HERBID: HERBAL PLANT IDENTIFICATION USING CONVOLUTIONAL NEURAL NETWORK ALGORITHM

A Thesis
Presented to the Faculty of the
College of Technology and Allied Sciences
BOHOL ISLAND STATE UNIVERSITY
Zamora, Bilar, Bohol

In Partial Fulfillment
of the Requirement for the Degree in
Bachelor of Science in Computer Science

Arsenio L. Pacatang Jr.
Mark Jairus P. Betinol
Irish R. Buñao

May 2024

APPROVAL SHEET

This thesis entitled **"HERBID: HERBAL PLANT IDENTIFICATION USING CONVOLUTIONAL NEURAL NETWORK ALGORITHM"** prepared and submitted by *Arsenio L. Pacatang Jr., Mark Jairus P. Betinol and Irish R. Buñao* in partial fulfillment of the requirements for the degree Bachelor of Science in Computer Science has been examined and recommended for acceptance and approval for oral defense.

THE THESIS COMMITTEE

NELIA Q. CATAYAS, Ph.D.
Dean, CTAS

CECILIO C. BA-AY JR.
Thesis Editor

JOEL A. PIOLLO, MATCS
Thesis Adviser / Chairperson, CSD

Approved by the Examining Panel during the Oral Examination conducted on April 16, 2024 with rating 1.3.

EXAMINING PANEL

PROCESO M. CASTIL, Ed.D.
Chairman

DARREL A. CARDAÑA, MIS
Panel Expert

REX VINCENT D. TEJADA
Panel Member

NELIA Q. CATAYAS, Ph.D.
Dean, CTAS

Accepted and approved as partial fulfillment of the requirement for the degree Bachelor of Science in Computer Science.

April 16, 2024
Date of Oral Defense

PROCESO M. CASTIL, Ed.D.
Campus Director

ACKNOWLEDGEMENT

The researchers wish to extend their heartfelt appreciation to the generous individuals whose valuable contributions have greatly enriched the progress of this research.

First and foremost, the researchers express profound gratitude to the **Almighty God**, whose unwavering support, blessings, and guidance have illuminated the path of this study, making its realization possible.

Dr. Proceso M. Castil, the esteemed Campus Director of Bohol Island State University – Bilar Campus, for her encouragement and support of our study.

Nelia Q. Catayas, **Ph.D, Mr. Darrel A. Cardaña**, and **Mr. Rex Vincent D. Tejada**, panelists for dedicating their time, sharing their ideas, and offering genuine support during the defense, despite the challenges we faced in completing this research;

Mr. Jomer Balag, the client, for his support and active involvement in the project, offering valuable input and guidance along the way;

Mr. Joel A. Piollo, thesis adviser and also one of the panelists, for their tireless efforts and for providing valuable suggestions, advice, comfort, assistance, guidance, and encouragement, all of which have significantly contributed to the enhancement of this manuscript;

Mr. Max Angelo D. Perin, for his invaluable assistance in navigating the

challenging terrain of machine learning concepts. His guidance, support, and expertise have been instrumental in helping us overcome obstacles and advance in our understanding of this complex field;

The **respondents**, for their time, participation and contribution. Their insights and cooperation have been invaluable in shaping the outcomes of this research;

To the **researchers' parents**, for their unwavering support and encouragement throughout this journey. Their love, understanding, and belief in our endeavors have been a constant source of strength and motivation;

To the **supportive friends and classmates**, for standing by throughout this journey. Their encouragement, understanding, and solidarity have been invaluable as we navigated the challenges of this project;

To everyone who contributed to the success of this study, thank you so much and God Bless to all of us!

Researchers

TABLE OF CONTENTS

Pages

LIST OF FIGURES

LIST OF TABLES

LIST OF PREVIEWS

Preview **Pages**

ABSTRACT

The accurate identification of herbal plants is essential for various purposes, including medicinal use, research, and conservation efforts. However, the manual identification of herbal plants poses a significant challenge, leading to errors, inefficiencies, and delays in the process. This study aimed to address such problems for the manual identification of herbal plants. HerbID is an Herbal Plant Identification Android Application that serves as a tool to identify herbal plants. The app used the Convolutional Neural Network Algorithm (CNN) for its business logic layer or backend and Supervised Machine Learning to create the application programming interface (API) for the said application. The Android application accesses the camera to capture an image of an herbal plant leaf and returns the name and the details of the identified herbal plant. After conducting testing, the machine learning model accuracy was 96.17% based on a average precision. A usability test was also conducted with herbal plant consumers, students, and IT experts as respondents. The usability review have 8 measurement items in which users can respond from 1 (Strongly Disagree) to 5 (Strongly Agree). The average for all the measurement items gathered from the users was 4.45 average mean.

Keywords: Herbal Plants, Convolutional Neural Network (CNN) Algorithm, Android Application, Supervised Machine Learning, Precision, Business Logic Layer, Machine Learning Model

Chapter 1

THE PROBLEM AND ITS SCOPE

Rationale

Herbal Plants, considered valuable resources in ecosystems, have been used for human health since ancient times and continue to play a crucial role in modern healthcare due to their enduring healing properties (Ahad et al, 2021).

Using herbal medicines for preventing and treating diseases is becoming more popular worldwide. (Chen et al, 2014) But with over 70,000 types of medicinal plants out there, telling them apart from similar plants or fake ones is tough. This mix-up can be dangerous for patients and affect how well the herbs work. Problems with identifying herbs correctly are causing safety issues worldwide.

Philippines is a country which contains tons of plants, which doses contain valuable property like medicinal properties. (De Luna et al, 2019) But small number of these plants, have been scientifically proven to be safe and effective for use. So, even though a bunch of herbs around are not all of them officially verified for their medicinal benefits. In order to identify medicinal benefits and effectiveness of herbal plants, a machine learning is developed by the researchers.

Naga and Murphy explain that machine learning is basically computers trying to learn like humans, absorbing information from their surroundings. It's super important these days with all the big data floating around, and it's used in tons of areas like recognizing patterns, understanding images, managing finances,

creating entertainment, and exploring biology and medicine.

According to Awati (2023), Machine learning includes convolutional neural networks, also known as convnets or CNNs. It is one of several different artificial neural network types that are employed for diverse purposes and data kinds. A CNN is a particular type of network design for deep learning algorithms that is utilized for tasks like image recognition and pixel data processing. Although there are different kinds of neural networks in deep learning, CNNs are the preferred network architecture for identifying and recognizing objects.

According to the study Kavish Mojhoa about detecting plant disease using CNN and KNN algorithm. The CNN model, employing direct image processing and leveraging deep learning techniques, achieves a significantly higher accuracy of 90.92%. In contract, the KNN model, which relies on a distance-based approach, demonstrates a lower accuracy of 67.85%. This discrepancy underscores the distinct advantages of deep learning methods, particularly CNN, in the context of plant identification from images.

The primary subject of this research is Jolit’s Eco Garden, one of the agricultural farms in Cambacay, Batuan, Bohol. Jolit’s Eco Garden employs traditional methods for the identification of herbal plants, relying on visual observation of plant appearances. If the staff encounters a herbal plant whose name is unknown, they use reference materials. To minimize the problems encountered by clients, there should be an innovative solution implemented. By providing a comprehensive and user-friendly tool specifically designed for Android,

it will help enhance client service in terms of plant identification.

Literature Background

According to Article XIV, Section 10 of the 1987 Constitution of the Republic of the Philippines, science and technology play a crucial role in national development and progress. The state emphasizes the following key points: research and development (R&D), and the promotion of science and technology education. In the context of modernization, technology adoption is vital. Online platforms, including websites, facilitate the utilization of modern technology to enhance services, such as medical care. For instance, the Herbal Plant Identification using CNN Algorithm can contribute to improving healthcare services by accurately identifying medicinal plants. By leveraging technology, we can address the challenges posed by modernization and promote the well-being of our society.

The theory of the Technology Acceptance Model (TAM) emphasizes the importance of social influence and cognitive instrumental processes in shaping user's perceptions and attitudes toward technology. It can provide a helpful framework for understanding the factors influencing user's acceptance of the Herbal Plant Identification using CNN Algorithm system. According to TAM, perceived usefulness and ease of use are two key factors determining users' attitudes towards technology. In the context of the HerbID system, these factors could be influenced by the system's ability to provide users with an informative and automated identification of herbal plants. (Yin & Lin, 2022)

Moreover, the Machine Learning Theory, also known as Computational Learning Theory, focuses on developing mathematical principles to comprehend how learning occurs computationally. These principles serve as a guide for designing efficient learning algorithms. In the context of HerbID, this theory forms the fundamental framework. By applying theses principles, the CNN algorithm efficiently learns and categorizes herbal plant species based on the image data, ensuring reliable and precise identification within the HerbID system. (Avrim Blum, 2007)

Additionally, the study by Abdollahi (2022) investigates the use of methods based on Convolutional Neural Networks (CNN) to identify leaf species from India. They employed a dataset containing 3000 images of medicinal plants from 30 different classes. The evaluation utilized pre-trained models, achieving an impressive 98.05% accuracy on an external test set. In the context of herbal plant identification system, using CNN algorithm could help make it more accurate and reliable when identifying different kinds of herbal plants.

Furthermore, according to the study of Daryl B. Valdez, et al, (2022) the advancement of computer vision has facilitated the identification of plants from images, particularly focusing on medicinal plants. The dataset contains images of 10 classes of medicinal plants and an additional miscellaneous class. The model is based on the MobileNetV3 architecture, demonstrated cost effectiveness, reliability, and efficacy in classifying medicinal plants. The model achieved an impressive 97.43% accuracy, showcasing its potential for robust and dependable

plant classification in real-world applications. In the context of herbal plant identification system, this study suggests that using computer vision techniques like MobileNetV3, could make the system more dependable and precise when identifying various medicinal plants from images.

Moreover, studies such as "Medicinal Plants Recognition Using Deep Learning" (Sharrab et al., 2023) and "DeepHerb: A Vision Based System for Medicinal Plants Using Xception Features" (Roopashree, 2021) have demonstrated the effectiveness of deep learning approaches in accurately identifying medicinal plants. These studies utilized datasets containing thousands of images and employed deep learning models such as CNN based on VGG-16 and Xception, achieving impressive identification rates. Incorporating deep learning techniques into herbal plant identification systems could significantly improve their accuracy and reliability, even when dealing with challenging conditions.

Additionally, HerbApp: A Mobile-Based Application for Herbal Leaf Recognition Using Image Processing and Regularized Logistic Regression Classifier (Barbosa et al., 2017). HerbApp is a mobile-based application that serves as a convenient tool in discriminating herbal from non-herbal plants. The app uses image processing and a Regularized Logistic Regression Classifier for leaf recognition. From the captured leaf image, the app performs a segmentation process based on the Localized Active Contour (LAC) model and extracts features, which are used to build a classifier for leaf classification. This study highlights the importance of leveraging innovative approaches within mobile applications to raise

awareness about the significance of plants, aligning with the broader goals of this research in promoting environmental education and awareness through technology.

Furthermore, MediNet: A Deep Learning Approach to Recognize Bangladesh Ordinary Medicinal Plants Using CNN (Bhuiyan et al, 2021). The study suggested the importance of classifying these plants correctly for medical preparation. The proposed algorithm used the popular Convolutional Neural Network (CNN) to automatically identify the plant from the leaf images. The algorithm achieved an accuracy of 84.58%, showing its effectiveness in plant identification. In the context of herbal plants identification system, this study suggest that using deep learning techniques like CNN, similar to the MediNet algorithm, could help improve the accuracy of identifying different medicinal plants.

The researchers believed that the above literature and studies served as bases in the creation of the Identification of Herbal Plants Using CNN Algorithm.

THE PROBLEM

Statement of the Problem

This study aimed to design and develop an image processing application for Jolit's Eco Garden in Cambacay, Batuan, Bohol to enhance the identification of herbal plants to clients.

Specifically, it seeks to answer the following questions:

1. What is the current process of identifying herbal plants in Jolit's Eco Garden?

2. How to design and develop the system with the modules:
   a) Data Management;
   b) Mobile Development;
   c) Machine Learning; and
   d) Reports

3. What is the level of the system instrument and machine learning as perceived by the target users?

Objectives

The objective of this study was to develop a mobile application that educate and specifically caters the needs of herbal plant consumer in Jolit's Eco Garden.

Specifically, the project aimed the following objectives:

1. To develop an Image Processing system for Jolit's Eco Garden, Cambacay, Batuan, Bohol.
2. To test and evaluate the system using Application Usability Survey.
3. To implemnt and deploy the system called Herb-Id of JEG in Cambay, Batuan, Bohol.

Scope and Delimitation

The study focused on herbal plants identification of Jolit's Eco Garden in Cambacay, Batuan, Bohol. These were the following processes:

1. **Data Management** – This module includes the initial processing of the acquired leaf images involves adjusting their size, making them consistent, and adding more details through a process called augmentation. These steps helped the images work well with the CNN algorithm, which was a smart part of the system. Then pick out important features from the images to teach the system. The dataset was split into two parts—one for teaching (training) and one for checking how well it's learned (testing). The CNN algorithm learns from the training set, recognizing patterns in the features. After learning, researchers made the model available online and connect it to the mobile app so it can classify leaves in real time. Add extra info about herbal plants, like their scientific classifications and ecological importance, into Firebase. This extra info got pulled in dynamically and

showed up in the mobile app when a herbal plant is identified.

2. **Mobile Development** – This module encompasses the design, creation, and implementation of an intuitive and user-friendly application dedicated to leaf-based herbal identification using CNN algorithm.

3. **Machine Learning** – This allows the intelligent identification system using the CNN (Convolutional Neural Network) getting an image, and then distinguishing them from each other. Limiting the classes to 20 images for conducting the study. These limitations should be considered during the implementation and interpretation of the results.

4. **Reports** – This classifies herbal plants based on the illnesses they can potentially treat. Users have the capability to search for specific herbal plants by name, facilitating easy access to information about their medicinal properties.

The study was confined only to the leaves and focusing exclusively on tree species found within Jolit's Eco Garden. Therefore, users should be aware that the app's accuracy was optimized for leaf-based classification and may encounter challenges when applied to other herbal plants or non-leaf features. Additionally, it's important to note that this study's training dataset did not include dried leaves.

Significance of the Study

The development of HerbId: Herbal Plant Identification Using Convolutional

Neural Network Algorithm brought forth a strategic point for identifying herbal plants Furthermore, the application have provided the benefits to the following individuals:

Jolit's Eco Garden. The application would eliminate the problems encountered in the current manual operation of the business. With the application, there would be an immediate and accurate identification of herbal plants.

The school (Bohol Island State University Bilar-Campus). This project would contribute to the research and innovation efforts of the university. Implementing projects that bridge the gap between academia and real-world applications helped establish the school as a center of excellence in agricultural research and technology. The project also would strengthens collaboration between different departments within the school, fostering interdisciplinary cooperation and knowledge sharing.

Local community. As the app would enable accurate herbal plant identification, community members could use it to learn about the herbal plant species found in their surroundings, whether in gardens, parks, or natural areas. This knowledge promotes health care and encourages the proper consumption of medicinal herbs.

Computer Science Instructors. It would serve as a valuable teaching resource for computer science instructors, providing an illustrative example for teaching concepts in machine learning, image recognition, and algorithm development.

Computer Science Student. This study would serve as a starting point for students interested in exploring similar projects or conducting further studies in related areas and inspire them to further research and innovate on how to leverage mobile technologies and machine learning algorithms for image identification and classification.

Agriculture Instructors. Instructors could utilize the app to enhance classroom discussions and field studies, fostering a dynamic and interactive learning environment. The real-time leaf classification feature would serve as an efficient teaching aid, allowing for on-the-spot exploration of herbal plant species. By incorporating modern technology into the educational process, the app contributes to a more engaging and resource-optimized teaching experience.

Agricultural Student. This practical tool for the identification and comprehension of herbal plants, facilitating streamlined processes associated with plant classification, research, and cultivation. By leveraging this tool, agricultural students could enhance their understanding of herbal plants, which in turn contributes to increased efficiency in agricultural practices. This comprehensive approach would aid students in acquiring valuable knowledge and skills essential for effective plant management and cultivation techniques. Furthermore, the integration of this tool into agricultural education would foster a deeper appreciation for the diversity and importance of herbal plants in agricultural systems, thereby promoting sustainable farming practices.

Researchers. This study would foster their continuous improvement and

contribution to the body of knowledge in educational technology and function as a steppingstone in their future career as full-pledged programmers.

Future Researchers. Future researchers could utilize the app's capabilities for fieldwork, enabling them to quickly and accurately identify herbal plants, gather data, and conduct experiments. The app's comprehensive herbal plants information would support future researchers in their efforts to explore and document herbal plant diversity, furthering agricultural research and contributing to the advancement of the field.

RESEARCH METHODOLOGY

Conceptual Diagram of the Study

Figure 1 below represents the conceptual diagram of the study that represents the principle of input-process-output. Inputs were the image that were captured by the researchers. The processes involve machine learning model using CNN Algorithm. The output would provide the identification and description of herbal plant.

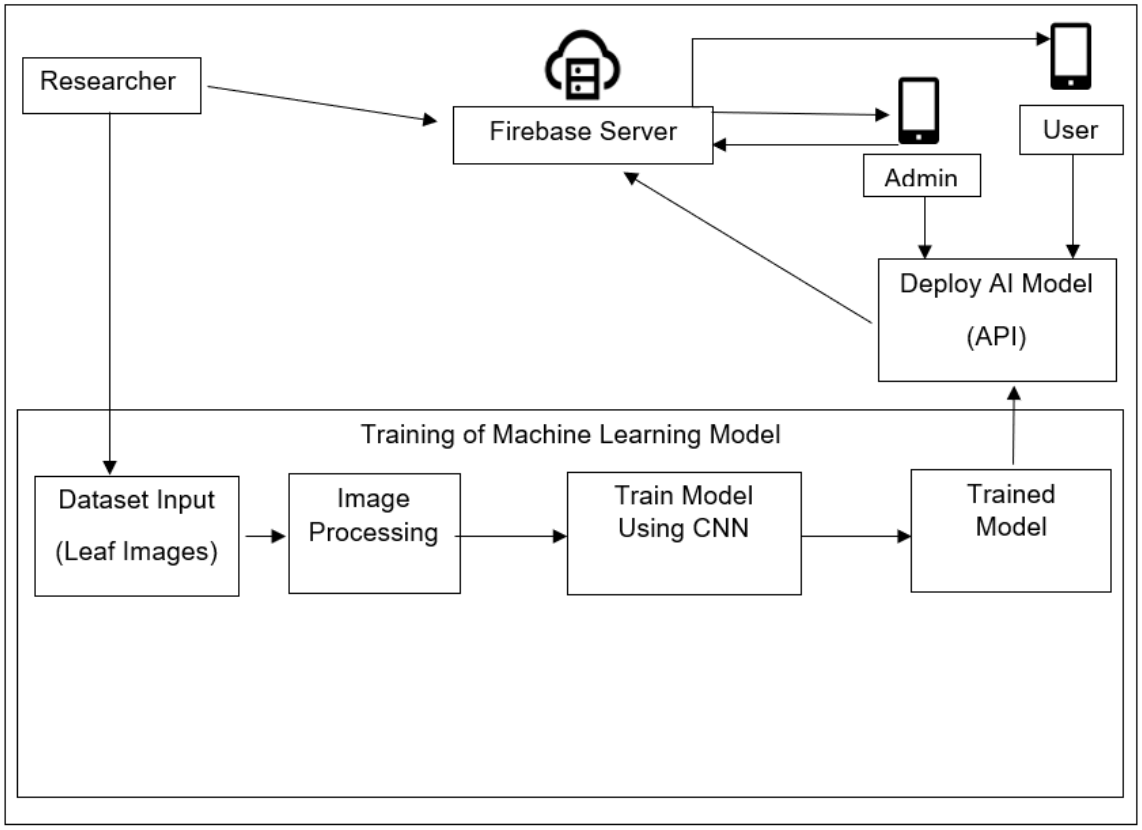


Figure 1: Conceptual Diagram of the Study

Block Diagram of the Study

Figure 2 shows the block diagram of the study Herb-Id: Herbal Plants Identification using CNN Algorithm of Jolit's Eco Garden, Cambacay, Batuan, Bohol. It covers the specification of the basic functionality of the system that represents the process of the user.

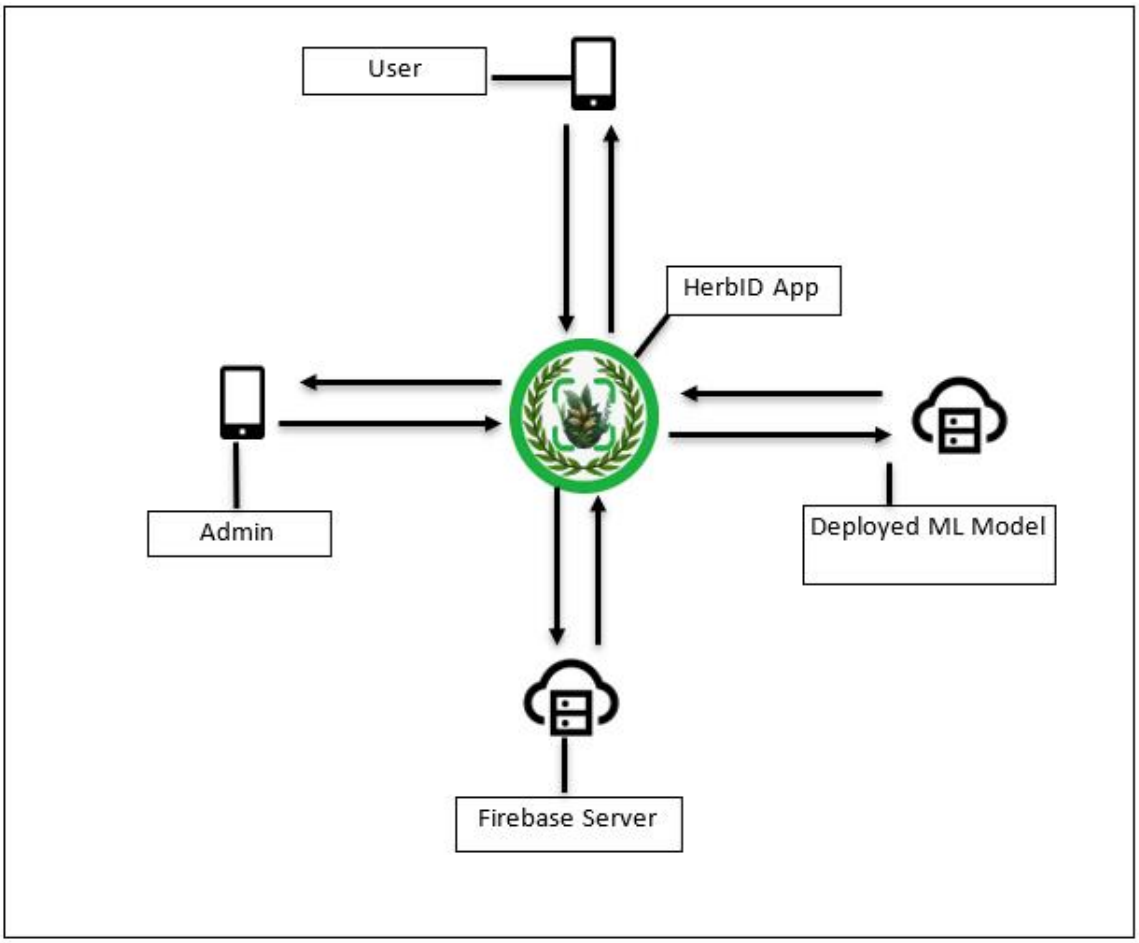


Figure 2: Block Diagram

Development Model and Approaches

Feature-driven development (FDD) is an iterative and increment software development process. It is a lightweight or Agile method for developing software. FDD blends some industry-recognized best practices into a cohesive whole. These practices are driven from a client-valued functionality (feature) perspective. Its primary purpose is to deliver tangible, working software repeatedly promptly following the principles behind the Agile Manifesto (Rachaelle Lynn et. al., 2021).

Researchers used this methodology for the users to understand the different project's scope and context quickly. It would also help future developers because it is easy to adapt, and the methodology suits most projects. Despite its simplicity, it is also quite thorough in its coverage of the software development lifecycle.

Figure 3 below shows the Feature-driven development (FDD) which has five phases to be followed.

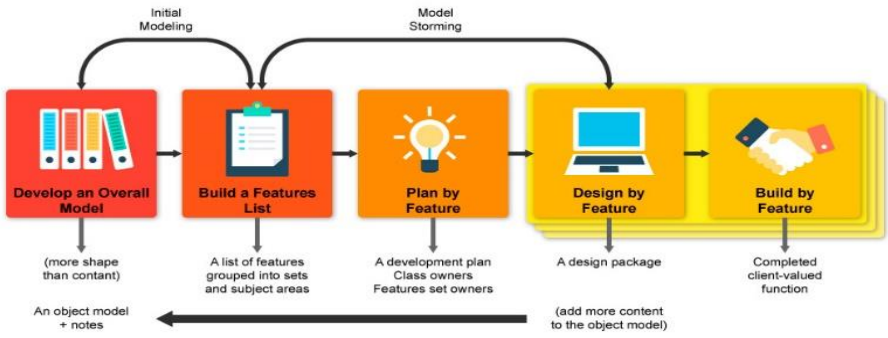


Figure 3. Agile: Feature Driven Development (FDD) Diagram

There were five phases of Feature Driven Development (FDD) that must be followed.

a. **Develop an Overall Model**. The researchers designed a complete plan development. The plan included the user interface, backend infrastructure, and the machine learning model.

b. **Build a Feature List**. The researchers listed down the features that were used in the project. One of the features was that users can identify herbal plants accurately. Additionally, a list of herbal plants that were within the Jolit's Eco Garden.

c. **Plan by Feature**. The researchers planned all the necessary components for building each feature. They used their cellphones to capture image of herbal plants on the Jolit's Eco Garden.

d. **Design by Feature**. The researchers created a user interface for capturing leaf images and designing an efficient data processing flow for the CNN algorithm.

e. **Build by Feature**. The researchers started building the different parts of the app one by one. They worked on each feature at the same time. By using GitHub, they merge together their work to make the whole app work.

Software Development Tools

The following were the tools used in the development of Herb-Id: Herbal Plants Identification Using CNN Algorithm of Jolit's Eco Garden, Cambacay, Batuan, Bohol.

1. **Android Smartphone (API 21)** –The researchers used this device to debug, and test the mobile app. Also, this device instantiated communication to the Django and Firebase server via API key.

2. **Android Studio (v2022.1.1)** – The tool that was used by researchers used to build the Herb-Id app for Android. It's like a workspace with everything needed to create, test, and improve the app. Android Studio has tools, a design space, and a strong debugger, making it the go-to place for developing the Android side of the Herb-Id app using Flutter.

3. **Visual Studio Code (v1.75)** – A cross-platform Integrated Development Environment. It is the IDE used by the researchers to develop Herb-Id: Herbal Plants Identification using CNN Algorithm.

4. **Flutter (SDK 3.10.6)** – An open-source, cross-platform Software Development Kit framework used by the researchers to develop Herb-Id.

5. **Phyton (v3.10.7)** – A user-friendly programming language known for its easy-to-read syntax and suitability for quick application

development and scripting. It's freely available on major platforms. The researchers picked Python because it's versatile and easy to use, making it a good fit for implementing the CNN algorithm, image processing, and other essential functions.

`

6. **Django (v4.2.6)** – A high-level, open-source web framework written in Phyton that follows the Model-View-Controller (MVC) architectural pattern, although it’s commonly referred to as the Model-View-Template (MVT) pattern in Django’s context. Django serves as a backend framework in creating the web API to seamlessly integrate the trained CNN algorithm into the mobile application.

7. **PhytonAnywhere** – Like an online space where one can easily host and launch Phyton web applications, including those built with Django. The researchers used PhytonAnywhere as the platform to host the Django web applications that contains the machine learning model.

8. **Dart (SDK 3.0.6)** – The programming language used in Flutter framework in developing cross-platform applications.

9. **Git (v2.41)** – A tool used in DevOps to manage source code. The researchers used it to keep track of changes in the source code and let multiple developers work together. It allowed for flexible development by using branches.

10. **Figma** – A tool that lets people design, share, and test layouts for websites, mobile apps, and other digital stuff. The researchers used it to create the design for the user interface.

11. **Firebase (v12.4.2)** – A Google-backed BaaS (Backend as a Service) application. The chosen backend service by the researchers in storing tree species data.

Environment Participants

The study was conducted at JEG located in Cambacay, Batuan, Bohol and there were 30 respondents.

The respondents of the study were the owner, students, owner, and IT experts. They gave their thoughts by rating the usability of the system. Jolit's Eco Garden provided to the researchers with the data and helped the development of the system successful.

Data Collection

Permission letter was compiled as an approval and guarantee that the proposed application was tested and implemented. An interview with the owner was conducted to identify the need and gaps prior to building the application. From this, the garden's workflows were familiarized as the basis for providing the standard need and requirements for application development. Process observation and document used review of the presently forms and reports will also be done to be integrated into the design of the proposed forms for the GUI

(Graphical User Interface).

The modules of the application was based on the events and scenarios as carried out by the current procedures of Jolit's Eco Garden. In testing and evaluating the application, the researchers used ISO 25010. This usability survey was distributed to determine whether the developed intelligent system meets the needs of the users. The target respondents of the study were the 30 respondents who were classified as two (2) owner, six (6) IT experts, and twenty-two (22) students. Table 1 shows the distribution of system usability respondents.

Table 1. Distribution of System Usability Respondents

Respondents	Frequency
Owner	2
IT Expert	6
Students	22
Total	**30**

Table 2 shows the interpretation of the results used for system usability. The rating was done based on the interpretation guide of device factors using ISO-25010.

Table 2. Interpretation Guide of the ISO-25010

Weight	Range	Description	Interpretation
5	4.6 – 5.00	Strong Agree	The respondents strongly believe and confident that the system is very usable.
4	3.7 – 4.5	Agree	The respondents are neutral in trusting that the system usable.
3	2.8 – 3.6	Neutral	The respondents are neutral in trusting that the system is usable.

2	1.9 -2.7	Disagree	The respondents tend not to trust that the system is usable.
1	1.0 – 1.8	Strongly Disagree	The respondents strongly believe that the system is not usable.

To determine the acceptability of the application, the weighted mean score was computed to evaluate the application usability level the following formula:

$$WMS = \frac{1f1 + 1f2 + 1f3 + 1f4 + 1f5}{n}$$

Where:

WMS = Weighted Mean Score

$f1$ = frequency of respondents who give a rate of 1

$f2$ = frequency of respondents who give a rate of 2

$f3$ = frequency of respondents who give a rate of 3

$f4$ = frequency of respondents who give a rate of 4

$f15$ = frequency of respondents who give a rate of 5

n = number of respondents

$1, 2, ...5$ = constant(rating)

The researchers selected 20 classes of herbal plant that were present around the Jolit's Eco Garden. To evaluate the HerbID positive predictions, the researchers used evaluation metrics specifically precision, recall, F1, and accuracy.

Precision measures the proportion of true positive predictions among the total predicted positive cases. Accuracy represents the overall proportion of correct predictions (both positive and negative).

Precision Formula:

$$Precision = \frac{TP}{TP + FP}$$

Accuracy Formula:

$$Accuracy = \frac{TP + TN}{Total\ Predictions}$$

Where:

$Precision$ = Accuracy of positive predictions

$Accuracy$ = Correctly classified instances out of all instances

TP = It is the total count having correct prediction of image.

FP = It is the total count having incorrect prediction of image.

TN = Counts the instances where the model correctly predicts the absence of a specific class in an image.

$Total\ Predictions$ = It is the total count of image.

OPERATIONAL DEFINITION OF TERMS

The terminologies used or stated were further defined operationally in the study:

Acquisition - Identifying and gathering relevant herbal plant information and leaf data for training the CNN algorithm. This involves collecting diverse samples of leaves to ensure the algorithm's robustness.

Admin – The Jolit's Eco Garden Owner.

Augmentation - Involves enhancing the training dataset by creating variations of leaf images to increase the diversity of the dataset.

CNN – Machine Learning algorithm used to train the model.

Deployed ML Model – Making the trained CNN algorithm accessible online for real-time leaf recognition within the mobile application.

Django – It serves as the backend framework for integrating the CNN algorithm into the mobile app, enabling real-time leaf recognition on the user's device.

Firebase Server – Database online server used for storing additional information about herbal plant species and facilitating real-time data retrieval for the mobile application.

HerbId App – The acronym of the system, standing for Herbal Plant Identification.

Identification – Involve recognizing herbal plants based on the unique leaf characteristics analyzed by the CNN algorithm.

Normalization – Scaling numerical features in the dataset, ensuring uniformity in the representation of leaf characteristics for effective training of the CNN algorithm.

User – The end-user of the application.

Chapter 2

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Existing Operation and Processes

Jolit’s Eco Garden currently relies on manual visual methods for identifying herbal plants, which are prone to errors due to subjective interpretations and varying levels of expertise among staff. Additionally, the availability and comprehensiveness of reference materials may be limited. This approach lacks efficiency and may lead to misclassifications. As a result, there is a need for a more reliable and streamlined identification process to enhance accuracy and effectiveness.

A. Identification Process

At Jolits Eco Garden, the owner undertook the task of physically inspecting herbal plants for identification within their farm premises. This manual process involved visually examining the herbal plants, relying on the owner's own knowledge or resorting to reference materials for matching plant characteristics to determine their species. However, this method presented significant challenges and drawbacks. Firstly, the subjective nature of visual identification introduced a level of subjectivity, potentially resulting in misclassifications of herbal plant species. Moreover, the varying expertise levels of the Jolits Eco Garden owner may have limited accurate recognition of herbal plant species. Additionally, reliance on reference materials may have been hindered by factors such as availability, currency, and comprehensiveness of such

resources, further complicating the identification process.

Data Flow Diagram

Figure shows the contextual diagram of the present system.

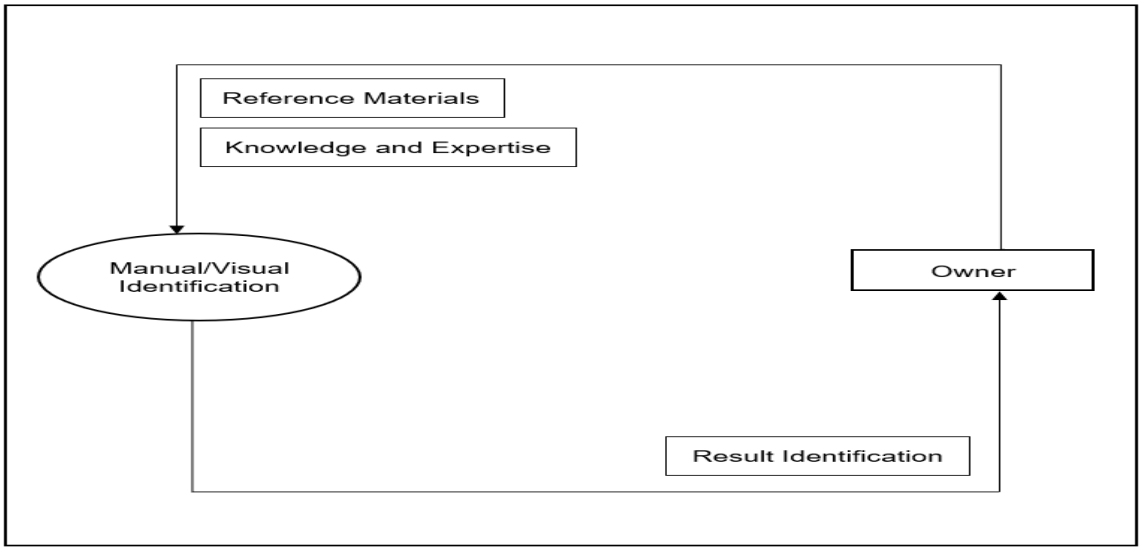


Figure 4. Contextual Diagram of the Present System

Event Specification

Event List:

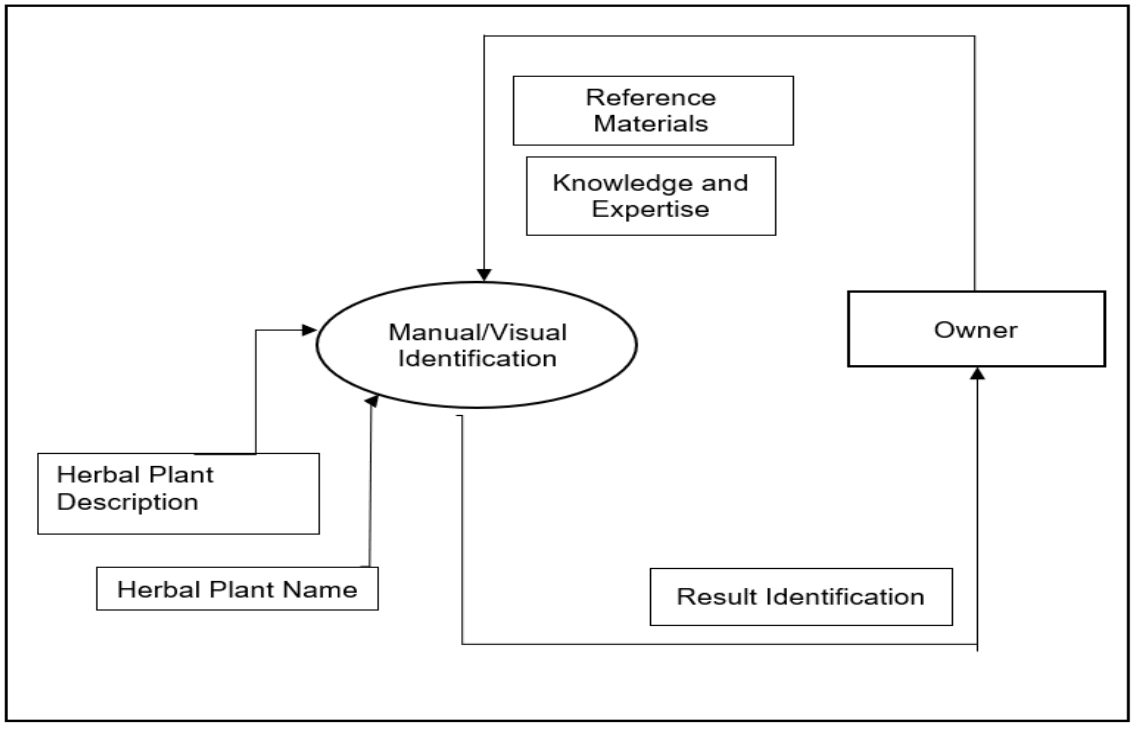


Figure 5. Identification Process

Needs of Existing Operation

Bases on the identified problems with the consideration of the existing method of identifying herbal plants in Jolit's Eco Garden, the following needs are identified:

1. **Efficiency:** An application could quickly and accurately identify herbal plants, saving time compared to manual identification methods.

2. **Accessibility:** The application could have been easily accessed by a wider audience, allowing individuals without extensive herbal knowledge to identify medicinal plants.

3. **Accuracy:** Advanced technologies, such as machine learning and image recognition, could have enhanced the accuracy of plant identification, reducing the risk of misidentification.

4. **Database Integration:** A comprehensive database within the system could have provided additional information about each identified plant.

5. **Education**: The application could have served as an educational tool, providing information about herbal medicine, promoting awareness, and preserving traditional knowledge.

HERBID: HERBAL PLANT IDENTIFICATION USING CONVOLUTIONAL NEURAL NETWORK ALGORITHM

The researchers gathered all the data and information of the current system of Jolit's Eco Garden and developed the "HERBID: HERBAL PLANTS IDENTIFICATION USING CONVOLUTIONAL NEURAL NETWORK ALGORITHM" that could identify herbal plants inside the Jolit's Eco Garden. The following list shows a user's interactions with the application.

A. Data Management

The new application empowered users to upload images of herbal plant leaves. These images were then processed and analyzed using a machine learning model, ultimately identifying the herbal plant from the processed image. Additionally, authorized users, upon logging in, could efficiently manage data, including herbal plant descriptions and images. The administration feature ensured secure access for authorized users, who could handle various aspects of herbal plant data, request updates, or suggest new species through the provided email link.

B. Machine Learning

The new application used machine learning model that will process and analyzed and the image input and identifies the herbal plant image and also give accuracy report.

C. Reports

The application allows users to classify herbal plants based on the illnesses they can potentially treat. Users can search for specific herbal plants by name. Each identification result will generate an accuracy percentage report.

Use Case Diagram

According to Erikson and Penker (2000), a use case diagram describes specific usage of the system by one or more actors. The use case is a list of actor or event steps typically defending the interactions between the role (known in the Unified Modelling Language as an actor) and a system to achieve a goal. Use case diagrams are usually referred to as behavior diagrams used to describe a set of actions (use cases) that some system or systems (subject) should or can perform in collaboration with one or more external users of the system (actors). Each use case should provide some visible and valuable result to the actors or other stakeholders of the application. Figure 6 shows the use-case diagram of HerbId which composes of actors namely:

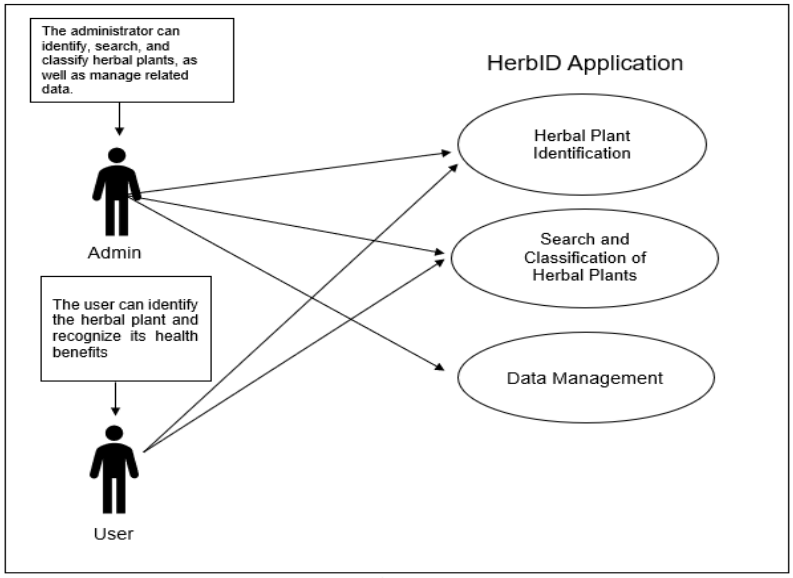


Figure 6. Use Case Diagram

Use Case Narrative

Use case narrative describing a use case that requires both frame context of the use case and represents the dialog between the user (actor or use case) to achieve a goal of observable value. It must provide more elements than a simple sequence of user to system interactions. In every use case narrative, there are pre-conditions processes, and post-conditions. Table 3 shows the use-case narrative of logging in to the system.

Table 3 show the use case narrative for herbal plants identification.

Table 3. Herbal Plants Identification

Use case name	Herbal Plants Identification
Actor	Admin/User
Precondition	User must be in the main page of the application
Description	Allow the end-users to identify herbal plants

Typical Course of Action

Actor Action	**System Response**
Step 1 Users open the HerbId application	**Step 2** Displays the home page
Step 3 User presses the camera button	**Step 4** Display the camera screen
Step 5 User presses the capture button	**Step 6** Display input image in the home page
Step 7 User presses the identify button	**Step 8** Display the herbal plant information
Alternative: **Step 3** – User presses the gallery button **Step 4** - Display all the save photo in the gallery **Step 5** – User select a photo	

Table 4 show the use case narrative for search and classification of herbal plants.

Table 4. Search and Classification of Herbal Plants

Use case name	Search and Classification of Herbal Plants
Actor	Admin/User
Precondition	User must be in the list page of the application
Description	Allow the end-users to search the name and classify the herbal plants based on the illness they can potentially treat
Typical Course of Action	
Actor Action	**System Response**
Step 1 Users open the HerbId application	**Step 2** Displays the home page
Step 3 User presses the plant button	**Step 4** Display the list of the herbal plants
Step 5 User presses the search bar and input a name of herbal plant	**Step 6** Dynamically display the list of herbal plants matches the input in search bar
Step 7 User presses the dropdown menu and select an illness option	**Step 8** Dynamically display the list of herbal plants matches the option selected in dropdown
Alternative: None	

Table 5 show the use case narrative for data management.

Table 5. Data Management

Use case name	Data Management
Actor	Admin
Precondition	Actors are already log in
Description	Allow the end-users to edit the data of herbal plants.
Typical Course of Action	
Actor Action	**System Response**
Step 1 User select an herbal plant	**Step 2** Display the description of herbal plant
Step 3 User presses the save button	**Step 4** Saves the new herbal plant data
Alternative: None	

Database Design

Database design is the process of producing a data model of the database. This data model contains all the needed logical and physical design choices and physical storage parameters needed to generate a design in a data definition language, which can then be used to create a database.

System design is the process of defining the components, modules, interfaces, and data for system to satisfy specified requirements of Jolit's Eco Garden, Batuan, Bohol. And the researchers aim to create a new system which be used in the identification of herbal plants.

The objective of this design is to offer a resolution to the issue highlighted and let the end users quickly and efficiently retrieve the information.

Class Diagram

A class diagram in the Unified Modeling Language (UML) is a graphical representation that depicts the structure of a system. It provides an overview of the classes present in the system, their attributes, operations, and the relationships or interactions among them. It provides visual representation of the system's structure. Figure 7, refers to the instances depicting the most utmost processes of HerbId.

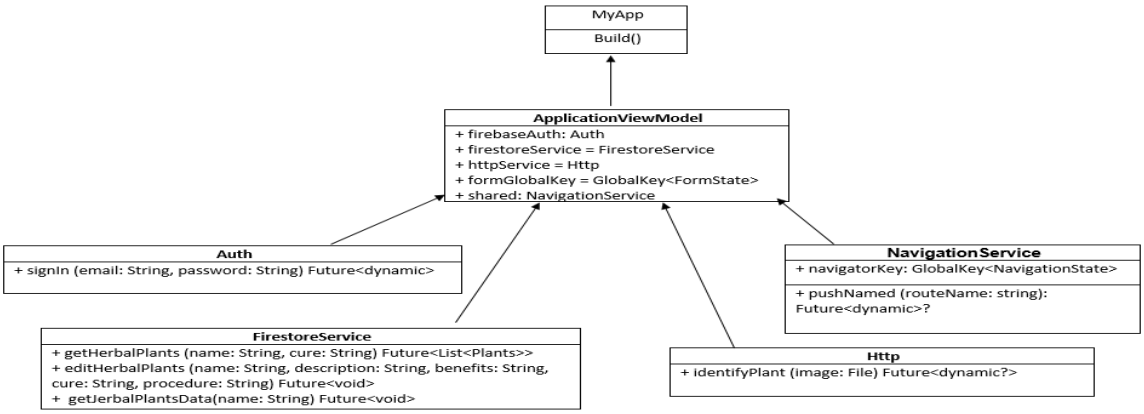


Figure 7. Class Diagram of the System

Database Structure

The following tables below were the database tables that were used in storing the information that was inputted in the system together with a collection of requirements that facilitate searching, sorting, and similar activities. It is a particular way of organizing data on a computer so that it can be used effectively. Table 6 shows the data structure for user account credential.

Table 6. User Account Credential

Field No.	Field Name	Type	Description
1	uid	String	User Id
2	email	String	Email
3	password	Hash	Password

Table 7 shows the data structure for herbal plants.

Table 7. Herbal Plants Data Structure

Field No.	Field Name	Type	Description
1	id	String	Herbal Plant id
2	name	String	Scientific Name
3	description	String	Description
4	procedure	String	Procedure of using herbal plant
5	benefits	String	Benefits
6	cure	array	Illness that can be treated
8	image	String	Image Uri

Program Hierarchy

A program hierarchy is a diagram that displays the system's breakdown into its most basic, controllable layers. Each Module is symbolized as a box that holds the Module within. The high-level design or architecture of a computer program is described using a program hierarchy.

Figure 8 show the program hierarchy of the HerbId system.

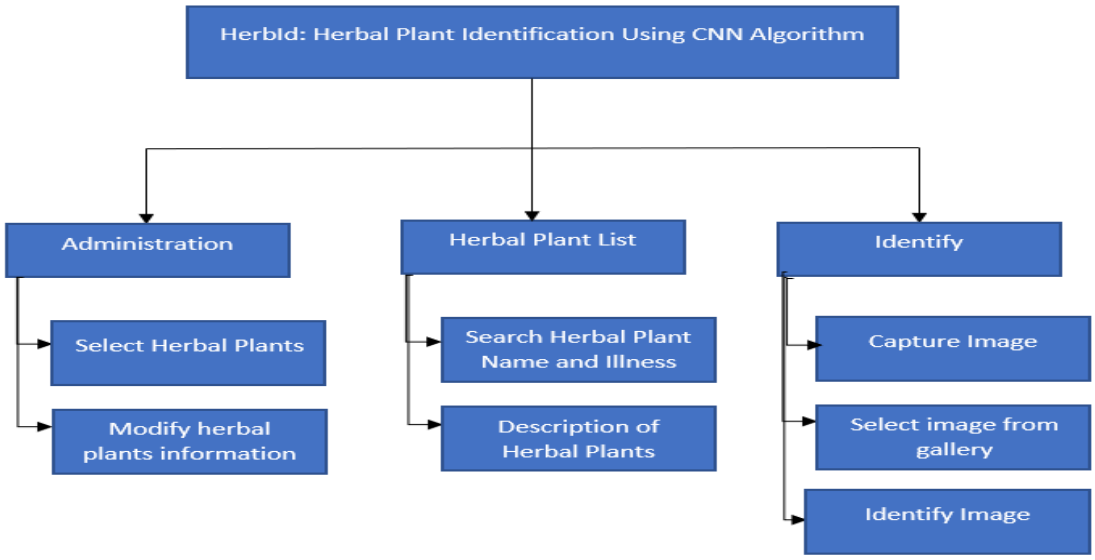


Figure 8. Program Hierarchy

Functional Requirement

The function of a software system or component was specified by its functional requirements. Three components made up a function: inputs, behavior, and outputs. Functional requirements included processes like calculations, technical specifications, data processing and manipulation, and other particular functionality that outlined what a system was intended to do. A prototype was used to assist in determining the functional requirements. A functioning prototype was developed in close cooperation with the owner of Jolit's Eco Garden in order to strategically identify functional requirements. Also, functionalities and modules were based upon the existing standard operating procedures of Jolit's Eco Garden. The resulting functionalities were as follows:

Process Log in

FREQ 1: Access to the system administration should be limited to the

Owner of Jolit's Eco Garden.

FREQ 2: The system should limit module accessibility corresponding their access rules and privileges.

FREQ 3: All information gathered should be saved and secured.

Process Acquisition

FREQ 4: The system should include the information of herbal plants.

Process Identification

FREQ 5: The system should take picture of herbal plants.

FREQ 6: The system should use machine learning model to identify images.

Generation of Reports

FREQ 7: The system should generate accuracy report after the identification of herbal plants.

FREQ 8: The system should display the information of identified herbal plants.

Sorting Herbal Plants Data

FREQ 9: The user can search the herbal plants according to their scientific names.

FREQ 10: The user can sort the herbal plants according to the illness they can cure.

Log out

FREQ 11: The system should automatically log out when the administration is not in use.

Non-Functional Requirement

A non-functional requirement specifies criteria that can be used to evaluate a system's functioning rather than specific actions. Functional requirements, on the other hand, describe specific behaviors or functions. The system design will include a plan for implementing functional requirements.

NFREQ 1: The system should be implemented with internet connection.

NFREQ 2: Classified modules must run on mobile device (Android).

Test Cases

Test Case is a set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular program path or to verify compliance with a specific requirement. A tester would determine whether an application or software system is working correctly or not, a detailed procedure that fully tests a feature or an aspect of a feature.

Test Case 1:

Module: Log-in

Severity 1:

Instructions:

1. Open HerbID android app
2. Click admin button
3. Fill in Email and Password
4. Click “Log – in” button

Expected Result:

The admin can now log-in to the HerbID app administration page and manage the herbal plants information.

Test Case 2:

Module: Identify Herbal Plant

Severity: 1

Instructions:

1.In bottom navigation bar, Click identify  button.

2.Users can click the camera  button to capture image or click the gallery  button to select images from the device. After selecting image to identify, the user will click the identify  button to identify the image.

Expected Result:

Users can identify the herbal plants image.

Test Case 3:

Module: Search Herbal Plants

Severity: 1:

Instructions:

1. In bottom navigation bar, Click plant list  button.
2. In the top corner click search bar, users can type the name of the herbal plants,

illness and attributes of herbal plants.

Expected Result:

Users can search herbal plants.

Technical Requirements

Users need to choose the right hardware and software for our Android app, and identify the people who will use it.

Hardware refers to the physical parts of the device, like the screen, processor, memory, storage, and battery.

Software includes all the programs and instructions that make the app work.

Peopleware is about the people who will use the app, like students, teachers, and herbal plant consumers. Everyone who uses the app needs to understand how to use it effectively.

Lastly, a network is like a system that connects different devices, allowing them to communicate with each other.

Minimum Hardware Specification

Table 8 show the minimum hardware specification that is highly needed by the system in order to function properly as designed and expected. These requirements were based on what was offered by most computer package systems and what is currently on the market.

Table 8. Minimum Android Hardware Specification

COMPONENT	SPECIFICATION
CPU	DUAL CORE AND UP
RAM	2 GB
ROM	4GB
CONNECTIVITY	WIFI or LTE

Minimum Software Specification

The Owner of Jolit's Eco Garden in Cambacay, Batuan requires various software to function properly. This software was enumerated below with its corresponding specification on the computer unit utilize the development of the system. Table 9 show the Minimum Software Specification.

Table 9. Minimum Software Specification

COMPONENT	SPECIFICATION
Operating System	Android
Android Version	At least Android 6.0

Business Intelligence Integration

Business Intelligence (BI) refers to the technologies, tools, and practices that collect, integrate, analyze and present large volumes of information to enable better decision making. It is a set of theories, methodologies, processes, architecture, and technologies that transform raw data into meaningful and useful information for business purposes. It aims to support business technique and

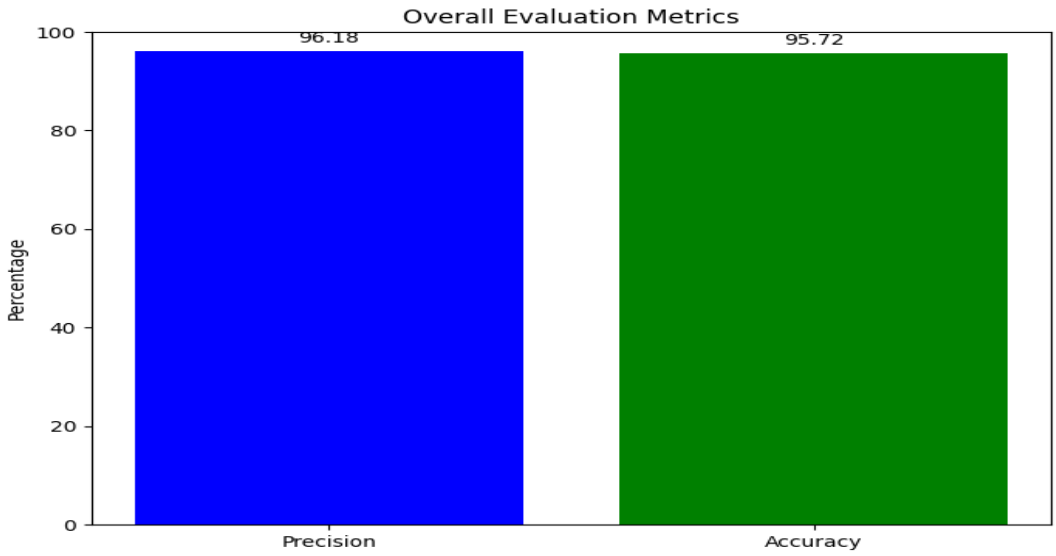
decision making with a solution that takes the business intelligence to a whole new level and getting the like information. In the context of evaluating the machine learning model created, the researchers used bar graph specifically to visualize the model's performance metrics specifically precision, recall, F1, and accuracy.

Precision measures the proportion of true positive predictions among the total predicted positive cases. Accuracy represents the overall proportion of correct predictions (both positive and negative).

The reports represented how the business intelligence is applied in the developed system. The x-axis represents the categorical evaluation metrics. The y-axis represents the corresponding score for each metric, ranging from 0 to 100. These reports show the preview 1 CNN performance evaluation.py and preview 2 Evaluation Metrics.

```python
import os
import numpy as np
import tensorflow as tf
from keras.preprocessing.image import ImageDataGenerator
from keras.applications.mobilenet_v2 import preprocess_input
from sklearn.metrics import accuracy_score, precision_score
import matplotlib.pyplot as plt

# Load the saved model
path_for_saved_model = "C:/Users/USER/tensored-django-main/MobileNetV3/dataset_for_model/mobileNetModel4.h5"
model = tf.keras.models.load_model(path_for_saved_model)

# Define the path to the dataset
test_data_path = "C:/Users/USER/tensored-django-main/MobileNetV3/unseen_image/validate"

# Create a test data generator
test_datagen = ImageDataGenerator(preprocessing_function=preprocess_input)

# Load the test dataset
test_generator = test_datagen.flow_from_directory(
    test_data_path,
    target_size=(224, 224),
    batch_size=1,
    class_mode='categorical',
    shuffle=False
)

# Predict probabilities for the test data
y_prob = model.predict(test_generator)

# Get the true labels for the test data
y_true = test_generator.classes

# Compute precision, recall, and F1 score for each class
precision = dict()

for i in range(len(test_generator.class_indices)):
    y_pred = np.argmax(y_prob, axis=1)
    precision[i] = precision_score(y_true == i, y_pred == i) * 100

# Compute accuracy
accuracy = accuracy_score(y_true, y_pred) * 100

# Calculate overall average precision, recall, F1 score, and accuracy
overall_precision = np.mean(list(precision.values()))
overall_accuracy = accuracy_score(y_true, y_pred) * 100

# Plot the overall metrics
plt.figure(figsize=(8, 6))
plt.bar(['Precision', 'Accuracy'], [overall_precision, overall_accuracy], color=['blue', 'green'])
plt.ylabel('Percentage')
plt.title('Overall Evaluation Metrics')
plt.ylim(0, 100)
```

Preview 1: CNN Performance Evaluation.py



Preview 2: Evaluation Metrics

Server Implementation

Model deployment or online inference service is a service that enables organizations and individuals to make their trained machine learning models accessible over the internet. A model deployment service provider provides the technologies and infrastructure needed for the model to receive input data and provide predictions or results in return. Models are deployed and run-on specialized servers or computing instances. When users want to make predictions using a deployed model, they send input data to the model's endpoint via an API (Application Programming Interface). The model processes the data and returns the predictions or results back to the users' devices through the API.

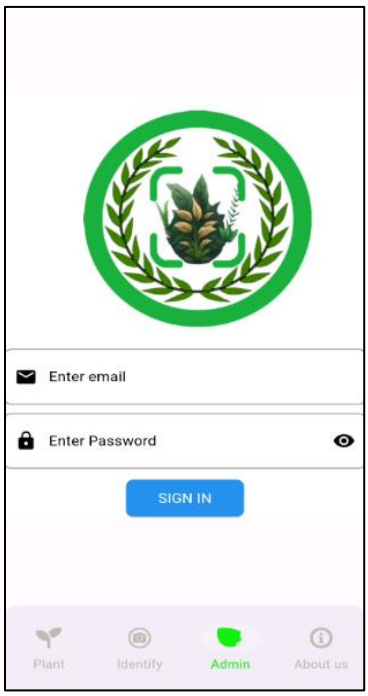
In the proposed system, the researchers utilized Firebase, a Backend-As-A-Service (BAAS) infrastructure which offers tools and services on demand such as database, authentication, messaging, crash analytics and more in storing data

and information of the tree species. The researchers utilized Pythonanywhere, a cloud-based platform that allows for easy deployment and hosting of Python applications. By leveraging Pythonanywhere, the trained model can be deployed and made accessible to the mobile platform seamlessly. This platform provides a convenient environment for running Python scripts, web applications, and scheduled tasks, making it an ideal choice for deploying machine learning models. With Pythonanywhere, the researchers ensured that their trained model is efficiently deployed and accessible to users on various mobile platforms, enhancing the reach and usability of their system.

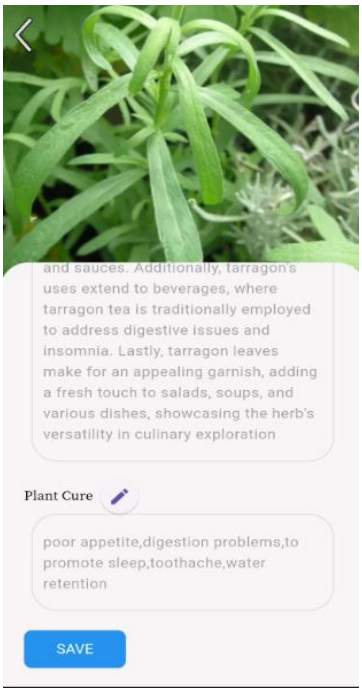
Screen Layout

The system's screen layout is crucial for making it easy for users to navigate and understand what they need to do. It's about arranging things like text, buttons, and menus on the screen in a clear and organized way. This layout plays a big role in how people use software and websites, making sure information is easy to find and use. By designing the layout carefully, we can create an interface that feels natural and enjoyable to use.

In the system, researchers designed various views like the Admin Login, Modification of Herbal Plants, Identification, Identification Result, Herbal Plants Description, and Herbal Plants List. Each of these views gave users a glimpse of how the screen layout has been carefully arranged to make it user-friendly and visually appealing. It's all about making sure users can navigate through the system effortlessly and get things done without any hassle.

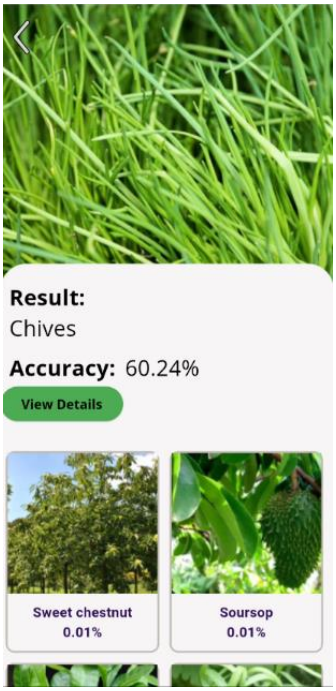


Preview 3: Admin Login View



Preview 4. Herbal Plants Modification View

Preview 5: Identification View



Preview 6: Identification Result View

Preview 7: Herbal Plants Description View

Economic Performance Evaluation

Table 10 shows the initial investment and annual operating costs of HerbID system. HerbID economic performance was assessed in terms of initial investment. The initial investment was the amount required by the client prior to the start of the system's operation and deployment.

Table 10. Initial Investment and Annual Operating Costs

Item	Qty	Unit	Unit Price	Total
A. **Initial Investment**				
1. **Hardware**				
Android Mobile Phone	2	Pieces	₱ 6,000.00	(Existing)

Wifi Modem	1	Pieces	₱ 5,000.00	(Existing)

2. **Software**

Model Deployment	12	Month	₱ 675.00	₱ 8,100.00
Internet	12	Month	₱ 1,300.00	₱ 15,600.00
Total Initial Investment Cost				**₱ 23,700.00**

B. **General Services**

System Maintenance	4	Quarter	₱ 1,500.00	₱ 6,000.00
Sub-total General Services Cost				**₱ 6,000.00**
Total				**₱ 29,700.00**

Testing And Evaluation

Testing evaluation refers to the process of assessing the effectiveness, accuracy, and comprehension of software testing activities. Testing evaluation helps it determine if the software meets the specified requirements and performs as expected. It involves analyzing test results, identifying defects, tracking defects to resolution, and generating reports to provide insights into the overall quality of the software.

The testing and evaluation were conducted at Bohol Island State Univesity – Bilar Campus and Jolit's Eco Garden from April 8 to 9, 2024, aimed to assess the performance and usability of the mobile app under development. The respondents included 2 herbal plant consumer, 5 IT experts and 8 BSCS student.

Through the collaboration of the selected respondents, the evaluation shown valuable and positive feedback for enhancing the mobile app.

Usability Tool Using the ISO 25010

The data and feedback collected were now prepared for validation and verification to enable researchers to determine the quality features of their developed project.

The Likert Scale had been used to interpret the respondents' responses. Random individuals responded to the outcomes of the feedback collected on the quality features of the developed project.

The researchers were able to determine their developed project using ISO 25010. Using the ISO 25010, the project's quality features were defined by functionality suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

System Usability

Table 11 shows below the based on the results of the system usability test using the questionnaire prepared by ISO 25010, the target users perceived the system to be acceptable with a general rating of "Agree". The respondents stated that the system was suitable for recording student data and met their expectations in terms of functions and capabilities. There may be room for improvement but overall, the system performed well in the test.

Table 11: System Usability

Criteria for System Usability		Weighted Mean	Rating Strongly Agree
Functionality Suitability			
	Functional completeness	4.55	Agree
	Functional correctness	4.45	Agree
	Functional appropriateness	4.45	Agree
Performance Efficiency			
	Time behavior	4.15	Agree
	Resource utilization	4.4	Agree
	Resource utilization	4.20	Agree
Compatibility			
	Co-existence	4.50	Agree
	Interoperability	4.30	Agree
Usability			
	Appropriateness Recognizability	4.28	Agree
	Learnability	4.70	Strongly Agree
	Operability	4.65	Strongly Agree
	User error protection	4.45	Agree
	User interface aesthetics	4.56	Agree
	Accessibility	4.35	Agree
Reliability			
	Maturity	4.48	Agree
	Availability	4.45	Agree
	Recoverability	4.40	Agree
Security			
	Confidentiality	4.65	Strongly Agree
	Integrity	4.6	Strongly Agree
	Accountability	4.40	Agree
	Authenticity	4.65	Strongly Agree
	Non-repudation	4.56	Agree
Maintainability			
	Modularity	4.30	Agree
	Reusability	4.65	Strongly Agree
	Analyzability	4.45	Agree
	Modifiability	4.4	Agree
	Testability	4.4	Agree
Portability			
	Adaptability	4.68	Strongly Agree
	Installability	4.65	Strongly Agree

	Replaceability	4.4	Agree
Overall Mean		**4.47**	**Agree**

CHAPTER 3

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATION

Summary of Findings

After a thorough study and analysis of the present system, the developers found that the existing system of identifying herbal plants at Jolit's Eco Garden lacks a reliable herbal plant identification tool that would help herbal plant consumers decide in identifying herbal plant species effectively. As a result, herbal plant consumers rely on the traditional method of identifying herbal plants by visually identifying it and decide base on their own knowledge and experience. This reliance on traditional method can be time-consuming and prone to error. To address the existing issues and help in effective decision-making process, the researchers proposed the implementation of the HerbID: Herbal Plant Identification Using Convolutional Neural Network Algorithm. This innovative solution aimed to help herbal plant consumers in an efficient and accurate decision-making process of identifying herbal plants.

The system successfully achieved the desired outcome by accurately identifying herbal plants utilizing various machine learning techniques, specifically the CNN algorithm. With a total of 20,000 unseen images, achieving a precision of 96.18% implies that for every instance in the dataset. With a dataset consisting of 20 herbal plants as classes and 7,200 images per class, the total number of images available is 20 × 7,200 = 144,000 images. This implies that the entire dataset of 144,000 images serves as the training dataset. This extensive dataset allows the

model to learn and generalize patterns effectively across all classes, contributing to its accuracy and robustness in identification tasks.

Based on the result of using CNN Algorithm. The use of CNN algorithm also demonstrated significant accuracy in identifying herbal plants, similar to the findings of Daryl B. Valdez study, where we agree with his findings.

Based on the needs identified, the developed system was developed with the following modules: data management, machine learning, and reports. The developed system was pilot tested and evaluated in terms of system usability. Based from the results of the survey, the respondents gave a rating for the system usability result with an interpretation of “Agree”. The result generally indicated that the system was usable in identifying herbal plants. Specifically, the expectations of the respondents as of functions and capabilities had been achieved by the system. Moreover, the system has clear organization of information, the content was very comprehensive with good user interface and ease of use.

Conclusions

Based on the findings of the study, the researchers concluded that the development of the system, “HerbID: Herbal Plant Identification Using CNN Algorithm," have successfully provided herbal plant consumers with an informative tool that helps herbal plant consumers’ decision-making process in identifying herbal plants more accurate and meet the requirements and expectations of the clients, which presumably the Jolit’s Eco Garden.

Moreover, the model trained achieved a accuracy rate of 95%. This highlights that CNN algorithm improves the system’s performance in developing robust machine learning models.

To address these issues, a solution called "HERBID: HERBAL PLANTS IDENTIFICATION USING CNN ALGORITHM" was introduced. This system aimed to identify herbal plants accurately in the garden. Based on the study's conclusions, it was determined that HerbID successfully enhanced the identification of herbal plants and met the requirements and expectations of the client, which presumably refers to Jolit’s Eco Garden.

Furthermore, HerbID system requires minimal investment and incurs low operational costs. This implies that implementing the system is affordable and economically feasible for the herbal plant consumers. By minimizing the financial burden associated with system adoption and operation, the system becomes a cost-effective solution for herbal plant identification in Jolit’s Eco Garden.

In summary, the study's findings indicate that herbal plant consumers’ identification of herbal plants was lacking a comprehensive tool that help on their decision-making process and relied on inefficient traditional processes. However, the introduction of the HerbID system resulted in a more accurate and reliable decision-making process in identifying herbal plants and aligned with the department’s requirements and expectations. Furthermore, the system was considered affordable and economical due to its minimal investment and low operational costs.

Recommendation

The researchers came up with the following recommendations for improving the performance and accuracy of the application based on the results and findings.

1. Explore alternative deployment options that can accommodate the computational requirements of the model. This involve utilizing cloud-based solutions and optimizing the model to reduce its memory footprint while maintaining performance.

2. Continue collecting and annotating additional image data to further enhance the model's accuracy and robustness. Additionally, ongoing refinement of the machine learning algorithms and feature extraction techniques can contribute to continuous improvement in classification accuracy.

3. Expand the herbal plant species database within the Tree-Learn system to include additional species that are present on campus. Incorporating a wider range of species will broaden the system's applicability and provide students with a more comprehensive learning experience in tree species identification

REFERENCES

REFERENCES

Ahad, B., Shahri, W., Rasool, H., Reshi, Z.A., Rasool, S., Hussain, T. (2021). Medicinal Plants and Herbal Drugs: An Overview. In: Aftab, T., Hakeem, K.R. (eds) Medicinal and Aromatic Plants. Springer, Cham. https://doi.org/10.1007/978-3-030-58975-2_1

Abdollahi, J. (2022, February). Identification of medicinal plants in ardabil using deep learning: identification of medicinal plants using deep learning. In 2022 27th International Computer Conference, Computer Society of Iran (CSICC) (pp. 1-6). IEEE.

Barbosa, J. B., Jabunan, V. I., Lacson, T. K. A., Mabaylan, M. L. W., & Napone, G. M. (2017). HerbApp: A Mobile-Based Application for Herbal Leaf Recognition Using Image Processing and Regularized Logistic Regression Classifier1. *International Journal of Innovative Science and Research Technology*, 2(10), 651-658.

Blum, A. (2007). Machine learning theory. Carnegie Melon University, School of Computer Science, 26. Retrieved from https://www.cs.cmu.edu/afs/cs/user/avrim/www/Talks/mlt.pdf

Roopashree, S., & Anitha, J. (2021). DeepHerb: a vision based system for medicinal plants using xception features. IEEE Access, 9, 135927-135941.

Shaheen, S., Ramzan, S., Khan, F., Ahmad, M. (2019). Why Study Herbal Plants?. In: Adulteration in Herbal Drugs: A Burning Issue. Springer, Cham. https://doi.org/10.1007/978-3-030-28034-5_3

Sharrab, Y., Al-Fraihat, D., Tarawneh, M., & Sharieh, A. (2023, June). Medicinal Plants Recognition Using Deep Learning. In 2023 International Conference on Multimedia Computing, Networking and Applications (MCNA) (pp. 116-122). IEEE.

Thanaa Hasan Yousif, Nahla Ali Tomah, Marwa Jaleel Mohsin (2023). Machine Learning-based diagnosis of eye-diseases. http://doi.org/10.11591/ijeecs.v32.i2.pp787-795

Valdez, D. B., Aliac, C. J. G., & Feliscuzo, L. S. (2022, September). Medicinal Plant Classification using Convolutional Neural Network and Transfer Learning. In 2022 IEEE International Conference on Artificial Intelligence in Engineering and Technology (IICAIET) (pp. 1-6). IEEE.

Yin, Y., & Lin, L. (2022). Predictors of customers' continuance intention of mobile. Retrieved from https://www.tandfonline.com/doi/full/10.1080/1331677X.2022.2

Zarsuelo, M.-A. M., Zordilla, Z. D., & Anacio, D. B. (2018). Review of Regulatory Policies on and Benefits of Herbal Medicine in the Philippines. Acta Medica Philippina, 52(5). https://doi.org/10.47895/amp.v52i5.334

Chen, S., Pang, X., Song, J., Shi, L., Yao, H., Han, J., & Leon, C. (2014). A renaissance in herbal medicine identification: from morphology to DNA. Biotechnology advances, 32(7), 1237-1244.

TechTarget. (2023, April 24). What are convolutional neural networks? Definition from TechTarget. Enterprise AI. Retrieved June 6, 2023, from https://www.techtarget.com/searchenterpriseai/definition/convolutional-neural-network

El Naqa, I., & Murphy, M. J. (2015). What is machine learning? (pp. 3-11). Springer International Publishing.

International Organization for Standardization. (2009). Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuaRE) – System and software quality models (ISO Standard No. 25010:2009).

APPENDICES

APPENDIX A

LETTER OF INTENT

BOHOL ISLAND STATE UNIVERSITY
Bilar Campus
Department of Computer Science Office

BAGONG PILIPINAS

Vision: *A premier Science and Technology university for the formation of world class and virtuous human resource for sustainable development in Bohol and the country.*

Mission: *BISU is committed to provide quality higher education.in the arts and sciences, as well as in the professional and technological fields; undertake research and development and extension services for the sustainable development of Bohol and the country.*

August 14, 2023

Jomer M. Balag
Jolit's Eco Garden Owner
Cambacay, Batuan, Bohol

Greetings!

We, the 4th year students of the Bachelor of Science in Computer Science of Bohol Island State University, will conduct a system development project titled "Herb-Id: Herbal Plants Identification using CNN(Convolutional Neural Network) Algorithm" as a requirement for the Bachelor of Science in Computer Science curriculum.

In this regard, we ask your good office to accommodate us for a short office visit at any time convenient to personally ask permission to conduct a systematic study based on your expertise in Herbal Plants Identification using CNN(Convolutional Neural Network) Algorithm.

We assure you that we shall honor secrecy and privacy to all data and information we handle as we continue our study. Our data collection method shall include interviews, observation, and document review. Your approval will be a great help to the success of our research.

We anticipate your favorable response. Thank you very much, and more power!

Truly yours,

ARSENIO L. PACATANG JR.
Researcher

IRISH BUÑAO
Researcher

MARK JAIRUS BETINOL
Researcher

Noted by:

JOEL A. PIOLLO, MATCS
Thesis Adviser

Noted by:

RENANTE S. DIGAMON, Ph.D.
Subject Instructor

Endorsed by:

SHEILA G. TABUNO, MSTCS
Chairperson, BISU-Bilar Campus(DCoS)

Endorsed by:

ARLEN B. GUDMALIN, Ph.D.
Dean, BISU-Bilar(CTAS)

Approved by:

JOMER M. BALAG
Jolit's Eco Garden Owner

APPENDIX B

LETTER OF IMPLEMENTATION

BOHOL ISLAND STATE UNIVERSITY
Bilar Campus
College of Technology and Allied Sciences

BAGONG PILIPINAS

Vision: *A premier Science and Technology university for the formation of world class and virtuous human resource for sustainable development in Bohol and the country.*

Mission: *BISU is committed to provide quality higher education in the arts and sciences, as well as in the professional and technological fields; undertake research and development and extension services for the sustainable development of Bohol and the country.*

April 8, 2024

MR. JOMER M. BALAG
Owner, Jolit's Eco Garden
Cambacay, Batuan, Bohol

Dear Sir Jomer,

Greetings!

It is our pleasure to inform you that the system "HerbID: Herbal Plants Identification" is now its final phase. With this, we would like to conduct benchmarking activities as part of the implementation.

This will be conducted on April 8, 2024 in your garden at any time of your convenience. This activity will allow you assess and developed system and give feedback, as well.

But this time, we would like to express our gratitude for allowing us to conduct our thesis study. We are hoping for future collaboration with you, our dear client.

May the good Lord continually bless you and your good office.

Thank You and more power!

Truly yours,

ARSENIO L. PACATANG JR.
Researcher

MARK JAIRUS P. BETINOL
Researcher

IRISH R. BUÑAO
Researcher

Noted by:

LEONIDA P. REVILLA
Subject Instructor

Endorsed by:

JOEL A. PIOLLO, MATCS
Chairperson, CSD

NELIA Q. CATAYAS, PhD
Dean, CTAS

F-SAS-ADS-004 | Rev. 1 | 09/18/23 | Page 1 of 2 - Balag

Recommending Approval:

PROCESO M. CASTIL, EdD
Campus Director

Approved by:

MR. JOMER M. BALAG
Owner, Jolit's Eco Garden

APPENDIX C

DOCUMENTATION

APPENDIX D

System Usability Questionnaire to Determine the Functionality, Performance, Compatibility, Usability, Reliability, Security, Maintainability, Portability, Maintainability and Portability of HerbID using ISO-25010

Instructions:

- Please rate the usability of the system
- Try to respond to all the items
- For items that are not applicable, use N/A
- Make sure these fields are filled in

Rating Scale:

5- Strongly Agree

4- Agree

3- Neutral

2- Disagree

1- Strongly Disagree

FUNCTIONALITY SUITABILITY	**5**	**4**	**3**	**2**	**1**
Functional completeness. The set of functions covers all the specified tasks and user objectives.					
Functional correctness. The project provides the correct results with the needed degree of precision.					
Functional appropriateness. The functions facilitate the accomplishment of specified tasks and objectives.					
PERFORMANCE EFFICIENCY	**5**	**4**	**3**	**2**	**1**
Time behavior. The response and processing times and throughout rates of a product or system, when performing its functions, meet requirements.					
Resource utilization. The amounts and types of resources used by a product or system, when performing its functions, meet requirements.					
Resource utilization. The maximum limits of a product or system parameter meet requirements.					
COMPATIBILITY	**5**	**4**	**3**	**2**	**1**

Co-existence. A product can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product.					
Interoperability. Two or more systems, products or components can exchange information and use the information that has been exchanged.					
USABILITY	**5**	**4**	**3**	**2**	**1**
Appropriateness Recognizability. Users can recognize whether a product or system is appropriate for their needs.					
Learnability. The project can be used by specified users to achieve specified goals of learning to use the product or system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use.					
Operability. The project has attributes that make it easy to operate and control.					
User error protection. The project protects user against making errors.					
User interface aesthetics. User interface enables pleasing and satisfying interaction for the user.					
Accessibility. The project can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use.					
RELIABILITY	**5**	**4**	**3**	**2**	**1**
Maturity. The project or component meets needs for reliability under normal operation.					
Availability. The project or component is operational and accessible when required for use.					
Recoverability. In the event of an interruption or a failure, the project can recover the data directly affected and re-establish the desired state of the system.					
SECURITY	**5**	**4**	**3**	**2**	**1**
Confidentiality. The project ensures that data are accessible only to those authorized to have access.					
Integrity. The project or component prevents unauthorized access to, or modification of, computer programs or data.					
Accountability. The actions of an entity can be traced					

uniquely to the entity.					
Authenticity. The identity of a subject or resource can be provided to be the one claimed.					
Non-repudiation. Actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later.					
MAINTAINABILITY	**5**	**4**	**3**	**2**	**1**
Modularity. The project is composed of discrete components such that a change to one component has minimal impact on other components.					
Reusability. An asset can be used in more than one system, or in building other assets.					
Analyzability. The effectiveness and efficiency with which it is possible to assess the impact on the project of an intended change to one or more of its parts, or to diagnose a project for deficiencies or causes of failures, or to identify parts to be modified.					
Modifiability. The project can be effectively and efficiently modified without introducing defects or degrading existing product quality.					
Testability. The effectiveness and efficiency with which test criteria can be established for the project and test can be performed to determine whether those criteria have been met.					
PORTABILITY	**5**	**4**	**3**	**2**	**1**
Adaptability. The degree to which a product or system can effectively and efficiently be adapted for different or evolving hardware, software, or other operational or usage environments.					
Installability. The effectiveness and efficiency with which a product or system can be successfully installed and/or uninstalled in a specified environment.					
Replaceability. A product can replace another specified software product for the same purpose in the same environment. diagnose a project for deficiencies or causes of failures, or to identify parts to be modified.					

APPENDIX E

GUIDE QUESTIONS FOR THE INTERVIEW

For Owner:

1. What are your manual process for identifying herbal plants?
2. How will you know the description of herbal plants?
3. How will you know the procedure in processing herbal plants to become herbal medicine?
4. Are you willing to cooperate with us, to establish an herbal plants identification application?

APPENDIX F

User's Manual

A. Admin Login

Step:

1. Open the application HerbID
2. Click "Admin" button
3. Fill in Email and Password
4. Click "Sign in" button

B. Admin Page

Step:

1. Select Herbal Plant
2. Modify the information of the Herbal Plants
3. Click "Save" button

C. Identification Page

Step:

1. Click button to capture image or click button to select image from gallery
2. Click to identify image

D. Plant List

Step:

1. Click button navigate to plant list
2. Select image in plant list to show the description
3. To search for herbal plants, input their respective names, including the common name, scientific name, and their associated uses or cure

APPENDIX G

SOURCE CODE

Upload_image.dart

```
class ImageImplService implements
ImageService {

 Future<Either<AppException,
Prediction>> uploadPlant(File image)
async {
  try {
    final url = Uri.parse(AppUrl.hostUrl);
    final request =
http.MultipartRequest('POST', url);
    final file = await
http.MultipartFile.fromPath('image',
image.path);
    request.files.add(file);

    final response = await request.send();

    if (response.statusCode == 200) {
      final responseBody = await
response.stream.bytesToString();
      final Map<String, dynamic>
responseJson =
jsonDecode(responseBody);

      final String prediction =
responseJson['prediction'];
      final double accuracy =
responseJson['confidence'];
      final List<dynamic>
lowAccuracyPredictions =
responseJson['all_predictions'];

      final List<String> otherPredictionList
= [];
      final List<String> otherAccuracyList
= [];

      for (var item in
lowAccuracyPredictions) {
        final String predictionClass =
item['class'];
        final double confidence =
item['confidence'];
if (confidence != 0.00) {
otherPredictionList.add(predictionClass)
;

otherAccuracyList.add(confidence.toStri
ng());
        }
        //
otherPredictionList.add(predictionClass)
;
        //
otherAccuracyList.add(confidence.toStri
ng());
      }

      print(otherPredictionList.length);
      print(otherPredictionList);
      print(otherAccuracyList.length);

      return Right(Prediction(
        prediction: prediction,
        accuracy: accuracy.toString(),
        otherPrediction:
otherPredictionList,
        otherAccuracy: otherAccuracyList,
      ));
    } else {
      throw Exception('Failed to upload
image');
    }
  } catch (e) {
    rethrow;
  }
}

}
```

predict.py

```
# Define the list of classes
categories = ['Alugbati',
          'American Mint', 'Tuwaytuway',
          'Blueternate', 'Chestnut',
```

```
'Chives',
        'Passion Fruit', 'Guava',
        'Guyabano', 'Lagundi', 'Lemon',
        'Malunggay', 'Mexican Mint',
'Miracle Fruit',
        'Stevia', 'Sweet Basil', 'Taragon',
'Tawatawa',
        'Wansoy', 'Wachichao']

# Load the pre-trained MobileNetV2
model
model_path =
os.path.join(settings.BASE_DIR,
'mobileNetModel4.h5')
model =
tf.keras.models.load_model(model_path
)

class
CustomFileSystemStorage(FileSystemS
torage):
    def get_available_name(self, name,
max_length=None):
        self.delete(name)
        return name

@csrf_exempt
def index(request):
    try:
        # Initialize variables
        predictions = []

        # Save the uploaded image
        image_file =
request.FILES["image"]
        fs = CustomFileSystemStorage()
        filename =
fs.save(image_file.name, image_file)
        path = str(settings.MEDIA_ROOT)
+ "/" + image_file.name

        # Read the image
        img = Image.open(path)
        img = img.resize((224, 224),
Image.BILINEAR)
        x = image.img_to_array(img)
        x = np.expand_dims(x, axis=0)
        x = preprocess_input(x)

        # Predict the class probabilities
        pred = model.predict(x)[0]
        top_index = np.argmax(pred)
        top_prediction =
categories[top_index]
        top_prediction_confidence =
round(pred[top_index] * 100, 2)

        # Get the top predictions and their
probabilities
        for index, confidence in
enumerate(pred):
            if index != top_index:
                category = categories[index]
                confidence =
round(confidence * 100, 2)
                predictions.append({"class":
category, "confidence": confidence})

        # Delete the uploaded image
        fs.delete(filename)

        # Return the top predictions along
with the top prediction and its
confidence
        return JsonResponse({
            "prediction": top_prediction,
            "confidence":
top_prediction_confidence,
            "all_predictions": predictions,
        })

    except Exception as e:
        return JsonResponse({"error":
str(e)}, status=500
```

RESEARCHER'S BIODATA

Name : Arsenio L. Pacatang Jr.

Place of Birth : Poblacion Sur,
Carmen, Bohol

Age : 23 years old

Home Address : Poblacion Vieja,
Batuan, Bohol

Email Address : ajpacatang1234@gmail.com

Religion : Roman Catholic

Citizenship : Filipino

Father's Name : Arsenio T. Pacatang

Mother's Name : Aileen B. Pacatang

EDUCATIONAL BACKGROUND

Primary : Lungsod-Daan Elementary School
Poblacion Vieja, Batuan, Bohol
S.Y. 2013-2014

Secondary
Junior High School : Batuan National High School
Poblacion Vieja, Batuan, Bohol
S.Y. 2017-2018

Senior High School : Saint Anthony Academy
Poblacion Sur, Batuan, Bohol
ICT - Information & Communication Technology
S.Y. 2019-2020

Tertiary : Bohol Island State University – Bilar Campus
Zamora, Bilar, Bohol
A.Y. 2023-2024

Degree Earned : Bachelor of Science in Computer Science

Work Experience : On-the-Job Training
Blendit Phillippines
Bool District, Tagbilaran City, Bohol
June- August 2023

RESEARCHER'S BIODATA

Name : Mark Jairus P. Betinol
Place of Birth : Tagbilaran, City, Bohol
Age : 22 years old
Home Address : Calunasan, Norte,
Loboc, Bohol
Email Address : markjairusbetinol@gmail.com
Religion : Roman Catholic
Citizenship : Filipino
Father's Name : Apolinar A. Betinol
Mother's Name : Nicefora B. Palen

EDUCATIONAL BACKGROUND

Primary : Bartolome Doria Elementary School
Calunasan, Norte, Loboc, Bohol
S.Y. 2013-2014

Secondary
Junior High School : Pedro S. Budiongan High School
Montesuerte, Carmen, Bohol
S.Y. 2017-2018

Senior High School : Pedro S. Budiongan High School
Montesuerte, Carmen, Bohol
TVL:GAS- General Academic Strand
S.Y. 2019-2020

Tertiary : Bohol Island State University – Bilar Campus
Zamora, Bilar, Bohol
A.Y. 2023-2024

Degree Earned : Bachelor of Science in Computer Science

Work Experience : On-the-Job Training
Provincial Capitol of Bohol
Gov Lino I. Chatto Drive,Tagbilaran City, Bohol
June – August 2024

RESEARCHER'S BIODATA

Name : Irish R. Bunao

Place of Birth : Cambacay, Batuan, Bohol

Age : 22years old

Home Address : Cambacay, Batuan, Bohol

Email Address : irishbunao3@gmail.com

Religion : Roman Catholic

Citizenship : Filipino

Father's Name : Florcilo C. Bunao

Mother's Name : Miguela R. Bunao

EDUCATIONAL BACKGROUND

Primary : Lungsod Daan Elementary School
Poblacion Vieja, Batuan , Bohol
S.Y. 2012 - 2013

Secondary

Junior High School : Batuan National High School
Pob.Vieja, Batuan, Bohol
S.Y. 2017-2018

Senior High School : Batuan National High School
Poblacion Vieja , Batuan, Bohol
HUMSS – Humanities and Social Sciences
S.Y. 2019-2020

Tertiary : Bohol Island State University – Bilar Campus
Zamora, Bilar, Bohol
A.Y. 2023-2024

Degree Earned : Bachelor of Science in Computer Science

Work Experience : On-the-Job Training
Municipality of Batuan
Pob. Norte Batuan Bohol
June – August 2024