can scan barcodes, measure light-colored petals or leaves, and save results (with the date, time, and GPS coordinates) to a spreadsheet on the phone or Google Drive. The difference between the LeafByte and HerbaLens is that the researcher app is focused on the medicinal plants, focusing on the fruit and leaf, while the LeafByte is only focused on the leaf area. The HerbaLens studies focus on image processing, but researchers have also integrated some interesting features to help users learn more about the world of medicinal plants.

Traditional Medicine and Plant Identification

The HerbaLens Application is designed to assist the residents of Makati Homeville in Calauan, Laguna, in identifying local plants, gaining knowledge about their medicinal properties, understanding their potential uses, distinguishing between different plants, and learning more about their uses, including how their leaves can be beneficial. Most people who practice traditional medicine in Africa do not have good knowledge about the plants used in the treatment. There is a high possibility of misidentification or the use wrong plant species, which could result in the toxicity of the herbal mixtures or products (Okaiyeto, 2021). Stating that it can be harmful if some people are not knowledgeable about medicinal plants, as it can lead to toxicity. That is why HerbaLens is there to help those who are not well-versed in medicinal plants, as a lack of knowledge can have adverse effects. In HerbaLens, all the necessary information is provided, including usage, dosage, application, and instructions for safe use. Users can simply view and learn from the application.

Machine Learning Frameworks

Advancements in machine learning, particularly deep learning, have revolutionized the field of botanical image recognition. Kavitha et al. (2022) have contributed to this evolving domain through their research on the detection of medicinal plant species using convolutional neural networks (CNNs). Their work, presented at the 2022 First International Conference on Electrical, Electronics, Information, and Communication Technologies (ICEEICT), showcased the ability of the Inception v3 model to outperform other CNN architectures in identifying Indian medicinal plants. Such technological strides are pivotal as they provide a more accurate, efficient, and automated approach to classifying plant species, which is essential for maintaining the integrity of medicinal plant databases and supporting pharmacological research. The promising results from their study, demonstrating a 95% accuracy in plant species classification, underline the potential of deep learning applications in the field of herbal medicine and open new avenues for research and application in digital agriculture.

Recent advances in artificial intelligence have significantly impacted the field of botany, particularly in the identification of herbal medicine plants through image recognition. De Luna et al. (2017) developed a novel system that leverages artificial neural network capabilities to process images and identify different species of Philippine herbal plants. By isolating leaf images and employing sophisticated image processing techniques, their system extracts vital features that are instrumental in distinguishing between various plant species. The effectiveness of their approach is demonstrated by the high accuracy rates achieved—98.16% for the overall dataset and 98.61% for a separate set of test images, underscoring the potential of neural networks in the classification and analysis of botanical data. This work, presented at the 2017 IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), marks a significant contribution to the field, suggesting a scalable

solution for the accurate identification of medicinal plants, which is crucial for both ecological studies and medical research.

Neural Networks in Botanical Data Analysis

Recent advances in artificial intelligence have significantly impacted the field of botany, particularly in the identification of herbal medicine plants through image recognition. De Luna et al. (2017) developed a novel system that leverages artificial neural network capabilities to process images and identify different species of Philippine herbal plants. By isolating leaf images and employing sophisticated image processing techniques, their system extracts vital features that are instrumental in distinguishing between various plant species. The effectiveness of their approach is demonstrated by the high accuracy rates achieved—98.16% for the overall dataset and 98.61% for a separate set of test images, underscoring the potential of neural networks in the classification and analysis of botanical data. This work, presented at the 2017 IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), marks a significant contribution to the field, suggesting a scalable solution for the accurate identification of medicinal plants, which is crucial for both ecological studies and medical research.

Plant Preparation and Distinguish

According to Ekor (2014), the use of herbal medicines has significantly increased worldwide, with many people turning to these remedies for various health issues. Previous studies have explored the biological, pharmacological, and pharmaceutical applications of plants, fungi, and other species within specific cultural and traditional contexts. The understanding of the origins, functions, and management of plants by native or local populations is influenced by cultural diversity and biodiversity. Ensuring the safety of herbal medicines, both traditional use and drug development, is a major concern for national health authorities and the public.

According to Tupas (2021), the practice of herbal medicine in the Philippines has come a very long way. Folkloric use of herbal plants by our forefathers in ancient times has been passed on from one generation to another. The understanding of the origins, functions, and management of plants by native or local populations is influenced by cultural diversity and biodiversity. Ensuring the safety of herbal medicines, both traditional use and drug development, is a major concern for national health authorities and the public.

In a study by Agapin (2020), the most commonly used plant parts for herbal medicines are the leaves, and the most employed method of preparation is decoction. The decoction was the most commonly used method, which proved effective for the extraction and preservation of the herbal treatment. The application of heat in herbal preparations enhances the availability of bioactive substances by accelerating biological processes.

Image Recognition Model

The research paper based on this recognition will clearly define all twenty-three medical plants. The ultimate goal is to design the software that carries out more than just displaying the images of plants, but also identifies the plants that are scanned or uploaded for an effective selection. By a pre-trained CNN network, leaf localization and extraction on different parts of leaves, and then classifying and telling the types of both caught and uploaded plant leaves will be implemented. It could be a support method that might be used in predicting and creating forecasts in line with a set of leaf characteristics by making a drawing from an extensive leaf picture database. The problem here is to make certain that the model can detect leaves with many different lighting conditions and from various plants. While the training data might not possess all the variations that are present in the real world, the model's faces in the field might not be fully represented, leading to errors and inaccurate recognition.

According to Huynh et al. (2020), replacing vein shape data through pre-processing of leaves with a CNN model using the red color channel for classifying leaves is a novel approach. Their research demonstrates a new CNN model that replaces vein shape data with the red channel of colors, which can significantly assist professionals in botany and medicine, resulting in an accuracy of 98.22%. This method not only provides a high level of precision in identifying plant species but also offers a practical solution for pathologists, plant breeders, and medical doctors specializing in herbal medicine. The practical implications of such a device could revolutionize fieldwork, allowing for rapid and reliable plant species identification in various settings.

Neural Network

The implementation of convolutional neural networks (CNN) has been of major importance in the botanical field. Akter and Hosen (2020) played a crucial role in developing a smart system that applies CNN technology to the online detection of Bangladeshi medicinal plants. In their work, they used a three-layer CNN to identify medicinal plants from a dataset of ten example plants from Bangladesh, achieving an accuracy of 71.3%. They augmented the data by training on more than 34,000 images and testing on an additional 3,570 images, which improved the model's accuracy. This approach not only simplifies the classification of plant species but also provides an accessible means for both specialists and novices to distinguish useful plants.

A neural network is like a human brain, since it is composed of neurons that form a network and are interconnected with each other. And every input travels much slower than the speed of light, it travels from one neuron to another. Each neuron represents a unit of computation that takes in a set of inputs, performs a set of calculations, and produces an output that is passed on to the next layer.

Each node in a neural network takes in information, processes it, and then transfers the output to the next node, just like the neurons in the human brain. Depending on the patterns in the data, the connections between the nodes get stronger or weaker as the data flows through the network. This enables the network to learn from the information and decide based on its newfound knowledge.

Image Processing

According to Pooja et al. (2017), the field of image processing is rapidly evolving in the agricultural sector, with research and advancements progressing significantly. Current studies focus intensely on detecting plant diseases, which can enhance crop yield and support various agricultural practices. From the study of Pokhrel et al. (2023), it is stated that image processing is widely used in technology due to the kernel itself being a matrix that is responsible for performing convolution in the first place, and it further indicates what type of image transformation should occur.

Ngugi et al. (2021) highlight the significant potential of integrating Image Processing Techniques (IPT) and Machine Learning Algorithms (MLA) for disease detection and recognition. This approach is valuable for early and precise identification of pests and diseases. Image processing algorithms can analyze digital photographs quickly, accurately, and cost-effectively, providing reliable feedback for users.

These insights underscore the importance of advanced image processing techniques in developing effective plant identification tools.

METHODOLOGY

The methodology section of this research paper outlines the systematic approach adopted to address the research objectives, which primarily revolve around the development of the HerbaLens: A Medicinal Plant Image Capture Application. The methodology encompasses various research designs, project development phases, testing procedures, evaluation methods, and data treatment techniques.

To achieve the research objectives effectively, a combination of exploratory and descriptive research designs is employed. Descriptive study designs are utilized to describe the characteristics of medicinal leaves and understand the developmental stages of various plant species. This understanding is crucial for enhancing the accuracy of the application's scanning algorithm. Additionally, developmental studies aid in structuring the project phases, including context analysis, prototype development, and evaluation.

The project development follows an Agile methodology, emphasizing iterative development, constant collaboration with stakeholders, and continuous improvement. The development process comprises several phases, including requirements gathering,

design, development, testing, deployment, maintenance, and documentation. Each phase is meticulously executed to ensure the creation of a robust and user-friendly application.

A comprehensive testing procedure is devised to evaluate the functionality, reliability, performance, and portability of the HerbaLens application. The testing encompasses various components such as user registration and login, plant identification, image capture, plant encyclopedia, user/community contributions, geolocation, and plant of the week feature. Testing scenarios are designed to simulate real-world usage conditions and assess the application's performance under different circumstances.

The evaluation procedure involves preliminary and final evaluations conducted by end-users, IT specialists, and non-experts. The ISO/IEC 25010 Software Quality Model serves as a framework for assessing software quality across multiple dimensions, including functionality, reliability, efficiency, sustainability, and portability. Evaluation criteria include the usefulness of the plant identification feature, system stability, performance on various devices, code organization, documentation, and compatibility with Android versions.

Data from the evaluations were treated using Table 1 Likert Scale, where each criterion is rated on a scale of 1 to 4, with 4 indicating Very satisfied and 1 indicating Very dissatisfied. The mean and overall mean are computed to interpret the results, providing a quantitative assessment of the research project's effectiveness and quality.

Table 1. Likert Scale

Ranking	Ranges	Verbal Interpretation
4	3.76 – 5.00	Very satisfied
3	2.51 – 3.75	Satisfied
2	1.26 – 2.50	Dissatisfied
1	1.00 – 1.25	Very dissatisfied

Overall, the methodology employed in this research paper ensures a systematic and rigorous approach to the development, testing, evaluation, and interpretation of the HerbaLens: A Medicinal Plant Image Capture Application.

Agile software development takes the view that production teams should start with simple and predictable approximations to the final requirement (Kumar & Bhatia, 2012). Agile Methodology is a process by which the researchers manage a project by breaking it up into several stages and involving constant collaboration with stakeholders and continuous improvement and iteration at every stage.

The Agile methodology begins with the initial step of gathering requirements. This involves a collaborative meeting with key stakeholders, including the University of Makati, the Institute of Pharmacy Secretary, to meticulously discern the specific needs essential for the application's development. The initial phase of Agile also involves the identification of

existing challenges, drawing insights from our primary collaborators, the students of the Institute of Pharmacy (IOP). Their observations stem from an in-depth study on Mini Ethnopharmacology and Ethnobotany of medicinal plants in Makati Homeville, Laguna. The research underscores that the local community in Makati Homeville predominantly relies on herbal plants due to the abundance of locally accessible resources and the challenges associated with reaching distant pharmacies. As developers, our commitment is to translate these invaluable research insights into a purposeful application, which is the HerbaLens App, designed to serve as a reliable tool for the people in Calauan, Laguna, helping them accurately scan medicinal plants.

Designing the context diagram, child diagram, and wireframe forms the foundation of the application before proceeding to development. In this phase, we tackle how the application works for the users, admin, and mostly the researchers. The flow of the application is also implemented in the design phase this is to help the researchers visualize the application that they are doing and with the help of this phase the application can be created with ease due to this phase. The Child diagram helps the researchers to identify how the main features will run efficiently and how they flow directly to the users, databases, and the process. The Context diagram is the illustration of the application from the user's and the administrator's sides. This way shows how the flow or the in and out process between the users into the application, and the administrator side, vice versa. It also included how the application created the wireframe as the application transitions into wireframe into transitioning into Figma, where the flow, colors, and icons that are needed for the application are defined. This Figma phase will be the life of the application, from the planning of the design of the application, and making it into the researcher application.

Developing the application addresses the problem identified in the researcher's study. First, the researchers are studying image processing to understand how it can be utilized and function effectively within the application. Second, they are completing other requirements to ensure that the application is not limited to a single feature and can offer more functionality.

Testing is the next phase, in which researchers evaluate all aspects of the application's quality so that it can't crash or have an error while the app is running, and all of the features, designs, and the flow of the application will be tested. In this phase, all of the testing is required so that it can be shown to the public. Unit testing to show how the application reacts if there are different units the units define into size, CPU, and the function of the application through these units. The user acceptance testing is also a part of testing. This phase helps the developers to know how the application will react if some buttons are functioning correctly. ISO25010 will be the evaluation kit of the application. This will be the tester of the application based on the following: Functional suitability, usability, reliability, and performance efficiency. This ensures that researchers understand how the application functions, its suitability for users, and its ability to operate smoothly without errors.

After all the planning, designing, and testing, the application will be published and made available to users. It can then be used as intended by the researchers. The deployment phase serves as the transition from a testing environment to a fully accessible application for the public, indicating that the app is ready for widespread use.

Maintenance will be applied in the application because of some bugs that can be found by the users, and by implementing the app in maintenance can help the app have a good quality and some new updates for the application. This phase also collects both positive and negative feedback, which the application can use for improvements.

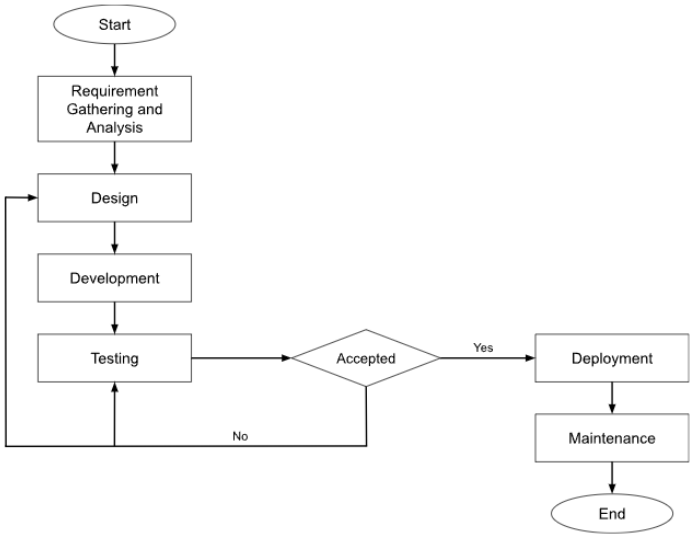

Figure 1. Flow chart of HerbaLens

Figure 1 represents how the project works in this study and how the flow works on this project. Firstly the requirement gathering all of the needed information for this project will be laid out and directly going to the design of the project with all of the diagram needed for the application or study and then the development which is the development process of the studies the testing this occurs when the prototype of the study is being process if the study is accepted it can be proceed on the deployment which is the releasing of the study and lastly the maintenance to ensure good usage from it until it the long run.

RESULTS

Table 2 consists of the survey questionnaire given to the participants, and it is also a tally and gives some verbal interpretation. As you can see, the verbal interpretation is consistent and has good results for the HerbaLens application.

The HerbaLens Application was evaluated by the users based on four areas relevant to the ISO 25010. Evaluation of the HerbaLens application, based on the ISO 25010 framework, reveals that both IT and non-IT experts rated its overall performance as

"Satisfied". Functional Suitability is one area where the application excelled, with a mean rating of 3.50 from IT experts and 3.63 from non-IT experts. There were consistent ratings of satisfaction in functional completeness, correctness, and appropriateness, which affirmed that the application had comprehensive and efficient features.

Usability also demonstrated positive outcomes as it received an overall rating of 3.51 and 3.59, respectively. Although there were favorable scores on attributes like user error protection and user engagement, it was evident that the application had strong learnability and operability, thus showing its ease-of-use and efficiency.

On matters of reliability, both expert groups gave high marks with average scores approximately around 3.40 to 3.56. Sub-components such as fault tolerance as well as recoverability stood out for their robustness, which enhances the dependability of applications in general.

Performance efficiency also did well, especially on time behavior, whereby it scored 3.47, while resource utilization had a score of 3.68. This suggests that the application works effectively under different operational conditions.

In conclusion, the HerbaLens application is considered satisfactory by expert reviewers, indicating its strong functionality, usability, reliability, and performance efficiency. Therefore, this indicates a good level of acceptance for users; hence, users' satisfaction levels are very high, which makes this an effective application.

Table 2. Weighted Mean and Verbal Interpretation

Indicators	Weighted Mean			
	IT Experts	Verbal Interpretation	Non-IT Experts	Verbal Interpretation
1. Functional Suitability	3.50	Satisfied	3.63	Satisfied
a. Functional Completeness	3.50	Satisfied	3.58	Satisfied
b. Functional Correctness	3.60	Satisfied	3.70	Satisfied
c. Functional Appropriateness	3.40	Satisfied	3.63	Satisfied
2. Usability:	3.51	Satisfied	3.59	Satisfied
a. Appropriateness Recognizability	3.70	Satisfied	3.58	Satisfied
b. Learnability	3.60	Satisfied	3.85	Satisfied
c. Operability	3.50	Satisfied	3.58	Satisfied
d. User Error Protection	3.30	Satisfied	3.40	Satisfied
e. User Engagement	3.50	Satisfied	3.70	Satisfied
f. Inclusivity	3.50	Satisfied	3.60	Satisfied
g. User Assistance	3.40	Satisfied	3.48	Satisfied
h. Self-Descriptiveness	3.60	Satisfied	3.55	Satisfied
3. Reliability:	3.40	Satisfied	3.56	Satisfied
a. Faultlessness	3.40	Satisfied	3.55	Satisfied
b. Availability	3.60	Satisfied	3.73	Satisfied
c. Fault Tolerance	3.30	Satisfied	3.45	Satisfied
d. Recoverability	3.30	Satisfied	3.50	Satisfied
4. Performance efficiency:	3.47	Satisfied	3.68	Satisfied
a. Time Behavior	3.60	Satisfied	3.70	Satisfied
b. Resource Utilization	3.40	Satisfied	3.68	Satisfied
c. Capacity	3.40	Satisfied	3.65	Satisfied

DISCUSSION

The HerbaLens Application was evaluated by the users based on four areas relevant to the ISO 25010. Evaluation of the HerbaLens application, based on the ISO 25010 framework, reveals that both IT and non-IT experts rated its overall performance as "Satisfied". Functional Suitability is one area where the application excelled, with a mean rating of 3.50 from IT experts and 3.63 from non-IT experts. There were consistent ratings of satisfaction in functional completeness, correctness, and appropriateness, which affirmed that the application had comprehensive and efficient features.

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In conclusion, HerbaLens application is considered satisfactory by expert reviewers indicating its strong functionality, usability, reliability and performance efficiency. Therefore, this indicates good level of acceptance for users hence users' satisfaction levels are very high, which makes this an effective application.

CONCLUSIONS AND RECOMMENDATIONS

The application will not stop improving on many things. This study will be the gateway for a new pathway of the medicinal plant image recognition on how it will be used, improved, and evolve for better use by the user. In conclusion, the first thing needed is patience and effort to strive more and get better results in the studies. Plants can have many functions in the environment, including self-enjoyment and healing agents. Creating an application that can help many people identify medicinal plants can be a good help for society to learn, study, and correctly use them.

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This study received no funding.

DECLARATIONS

Conflict of Interest

The researchers declare no conflict of interest in this study.

Informed Consent

We have read and understand the provided guidelines in this journal publication. I am fully knowledgeable about this publication, including all its rules and regulations.

Ethics Approval

We declare adherence to the accepted ethical standards.

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