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Ayurvedic (Herbal) plant identification system
Aayu mobile application - Proposal

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Abstract

Ayurvedic medicine is a very underrated and undervalued sector in the modern world. People with knowledge on Ayurvedic plants are slowly dying out which is very unfortunate. Ayurvedic plants can be used to treat various kinds of diseases ranging from Bone fractures to Neurological diseases. People nowadays carry a lesser knowledge on this valuable aspect of medicine and their usages. Knowledge about this domain among the Younger generation is getting worse day by day. So team Aayu aimed to overcome this matter and develop the knowledge among the people by introducing a modern Mobile Application. The suggested solution, Aayu mobile application is to identify ayurvedic plants and usage of these plants for treatments by scanning the plant leaf. It is expected by team Aayu that this mobile application will enable a path for everyone to discover more about these ayurvedic plants and use those for medicinal purposes effectively.

Acknowledgement

Foremost, team Aayu would like to grant heap of thanks to parents of the members for bearing up with the members and giving them courage, strength and support during the tough situations faced by team Aayu. Also, the team would like to thank the Module Leader, the Feedback committee of the SDGP module for giving valuable feedback every week and correcting whatever mistakes done on the way. The valuable feedback they gave made a huge positive impact on the development of this project. The team also thanks to other academic and non-academic staff at IIT.

Special thanks to domain experts, researchers for providing the necessary knowledge and various kinds of valuable information.

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Abbreviation

- IDE - Integrated development environment
- SRS - System Requirements Specification
- UX/UI - User Experience/ User Interface
- HDD - Hard Disk Drive
- SSD - Solid State Drive
- FTTx - Fiber to the x
- OOP - Object-oriented programming
- UML - Unified Modeling Language
- API - application programming interface
- AVD - Android virtual device
- AWS - Amazon web services
- IEEE - Institute of electrical and electronic engineering
- AI - Artificial Intelligence
- CNN - Convolutional Neural Network
- LSVRC-2012 -Large Scale Visual Recognition Competition 2012
- UKCI - UK Workshop on Computational Intelligence
- FC- Fully connected
- XP - eXtreme Programming
- MVC - Model View Controller
- PRINCE2 - Projects IN Controlled Environments
- PMBOK - Project Management Body of Knowledge
- SDLC - Software Development Life Cycle
- OOD - Object Oriented Design
- FR1 - Functional Requirement 1
- FR2 - Functional Requirement 2
- FR3 - Functional Requirement 3
- FR4 - Functional Requirement 4
- NFR1 - Non-functional Requirement 1
- NFR2 - Non-functional Requirement 2
- NFR3 - Non-functional Requirement 3
- NFR4 - Non-functional Requirement 4

Chapter 1 – Introduction

1.1 Chapter Overview

This initial chapter is focused on establishing the associated domain-related information to provide an in-depth understanding of the problem domain and the proposed solutions. As well as discussing the shortfalls of the solutions currently available are highlighted within this chapter. Furthermore, this chapter will discuss the challenges faced, objectives, and the features of the proposed solution.

1.2 Project Background

This research project is conducted as a requirement for level 5 of the BEng- Software Engineering degree program offered by the University of Westminster in collaboration with the Informatics Institute of Technology.

Ayurvedic medicine is highly regarded within Sri Lanka and the wider South Asian region. Furthermore, many millions of people depend on this branch of medicine to maintain their health and wellbeing. As such this area was selected as the domain for this project.

1.2.1 Introduction to problem

Team Aayu noticed that the knowledge among the general public about ayurvedic medicinal plants is less nowadays and because of that the indigenous medicinal system has been neglected. The main reason was, there wasn't any easy way to identify ayurvedic medicinal plants by the general public. So Aayu mobile application is introduced to solve the above problem where team Aayu has developed an automated system to identify ayurvedic medicinal plants by scanning the leaves of that plant. The following sections discuss the problem domain of the project Aayu.

1.2.1.1 Problem boundary

Traditional systems of medication still are widely experienced on several accounts. Population rise, inadequate supply of medicine, preventative price of treatments, aspect effects of many artificial medications and development of resistance to presently used medication for infectious

diseases have led to enlarged stress on the utilization of plant materials as a supply of medicines for a large form of human ailments.

As such it has been recorded that the usage of herbal medicinal products and supplements has increased tremendously over the past three decades with no less than 80% of people worldwide relying on them for some part of their primary health care (Ekor, 2014). Therefore, having at least a rudimentary knowledge about these medicinal plants could be convenient for all the people in the society.

The problem is, it was noticed by the research team that there isn't much knowledge among the younger generation about these plants. Even though herbal medicine has no side effects, inaccurate treatments may even cause death. Furthermore (Jayanka, M. and Fernando, 2020) and (Dileep and Pournami, 2019) have emphasized above-mentioned complications in a critical manner and provided solutions to a limited extent. Since it has been critically discussed by several research teams, the necessity of a solution for the less discussed areas in Identifying plant leaves from an artificial system has been raised. So the above-mentioned facts manifest the necessity of a fully automated system to correctly classify the medicinal plants is inevitable at this point of time.To clarify the problem background specifically, Aayu team has conducted an online survey.

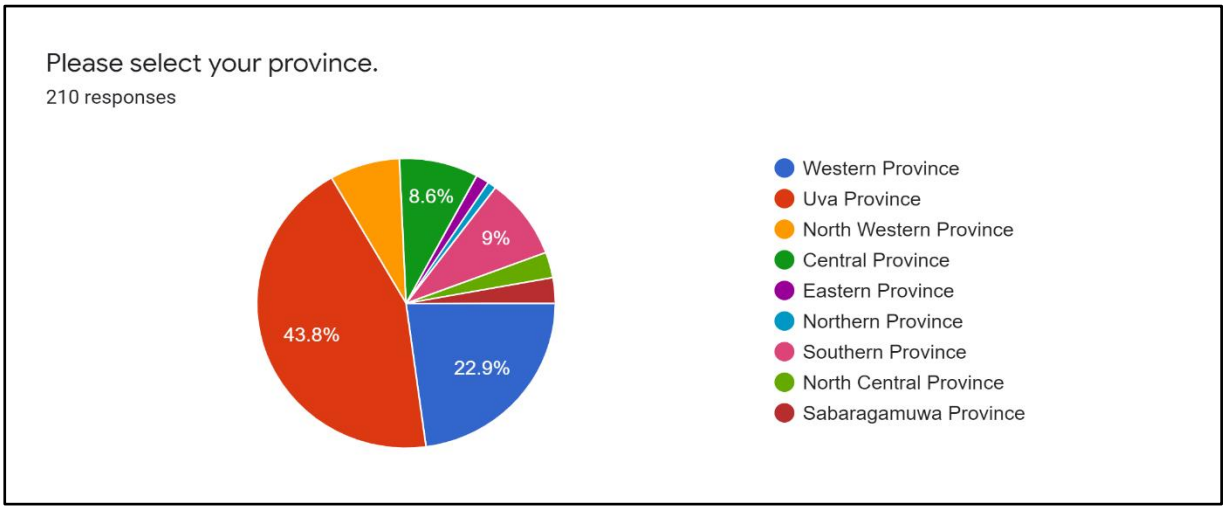

Figure 1 : Distribution of the provinces of respondents

As shown in this figure 1, 210 responses were captured from all the provinces in Sri Lanka. University and college students participated in the survey.

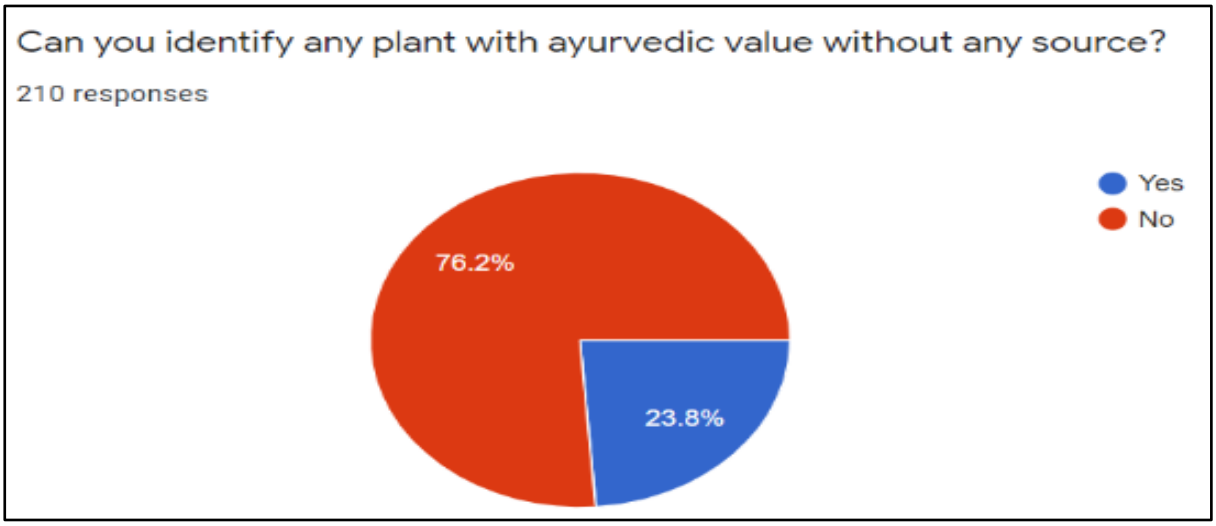

Figure 2 : Percentage of respondents who can and cannot identify ayurvedic plants

Out of 210 responses collected, it was noticed that more than 76.2 % respondents have responded that they cannot identify any plants of medicinal value without any source. Below image authenticates the mentioned percentage.

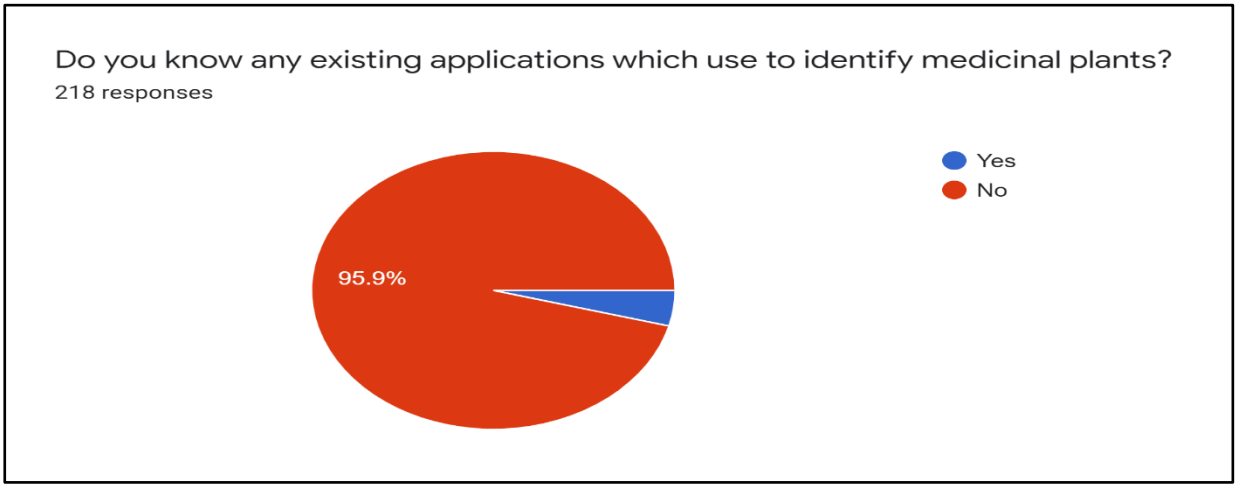

Figure 3 : Percentage of respondents who came across an App that can identify Ayurvedic plants.

As shown in the above figure, more than 95% of respondents claimed that still they cannot find any mobile application used for the identification of Ayurvedic plants.It is obvious that the necessity of an automated system to identify the ayurvedic plants is demanded at the moment within the society.

1.2.1.2 Examples in the problem

Identification of ayurvedic plants is very meticulous art. It requires a great deal of expertise along with years of experience as there are multitudes of plants which have similar physical characteristics. Choosing the wrong plant when making an ayurvedic prescription can have dire consequences. Therefore, this is a job which should be done with utmost caution.

But there are very few people who can accurately locate and recognize these elusive plants. And the number of such people continue to decrease as a result of the lack of interest from the younger generations.

Therefore, Aayu intends to help the public to locate and recognize medical plants that they require to a high degree of accuracy while also making the process more efficient thus promoting the use of indigenous medicine.

1.2.1.3 Attempted solutions of the Competitors

There are multiple tools such as PlantNet and PlantSnap which help users to identify the plants. Whoever all of those solutions are focused mainly on plants in European countries. This means that most of these platforms do not offer the ability to identify ayurvedic plants. Even those that do, don't give information about the ayurvedic medicinal values of the plants.

While there are mobile applications and websites which provide information about ayurvedic medicinal plants, they are not effective in helping one to accurately recognize a plant with a high degree of accuracy.

1.2.2 Problem definition

In the present day, most people lack the knowledge passed on for generations about the ancient art of ayurvedic medicine. But recently there has been a surge in the interest in natural products and herbal remedies. Even though the interest has increased there still exists a gap in the knowledge of ayurvedic medicinal plants. This project has been done in order to tackle this very problem mentioned above.

Introducing a mobile application that enables the general public to identify the plants by scanning their leaves will enable them to learn more about the ayurvedic medicinal plants and remedies created using those plants.

1.2.3 Research questions

Mainly this research project targets to solve the below questions.

- What are the ayurvedic plant types that can be identified?
- What image processing techniques can be used to identify ayurvedic plants?
- How far these techniques could overcome ayurvedic plant identification?

1.3 Aim

Team Aayu has several aims for this project. One of the main aims is to enhance the knowledge about medicinal plants among the people in society. Most of the younger generations have lesser knowledge about the medicinal value of the plants around us. The Aayu team is trying to give knowledge to the younger generation via a familiar medium. So that people can identify ayurvedic plants for their medicinal purposes.

Secondly, Product Aayu will give information about the locations of the plants by using a geotagging system. So that anyone with the mobile app Aayu, will be able to find even the rarest medicinal plants needed for treatments with the help of the geotagging technique.

1.4 Scope

The scope of the project is defined below with In-Scope of the project and out-scope of the project detailed.

1.4.1 In-Scope

As the scope, the system will identify the medicinal plants using image processing. It provides information about the medicinal significance of the plants. Therefore, the user will be able to identify the uses of those plants. Furthermore, the system shows different plants with similar characteristics and shows available locations. Aayu team planned to implement a mobile application where the information of medicinal plants will be displayed in a global language and a local language.

1.4.2 Out of scope

At this point, due to the time constraints, Aayu prototype will identify only 5 selected medicinal plants varieties Additionally, Aayu provides identification methods using damaged medicinal

leaves. In the prototype, the additional feature will be limited to two selected damaged plant species due to the limited timeframe.

1.5 Objectives

1.5.1 Research Objectives

The following are identified as the research objectives of this project.

- To combine AI & image processing technologies with the ayurvedic medical plan identification process.
- To identify the best algorithms which can be used to identify leaf images by using AI.
- To get an understanding of the best model appropriate for the leaf identification system.
- To gain good knowledge about image processing techniques.

1.5.2 Academic Objectives

The following are identified as the academic objectives of this project.

- Improving time management, team working & project management skills.
- Identifying best practices in coding and researching.
- Gaining theoretical knowledge about deep learning and machine learning techniques.
- Applying deep learning and machine learning principles.

1.5.3 Operational Objectives

Objective	Objective Description
Objective 1 - Purpose	• Conducting background research on existing approaches and how to implement Deep Learning and Image Processing. • Conducting a questionnaire survey to get an idea about the public audience regarding the ayurvedic plant leaves. • Explain the problem domain. • Do an analysis with competitors. • Submit a project initiation report
Objective 2 - Gather Data	• Congregate data from plant identification-related websites like www.data.mendeley.com.

	• Information about Medicinal plants was taken from www.instituteofayurveda.org.
Objective 3 - Study and Review of Existing Work	• Team Aayu performs a deep literature survey about previous researches in the domain of leaf identification. • Perform a deep search for necessary technologies that can be used in the project. • Identity necessary algorithms needed for models.
Objective 4 - Design	• Identifying techniques expected to use. • Recognizing appropriate approaches for the design of the system. • Identifying development tools, technologies that suit the projects • Creating the SRS. • Recognizing functional, non-functional requirements of the system.
Objective 5 - Implement	• Utilizing the fitting methodologies and advances distinguished in the Literature Survey. • Enhance the client experience by utilizing the best methods in UX/UI designing. • Build up a pilot model for the system.
Objective 6 - Test	• Execute the prototype, identify reasons for system failures, and fix those. • Analyze issues and prepare a report on test results.
Objective 7 - Evaluate	• Evaluate the final project

Table 1 : Operation objectives table

1.6 Proposed Solution

1.6.1 Rich picture diagram

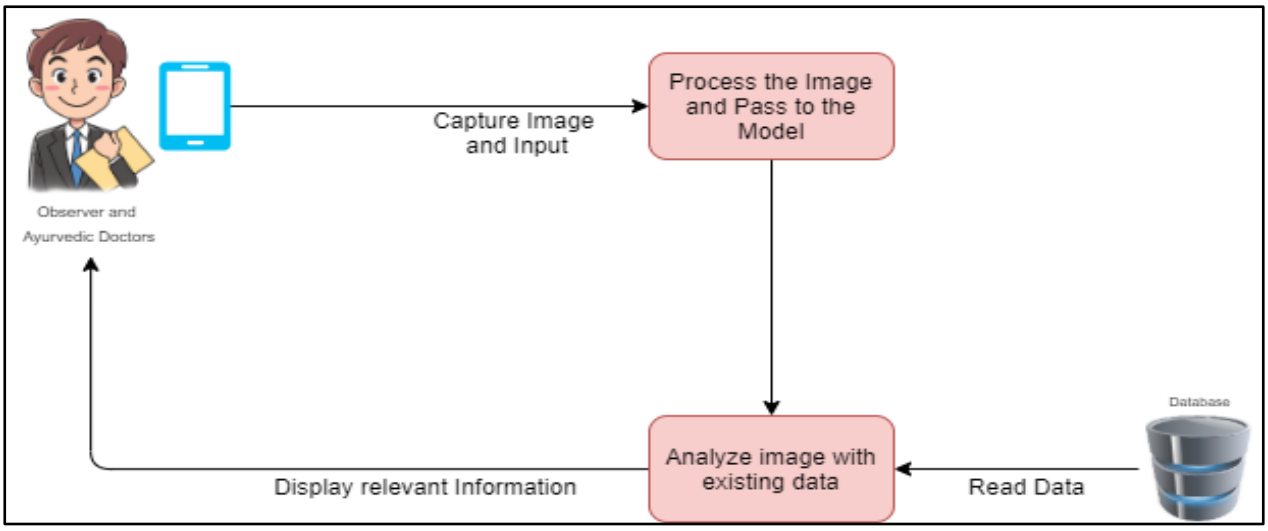

Figure 4 : Simplified process diagram of 'Aayu'

The Rich picture diagram for the Aayu mobile application shows in figure 4. The observer captures images of the plant leaf and can read the advanced information regarding the plant. The image captured by the observer will be used by Aayu to identify the plant and finally display the information regarding the plants like scientific name, local name, etc.

1.6.2 Features of the prototype

When it comes to the prototype project team planning to implement a mobile application to classify medicinal Plants using image processing. Below mentioned technologies will be used to develop the mobile application and Data science part.

Overall, there are 5 basic features. The project team is going to implement also helpful to users who are seeking knowledge of medicinal plants.

1. Identify medical plants using a leaf.

Aayu mobile app will use the camera of the mobile phone and identify ayurvedic plants by scanning its leaf. Then the user can get relevant information regarding the plant.

2. Suggesting other plants with similar qualities.

After the identification process of the plant, Aayu application will shows plants with similar qualities.

3. Users can find out the location of the plant when they need it.

When users enter photos of plants, the location will be tracked, and the database will be updated with the location of the plant. Then the user can find locations of medical plants in a medical emergency.

4. The mobile application will display information in global language and a local language in Sri Lanka.

Users can get major information on ayurvedic plants in English and other local languages in Sri Lanka,

5. Quiz to give some knowledge about the medicinal plants.

Users can use the Q & A session in Aayu app to enhance the knowledge about medicinal plants. It will be an interactive platform for the younger generation to develop their knowledge about medicinal plants.

1.7 Resource Requirements

1.7.1 Hardware requirements

Device	Specification
Android Mobile Phone (Xiaomi Pocophone F1) • Android mobile phone for the testing purposes of Aayu mobile app.	Android 8.1 (Oreo) , Qualcomm SDM845 Snapdragon 845
Laptop computer (Asus VivoBook S15) • To train the model and develop the application.	Windows 10,Intel Core i7,8GB RAM,512GB SSD,1TB HDD, NVIDIA GeForce MX250
SLT Fibre (FTTx) • For fast internet connection.	Up to 100 Mbps download speed & 50Mbps upload speed

Table 2 : Hardware requirements

1.7.2 Software requirements

Languages	
Python (v 3.6)	For Deep Learning and Image Processing
React Native	For the mobile application user interface development
Spring boot	For connect backend and frontend
IDE and Other Applications	
Anaconda	Python package management system
Jupyter Notebook/Google Colab	For programming the backend part of the application
Pycharm	For backend development python with OOP concept.
Visual Studio Code	For programming
StarUML	For designing UML diagrams
Microsoft Word	For making the reports and other documentation
PicsArt	For data clearance
Microsoft Excel	For making the work breakdown structure diagram
Visual Paradigm	For making rich picture diagram
Git,GitHub and Bitbucket	For version controlling
Google Drive	For maintaining and managing all document and other in cloud
APIs , Libraries and Frameworks	
Maps JavaScript API	For managing plant location
Login API	For get the user data
NumPy	Creating NumPy Arrays to store data

Joblib	Save trained model locally
OpenCV	Read and Write data
Keras	Deep Learning Library with Pre-trained models and algorithms

Table 3 : Software requirements

1.7.3 Technology stack

Choosing the right tech-stack is very crucial when it comes to IT-related projects. A careful discussion among the team members and background research was done to determine what kind of platforms, IDEs, and languages should be used to develop this project.

Languages and Frameworks	
React Native	• React Native is backed by a huge community of Developers. • Easy to identify the problems that can occur. • React Native is a cross platform framework.
Python	• Python is Platform Independent. • Python supports many Libraries and frameworks. • Python is backed by a huge community and is popular among the developers.
Spring boot	• Spring Boot saves lot of development time and increases productivity.

	• It provides many plugins and build tools such as Maven and Gradle to make the development process much more easier
Version Controllers	
GitHub	• All the IDEs that are used in this project support GitHub. • Contribution of the team members can be monitored easily. • Team members can collaborate with each other easily.
Bitbucket	• Alternative to GitHub. • All the IDEs that are used in this project support GitHub. • Contribution of the team members can be monitored easily. • Team members can collaborate with each other easily.
IDEs	
Visual Studio Code	• Easy to develop code with the autocomplete features. • Live reloading the project. • Easy to refactor the code. • Easy to identify and fix bugs. • Lightweight and easy to use.
PyCharm	• Easy to identify bugs and refactor. • Supports important libraries.

	• Can be used in different Python versions according to the needs.
Virtual Devices	
Android Studio AVD	• Accurate representation of a real device. • Easy to reload and see the preview in real time.
Cloud Computing Execution Model	
AWS Serverless Architecture	• Serverless Architecture is event based. • Fast Deployment, Greater Flexibility. • Easy to manage and update.

Table 4 : Technology stack

1.8 Chapter Summary

This chapter provides an outline of the Aayu software development project. It provides a detailed description about the problem domain , features of the application ,project background and along with resource requirements. The high-level and most important features of the prototype were also identified. The aim and the objectives which are needed to successfully complete this project also include in detail. In here identified the resource requirements of the project including technology stack, software requirements , hardware requirements. The next chapter is Literature Review chapter where the past research , products, approach, techniques ,algorithm will be critically evaluated.

Chapter 2 – Literature Review

2.1 Chapter Overview

The previous chapter went over the problem background, the aim of the project, and the scope. This chapter evaluates a critical comparison between overall similar products, research gaps, and how to overcome the gaps in an effective manner. Furthermore, existing research and products will also be inspected in this indenture.

2.2 Comparison of similar researches, products, and technologies

This section aims to assess the functionalities, methodologies, and technologies used in related research and existing commercial products to compare the research and proposed solution.

There are a few products that allow users to use machine learning for Plant Identification. Some of the commercial products use their database for providing information but most of them use google image API to identify ayurvedic medical plants. Given below is a product feature comparison chart between such products found on Google Play.

	Identify ayurvedic medical plants	Provide ayurvedic medicinal qualities of the plant	Suggesting plants with similar qualities.	Provide locations of plants	Quiz on ayurvedic plants	Available in all Sinhala, Tamil, English
PlantNet	✓	-	-	-	-	-
Leafsnap	✓	-	-	-	-	-
Plant.id	✓	-	✓	-	-	-
PictureThis	✓	-	-	-	-	-
PlantSnap	✓	-	-	✓	-	-

Table 5 : Feature Comparison Chart

As apparent from the above table, none of the competitors has the functionality to recognize and provide details about the ayurvedic medicinal values and use neither do they have the service in all 3 major Sri Lankan languages(Sinhala, English and Tamil). The Aayu team has also proposed a feature to improve the knowledge of the user by providing a quiz on ayurvedic plants. The most important key point is the team uses the most suited deep learning models to identify medicinal plants and their ayurvedic value. Models and other Data science components are well explained in the following research gap section.

When it comes to similar researches, Aayu team mainly focused on (Dileep and Pournami, 2019) and (Jayanka, M. and Fernando, T.G.I., 2020). Both of these researches have used similar models including AlexNet and techniques like identifying plant leaves using the segmented vein pattern methods which will be used by the Aayu research team.

Aayu aims to bridge the gap between the commercial product currently existing in the market and add additional functionality than its competitors currently offer while utilizing deep learning and other similar technologies. Eventually, to fulfil the research gap discovered by the Aayu research team, it is expected that the final product, the Aayu mobile application will perform its best to surpass the faults amidst the similar mobile apps currently available. The next sections will explore the above-mentioned facts furthermore.

2.3 Research Gap

The Aayu project team, after referring to several research papers on the relevant field, has figured out the limitations that can be extended. In the process of analyzing the facts, it was noticed that (Dileep, M. and Pournami, P., 2019) has carried out the research on identifying plant leaves using the segmented vein pattern method, where they have used healthy leaves in a vivid range of ayurvedic plants to train the CNN model AlexNet. And in that case, leaves with damages because of leaf diseases were unable to identify.

The research team (Jayanka, M. and Fernando, T.G.I., 2020.) has used healthy leaves from 17 different plant types to train the AlexNet. Since it is healthy leaves they have used, leaves with damages because of the disease, were unable to identify.

Team Aayu noticed that identifying plant leaves with diseases is a less-discussed area within the above-broached research articles and determined to extend it as a feature of the Aayu mobile application. Specified models, techniques, and algorithms will be used to improve accuracy. Improved features have been discussed in chapter 1, Scope. Eventually, specifications and a detailed description of the model, techniques, and algorithms will be considered in upcoming chapters.

2.4. Research on approaches and techniques

There are no direct applications to identify an ayurvedic plant with their medicinal values. Area of Artificial Intelligence is a vastly growing field in the technology world, but it can be broken down into many areas such as Computer Vision, Machine Learning, Deep Learning, Expert System, Robotics as shown in the below diagram.

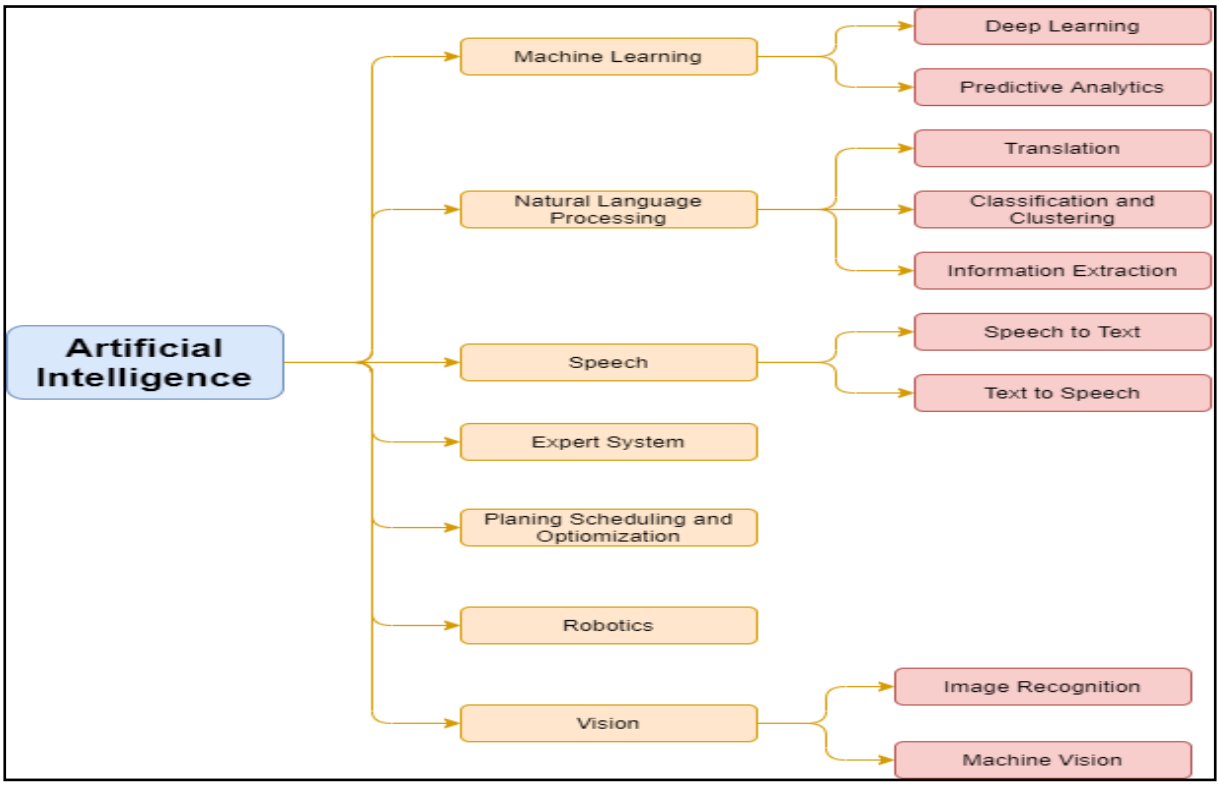

Figure 5 : AI breakdown

The proposed ayurvedic plant leaf identification mobile application Aayu, can identify 5 categories of plant and give the local name, scientific name, English name and also Ayurvedic information. As explained in the above Chapter 1 problem background, Aayu application is

useful to protect and learn ayurvedic plants in Sri Lanka that are used for the eastern medical treatments. For ayurvedic doctors, undergraduate students and also other communities.

Aayu is useful to learn and identify herbal medicinal plants. Aayu used images of plant leaf to identify the plant using leaf shape, venation structure and colour of the leaf. Therefore, the scope of this research will turn to Deep Learning and Image Processing. While they go through the more complicated algorithm, they can approach high accuracy and informative details regarding the plants.

2.4.1 Convolutional Neural Network

Convolutional Neural Network is a deep learning neural network which can take an input of image (For an example: Alex Net - 227 x 227 px image). It's a class of neural networks that specialize in processing data that has a grid-like topology similar to an image.
CNN typically has three layers as convolution layer, pooling layer, and fully connected layer.

In the Convolution layer, this layer performs a dot product between two matrices where one layer consists of learnable parameters or kernel and filter that is used to identify the edges of the images.

Image with input of height width of W and filter size of F with stride S and amount of padding P, then the output image size can be calculated using the following formula

$$W_{out} = \frac{W - F + 2P}{S} + 1$$

Figure 6 : Formula used to calculate the output image size in convolutional layer

The pooling layer replaces the output of the network at certain locations by deriving an average statistic of the outputs. This helps in reducing the spatial size of the representation, and it helps to decrease the required amount of computation and weights. The pooling operation is processed on every slice of the representation individually.

If it has the activation function of width and height W and pooling kernel size of F and stride S the output image width and height can be calculated by following formula

$$W_{out} = \frac{W - F}{S} + 1$$

Figure 7 : Formula used to calculate the output image size in pooling layer

In the Fully Connected Layer, Neurons in this layer have full connectivity with all neurons in the preceding and succeeding layer as seen in regular FCNN. Therefore, it can be calculated as usual by a matrix dot multiplication followed by a bias effect. The Fully Connected layer helps to map the representation between the input output images.

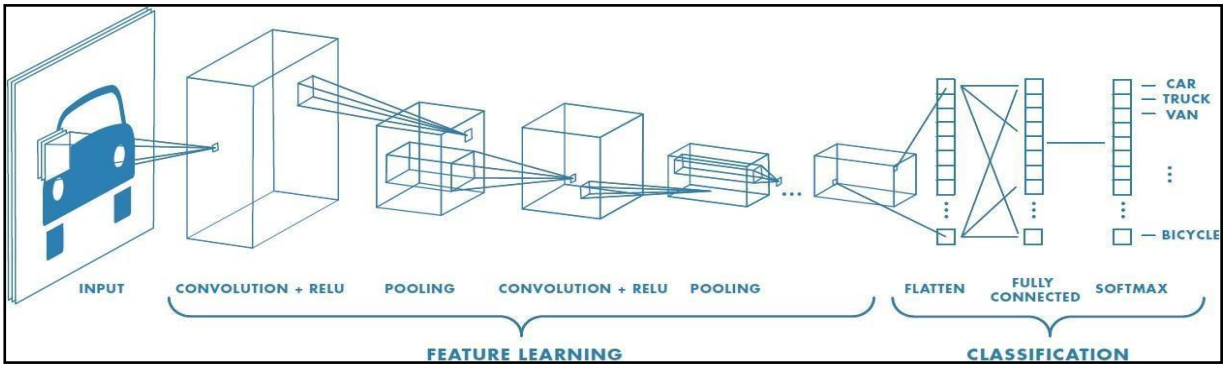

Figure 8 : A simple CNN architecture, comprising just five layers.

2.4.2 Comparison

GoogleNet model can reach up to 100% accuracy but it has an average elapsed time of 41 minutes and 5 seconds. GoogleNet carries more layers relative to other CNN models. That is the main reason for that high accuracy rate. Nevertheless, high accuracy and shorter elapsed time are required for the Aayu app. The next best model is AlexNet which has a lesser accuracy rate than GoogleNet but AlexNet has a way less elapsed time than GoogleNet. The average elapsed time of the AlexNet is 2 minutes and 1 second.(Sabri et al., 2018)

VGGNet is another CNN model used in Image processing. It carries 16 to 19 convolutional layers. This model is a little bit difficult to train than other layers because VGGNet is substantially deeper than other CNN models. Training this model requires far more memory and computational power than the selected AlexNet and (Alom et al., 2018) stated that AlexNet was eight times faster than VGGNet in their experiment.

ResNet is another popular and successful image classification model that gets inputs from multiple layers and gives outputs to multiple layers. AlexNet has shown resilience in varying test cases because AlexNet carries a hierarchical layer connection. In addition to that ResNet carries more than 50 convolutional layers which makes it more time-consuming to train while AlexNet carries 8 convolutional layers and can be trained relatively quickly.(Alom et al., 2018) So, team Aayu gives priority to AlexNet at the implementation also considering ResNet for the implementation as an option.

2.4.3 AlexNet

Alexnet is a deep learning neural network invented by Alex Krizhevsky and in 2012 Alexnet won the ImageNet competition by a large margin. Alexnet is a novel neural network which consists of five convolutional layers and three fully connected layers.

AlexNet contains 8 layers with different weights. The first five are convolutional layers and rest of three layers are fully connected layers. The output of the last fully connected layer is fed to a 1000-way soft-max which produces a distribution over the 1000 class labels to the image. The neural network maximizes the multinomial logistic regression objective, which is equivalent to maximizing the mean across the training cases of the logarithmic probability of the correct label under the prediction distributions. The kernels of the second, fourth, and fifth convolutional layers are connected only to those kernel mappings in the previous layer which

reside on the same GPU. The kernels of the third convolutional layer are connected to all kernel mappings in the second layer. The neurons in the fully connected neural network layers are connected to all other neurons in the previous layer.

AlexNet takes 90 epoch (Complete Forward and Backward propagation) which were trained for 6 days consecutively two Nvidia GeForce GTX 580 GPUs which is the reason for why their network is split into the two pipelines. The learning rate is decrease 3x times during the training process of the model and proportionally increase the accuracy of the model. AlexNet was the pioneer in Convolutional neural network and open-source to researches in TensorFlow, Keras and PyTorch.

2.5. Chapter summary

The Literature Review chapter gave the approach about the existing approach, technologies, algorithm techniques and image recognition and weakness of identifying leaf. The existing research and mobile application were achieved to identify leaf and display common details. AlexNet was selected as the main convolutional neural network to identify the ayurvedic plant leaf.

The AlexNet highlighted due to the dataset for the training model is comparatively less and elapsed time for the model training is low with other CNN models. The final selected approach for identifying damaged leaves and diseases leaves and displays the whole medicinal value and description in three main languages as English, Sinhala and Tamil. Further information will be detailed in the implementation chapter. The next chapter will discuss the project management phase of the project and will detail the methodologies used in this project.

Chapter 3 – Project Management

3.1 Chapter Overview

The last section focused on assessing the literature review identified with the project. This section will inspect the most appropriate task management scheme for the project. The involved risks and alleviation plan for the framework are identified. The most suitable programming advancement techniques and techniques for the project are discussed in detail. The action schedule and undertaking expectations are defined. The work breakdown structure and Gantt graph chart are likewise outlined in this chapter.

3.2 Methodologies

3.2.1 Research Approach

The principle of the research approach can be divided into inductive and deductive approaches. The inductive approach aims to develop a theory. Besides, deductive reasoning aims the test an existing theory.

In this project, Aayu follows the deductive approach to identify the ayurvedic value of medicinal plants. Additionally, Aayu uses the pre-existing AlexNet and ResNet models to improve the image recognition component and give the possibility to the user to identify the ayurvedic value of the medicinal plant using leaves in various shapes.

3.2.2 Process Model

Software development industry consists of a mass number of process models used in numerous scenarios. Aayu mobile app is a research-based project which performs the image processing technique for classifying ayurvedic value of medicinal plants. Amidst the available process models, Aayu research team is determined to follow the most suitable process model for a research-based approach. To select one of the best-suited models, Aayu examined several proved methodologies and compared them based on the requirement and blueprint for this project.

In the table given below, popular models currently available in production and pros and cons of those models are detailed.

Model	Pros	Cons
Waterfall	• Plain, simple to understand and follow. • Well structured, suitable for the low-level project	• Can't adapt to changes in specifications.
Spiral	• Well, suitable for complex projects. • Specifications can be captured more accurately.	• Management is more complex. • The process is also more complex.
Agile	• Suitable for changing requirements. • Easy to manage.	• The project can easily get taken off track.
Iterative	• The modular structure is adaptable and simple to follow. • Easier to handle risk - High-risk part is done first.	• More resources may be required. • It is not suitable for smaller projects.

Table 6 : Process Models

By considering the above-mentioned facts, the Aayu research team has figured out that the most appropriate model to be used for this project is the Iterative Process Model. And the justification of the usage of the Iterative Process Model is detailed as below.

The research team first analysed the details of models that can be used. In that case, it was noticed by the team that, Since requirements have been completely identified and there are extensions to be added, the above-mentioned model matches the best. At the development stage adaptations for new technologies and techniques are expected as the research team is somewhat strange to advanced industrial technologies. In such situations also, Iterative Model is the best model that suits the project, Aayu. Eventually, by considering the above-mentioned facts, It

was discussed to finalise the decision that the most appropriate model to be used for the Aayu research project is Iterative Process Model.

3.2.3 Design approach & Analysis

The OOD approach is mainly selected for the Design Approach and Analysis. It promises to reduce development time, reduce the time for implementation and resources required to maintain the existing applications, increase code reuse, decrease the code duplications and provide a competitive advantage to organizations that use it. This designing approach adds in the reusing the components with object-oriented techniques.

3.2.4 Programming methodology

3.2.4.1 Object Oriented Programming

Implementation of Aayu mobile application will be completed using OOP programming methodology. With the usage of OOP concepts, it is expected to maintain the quality of code, reduce redundancy, and maintainability in troubleshooting processes.

3.2.4.2 Model View Controller

Model View Controller (MVC) which is an application design model will be used to specify the information related to presentation, control and data model in the interaction layer of the application.

3.2.5 Testing Process

To make the vision of Aayu mobile application a reality, it is important to test the process to identify issues within the programme and resolve those issues to deliver the product Aayu in a high end quality. Below mentioned testing processes were carried out to test the programme.

i. Black box testing - This method will be used to test the functionalities of the Aayu mobile application without examining the internal code, structure and execution methods for valid inputs and outputs.

ii. White box testing - This will be used to examine and demonstrate the inner workings of the code and other integrations of the Aayu mobile application system.

3.3 Project management method

While there's a wide range of project management methodologies such as Scrum, Agile, Kanban, eXtreme Programming (XP), Scrumban, Lean, Waterfall, PRINCE2, PMBOK it is absolutely critical that the correct methodology for the project is chosen.

Due to the nature of this project the team has decided to use a methodology which is inspired by PRINCE2. The following having have been identified as the advantage of using PRINCE2

- Adaptability to variety of different projects
- Clearly defined stages and processes
- Risk management

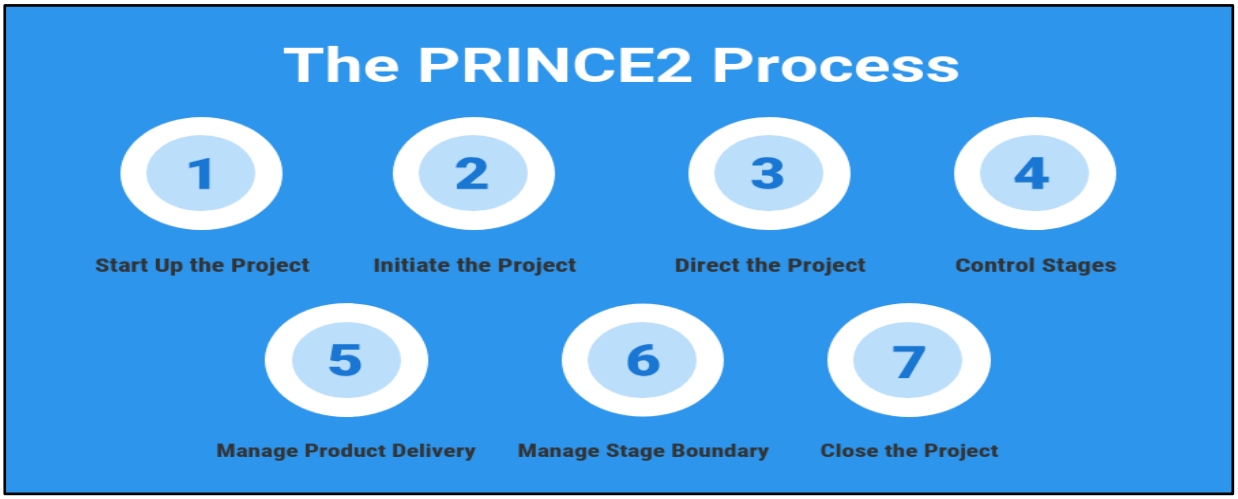

Figure 9 : PRINCE2 Process

1. Start Up the Project

Starting up the project is considered pre-project work as it consists of work done prior to actually starting the project. This includes assigning the team members and their responsibilities. The reasons and the goals for the project are also established here.

2. Initiate the Project

The purpose of this set in the process is to establish what actions need to be taken in order to produce the required products. This set is crucial to achieving a product which meets all requirements

3. Direct the Project

This set of the process is all about the day-to-day running of the activities which need to be performed in order to complete the project.

4. Control Stages

In this stage the work to be performed in each of the current stages as well as the next stages are planned. Also the project board will see if the required standards are followed

5. Manage Product Delivery

Ensuring the product is delivered in a timely manner whilst also ensuring that all of the requirements are met by through structured coordination with Project Manager and the Team Manager.

6. Manage Stage Boundaries

Planning what are the thing which need to be done in the next stage after the completion of the current stage

7. Close the Project

In this stage the team checks if all the requirements are met in the finished project and if all the requirements are met then proceed to handover the project to the end users.

3.4 Data gathering method

Team Aayu uses different data gathering methods for this project.

Method	Description
1.Meetings with the domain experts	This project is based on an ayurvedic plant identification system and it is important to maintain the accuracy of the gathering data. The project team can get direct and accurate data from domain experts like ayurvedic doctors.

2.Online questionnaire	Online questionnaires can easily help to gather data from a target audience about the user requirements and other important facts.
3.Online sources	Many online sources can be used to gather data related to ayurvedic plants. Examples are Web sites, online journals, e-books, etc.
4.Written documents	Team Aayu can use books, journals, papers, and other written sources to gather data related to the project. There are many ayurvedic books available for data gathering purposes.

Table 7 : Data gathering methods

3.5 Constraints

A lot of effort has been put to avoid the impact of the constraints faced during the project. The three main constraints affecting the project were identified as followed.

i. The limited experience and familiarity

The team has relatively limited experience in developing data science related projects which might lead to difficulties when developing the project. To overcome this limitation the team has spent a considerable amount of time studying other image processing project to learning related best practices which will help in the implementation of the project

ii. Time constraints

Due to the tight deadlines and the compacted schedule of team members, it will be challenging to meet all the deadlines. To overcome this work has been evenly distributed among the team members and a timeline has been made to make sure that work is done on time.

iii. Resources

Training image recognition algorithms require a large amount of computing power and the team does not have physical access to devices with such computing power. This constraint has been overcome by Amazon Web Services.

3.6 Progress evaluation & Communication plan

Progress of the project, Challenges, and problems encountered by the team, and future challenges that can occur, were discussed with the instructors at the weekly feedback sessions. The team got good clarifications and solutions for the above-mentioned aspects at the sessions. Email communications were done with the feedback team when approving ideas and other necessary instances. Apart from that, team members connected via Discord voice, Google meets, and Google Docs to discuss and implement the project.

3.7 Risks and mitigations

No	Description	Probability	Impact	Mitigation action
R1	Lack of knowledge about technologies	High	High	Self-studying on the related domain and getting advice from experts.
R2	Implementation Issues	High	High	Prioritize the requirements based on the most important one first.
R3	Dataset being too small	Medium	High	Utilizing data augmentation methods to increase the effective size of the dataset
R4	Being unable to meet the deadlines due to the complexities of the project	Medium	High	Dividing the work among the members in a way which makes it manageable to every member. Discussing each others' progress and identify members who require additional assistance and helping them to complete their work.
R5	Certain members not being able to work due to various reasons	low	Medium	Discussing each other's difficulties and limitations and working together to overcome them

R6	Group members not being able to collaborate due to covid	High	High	Using discord, WhatsApp and other online platforms to effectively communicate. Using Google Drive, Docs to maintain project documentation and Trello will be used to manage the project.

Table 8 : Risks and mitigations

3.8 Activity Schedule

Date	Activity	Time frame
08/25/2020	Brainstorming for new ideas and discussing those ideas	20 Days
09/15/2020	Pitching ideas	6 Days
09/21/2020	Creating draft of the the selected idea	6 Days
09/30/2020	Initiating the selected project for the proposal	7 Days
10/25/2020	Submission of the Project Proposal	1 Day
10/26/2020	Working on the Literature Review	2 Days
11/30/2020	Submission of the Literature Review	1 Day
12/01/2020	Working on the SRS	30 Days
01/04/2021	Submitting the SRS	1 Day
01/04/2021	Final discussion about the design and implementation	1 Day
01/04/2021	Prototype implementation	51 Days

02/25/2021	Documenting the Implementation of the Prototype	4 Days
03/01/2021	Testing and Evaluating the Prototype	5 Days
03/06/2021	Working on the Final Report	14 Days
03/25/2021	Submitting the final Report	1 Day

Table 9 : Activity Schedule

3.9 Work breakdown structure

Work breakdown structure has been moved to Appendix Chapter 3.

3.10 Gantt chart diagram

Gantt chart diagram has been moved to Appendix Chapter 3.

3.11 Chapter Summary

The Project Management chapter gave an overview of project management methodologies and an iterative model was selected as a process model of the application.The risk and other problems come out while doing the project and mitigation plans were identified.The most appropriate software development methodologies and other project management strategies were also discussed in detail.The activity schedule and project deliverables were also detailed. The work breakdown structure and Gantt chart diagram were also illustrated in this chapter.The next chapter is regarding the System requirements Specification.

Chapter 4 – System Requirements Specification

4.1 Chapter Overview

The SRS chapter contains all information with regards to how the stakeholders are affected by this project, how the requirement gathering process was done including how the functional and nonfunctional requirements were identified, how the analysis of all gathered data was performed and it also explains in great detail the model for Aayu.

4.2 Stakeholder

4.2.1 Model

4.2.1.1 Onion model

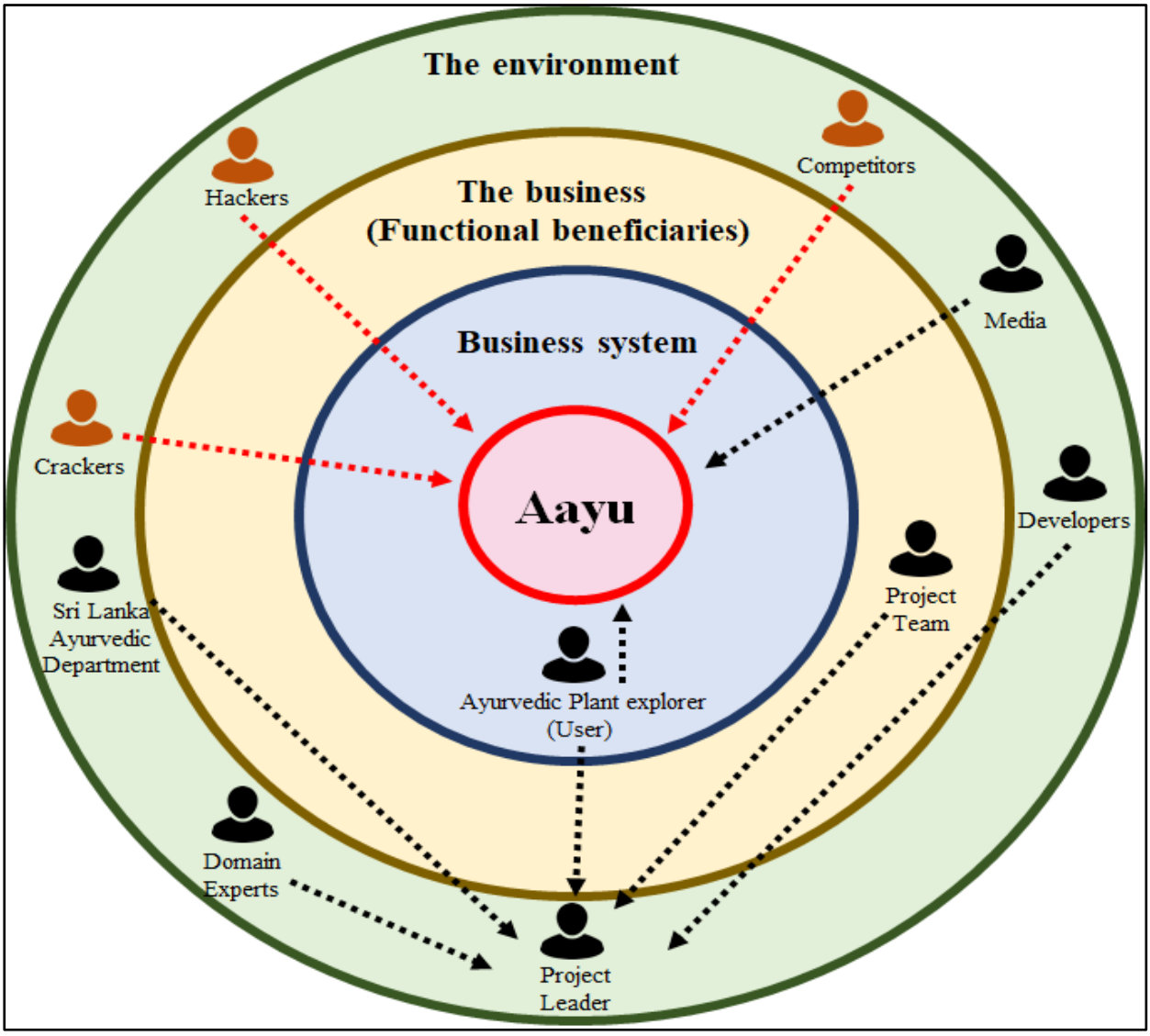

Figure 10 : Onion model of Aayu

4.2.2 Stakeholder descriptions

Stakeholder	Viewpoint	Role
Project leader	Supervising project and guiding developer and project team.	Expert
Developers	Developing the system and maintaining the application.	Experts
Sri Lanka Ayurvedic Department	Want to make sure "Aayu" is working properly and not harming the policies and not dangerous to ayurvedic plants and industry.	Regulator
Domain experts	Will guide developers and project team by domain subject knowledge.	Experts
Competitors	Trying to build a better product/system than the product "Aayu"	Negative Stakeholders
Hackers	Want to damage the system and corrupt the functionality of the application	Negative Stakeholders
Crackers	Want to do unauthorized modifications and remove/disable features.	Negative Stakeholders
Media	Media(Social media/television/radio/newspapers) will help to get public and social attention to the product.	Neighbouring systems
Project Team	Want to maintain the system regularly	Experts
Ayurvedic Plant explorer (User)	Ayurvedic Plant explorer or the user will use the system/product and gets benefits from it. And also will give reviews about the product.	Functional beneficiary

Table 10 : Stakeholder descriptions

4.3 Requirements Gathering

4.3.1 Techniques for requirements gathering

Method 1	Literature Review
Similar types of procedures come under the plant leaf identification using image processing techniques domain will be compared. Library resources like journals, research papers, and many more online resources will be used to figure out the components of the similar systems within the domain, and also to get an idea about the solidities and defects. This will furthermore manifest the necessity of the parts to be developed within the Aayu mobile application.	
Method 2	Online questionnaire for Targeted Audience
An online survey was conducted where answers were collected from University students and college students to get an idea about the phases to be extended within the project.	
Method 3	Interview with domain experts
The interview was conducted with domain experts to gather data effectively. Guidance of domain experts was taken to improve the quality of the process, especially when getting approval for the Ayurvedic plant leaf data set.	
Method 4	Observations
Gathered data and suggestions from the domain experts were observed when developing the system.	
Method 5	Prototyping
It will be expected by the implementation of the prototype model to permit users of the software system to gauge developers' proposals for the look of the ultimate product by truly attempting them out, instead of having to interpret and judge the look supported descriptions. Once the archetypes of the system are created on the earlier level, concepts	

will be collected from stakeholders to further enhance the system in a very method. It is expected that the chance of evolving blunders and confusion throughout the implementation will be reduced after exhaustive prototyping is done.

Table 11 : Techniques for requirements gathering

4.3.2 Questionnaire design

A questionnaire was designed and sent via google forms to gather data. It was reached mainly to the general public, especially university and college students in Sri Lanka. The main goal was to get an idea about the knowledge amidst the general public about Ayurvedic plants and whether there are any mobile applications used by them to identify those Ayurvedic plants.

4.3.2.1 Feedback from the general public

Purpose of the question	Question Asked
To know if the user can identify Ayurvedic plants without any source.	Can you identify any plant with ayurvedic value without any source?
To know if the user knows how important those Ayurvedic plants are for medicinal purposes.	Do you know that plants with medicinal value are used to treat various kinds of diseases?
To know if the user already uses a mobile application to identify Ayurvedic plants (This was to manifest the necessity of such a mobile application to the general public)	Do you know any existing applications which use medicinal plants?

Table 12 : Questions asked from general public

4.3.3 Formal interviews with domain experts

The interview was conducted with an Ayurvedic doctor and the findings are summarized as below. Due to the COVID - 19 global pandemic, the interview was conducted via Skype.

	Target group – Ayurvedic Doctors
Aim	To identify how important it is to have general knowledge about Ayurvedic plants amidst the younger generation. To discuss the fact, the importance of an automated system to identify ayurvedic medicinal plants and how such a system will enhance the effective use of Ayurvedic medicinal use within Ayurvedic doctors and the general public.
Interviewees	Mrs. N.C. Karunarathne (MD,Specialize in Bone Fractures and dislocations) (Ayurvedic Doctor,Polgahawela)
Findings	There are ayurvedic plants with similar qualities and similar shapes. There are different types of Ayurvedic plants with similar medicinal value.

Table 13 : Details of domain expert interview

4.4 Analysis of gathered data

4.4.1 Student idea collecting questionnaire

4.4.1.1 Importance of questionnaires

Providing questionnaires when doing research is vital.Team can gather large amounts of data in a short period of time almost without any cost.When properly constructed and responsibly administered, questionnaires become a vital instrument by which statements can be made about specific groups or people or entire populations.It confirms the importance of creating and using questionnaires.

4.4.1.2 Participants

Aayu Mobile App is targeted to the general public, mostly to the people who are interested in Ayurvedic Medicine and other related domains. The team has set a goal to develop the knowledge among the people about the medicinal value of plants. So, the questionnaires were sent to all the provinces in Sri Lanka to gather information such as the general opinion of the public and their level of knowledge.

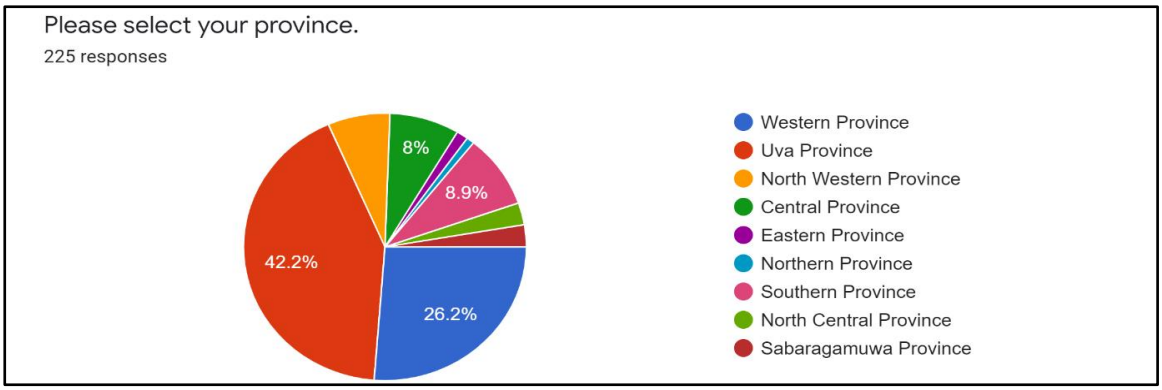

Figure 11 : Provinces of respondents of online survey

Questionnaires were handed out to people who live in every province in Sri Lanka and to get the most information so the team can also be sure about the fairness of the data gathered. All the respondents were students and undergraduates. The team believes that the younger generation can use a modern Mobile application to identify a medicinal plant. The team can rely on the general applicability of the data gathered when the data was collected from people from every province.

As the Pie chart shows this implementation is mostly applicable to the Uva province and Western province since most of the respondents are from those provinces.

1. Can you identify any plant with ayurvedic value without any source?

The team suspects that there is a lesser knowledge among people, mainly the younger generation. So this question was handed out to justify that suspicion.

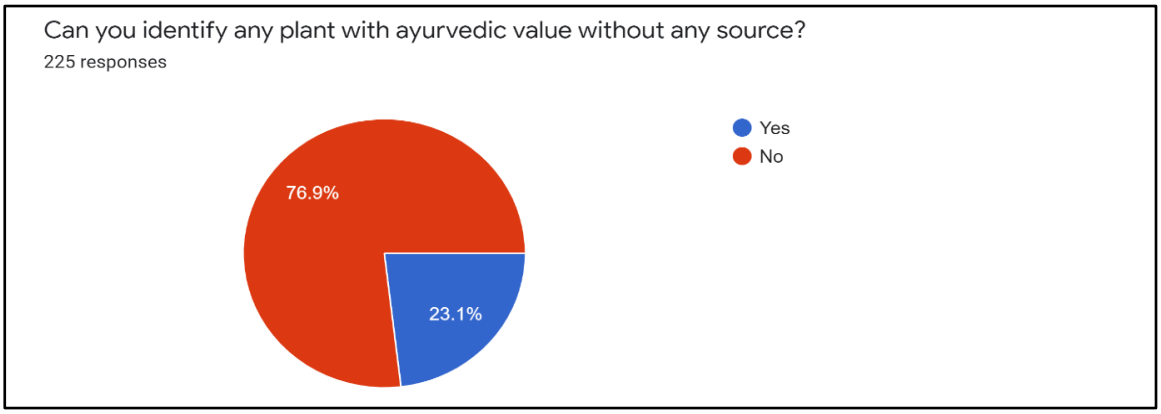

Figure 12 : Knowledge about ayurvedic plants of respondents of online survey

76.9% of the respondents couldn't identify an ayurvedic plant without a source or just by seeing it. So a mobile application that can identify a plant with medicinal value would be so valuable to them.

So this response showcases the level of knowledge the younger generation carries when it comes to the medicinal values of plants and one of the team's main goals is to tackle that problem too.

2. Do you know that plants with medicinal value are used to treat various kinds of diseases?

This question was carried out to identify the lack of knowledge among the people about the medicinal values of plants and their usages when it comes to treating various kinds of diseases.

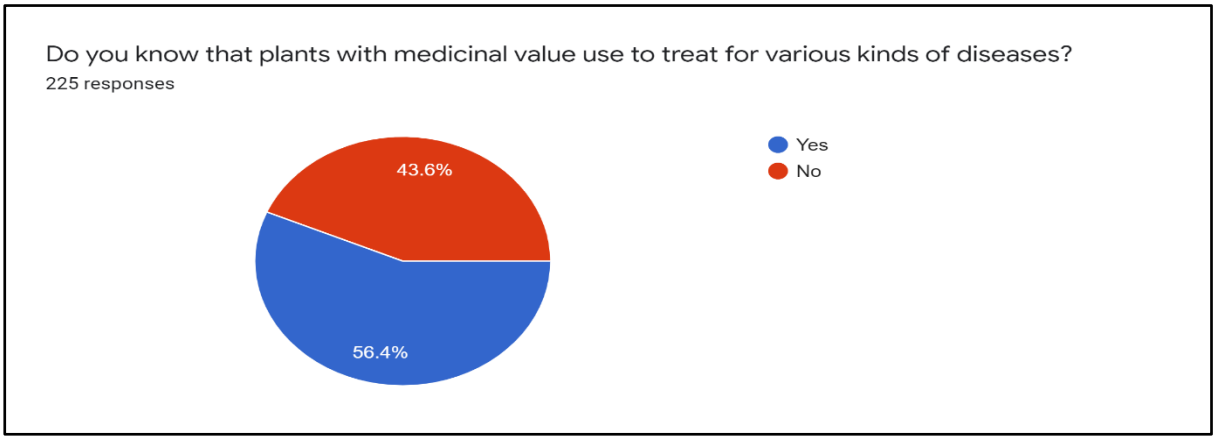

Figure 13 : Knowledge about the usage of ayurvedic plants

This pie chart shows that 43.6% of total respondents didn't even know about the medicinal values of plants. These responses point out a major problem. As Sri Lankans who carry a history with medicinal plants, that 43.6% of the respondents who responded "No" shows the lack of knowledge that was mentioned before.

3. Do you know the uses of different types of plants with medicinal values ?

Some plants have more than one medicinal usage. Those plants can be used to treat more than one disease. This question was sent out to know if the audience knew about that matter.

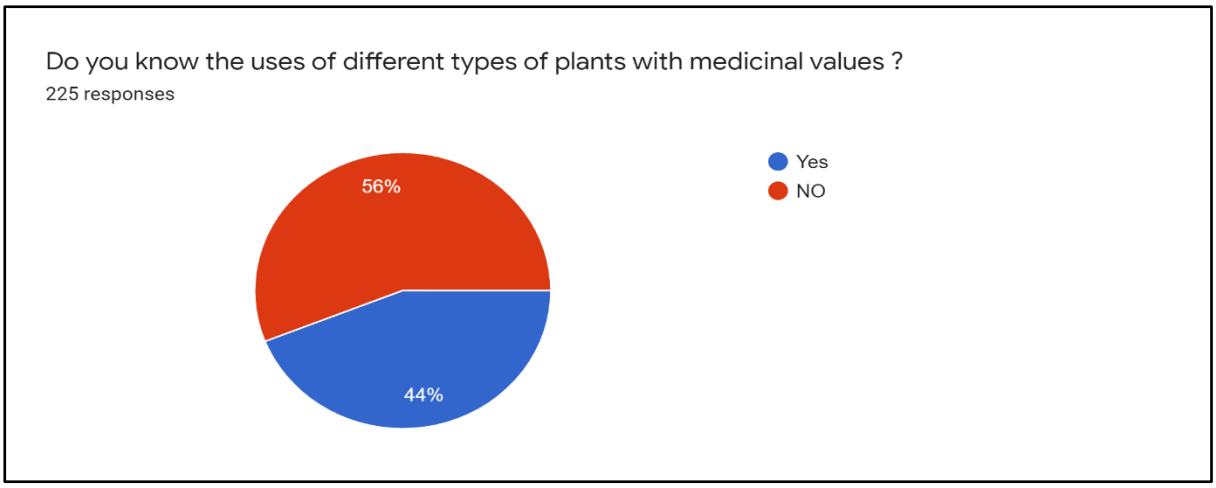

Figure 14 : Knowledge about the types of ayurvedic plants and their uses

Just as mentioned before, people have lesser knowledge about this domain. Responses to this question also confirms it. The majority of the respondents(56% out of 225) are incapable of identifying those kinds of plants or the usages of those plants. People must have the knowledge to identify different plants with medicinal properties to treat diseases.

4. Do you know any existing applications which used to identify medicinal plants?

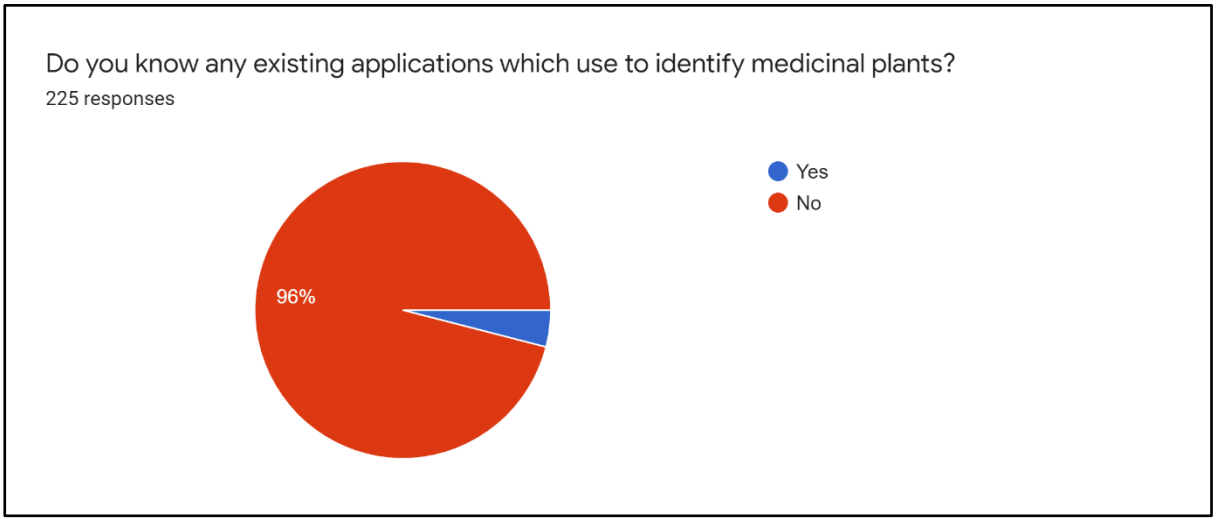

Figure 15 : Information about existing applications similar to Aayu

This question was carried out to identify the vacuum of the technological applications when it comes to identifying medicinal values using image processing. 96% of the whole 225 respondents haven't come across any sort of programmed application on this domain. The Aayu mobile application is designed to fill this gap and this survey also confirms the lack of such application's present day.

4.5 Model

4.5.1 Use case diagram

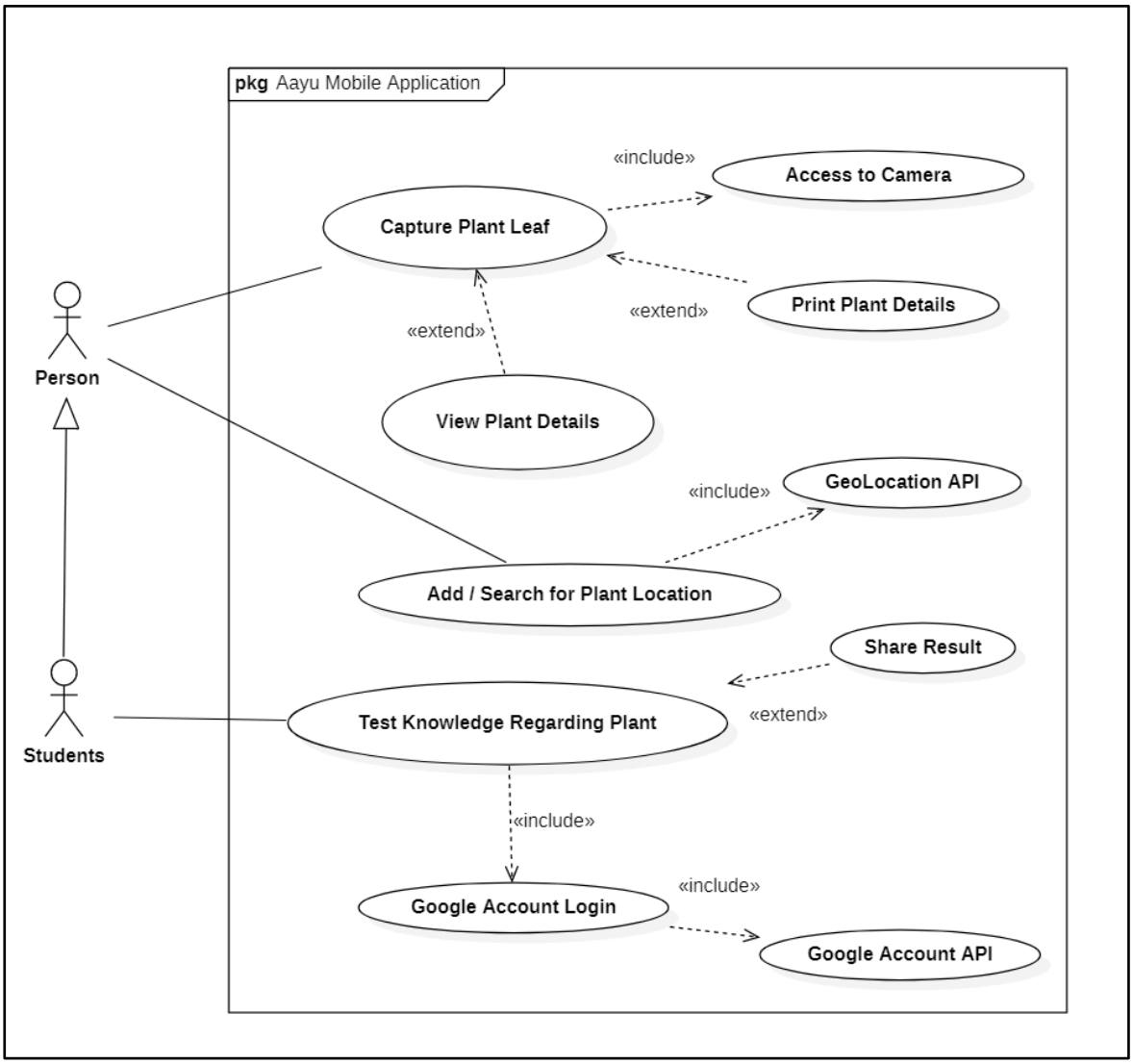

Figure 16 : Descriptions of the use case diagram

Use Case ID	UC - 01
Use Case	Capture Plant Leaf
Description	To identify the plant from the plant leaf Person should capture the image of the plant leaf
Actor	Person
Pre-Conditions	Application upto Run

	Internet Connection
Extending	Print Plant Details View Plant Details
Including	Access to the Camera
Main Flow	Use case start when access the camera capture image The Actor should focus the plant leaf before capture Use case end when the plant leaf captured
Alternative Flow	Upload a photo of the plant leaf and identify the Plant.
Exception	N/A
Post-Conditions	If the plant is successfully identified, the image will be saved in the database to increase accuracy.

Table 14 : Use Case 01

Use Case ID	UC - 02
Use Case	Test Knowledge regarding the Plants.
Description	Actors can test knowledge regarding the plant and plant leaf and their uses.
Actor	Student
Pre-Conditions	Access to the Internet Existing Google Account
Extending	Share Result
Including	Google Account API

Main Flow	Use cases started when the Actor switched to the quiz. First Google Account Login Required. Use case end After answering all questions, the result will display with the correct answers.
Alternative Flow	If the Actor doesn't have a google account then the user can log in as Guest User and Test Knowledge.
Exception	N/A
Post-Conditions	Record the Quiz score to the database.

Table 15 : Use Case 02

Use Case ID	UC - 03
Use Case	Add / Search for plant location
Description	Here the Actor can add the location of the plant. Then it will help others to find the plant for treatment and other production of the medicine.
Actor	Person
Pre-Conditions	Access to the Internet Location access in mobile phone
Extending	N/A
Including	GeoLocation API
Main Flow	Use case starts when Actor chooses the share location option and it thought the google

	geolocation API helps to find the current location and added to the Database. Use case end after location record added to the database.
Alternative Flow	Add the location of the plant manually.
Exception	Users can skip adding the location of the plant.
Post-Conditions	Record location of the plant to the Database.

Table 16 : Use Case 03

4.5.2 Domain model

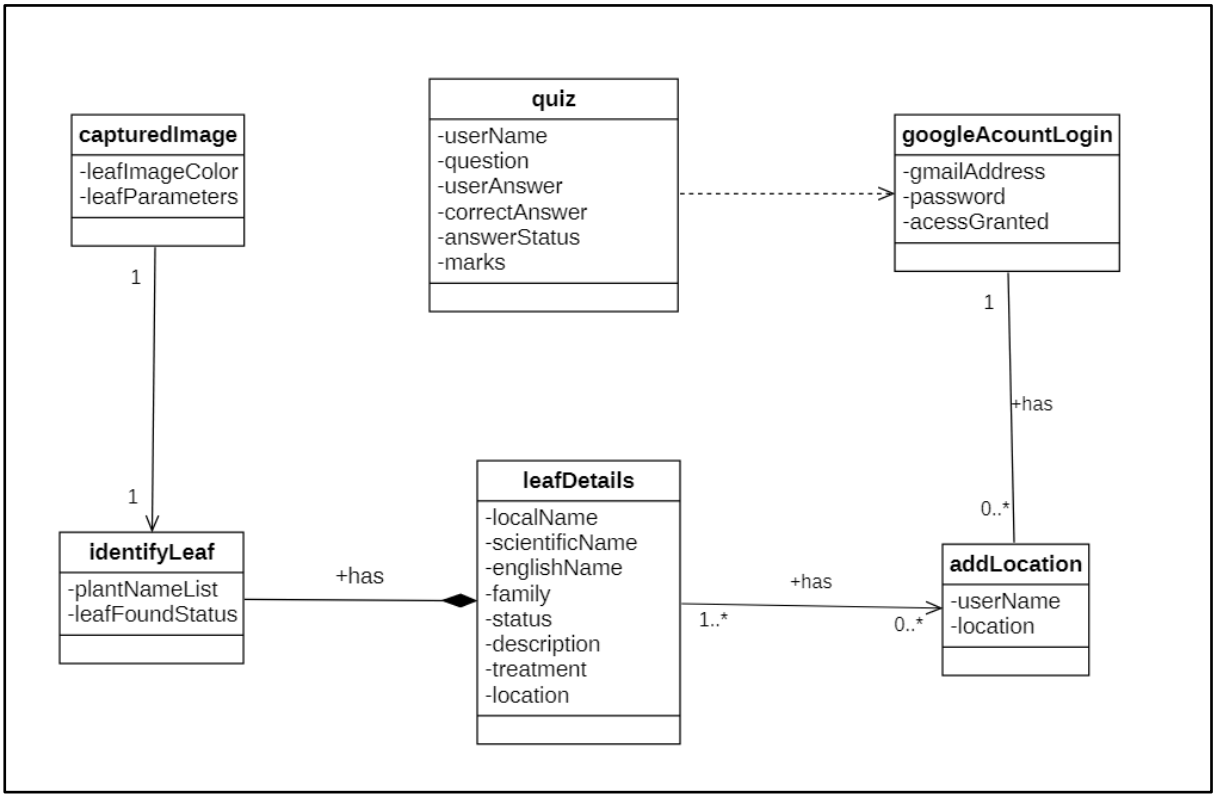

Figure 17 : Domain model

4.6 Functional Requirement

In this subdivision, the Aayu project directs on listing out the functional and non-functional requirements along with the priority level.

- Critical - The requirements are critically important to the success of the system.
- Standard - The standard requirements that can add value to the system.
- High end - High-end requirements that can add luxury to the system.

Requirements list		Priority Level	Description
FR1	Identify medical plants using their leaf.	Critical	The Aayu mobile app should be able to critically classify the ayurvedic value of the plant by scanning its leaf.
FR2	Suggesting other plants with similar qualities	Critical	The system should be able to suggest plants to the user besides similar qualities.
FR3	Users can find out the location of the plant when they need it.	Standard	When the user updates the location of the plant, it should be tracked automatically while the Aayu database should be updated.
FR4	The mobile application has all major languages in Sri Lanka.	High end	Users should be able to get information on ayurvedic plants in all three main languages.
FR5	Quiz to give some knowledge about the medicinal plants.	High end	Users should be able to use the Q & A session in Aayu app to enhance the knowledge about medicinal plants.

Table 17 : Functional Requirement

4.7 Non-functional Requirement

Functional and non-functional requirements are necessary to implement an accomplished system. So in this section Aayu lists out the non-functional requirements along with the priority level.

Requirements list		Priority Level	Description
NFR1	Accuracy	Critical	The Aayu mobile app should be accurate when predicting the medicinal plant using its leaf. Overall, Team Aayu planned to get above 80% accuracy.
NFR2	Performance	Critical	The Aayu system should work without any delay or production issues.
NFR3	Usability	Standard	The Aayu system user experiences have to be good without any bugs.
NFR4	Scalability	Standard	The system should be scalable to future updates and identify a tremendous number of medicinal plants.

Table 18 : Non- Functional Requirement

4.8 Scope refinement

The number of plants recognizable using this app may or may not be increased or decreased depending on the practical issues faced during the implementation phase.

4.9 Chapter Summary

The system requirements specification chapter gave an overview of the stakeholder, requirement gathering, functional requirement along with priority levels, use case diagram domain model, and use case description of the project prototype. The next chapter is regarding Legal, Ethical, and Professional issues and also the plan for implementation of the prototype.

Chapter 5 – Design

5.1 Chapter Overview

This chapter focuses on the design aspect of the Aayu project. The smooth execution of the design phase is extremely crucial for the success of the project. To ensure that the design architecture is understood without any ambiguities the team has utilized various diagrams and visual representations extensively. Diagrams such as High-Level Architecture Diagrams, Class Diagrams, Sequence Diagrams, Activity Diagrams are utilized to visually represent the underlying architecture and design of the project. Additionally, this chapter will discuss the wireframes which contain the design blueprint of the system.

5.2 High-Level architecture Diagram

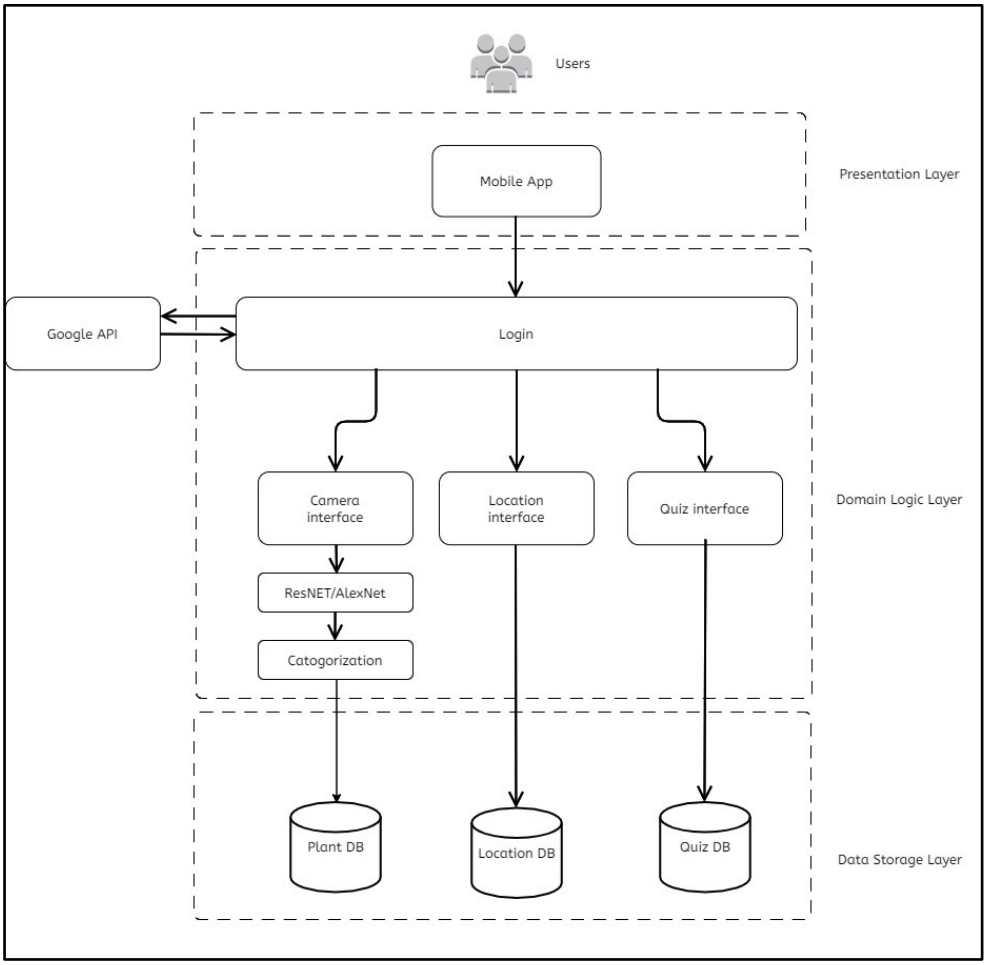

Figure 18 : High-Level architecture Diagram

The above diagram depicts the high-level architecture diagram for Aayu. The architecture for the system has been divided into 3 sections such as the presentation layer; where the user interacts with the system, domain logic layer; where the logic of the system is depicted and finally the data storage layer; where the data methods are depicted.

The front-end user interface will be built utilizing react-native. Emphasis will be placed on the user-friendliness of the interface while also ensuring that it remains aesthetically pleasing.
The domain logic layer of the diagram gives a high-level overview of the overall business logic of the Application. This layer also emcompasses the CNN architecture which will be utilized for the classification of plant leaves.

The data storage model shows how the data storage occurs in the Aayu project. 3 database namely, plant database, location database and quiz database. The plant database stores all data about the plants. The location database will keep track of where the plants are located. Quiz database will be used for all the data related to the quiz.

5.3 Class Diagram

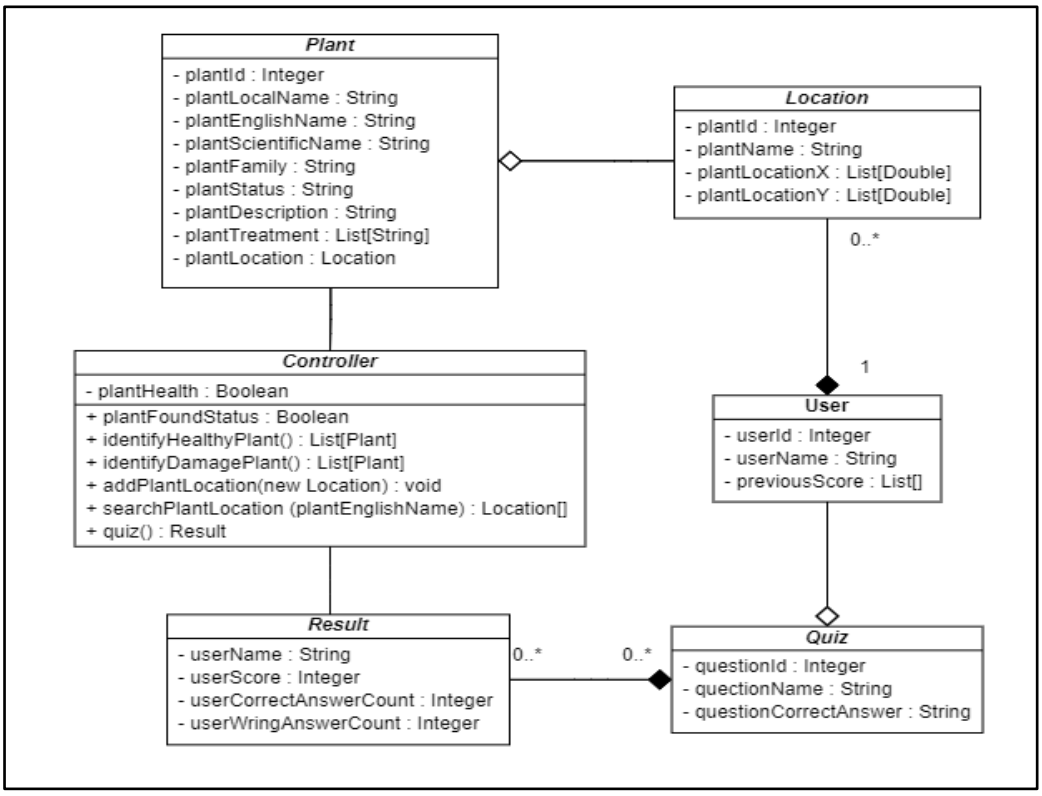

Figure 19 - Class Diagram

Location, Plant, Quiz, Results, and Controller classes are selected as key major classes of the "Aayu" application. Plant id number, plant name, and location details come under the Location class. It extends to the class "Plant" and all the plant details are included in it. Aayu mobile application has a Quiz section and its question id, question names, and other details come under the "Quiz" class. Results and score of the Quiz are coming under the class "Result".

5.4 Sequence Diagram

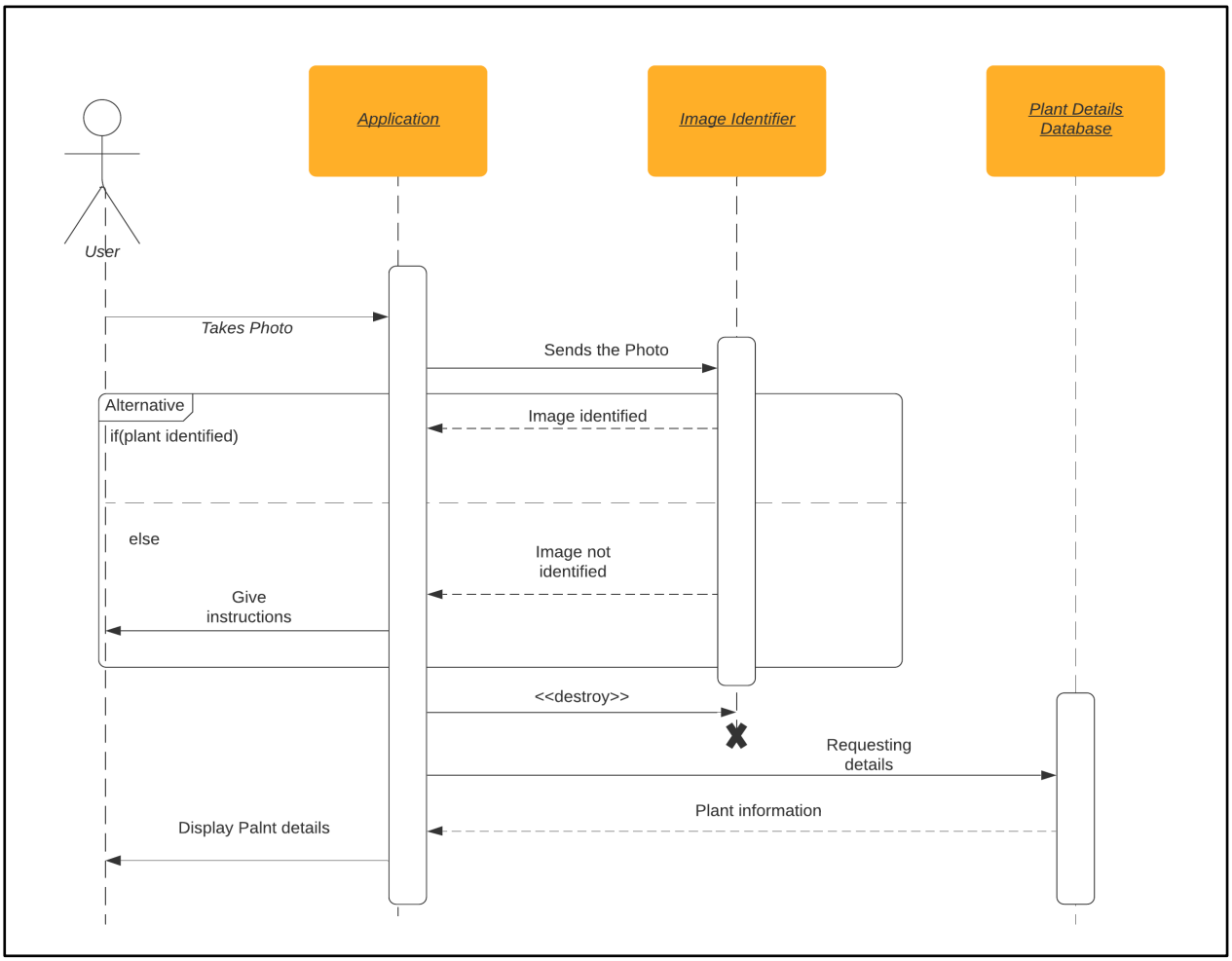

Figure 20 - Sequence Diagram 1

Above figure shows the flow of data hierarchically within the Aayu mobile application. When the user takes the photo, a request is sent to the application and then to the Image Identifier, respectively. This runs a method to retrieve data within a condition. And if the condition is true and data is obtained, then some functions will be executed to display the required information to the user those obtained from the database relevant to the request.

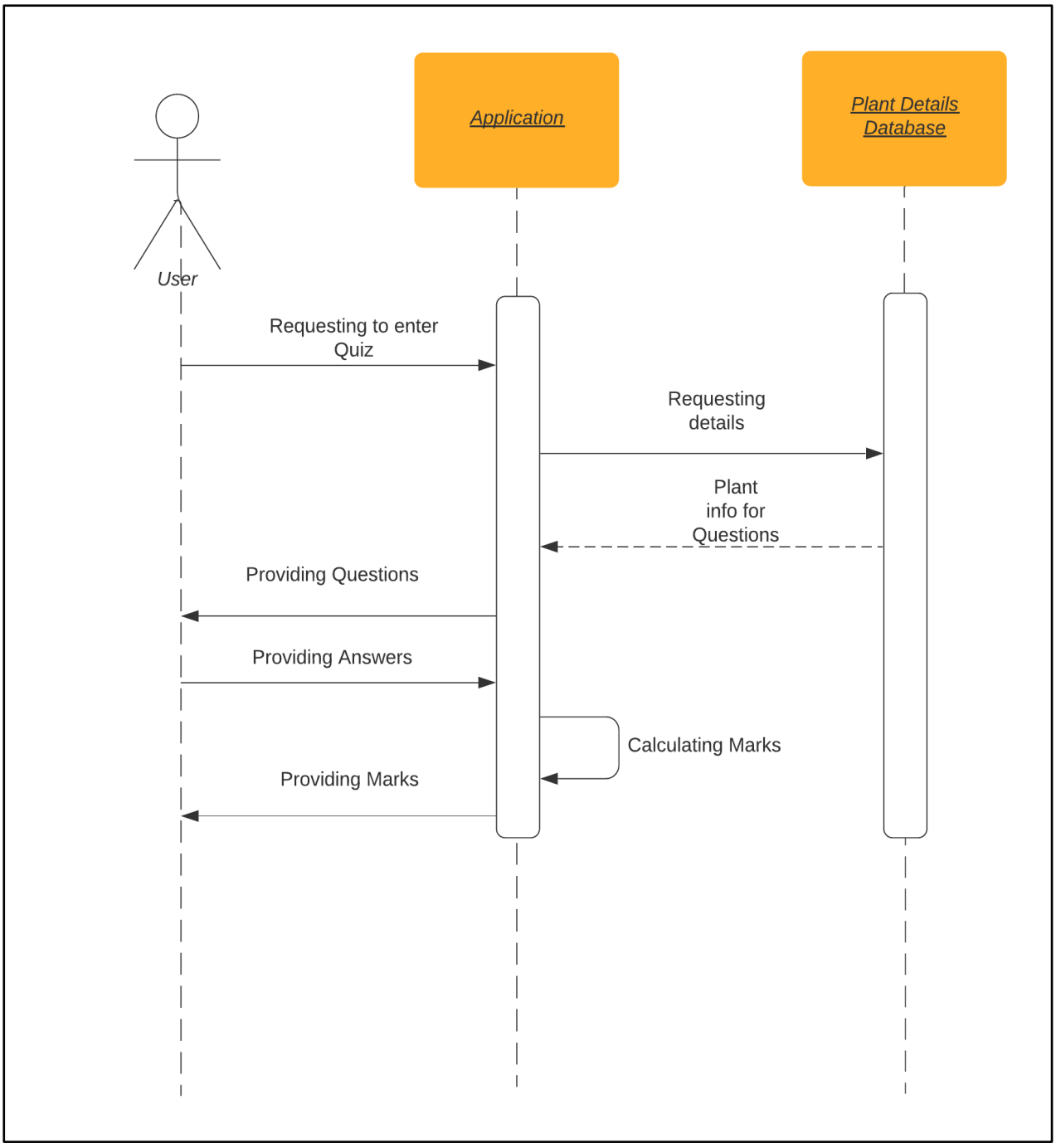

Figure 21 - Sequence Diagram

Above diagram shows the flow of data within the quiz in the Aayu mobile application. When the user enters the quiz, a request is sent to the database consisting of plant details and questions will be delivered to the user through the presentation layer. Then after the user provides answers, marks will be calculated and presented to the user through the application interface.

5.5 Activity Diagram

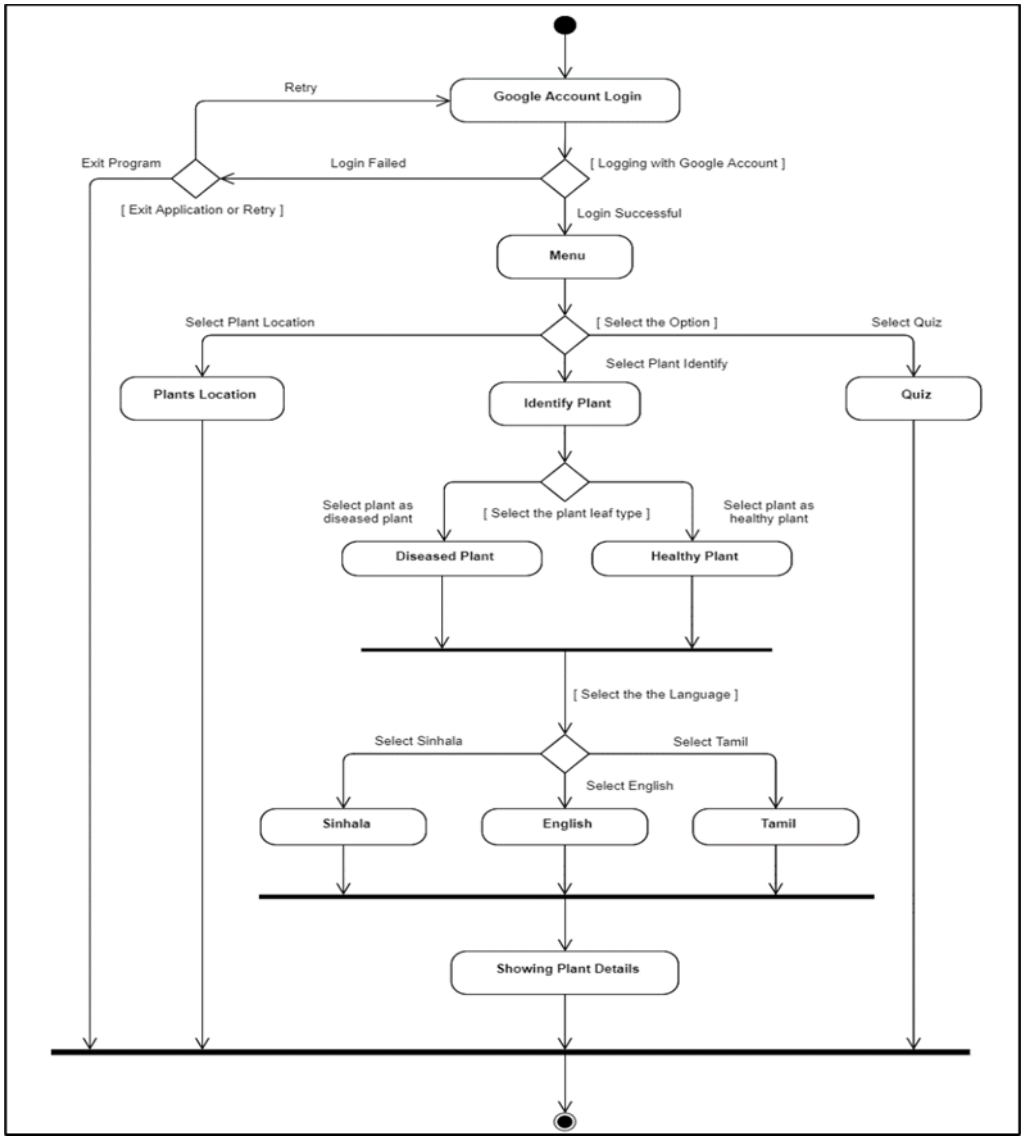

Figure 22 - Activity Diagram

The above diagram designed by Team Aayu is the activity diagram for the Aayu mobile application. Different decision paths linked with each describe the flow within the mobile application. As of the first step, the user login will either be successful and if it is not the user can either try again or exit the application. And if the login is successful, then the user will be directed to the main page where plant scanner, location identification service and the questionnaire will be available. And if a user chooses to identify a plant, there are again options such that to either identify healthy plants or disease plants. According to the user input required information will be displayed in the only selected language. Same as the above if the user

selects plant location or quiz in the main menu required information will be displayed in English. When the user decides to exit, user will be logged out from the account.

5.6 Wireframes (Front end design mockups)

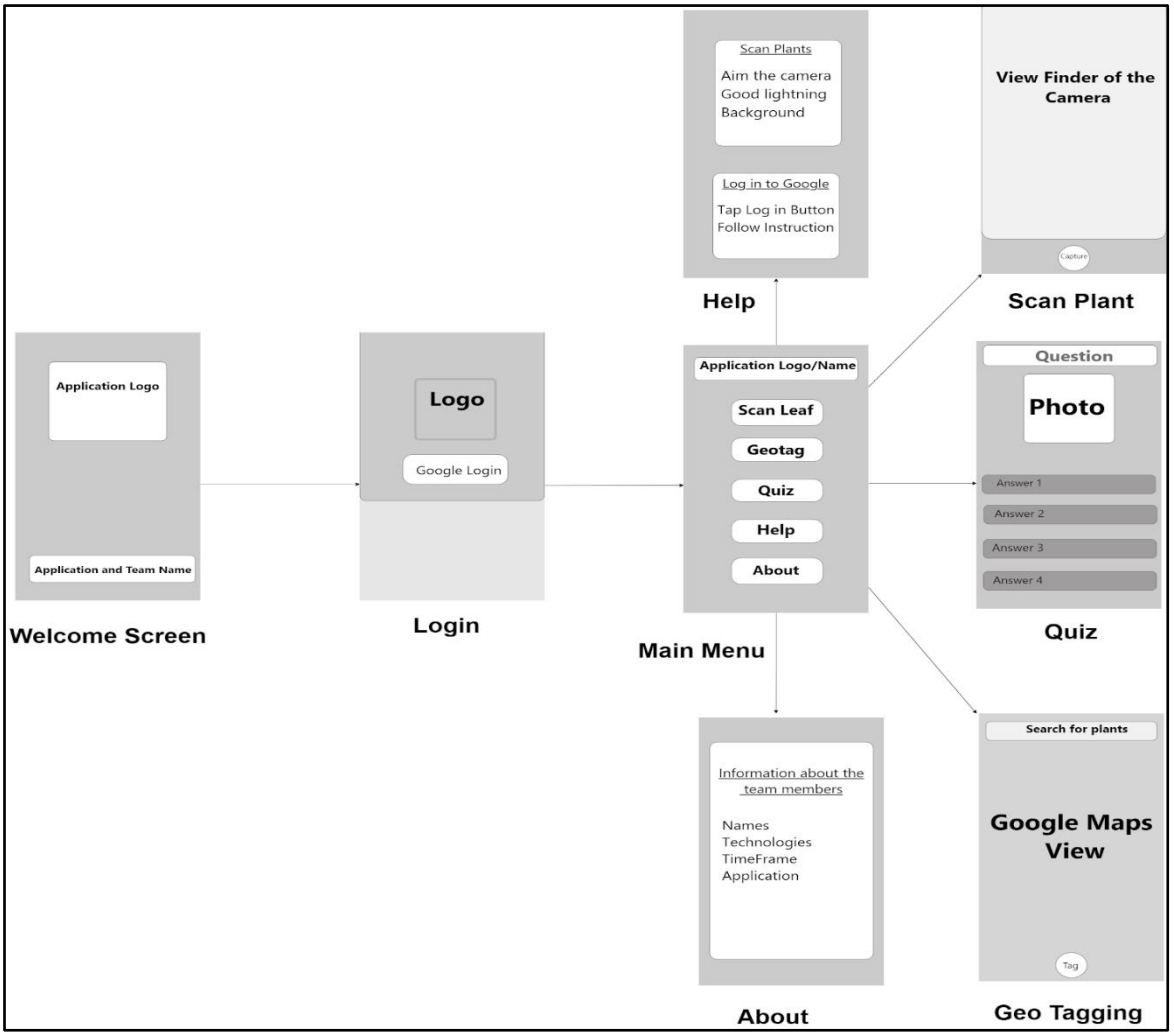

Figure 23 - Wireframe

5.7 Chapter Summary

This chapter goes through all the work done in the design phase of the Aayu project. This includes all the diagrams which were created throughout the design process including High-Level architecture Diagrams, Class Diagram, sequence Diagram, activity Diagram and Wireframes (Front end design mockups).

Chapter 6 – Conclusion

6.1 Chapter Overview

The previous chapter discussed the System Requirements Specification. This chapter will discuss the project implementation, critical information regarding the dataset, and legal, ethical, and professional issues of this project. The challenges and problems faced in different stages of the project will also be discussed. This chapter will end with a concluding remark.

6.2 Dataset

The data set for the project was gathered from an open-source resource. The achieved dataset was verified and got approved by an Ayurvedic doctor from Kurunegala, Sri Lanka. Information about Ayurvedic plants to be identified using the Ayu mobile application was also gathered from websites. Those websites are "Ayurvedic Medicinal Plants of Sri Lanka" and "Sri Lankan Flora & Agricultural Heritage" where details are accessible to the general public.

6.3 Legal, Social, Ethical and Professional Issue

6.3.1 Legal issues

- Data set

The data set was downloaded from a free website that provides free datasets without any legal regularities. The data set does not contain any sensitive information. It only contains pictures of several plant leaves. The publishers of the above-mentioned dataset have given the permission to use it as preferred.

- Privacy policy

Several privacy issues can occur while launching and using a mobile application. It is a must to protect user data from unauthorized access. The Aayu application will only access the camera, location, and other access points while running the app. It will not collect data that will not be given by the user.

- Copyright issues

All the research papers and other referred knowledge sources were properly cited and credited to the original publishers in the document.

6.3.2 Social issues

The project Aayu does not have any bad social effect on society. However, If the project will be implemented in only English and it might affect the people who do not understand the English language, therefore, the project will be implemented in the main languages in Sri Lanka as Sinhala, English, and Tamil. Therefore the project could have a low-level of social impact.

6.3.3 Ethical issues

Project "Aayu" will be implemented in the best ethical manner. No pirated, cracked, or illegally downloaded software was used to complete this project. The geotagging facility can only be used if the user allows it. Proper instructions were given to the user when sharing the location of their plant to avoid any sort of privacy violations. Data gathered from the application are only used to process and identify the plants.

The data which the Application collects will not be shared with any other party. It will only be used to identify the location of the plant.

6.3.4 Professional issues

This has been implemented to the highest professional standards by ensuring that all professional ethics were always followed at all times. Moreover, the datasets used in training the algorithms were obtained from publicly available 'open source' sources. These data will not be used for any commercial purposes.

All respondents of the questionnaires were informed that the questions were used for the purpose of this project. At no point during the questionnaires, respondents were required to provide personal information.

6.4 Plan for implementation

6.4.1 Languages for back-end and front-end

The backend of the system will be implemented using Python while the frontend will be implemented using React Native. All implementations will be grounded on the OOP and MVC concepts to ensure high-quality coding is achieved.

6.4.2 API selection

Google account API will be used in the implementation to ensure that the users are able to easily sign up and log in to the application without going through the hassle of remembering a new set of usernames and passwords. Google geolocation API will be used for the purpose of saving the locations of plants found by users. Using the Google API for this purpose ensures that the users feel confident in sharing their location information because of the fact that Google is a trusted name among many users.

6.4.3 Data science section

The main data science component of this project is the Convolution Neural Networks which are utilized for the purpose of leaf recognition. Pycharm will be used to train this CNN model.

6.4.4 Project implementing method

Github and bitbucket will be extensively used to store, commit, and comment when implementing the code. This will help the team to effectively collaborate and corporate while also documenting the process.

6.4.5 Prototype

6.4.5.1 Welcome page and logging pages

Figure 24 - Welcome and Login pages of Aayu

6.4.5.2 Scanning and information pages

Figure 25 - Information and Scan pages of Aayu

6.4.5.3 Question page

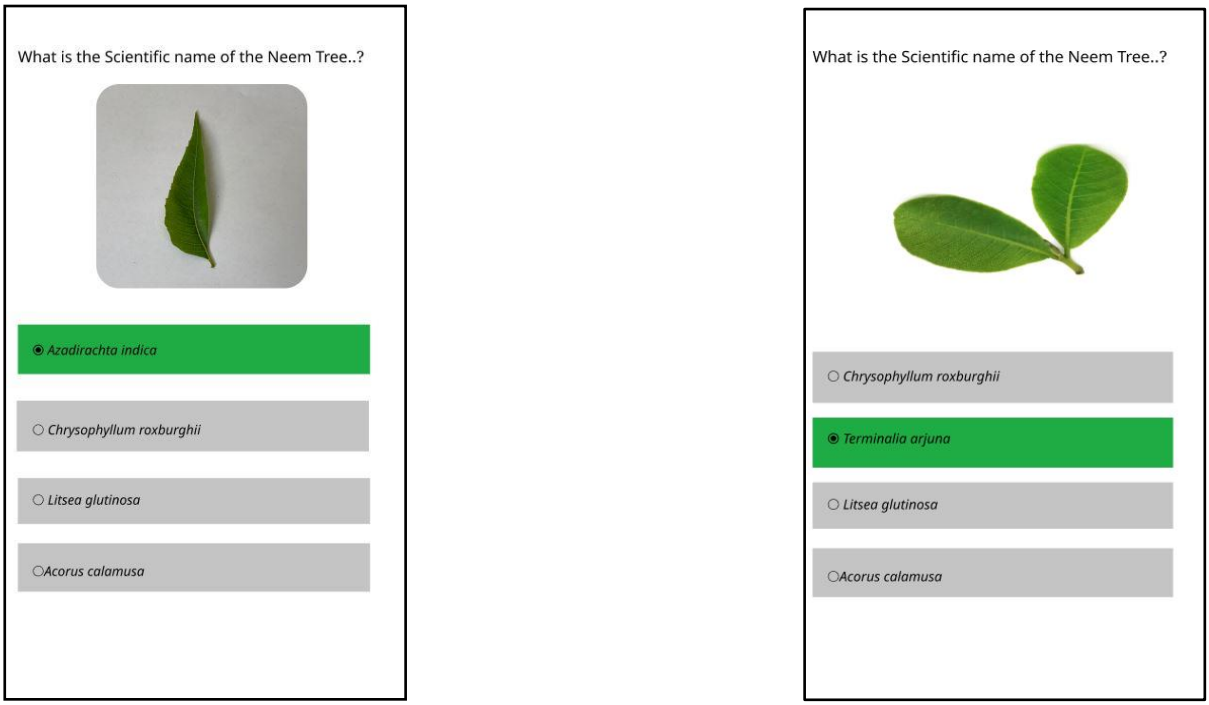

Figure 26 - Quiz Page of Aayu

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Appendix

Appendix Chapter 3 - Work Breakdown Structure

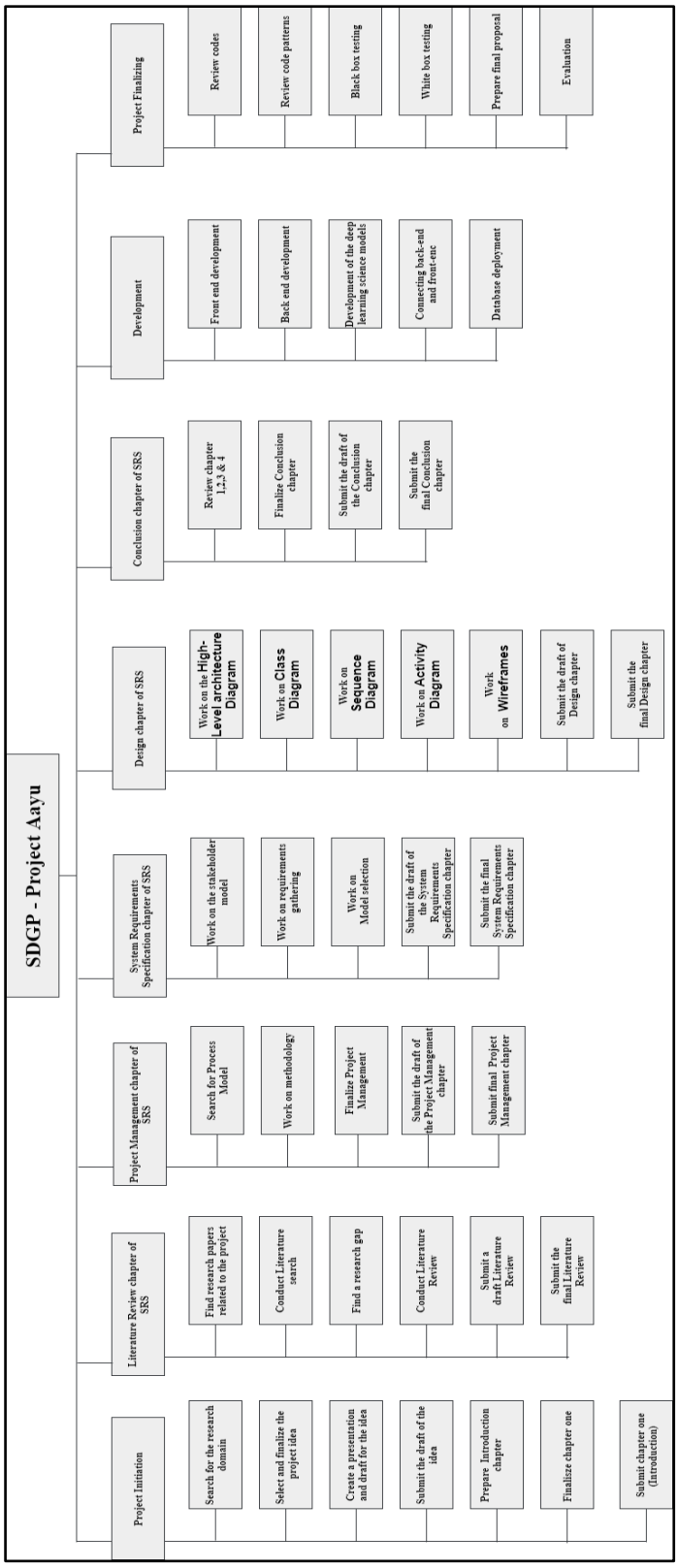

Figure 27 - Work Breakdown Structure

Appendix Chapter 3 - Gantt chart diagram

k Mode	Task Name	Duration	Start	End
	Software Development Group Project	**218 days**	**8/25/2020**	**6/24/2021**
	Project Initiation	**61 days**	**8/25/2020**	**11/17/2020**
	Select Research Domain	20 days	8/25/2020	9/21/2020
	Select Project Idea	6 days	9/15/2020	9/22/2020
	Prepare Presentation Regarding Ideas	9 days	9/21/2020	10/1/2020
	Prepare Project Proposal	21 days	9/30/2020	10/28/2020
	Submit Project Proposal	-	10/25/2020	10/25/2020
	Literature Review and Data Gathering and	**36 days**	**10/25/2020**	**12/14/2020**
	Gathered Required Data set	3 days	10/25/2020	10/28/2020
	Data Clearance and Data Augmentation	3 days	10/29/2020	11/2/2020
	Conduct Literature Research	5 days	11/1/2020	11/6/2020
	Conduct Literature Review	6 days	11/9/2020	11/16/2020
	Prepare Literature Review	10 days	11/15/2020	11/27/2020
	Further Research on Domain	4 days	11/26/2020	12/1/2020
	Submit Literature Review	-	11/30/2020	11/30/2020
	Requirement Gathering and Analysis	**34 days**	**12/1/2020**	**1/15/2021**
	Gathering Requirements	3 days	12/1/2020	12/3/2020
	Collect Information from Domain Expert	3 days	12/7/2020	12/9/2020
	Analyzing and Evaluating Collected Data	3 days	12/11/2020	12/15/2020
	Prepare SRS Report	11 days	12/14/2020	12/28/2020
	Discuss the SRS with the Feedback Team	6 days	12/29/2020	1/5/2021
	Submit the SRS Report	-	1/4/2021	1/4/2021
	Prototype Implementation	**52 days**	**1/4/2021**	**3/16/2021**
	Creating High-Level Architecture Diagram	4 days	1/4/2021	1/7/2021
	Designing a Sample Prototype	8 days	1/10/2021	1/20/2021
	Initial Implementation of the Prototype	27 days	1/19/2021	2/24/2021
	Prepare Progression Report and Discuss with the Feedback Team	9 days	2/15/2021	2/25/2021
	Submit Progression Report	-	2/25/2021	2/25/2021
	Prototype Analysis and Documentation	**5 days**	**2/25/2021**	**3/3/2021**
	Code Review	2 days	2/25/2021	2/27/2021
	Submit Prototype Report	-	2/27/2021	2/27/2021
	Changes to the Prototype	3 days	2/27/2021	3/3/2021
	Testing and Evaluation	**5 days**	**3/1/2021**	**3/6/2021**
	Unit Testing	1 day	3/1/2021	3/1/2021
	Integration Testing	1 day	3/2/2021	3/2/2021
	Bug Fixing	3 days	3/3/2021	3/6/2021
	Finalizing the Project	**19 days**	**3/6/2021**	**4/1/2021**
	Prepare Draft Final report	5 days	3/6/2021	3/12/2021
	Submit Draft Report	-	3/10/2021	3/10/2021
	Discussion with Feedback Team and Getting checked Report	14 days	3/10/2021	3/29/2021
	Submission of Final Report	-	3/25/2021	3/25/2021

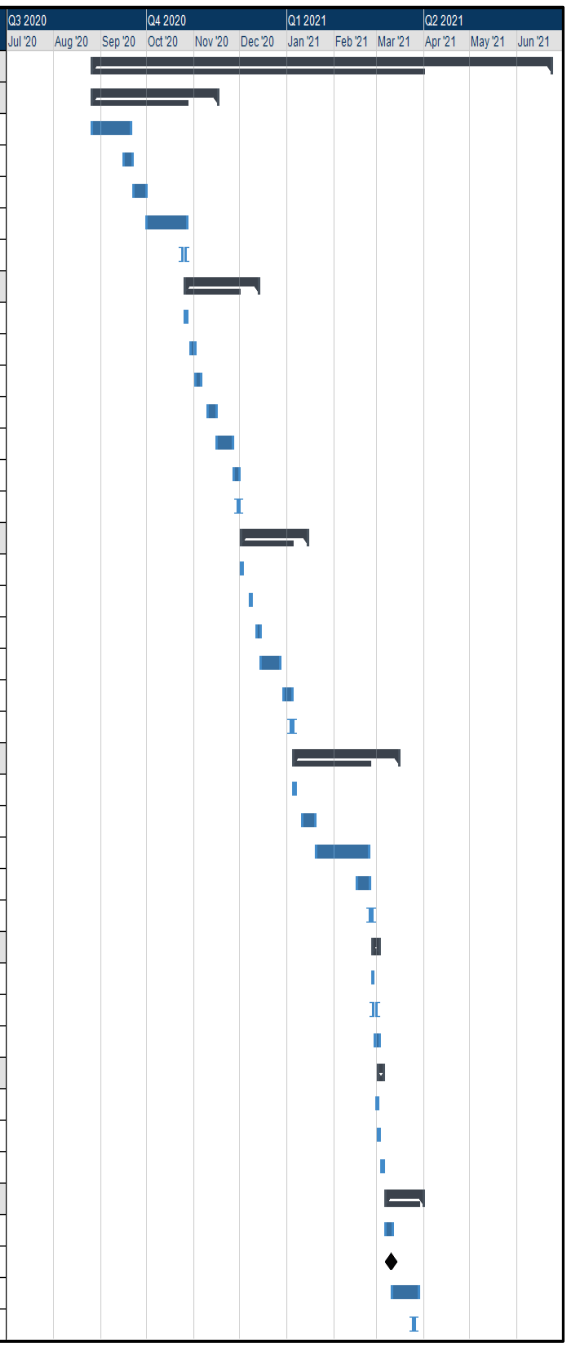

Figure 28 - Gantt Chart