

INFORMATICS INSTITUTE OF TECHNOLOGY

In Collaboration with

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**LifeVeda: Recognizing Ayurvedic Medicinal plants under natural background conditions.**

An Initial Project Proposal by

Ms. Minoli Jayasiri

w1867669/20210558

Supervised by

Ms. Malsha Fernando

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# LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| Acronym | Description |
| CNNs | Convolutional Neural Networks |
| SVMs | Support Vector Machines |
| OOAD | Object Oriented Analysis and Design |
| OS | Operating System |

# **CHAPTER 01: PROBLEM**

## **1.1Chapter Overview**

## This chapter aims to give the reader an insight into the problem that the author is going to solve through this research and the gaps in the existing systems that have been proposed to solve this problem. The objectives and the scope of the research and the anticipated challenges in implementing the solution will also be outlined in this chapter.

## **1.2 Introduction**

## Ayurveda holds a significant place as a traditional medical system in Sri Lanka. Ayurvedic medicine is used by many citizens of Sri Lankan. Natural ingredients like plants, plant leaves, flowers, roots, minerals etc. are used in the preparation of Ayurvedic medicine. Due to certain issues that have been identified in the process of preparing ayurvedic medicine, the author has identified an application to recognize ayurvedic medicinal plants would be beneficial in aiding the ayurvedic medical system in Sri Lanka.

## **1.3 Problem Domain**

### **1.3.1 Ayurvedic Medicine in Sri Lanka**

Ayurveda, originating in India, is a traditional system of medicine in Sri Lanka. Ayurveda has been practiced in Sri Lanka for more than 3000 years. In Ayurveda various parts of plants such as leaves, roots, fruits, flowers, and barks are used for the treatment of diseases. Among these, leaves play a significant role in the formulation of ayurvedic medicines. Plants used in ayurvedic medicine are mostly collected from forests and gardens.

To collect the correct plants needed for the preparation of the medicines which are used to cure diseases, one should be able to accurately identify them but those who collect these plants are not properly trained for it. There is a risk of human error in this situation. Incorrect plants used in the preparation of the medicine used for treatment of diseases can cause the medicine to be ineffective. This might also result in a decline of trust among individuals towards the principles of Ayurvedic healthcare.

Certain plants and herbs are at risk of disappearing because the forests they grow in are being destroyed (Weragoda, 1980). Since individuals aren't familiar with these plants, they might unintentionally remove them. If there was a method to easily identify these plants, it could contribute to their preservation.

### **1.3.2 Image Recognition**

Image recognition is a subset of computer vision, computer vision involves utilizing computers to interpret digital images. A fundamental aspect of computer vision is image recognition, which aids in identifying and classifying components within images. Image recognition enables machines to recognize and identify objects, individuals, elements, and other factors within images. In image recognition labelled images can be trained using a machine learning model, once model is trained it can be used to predict the class of previously unseen images. Image recognition technology automatically extracts features of the image and performs image classification ([Yinglong](https://ieeexplore.ieee.org/author/37089736255), 2022).

In recent years rapid developments have been made in image recognition technology. Among these the most popular traditional machine learning models are Support Vector Machines (SVMs), a type of supervised machine learning algorithm that is used for classification and regression tasks and Bag of Features Models, a classification method that uses unordered collection of image features.

However, the latest advancement in the field of image recognition is deep learning. It has introduced more accurate and efficient models for image recognition. In simple words, deep learning is a subset of machine learning that mimics our brain’s functioning that enables systems to learn without human intervention. Convolutional Neural Networks and transformer-based models are two significant deep learning algorithms that are used in recognizing images. The key feature of CNNs is that they do the feature extraction themselves using convolutional layers unlike traditional machine learning models where features must be extracted manually. The Transformer architecture was first introduced in 2017 in the paper “Attention Is All You Need” (Vaswani, 2017).

### **1.3.3 Plant recognition**

Plant recognition involves training computer systems to automatically recognize and classify plants mostly using their leaves, flowers, fruits etc. Identifying plants through image recognition has been an area of research for many years now. Often leaves have been used for the classification of plants. A leaf can be characterized by its color, its texture, and its shape (Sharma and Gupta, 2015).

The process of detection consists of various stages, including image pre-processing, image segmentation, image enhancement, and localization. The effective implementation of pre-processing is important as it significantly reduces computation time and noise, resulting in higher accuracy (Pushpanathan et al., 2020).

## **1.4 Problem Definition**

Medicinal plants are gaining more attention in the pharmaceutical industry as they tend to have less harmful effects and are cost effective compared to modern medicine (Pushpanathan et al., 2020). Ayurveda is a traditional system of healing in Sri Lanka where plants and various plant components including leaves, roots, bark, flowers, and fruits, are widely employed as fundamental ingredients in the preparation of ayurvedic medicine. As a result of post-pandemic inflation, the prices of Western medicines have significantly risen. Additionally, with the occurrence of recent cases of western medicine toxicity in Sri Lanka, an increasing number of individuals have turned to Ayurvedic medicine as an alternative remedy for various ailments. Currently the plants used in the preparation of ayurvedic medicine are collected manually, and individuals involved in the collection process often lack professional training in accurately identifying medicinal plants (Jayalath et al., 2019). In the scenario where one needs to collect these plants, seeking guidance from someone with expertise in their identification becomes essential. Improper collection of plants can lead to the ineffectiveness of Ayurvedic medicine. Certain Ayurvedic plants also thrive within home gardens. Facilitating easy recognition of these plants is important, as otherwise, they might be removed unintentionally due to limited knowledge regarding them. Therefore, an application that could recognize ayurvedic medicinal plants under natural environmental conditions could contribute significantly to both the collection and preservation of these plants, thereby supporting the Ayurvedic medical industry.

### **1.4.1 Problem Statement**

Ayurvedic medicinal plants are currently collected manually which can lead to the collection of incorrect plants due to human error, furthermore, due to limited knowledge about these plants, they often face inadvertent destruction.

## **1.5 Research Aim**

*The aim of this research is to design, develop and evaluate a system that can detect and identify Ayurvedic Medicinal plants in their natural environment using image processing.*

Further elaborating on the aim, the proposed system would help classify ayurvedic plants in their natural habitat with the use of image processing technology. A suitable deep learning model will be developed utilizing available deep learning architectures that would be able to accurately perform image classification. This system mainly targets the Ayurvedic Medicine industry in Sri Lanka. This could be used to assist in the process of collecting Ayurvedic medicinal plants. This application could also be used by patients undergoing ayurvedic medical treatments as some medicines are required to be prepared by patients on their own according to the advice of the doctor.

## **1.6 Research Objectives**

|  |  |  |  |
| --- | --- | --- | --- |
| **Research Objectives** | **Description** | **Learning Outcomes** | **Research Questions** |
| Literature Review | R01: Identifying gaps and limitations in existing research on the chosen domain.  R02: Research on techniques that are used for plant recognition using image processing.  R03: Analyze the algorithms, machine learning models and technologies that have been used in previous research to solve this problem.  R04: Research on methods that can be used to recognize objects with natural backgrounds. | L02, L04, L06 | RQ2, RQ3 |
| Requirement Elicitation | R05: Get feedback and opinions on proposed system through surveys and interviews.  R06: Get insights from domain and industry experts and analyze them to build a suitable application.  R07: Gather data on Ayurvedic medicinal plants that can be used for the research. | L02, L03, L04, L05 | RQ1 |
| Design | R08: To design the machine learning classification model required to build the proposed system.  R9: To design the frontend for the proposed system.  R11: To design the backend for the proposed system. | L01, L03, L06 | RQ2, RQ3 |
| Implementation | R12: To develop an appropriate machine learning model to classify the ayurvedic plants accurately.  R13: To develop the core functionalities of the proposed system.  R14: To develop an application with all proposed functionalities. | L01, L03, L05, L07 | RQ2, RQ3 |
| Evaluation | R15: Test the created plant recognition model using evaluation metrics, calculate accuracy, precision, recall and f1 score to evaluate the performance of the model.  R16: Check if the training dataset has a class imbalance.  R17: Compare created plant recognition model with existing systems.  R18: Ensure each software component operates as expected individually and the system works as intended as a whole.  R19: Carry out usability testing to determine how well a user can use the created web application in a real-world scenario.  R20: To get feedback from industry and domain experts on the final prototype. | L04 | RQ2, RQ3 |

Table 2: Research objectives

## **1.7 Novelty of the Research**

### **1.7.1 Problem Novelty**

### **1.7.2 Solution Novelty**

## **1.8 Research Gap**

Research has been carried out for the recognition of ayurvedic plants in Sri Lanka. An approach using Transfer learning techniques has achieved an accuracy of 95.5% for a dataset with 5 classes and 369 images in total (Azeez and Rajapakse, 2019). One attempt using CNNs achieved an accuracy of 90% ( Jayalath et al., 2019). Another attempt was carried out using scanned images of leaves, this was trained using a convolutional neural network based on AlexNet and the model achieved a validation accuracy of 97.71% (Jayanka and Fernando, 2020).

Although these approaches perform well and have good test accuracies, it’s important to note that all leaves were captured against a white background when creating the dataset used to train the models. So, these models may not work well under natural environment conditions, varying light conditions and noisy backgrounds could lead to poor performance and misclassification. These limitations would be addressed in this research project.

## **1.9 Contribution to the Body of Knowledge**

The proposed research project contributes to the problem domain and research domain as follows.

### **1.9.1 Contribution to the problem domain**

This project aims to create an application that would recognize ayurvedic medicinal plants under natural environment conditions. This application holds significant value in the preparation of ayurvedic medicine as it enables the accurate recognition of medicinal plants used in the production process. Given the limited awareness regarding ayurvedic medicinal plants, the preservation of these valuable plants is often compromised due to human activities, therefore this application holds the potential to mitigate this issue by aiding the recognition of medicinal plants contributing to their conservation.

### **1.9.2 Contribution to the research domain**

The proposed research project will utilize image processing technology to recognize ayurvedic medicinal plants, therefore several concepts in machine learning will be used in the development process. The findings discovered during this research can be used by other researchers for evaluation and future research. Recognizing plants in their natural setting remains a challenge in the machine learning domain till date. Limited research has been done regarding the recognition of plants in their natural environments. This study aims to introduce an architecture that leverages existing deep learning models to precisely classify plants in their natural habitats. This research could demonstrate that deep learning models can be used in more complex real-world scenarios as well rather than under controlled conditions. The outcome of this research could also contribute to the development of more robust architectures in this domain.

## **1.10 Research Challenge**

During the implementation of this research project the author will encounter several challenges. Listed below are some of the challenges identified so far.

* As there is no publicly available dataset the author would have to create a dataset by capturing images of ayurvedic medicinal plants.
* Research would have to be done to select the most efficient machine learning algorithm for accurate image classification.
* Since the application would be developed to recognize ayurvedic medicinal plants in natural environment conditions the author would have to develop a technique to effectively distinguish the plants from their backgrounds.
* Machine learning methods like edge detection and image segmentation would have to be used to separate the foreground and the background, another challenge would be to select the best algorithm for this task.

## **1.11 Chapter Summary**

The chapter presents the user with an overview of the research, including the identified problem in the Ayurvedic Medicinal system of Sri Lanka and the proposed solution. It justifies the need to provide a solution to this problem by using the latest technologies in machine learning and how this would be a contribution to both the Ayurvedic Medicinal industry and the field of plant recognition using deep learning.

# **CHAPTER 02: SOFTWARE REQUIREMENT SPECIFICATION**

## **4.1 Chapter Overview**

## **4.4 Rich Picture Diagram**

A diagram of a life cycle

Description automatically generated

Figure 1: Rich Picture Diagram (Self-Composed)

## **2.3 Stake Holder Analysis**

## **2.3.1 Stake Holder Onion Model**

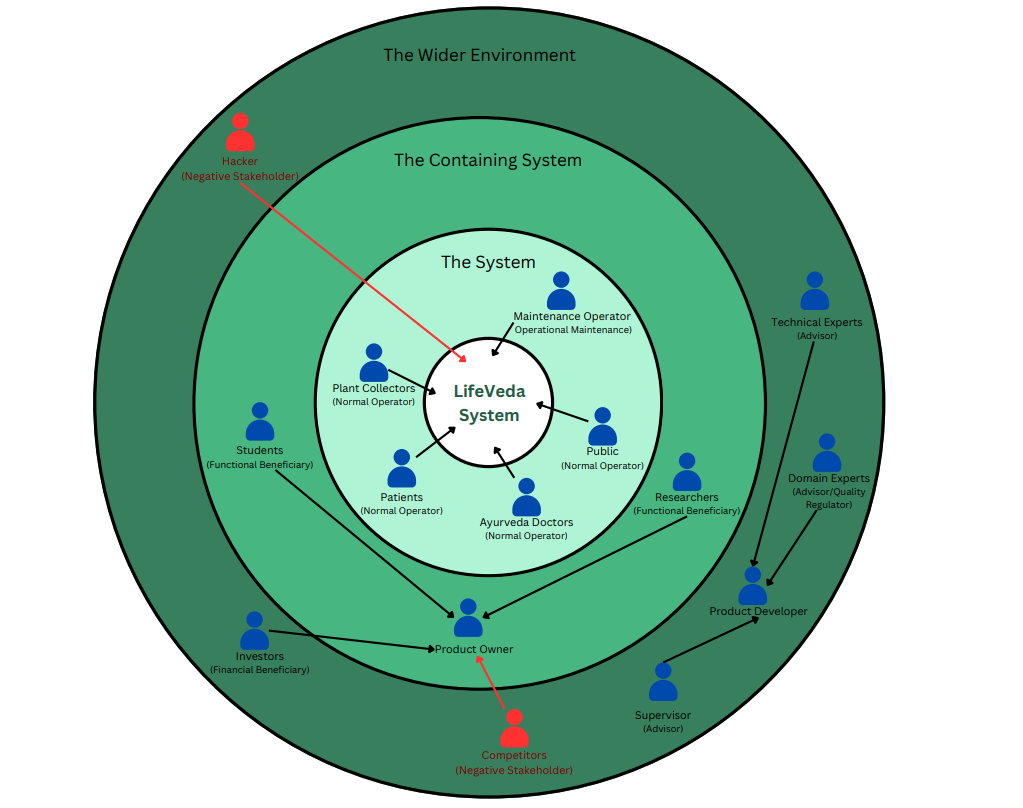


Figure 2: Onion Model (Self-Composed)

## **2.3.2 Stake Holder Onion Model**

|  |  |  |
| --- | --- | --- |
| **Stakeholder** | **Role** | **Description** |
| **The System Stakeholders** | | |
| Plant collectors | Normal operator | Uses the LifeVeda application to identify plants with an Ayurvedic value. |
| Ayurveda doctors | Normal operator | Uses the LifeVeda application to validate the identity of collected plant leaves. |
| Public | Normal operator | Uses the LifeVeda application to identify Ayurvedic plants to use for home remedies and to identify plants to avoid unintentional destruction. |
| Patients | Normal operator | Uses the LifeVeda application to identify Ayurvedic plants to prepare medicine advised by Ayurvedic doctors. |
| Maintenance operator | Operational Maintenance | Maintains the LifeVeda system and investigates user inquiries. |
| **The Containing System Stakeholders** | | |
| Students | Functional beneficiary | Explore the techniques used in the research to use it in other problem domains. |
| Researchers | Functional Beneficiary | Investigates the techniques used in the research to further improve it. |
| Product owner | Functional beneficiary | Owns the product, communicates with other stakeholders, and takes decisions regarding the system. |
| The Wider Environment Stakeholders | | |
| Hackers | Negative stakeholders | May steal data and disrupt the system. |
| Competitors | Negative stakeholders | Build better systems that outperform the LifeVeda application and decreases its market value. |
| Investors | Financial beneficiary | Provide funding to the system and gains profit from investing. |
| Product Developer | Developer | Develops and improves the system. |
| Supervisor | Advisor | Guides the developer and gives feedback to make improvements. |
| Technical experts | Advisor | Gives expert opinions and feedback helpful in developing the system. |
| Domain Experts | Advisor/Quality regulator | Provides information on the chosen domain helpful for the system development and evaluates the system. |

## **2.4 Selection of Requirement Elicitation Methodologies**

Requirement Elicitation is used to gather requirements needed for the development of this research project. The table below shows the requirement elicitation methods that were used and discusses the rationale behind the choices.

|  |
| --- |
| **Method 01: Literature Review** |
| A literature review helps identify research gaps and problems in existing systems implemented to identify Ayurvedic medicinal plants in Sri Lanka. Identifying a good research gap to carry out the research is a vital component of a research project. The author reviewed research papers of existing systems that have been implemented in the chosen problem domain to identify their limitations. Possible techniques available for the implementation of the system were also identified through this. |
| **Method 02: Survey** |
| There is no specific target audience for this application . The purpose of the system is to help recognize Ayurvedic medicinal plants and their properties. This system can be used by the individuals who collect Ayurvedic plants, doctors who prepare Ayurvedic medicine, patients who were advised doctors to use Ayurvedic medicine prepared at home and the public to identify these plants to preserve them if available in their home gardens. Since this system if useful in many ways it is important to gather insights and requirements from a large group of people to get their ideas. The author can determine which age group to target from the results of the survey. |
| **Method 03: Prototyping** |
| It is important to implement an effective novel technique in order to address the identified research gap. ML models used for image recognition tasks tend to underperform when images are noisy. To build a robust system which is able to identify edges and distinguish between the foreground and background to identify Ayurvedic medicinal plants in their natural environments, continuous developments, testing and fine-tuning is required therefore prototyping was chosen as a requirement elicitation method. |

## **2.5 Discussion of Findings**

### **2.5.1 Literature Review**

|  |  |
| --- | --- |
| **Findings** | **Citation** |
| The leaves of plants contain lot of features, and these can be automatically learned by DL algorithms. | Kanda, Xia and Sanusi, 2021 |
| Data augmentation technique can be used to increase the size of datasets and the use of augmented images increases model performance. | Kanda, Xia and Sanusi, 2021 |
| Small datasets can cause CNNs to overfit therefore CNNs require large datasets for training. | Kanda, Xia and Sanusi, 2021 |
| The use of DL models for feature extraction gives better performance than using hand-crafted features. | Kanda, Xia and Sanusi, 2021 |
| The use of Deep Ensemble Learning can give better performance than using individual CNN models. | Chompookham and Surinta, 2021 |
| Model did not perform well when tested on images of leaves captured in their natural environment. | Jayanka and Fernando, 2020 |
| Reasons for poor quality of Ayurvedic medicine and absence of enough supply is related to the lack of knowledge in recognizing these plants and due to the extinction of plants and their extinction. | Kankanamalage et al., 2014 |

### **2.5.2 Survey**

|  |  |
| --- | --- |
| **Question** | Which age group do you belong to? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Have you used Ayurvedic medicine before? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Do you believe that the Ayurvedic medicinal system in Sri Lanka is important? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Are you aware that plant leaves are used as an ingredient in the preparation of Ayurvedic medicine? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Are you able to identify Ayurvedic plants on your own? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Are you able to identify Ayurvedic plants on your own? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | To which plant do you think this leaf belongs to? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Could you identify the plant to which the above shown leaf image belongs to? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | If there were Ayurvedic medicinal plants in your home gardens, would you preserve them? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Have you ever heard of a system that could recognize Ayurvedic plant leaves while in their natural environment? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |
| **Question** | Do you believe that a system that could recognize Ayurvedic medicinal plants and display their properties while in their natural background would be useful? |
| **Aim of the Question** |  |
| **Observation** | |
| **Conclusion** | |

### **2.5.3 Prototyping**

### **2.5.4 Summary of Findings**

## **2.6 Context Diagram**

## **2.7 Use Case Diagram**

## **2.8 Use Case Descriptions**

## **2.9 Requirements**

## **2.9.1 Functional Requirements**

## **2.9.2 Non-Functional Requirements**

## **2.10 Chapter Summary**

**CHAPTER 03: DESIGN**

**3.1. Chapter Overview**

**3.2 Design Goals**

**3.3 System Architecture Design**

**5.3.1 Tiered Architecture – three different processes connected**

**5.3.1.1 Presentation Tier**

**5.3.1.2 Logic Tier**

**5.3.1.3 Data Tier**

**5.4 Component Design**

**5.5 System Design**

**OOAD**

**5.5.1 Class Diagram**

**5.5.2 Sequence Diagram**

**5.5.3 DL Model Design**

**5.5.4 Process Flowchart**

**5.5.5 UI Design**

**5.5.5.2 High Level Architecture**

**5.6 Chapter Summary**

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