SMART PLANT DISORDER IDENTIFICATION

CDAP 2020-025

Project Proposal Report

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Declaration

I declare that this is my own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
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The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

…………………………..   ………………………

Signature of the supervisor   Date

(Dr. Janaka Wijekoon)

Abstract

Economic development of a country is highly depended on agriculture productivity. According to the criteria of economy, quality and quantity of the agricultural products are important in its trading. Farmers are expected to produce high or sufficient quantity of products with optimum quality. But, in most of the times, farmers are failing to fulfill these expectations due to various issues. Major issue is to identify nutrient deficiency that are prominently occurring in crops early. Early prediction and identification of the exact nutrient element with deficiency will help the farmers to prevent from the diseases spreading in crops. This can improve the productivity in agriculture. In present era, technology in different areas are utilized to get numerous benefits. According to our research, this component is trying to solve the above mentioned problem using image processing and machine learning which has been proved to be an effective technique for analysis in various fields and applications. And final solution of our research will be presented to the user as a smart mobile application named as “CropMedic 2.0”. Here the user will be facilitated to upload an image of the leaf of a plant to perform the nutrient deficiency detection accurately. To identify and predict the different nutrient deficiencies in the plant, data gathering for the images will be obtained from the online resources, as well as from images captured during field visits.

Keywords: Convolutional neural network, Nutrient deficiency, Macronutrients, Micronutrients, Image processing, Feature Extraction

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LIST OF ABBREVIATIONS

CNN	Convolutional Neural Network
GA	Genetic Algorithm
GDP	Gross domestic product
R-CNN	Region-based Convolutional Neural Network
SVM	Support Vector Machine

1. INTRODUCTION

1.1 Background

Agriculture is the most important sector in Sri Lankan economy. This is the only sector which provides the essential need of people. Majority of the labor force is engaged in to this sector. Approximately 38 percentage of the labor force was engaged in agriculture in 1999 [9]. However, during last three decades the contribution of Gross Domestic Product of agriculture was declined [9]. In this sector, rice is the most important activity of the rural area people. According to figure 1.1, currently Agriculture sector is contributing to 6.9 percent of nation's Gross Domestic Product and over 25 percent of the people in Sri Lanka are employed in this agriculture sector.

Srilanka GDP from Agriculture

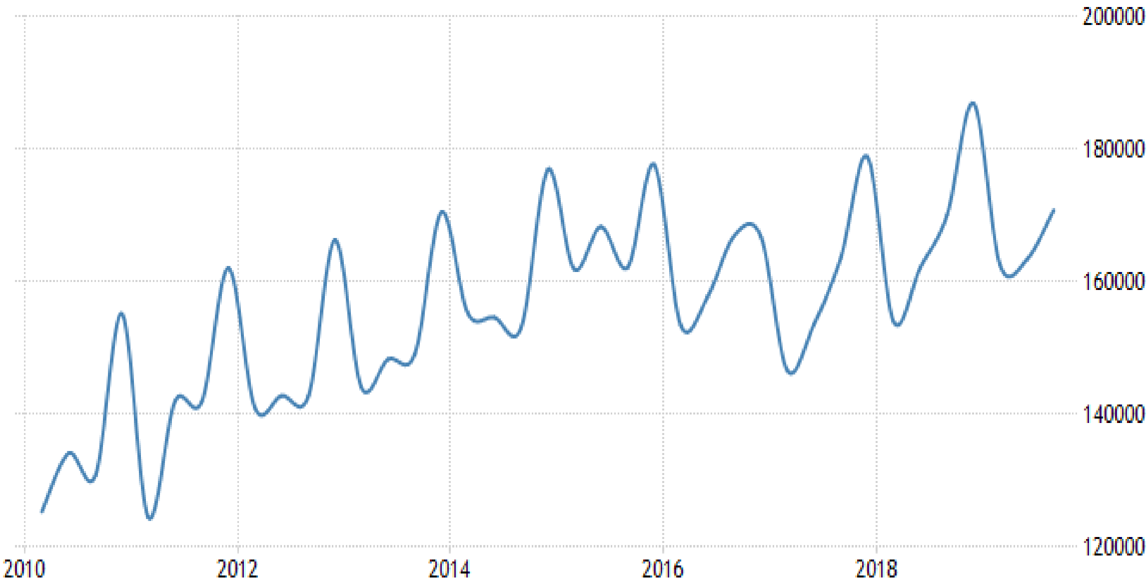

Figure 1.1 - GDP Chart
Source: Srilanka GDP Agriculure, https://tradingeconomics.com/

Most of the cash crops mass scale production are done in the up country districts such as Badulla, Nuwara Eliya, Kandy and Matale. Bandarawela is the second largest town in the Badulla district situated in the hill country of Srilanka. As in the Figure 1.2, Bandarawela is considered to have much favourable conditions for the cultivation of cash crops. The Regional Agricultural Research and Development Centre situated in Kahagolla, Bandarawela is one such centre which has highly contributed to this research project. In that research center, we have planned to grow the plants in control environment with suitable conditions.

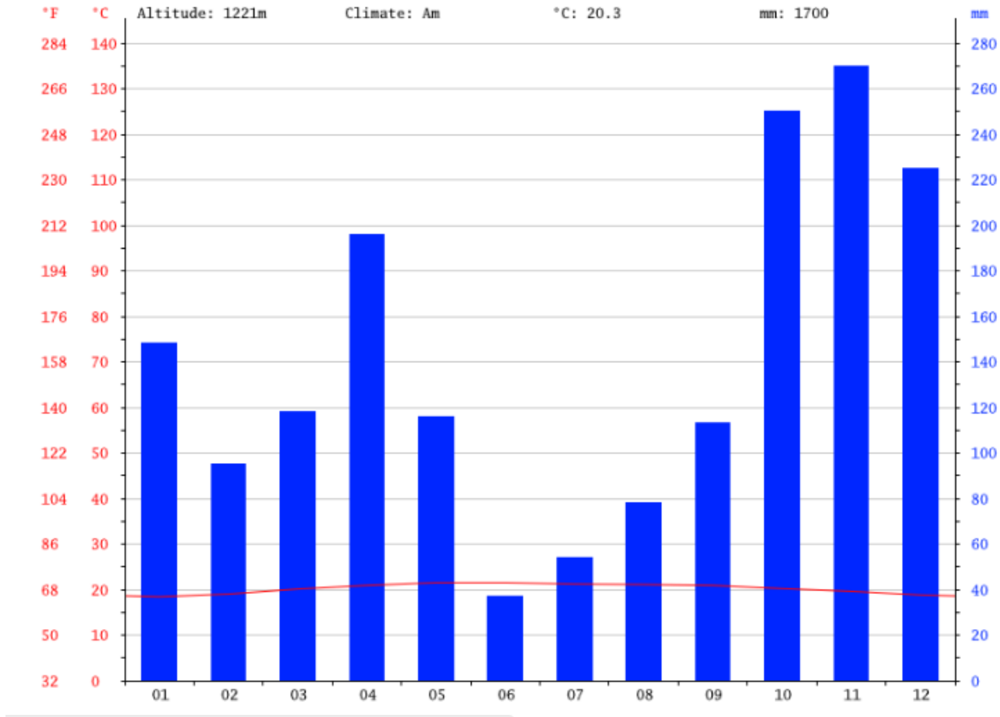

Figure 1.2: Bandarawela Climate Chart
Source: Bandarawela Climate Summary, https://en.climate-data.org/

In agriculture sector there are many unsolved problems related to crop cultivation. The planters are facing a lot of problems to get quality and quantity output of the cultivation effectively. Mainly they are facing problems to identify nutrient deficiency in the early stages because of different plants having different nutrient deficiencies and most of the nutrient deficiency symptoms are very similar. Usually nutrient deficiencies will cause diseases to spread faster [8]. So, the absence of a system to identify the occurrence of nutrient deficiency in plants has hindered the growth of the production rate of cash crops in Sri Lanka.

“CropMedic 2.0” is aimed at solving this issue by developing a mobile application to identify the nutrient deficiencies such as Nitrogen, Potassium and Phosphorus deficiency in plants. Through this application, it is expected that the farmers will be able to identify the nutrient deficiency with its degree.

1.1.1 Overview of nutrient deficiency in plants.

Normal functioning and important nutrients for growth are needed for plants. Nutrient deficiency occurs when a needed nutrient isn’t available in enough quantity to satisfy the needs of a plant. Nutrients can be divided in to two types [8] such as macronutrients and micronutrients. Macro nutrients are nitrogen (N), phosphorus (P), and potassium (K). As shown in the Figure 1.3, Macronutrients deficiency symptoms are shown in the old leaves. Micronutrients are sulfur (S), boron (B), chloride (Cl), copper (Cu), manganese (Mn), iron (Fe), and zinc (Zn). Mostly macronutrients deficiency affect the crops abundantly compared to micronutrients deficiency [8]. Therefore, in this research we are mainly focusing on identifying the deficiency of macronutrients such as Nitrogen, Phosphorus and Potassium.

Precautions in identifying nutrient deficiency symptoms include the following:

- Most of the nutrient deficiency symptoms appear to be very similar [15]. For example, Sulfur deficiency and Nitrogen deficiency symptoms can be very alike, depending on the severity of the nutrient deficiency and plant growth stages.
- Many deficiencies can occur at the same time [8]. More than one deficiency symptoms in one plant, or possibly an existence of one nutrient deficiency can induce the deficiency of another [13] (e.g. excessive P causing Zn deficiency).
- Different plant species, and even some plants of the same species, differ in their ability to show nutrient deficiency symptoms [8].

- Hidden hunger: Plants might be nutrient deficient without showing symptoms directly.

In addition to the above precautions, direct observation is additionally limited by time. Between the time a plant is nutrient deficient (hidden hunger) and visual symptoms appear, crop health and productivity could also be substantially reduced.

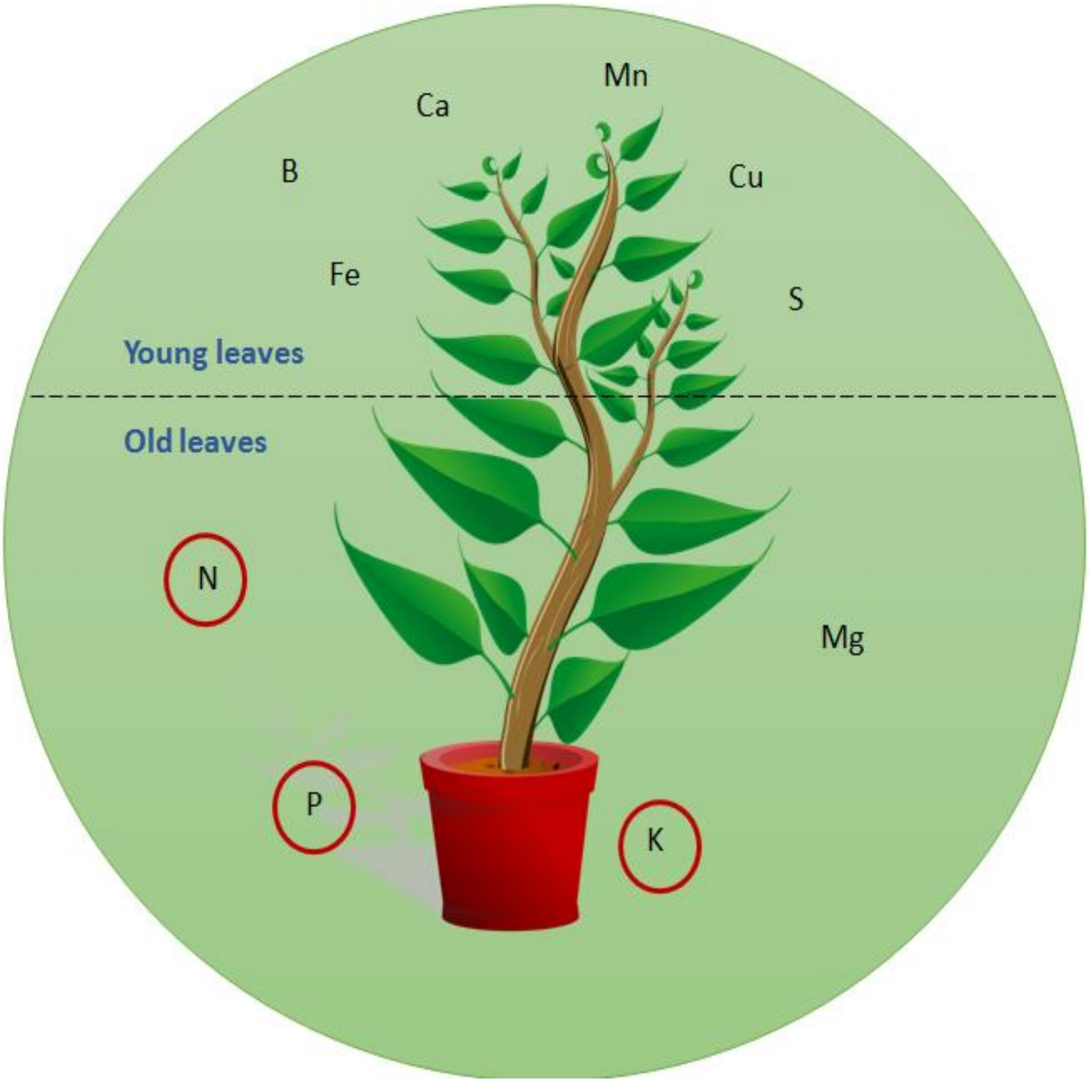

Figure 1.3: Macronutrients and micronutrients

1.1.2 Overview of Nitrogen deficiency and Symptoms

Nitrogen is an essential component in the plant growth. It is an important part of chlorophyll, proteins, vitamins, DNA and hormones [8]. As it is a component of enzymes, nitrogen is involved in all enzyme reactions and plays an active role in the plant's metabolism [3]. It is mainly absorbed by the plant in the form of nitrate and ammonium. It can also be absorbed via very small organic molecules. It is important to maintain the balance between ammonium and nitrate in applying, otherwise the pH in the rhizosphere will become very high or very low [8].

Symptoms of Nitrogen deficiency are slow growth, lower leaves becoming pale yellow in colour, stunted and necrosis of old leaves in severity of deficiency [3]. This deficiency affects the crop quality and yield very frequently [3]. Plants maturation happens early because of this deficiency [8]. In most of the plants, yellow discoloration happens in the form of 'V' shape in general [15].

Fig 1.4 illustrates the Nitrogen deficiency symptom occurring in the leaves of a plant.

Figure 1.4: Nitrogen deficiency symptoms
Source: Yara- Crop nutrient solutions, https://www.yara.co.uk/crop-nutrition/

1.1.3 Overview of Phosphorus deficiency and Symptoms

Phosphorus is important for its job in capturing and transferring the sun's energy into valuable plant elements. Phosphorus insufficiency effects are extremely hard to distinguish than nitrogen and potassium deficiency [17]. Plants do not show direct symptoms for the deficiency of phosphorus rather than stunting of crop during its development process [8]. By the time of symptom is identified visually, it might be very late to cure. Some plants, such as corn will show the symptoms like discoloration in deficiency of phosphorus [8]. The leaves of crops will become dark green in color. Some parts of leaves will be becoming purplish colour, dully thin and upright shoot leaves [15].

Phosphorus is highly absorbable in crops, and when insufficient, it might be transferred from lower plant leaf tissue to top effectively [8]. Subsequently, early vegetative reactions to phosphorus are observed frequently. Phosphorus insufficiencies are late in the development stage which would influence both seed improvement and plant maturity [17]. The percentage of the whole quantity of each nutrient taken up is very high for phosphorus than potassium and nitrogen in the growth phase [8].

Fig 1.5 illustrates the Phosphorus deficiency symptom occurring in the leaves of a plant.

Figure 1.5: Phosphorus deficiency symptoms
Source: Yara- Crop nutrient solutions, https://www.yara.co.uk/crop-nutrition/

1.1.4 Overview of Potassium deficiency and Symptoms

Plants absorb potassium nutrient in the form of potassium ion (K+) [15]. Potassium is a highly mobile component in the plant and is transferred from the older tissue to younger tissue. Accordingly, potassium deficiency symptoms occur first on the lower leaves of the plant usually and progress toward the top as the severity of the deficiency increases [8]. One of the most common symptoms of potassium deficiency is the yellow scorching or firing (chlorosis) along the leaf margin. In severe cases of potassium deficiency, the fired margin of the leaf may fall out [3]. Normally, Potassium deficient plants grow slowly and have poorly developed root systems.

Fig 1.6 illustrates the potassium deficiency symptoms occurring in a plant leaf.

Figure 1.6: Potassium deficiency Symptoms
Source: Yara- Crop nutrient solutions, https://www.yara.co.uk/crop-nutrition/

1.2 Literature Review

Various number of methodologies and techniques that were used in this area is reviewed and briefly explained in this section.

Jayamala.K, Patil, Raj Kumar stated in a paper titled "Advances in image processing for detection of plant disease" [5]. The intention of this paper is to advance in various methods used to study plant diseases using image processing. The methodologies which are studied for increasing throughput and decreasing subjective, those are arising from human professionals in detecting the plant diseases. The paper considers accuracy and speed, those two main characteristics of plant disease detection using machine-learning methods that must be achieved. Hence there is a space for working on the development of innovative, effective and fast interpreting algorithms which will support plant scientist in detecting the disease. It uses $YCbCr$ color space and co-occurrence matrix to excerpt disease spot texture feature and BP neural network is applied as a classifier with an accuracy of 98 % [5].

Image processing technique used for classifying the absence of nutritional disease occurred in oil palm leaves by investigating the leaves' surface only. The outcome is functioning as a guide for fertilization since the trees reply rapidly to the used fertilizers. The main significant concern is to ensure an adequate amount of fertilizer since an extreme intake of fertilizers will cause toxicity to trees and ultimately increase the cost of fertilizers. Images of oil palm leaves will be taken using a high-end digital imaging device to examine the leaves' surface. Further, feature extraction algorithms will also be progressed based on the texture, and color of the disease type. The feature vectors will be reached acting as inputs to a fuzzy classifier [6].

Jonilyn A. Tejada, Glenn Paul P.Gara had implemented the LeafCheckIT, web based solution that uses Random Forest machine learning algorithm to identify the Nitrogen (N), Phosphorus (P) and Potassium (K) collectively in banana leaves. They have used 10-fold cross validation test conducted on WEKA data mining software based on the training data set. The outcome of this study resulted in 89.64% accuracy rate [22].

Considering the importance of the accuracy of leaf disorder disease identification, N.Minni and N.Rehna stated that farmers have been practicing the manual procedure to identify the nutrient deficiency in plants. This process with a lower accuracy and throughput was proposed to be replaced with computer oriented concepts such as Image Processing and Machine Learning, with the intention of achieving speed and accuracy. Initially, images of various types of leaves were captured using digital camera. The captured RGB images represented into Hue Intensity Saturation (HIS) color model. In image segmentation, the pixels which are mostly green were identified first. Further, threshold value was calculated and if the pixel intensity is less than the computed threshold value, those pixels were masked. In Feature extraction infected portion of the leaves were segmented in to equal size. Feature extraction was done only for colour separation. For colour separation HIS models represented the colors of the image and denoted in color histogram. With the use of the K means clustering algorithm which is used for clustering the Normal leaves and deficient leaves. K-NN algorithm was applied to classify the particular deficiency which affects the plant leaf [3].

Leaf disease identification can be done in two phases. In the first phase, the leaf is known based on preprocessing of stages of image processing and an artificial neural network is used as a classifier throughout the phase. During the second phase k-means, based segmentation is relayed to identify defected areas [26]. The color of leaves plays a vital role in recognizing major deficiencies such as NPK (Nitrogen, phosphorus, and Potassium) when a crop is in the mid of its growth. To make it happen, a group of database should be created, which includes healthy, nitrogen defected, phosphorus defected and potassium defected leaves. Color features of both healthy and defected leaves are extracted using the HSV color model [27]. Similarly, color features of test images are extracted and compared against database properties. Evaluated results are validated against the rules set to regulate the specific deficiency. The rules are framed based on rough experiments. The efficiency can be further enlarged by including leaf pattern analysis [27].

Mrityunjaya V Latte and Sushila Shidnal had discussed about the multiple nutrient deficiency detection in paddy leaf images. This paper had explained the pattern analysis in which RGB color features were extracted to identify the nutrient deficiency in paddy leaves. Further, Image effective comparison was trained at different levels such as multiple color comparison, multiple pattern comparison and combination of color and patterns comparison, so that defectiveness would be accurately identified for the combination of deficiency such as nitrogen-phosphorus(NP), nitrogen-potassium(NK) and phosphorous-potassium (KP) [21].

In the research article, which is based on the topic of "Use of leaf color images to identify nitrogen and potassium deficient tomatoes" [10]. This paper showed a novel idea based on computer vision that was presented. The approaches such as percent intensity histogram, percent differential histogram, Fourier transforms, and wavelet packet can be used to extract color feature of leaves. Moreover, a Genetic Algorithm (GA) had been used to select features to receive the ideal information for diagnosing the disease. Experiments illustrated that the accuracy of this diagnostic system is above 82.5 % and it can diagnose disease about 6–10 days before experts could determine.

1.3 Research Gap

With the comprehensive study of literature review mentioned above in section 1.2, it clearly defines that a system which need to identify the nutrient deficiencies in a plant and their degrees of identified deficiency with speed and accuracy. Several researches had been conducted in the past for identification of diseases with machine learning and image processing techniques but few researches had done to identify the nutrient deficiency.

Through the literature survey of available researches, the following features are identified:

Table 1.1 : Comparison between similar products.

Features and Previous works	Advances in image processing for detection of plant disease [28]	Overview of image processing approach for nutrient deficiencies detection [6]	LeafcheckIT a banana leaf analyzer for identifying macronutrient deficiency [22]	Use of leaf color images to identify nitrogen and potassium deficient tomatoes [23]	Detection of nutrient deficiency in plants using image processing techniques [3]	Multiple nutrient deficiency detection in paddy leaf images [21]	Detection of nutrition deficiencies in plants [4]	Proposed System
Mobile Application	✓					✓	N/A	✓
Nutrient Deficieny Identification 1. Colour Analysis		✓	✓	✓	✓	✓	✓	✓
2. Texture Anlaysis		✓			✓			✓
Multiple nutrient identification						✓		
Using CNN								✓
Degree of Nutrient deficiency identification								✓
Suggesting fertilizer		✓						✓
Accuracy of Results	89.94%	Positive Results	89.64%	82.5%	Positive Results	Results with 0.67 error rate	Positive results	
Plant	N/A	Elaeis Guineensis	Banana	Tomato	Rose	Paddy	N/A	Three Cash Crops

Technology used	$YCbCr$, Co-occurance matrix	Fluzzy Classifier	WEKA Data mining	GA Algorithm, Intensity Histogram	HIS model, K-NN algorithm	Pattern Analysis, HIS model	expensive chlorophyll meters	CNN, Image Processing

There are nutrient deficiency identification researches that were done by researchers which still hadn't predicted the degree of the nutrient deficiency which is most needed to be identified. There is research that contains leaf color images to identify nitrogen and potassium deficient tomatoes [23]. It is focusing only on the nutrition deficiency of the plants but those are not suggesting any solution for the crops to cure the disorder.

There are several researchers [28], who used the CNN model to diagnose the diseases in plant. But there are less researchers who used CNN model to the identification of nutrient deficiency in plant leaf. The main idea of this research component is depending on the Convolutional neural network, so the accuracy level of the neural model [7] identification made a huge impact. From the previous works, CNN [9] had been experimented and an accuracy of 99.53% was achieved in plant disease identification. Compared to other classification algorithm, it has very less preprocessing [10]. Another special feature of CNN is, it automates the feature extraction. These advantages and accuracy level clearly indicates the importance of the selected neural model.

The main feature of the research is to identify the degree of nutrient deficiency of plants and to suggest suitable fertilizer for that nutrient deficiency. For this purpose, it is necessary to identify the nutrient deficiency in a particular plant. As shown in the Figure 1.1, "CropMedic 2.0" mobile application will be able to fill the above mentioned gaps which are left by the past researches and give facilities to the targeted customer.

1.4 Research Problem

According to the criteria economy, quality and quantity of the agricultural products are important in its trading. Farmers are expected to produce high or sufficient quantity of products with optimum quality. But, in most of the times, farmers are failing to fulfill these expectations due to various issues. Major issue is the disease conditions in crops. Different conditions of weather, soil, water and land causes different disease conditions in crops. Diseases are spreading quickly due to deficiency of one or more types of nutrient elements [17].

Early Prediction and identification of the exact nutrient element with deficiency will help the farmers to prevent from disease spreading in crop. This can improve the productivity in agriculture. Various models, analysis methods and solutions for this problem are provided by different communities of human experts [22]. This instigates the need of a specific system that is helpful in developing solution for various conditions.

Early detection of nutrient deficiency is important because possibilities of spreading of disease are increase with time. Nutrient deficiency cannot be identified early by direct observation because same plant may deficit in many nutrients. Sometimes, same symptoms are produced in different nutrient deficiency. Inability of farmers to detect the nutrient deficiency early in crops is the major problem identified [18]. For example, deficiency of sulphur and nitrogen can produce same symptoms [8]. So, early and precise detection of nutrient deficiency in crops are the major problems for farmers in increasing productivity of agriculture.

2. OBJECTIVE

2.1 Main Objective

The main intention of this component is to provide an intelligent solution to identify the crops and nutrient deficiency in a crop with speed and accuracy to farmers. First, “CropMedic 2.0” is expected to identify whether it is a healthy leaf or unhealthy leaf and further it will identify which nutrient deficiency type affects the crop specifically. From our system, user can be able to upload an image of a plant leaf dubious of being affected by nutrient deficiency, and the system should be able to perform the detection with the help of a well-trained convolutional neural model[2].

2.2 Specific Objective

- To study about the different types of nutrient deficiencies in the plant leaf.

  Nutrients can be divided into two. Such as micronutrients and macronutrients. The aim of this component is to identify the macronutrients deficiencies in plants. In the background study mentioned in the above section 1.1.1, several symptoms of each nutrient deficiency were explained and studied.

- Implement a control environment to practically observe each symptom separately.

  To identify the nutrient deficiency symptoms visually, a controlled environment is planned to implement in Bandarawela with the help of Regional Agricultural Research and Development Centre.

- To study about the different techniques which are related to machine learning and transfer learning for image classification with accuracy.

  From the previous researches [11], the successful CNN model is recorded, VGG has also been experimented and an accuracy of 99.53% has been achieved. This level of accuracy clearly indicates the importance of training the selected neural model under controlled conditions.

- To study about the way to gather the datasets for train model.

    Data gathering for the images will be obtained from the online resources, as well as images captured during the fields visits and laboratory test.

- Implement a mobile application that can able to identify the nutrient deficiency.

    To develop a mobile application, these technologies were decided to implement such as android, java and firebase dB

3. RESEARCH METHODOLOGY

3.1 Methodology

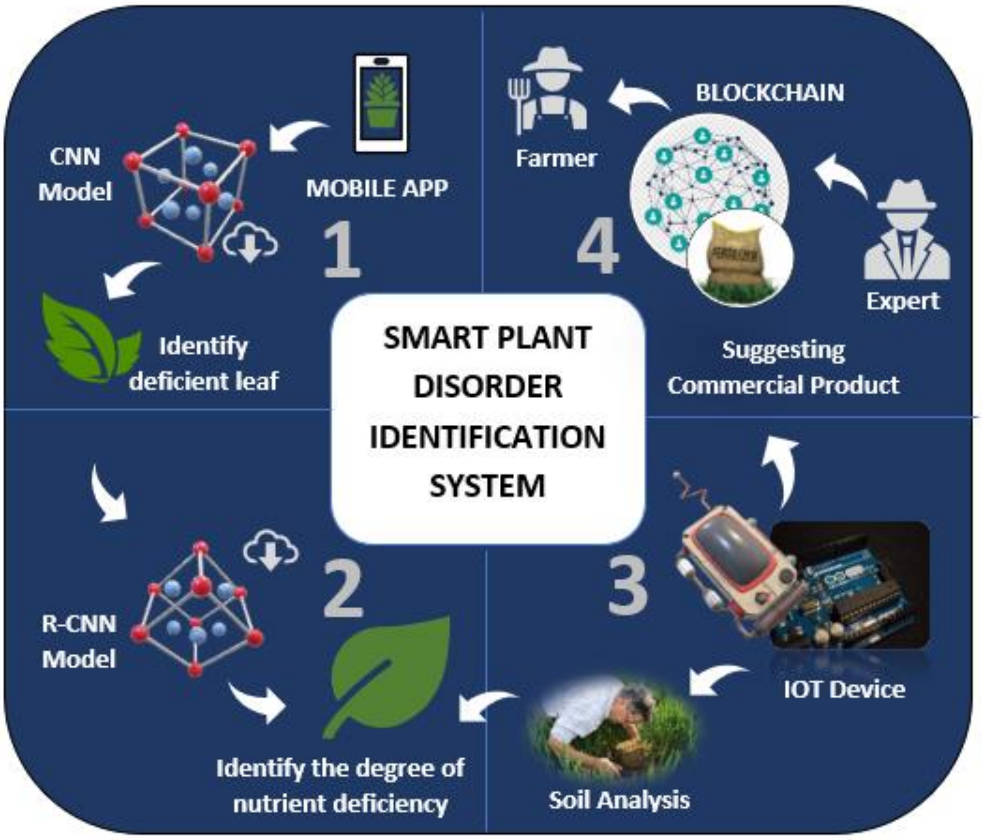

Figure 3.1: Overall diagram of our proposed System

In Figure 3.1, the first component illustrates the identification of plant nutrient deficiency of affected crops by detecting the symptoms through the image processing and machine learning. The outcome of the system is expected to come in the form of a mobile application that can be able to identify the crop and nutrient deficiency with more accuracy and speed. Special Feature of CropMedic 2.0 is to identify the degree of nutrient deficiency using the RCNN [2].

To achieve the functionality of first component, we can divide it into the subtasks;

3.1.1 Development process

In the development process, every phase of work that is going to be demonstrated will be identified. The project scope and problem of the project should be outlined and through that perception the function will be defined to solve the proposed problem. Furthermore, development process will be circulated according to the time management and expected outcomes of the project during the period of one year. Iteration-model is the method which is going to be chosen as the software development methodology for the "CropMedic 2.0" project.

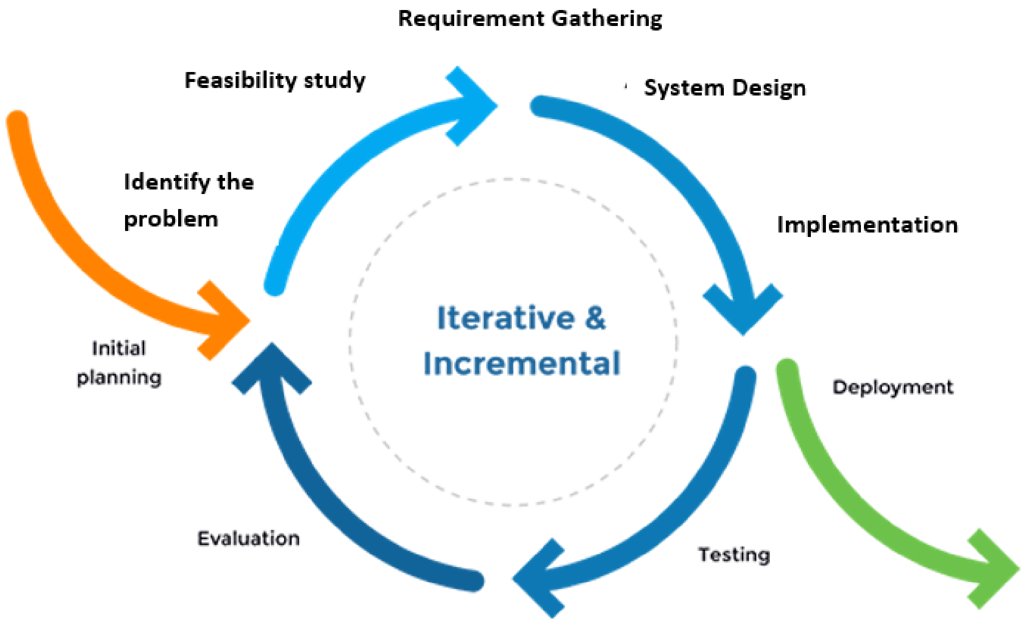

Figure 3.2: Iterative Development Model

In this incremental model, the entire requirement is separated into various builds. Figure 3.2 illustrates each iteration, the development module goes through the steps such as identify problem, feasibility study, requirements gathering, system design, implementation and testing phases.

3.1.2 Identify the Problem

Early detection of nutrient deficiency is important because possibilities of spreading of disease increases with time. Nutrient deficiency cannot be identified exactly by direct observation because same plant may deficit in many nutrients. Sometimes, same symptoms are produced for different nutrient deficiency. Inability of farmers to detect the nutrient deficiency early and identify its degree precisely in crops is the major problem identified.

In order to identify the degree of nutrient deficiency in every stage, first we need to identify which nutrient deficiency affects the plant. Because of that, problem planned to be solved by this component by implementing a system which can classify a plant based on the nutrient deficiency types. Once a nutrient deficiency is identified in this component, component two will identify the degree of nutrient deficiency.

3.1.3 Feasibility Study

Under the Technology feasibility study, the technological resources were discussed to undertake the project to success. The point that was taken to the system can be developed using the modern topics like image processing and machine learning to solve the research problem effectively. There are image processing and machine learning algorithms to investigates the color of the leaf from a specific images to find the meticulous information about the plant. Therefore, this research project is technically feasible.

3.1.4 Requirement Gathering

As shown in the figure 3.3, after the discussion with the Deputy Director of the Regional Agriculture Research and Development Centre located at Kahagolla in the first field visit, we have decided to grow the plants in the control environment to get more accuracy and feasibility in results. They have suggested three methods to grow the plants in control environment. They are,

1. Reduce each nutrient level in a plant and prevent the absorption of nutrients individually through the Standard protocol. This method is not feasible because it is very expensive to apply.

2. Soil and tissue analysis of crops which had grown under the field condition. The main problem of this method is in differentiating the disease symptoms and disorder symptoms in a plant leaf separately.

3. Nitrogen, Potassium and Phosphorus are absorbed via soil. So, apply various amount ratio of fertilizers to each plant and then it would be able to see the symptoms of nutrients visually. For example, to grow the plants as nitrogen deficient plant, the urea fertilizer could be applied in the amount than the recommended amount. This method is more feasible to identify the nutrient deficiency symptoms individually.

According to the third method, we have planned to grow the plant in the control environment.

Selection of crops to identify the nutrient deficiency will be decided in the next field visit which is to the Research Center of the Agricultural Complex situated in Gannoruwa. From that field visit we can confirm the selection of plants through their necessity and impact factor to the society.

Figure 3.3 –Field Visit 01 to Agriculture Research Center, Kahagolla

On discussion with relevant officials in Agriculture Research Institute and as well as small and medium scale farmers, it was accepted that, Macronutrients such as Nitrogen, Potassium and Phosphorus affects the production of crops most frequently. Nutrients are limited to Nitrogen, Potassium and Phosphorus to identify deficiency in three types of plants. For Each plant we are going to have separate three plots of lands to visually identify the symptoms of macronutrients in controlled environment.

3.1.5 System Design

Nowadays, everyone uses the mobile for all day to day activities. It is decided to implement a mobile based solution for the problem identified in the above phase. It is expected to encourage the young farmers to engage in agriculture using mobile solution.

Figure 3.4: System flow diagram

As shown in the figure 3.4, first user can be able to upload or capture the leaf image through the application. Then the system will do the pre-processing and image segmentation to the image which was uploaded by user.

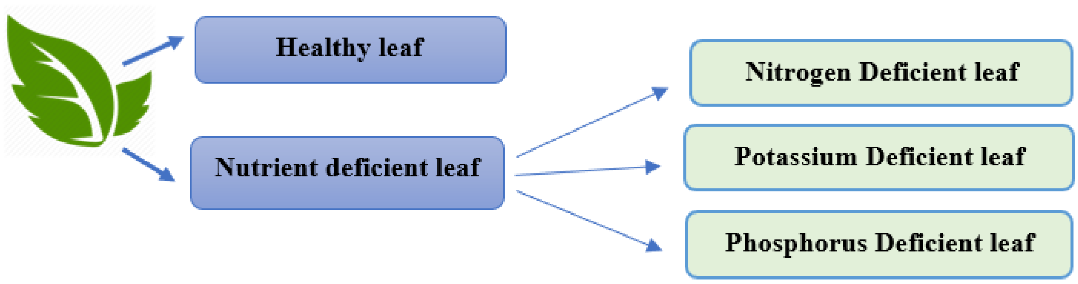

Figure 3.5 Image Classification based on machine learning

According to the Figure 3.5, The image is classified into healthy leaf or deficient leaf. It will further be classified into potassium, nitrogen and phosphorous deficiency. For the image classification, we need to select the suitable model to train the dataset.

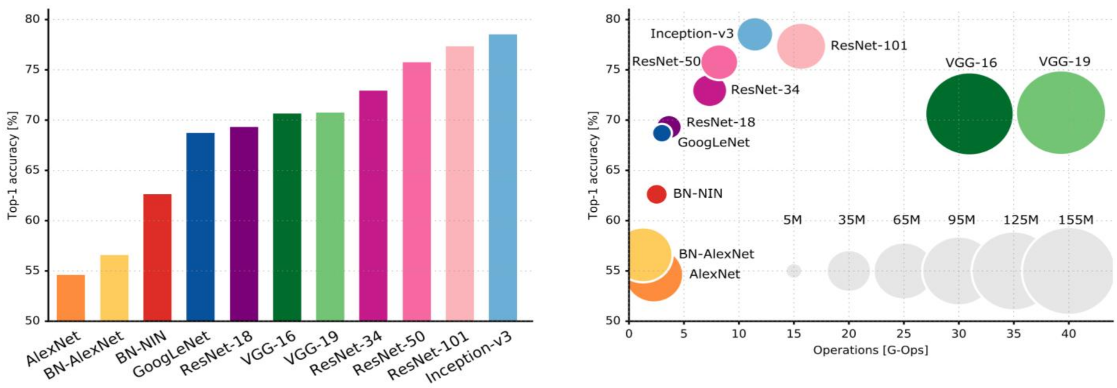

Figure 3.6 : Graph represents about the accuracy level of common neural network.
Source: An Analysis of Deep Neural Network Models for Practical Applications, 2017

After several background study [10], it is decided to use the Google Inception V3 architecture for the Convolution Neural Network to identify plant type and nutrient deficient type. Figure 3.6 illustrates the accuracy of selected architecture of neural network.

To improve the accuracy and the validation of the results, these CNN models have been trained with a dataset. In order to test the accuracy CNN, Google Inception V3 model from the internet was expected to be use. For the evaluation of selected model, flower datasets are planned to use for training until real datasets was prepared for the testing.

3.1.6 Dataset

Data gathering for the images will be obtained from different ways. Such as.

- Using Online sources to download images

  For example, Kaggle is an online image pool to download the images.

- Manually capturing images during field visits
- Manually capturing the images of crops that will grow in the Research institute.

3.1.7 Implementation

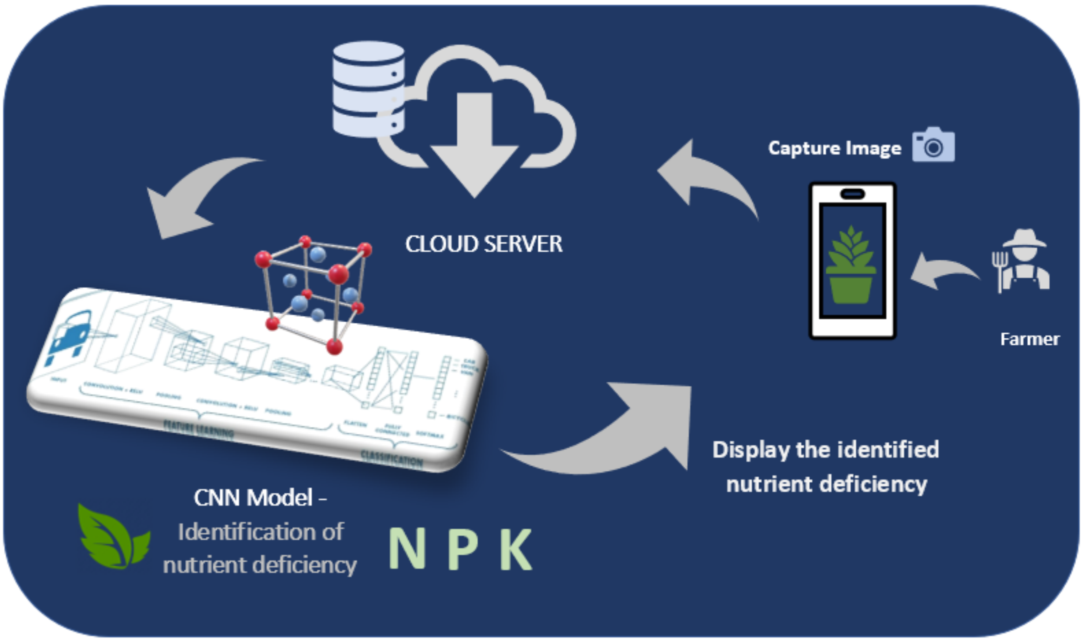

Figure 3.7: System diagram for component 01

As shown in the figure 3.7, Implementation of mobile application is decided to develop using android, java as programming language and that application should be able to identify the nutrient deficiency through the image processing and CNN model which is written using the python language.

RGB images will be needed in high quantities and quality for image processing. Figure 3.8 illustrates the classification of images done using the Google Inception V3 multilayered neural network. Image recognition can be divided the into two parts. Such as, feature extraction and classification with fully connected and softmax layers. This model extracts the color and texture features of leaf from input images and classifies them based on the features as nitrogen, potassium, phosphorus deficiency through the Convolution, max pooling layers [2]. These convolution layers have different types of filters and that can be added as required Until the requirement is satisfied [10]. By including transfer learning feature extraction is to be automated. Transfer learning allows retraining the softmax layer of an existing model, resulting in a significant decrease in not only training time, but also the size of the dataset required [25].

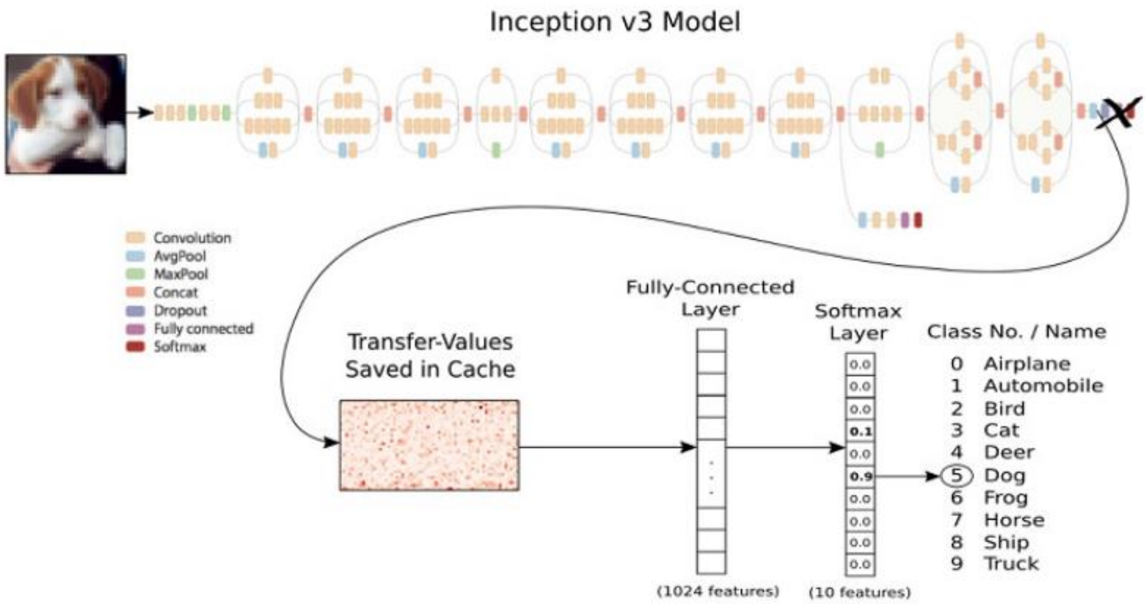

Figure 3.8: CNN model architecture
Source: Intel AI Developer Program- Inception v3 Deep Convolutional Architecture

3.1.8. Testing

In the testing phase, bugs are going to be found and fix. According to do that, unit testing, integration tests, module testing, system tests and user acceptance testing would be considered. Moreover, testing phase enhances the quality of application for users.

3.1.8.1. Unit testing

In the unit testing phase, each and every module has to be tested individually and ensure that every function is working correctly which leads to bug-free. As a result, it will become an error-free component that will be ready to integrate with other components. This type of testing phase is known as the white box testing phase.

3.1.8.2. Module testing

Module testing can be done by checking each and every class, file and component and subsystem. It is reviewed by another group member which means the owner does not test his/her own module.

3.1.8.3. Integration Testing

In integration testing, individual units are combined and tested as a team. To expose faults in the interaction between integrated units is the main purpose of this level of testing. Integration testing is assisted by test drivers and test stubs.

3.1.8.4. System testing

When the entire component is integrated, system testing will be done. The system does not require any previous knowledge about the inner design of the component and if identify any bug in the system testing it will be debugged by the group members.

3.1.8.5. User Acceptance testing

At the end, the software will be built and provide for some targeted users. The experience and the feedback given by the user will help to find the user satisfaction.

3.1.8.6. Maintenance

The maintenance phase is the final phase of the software life cycle model and it can include the software upgrades, fixes and repairs of the software. It plays an important role to keep the system effectively and user friendly.

3.1.9 Flowchart

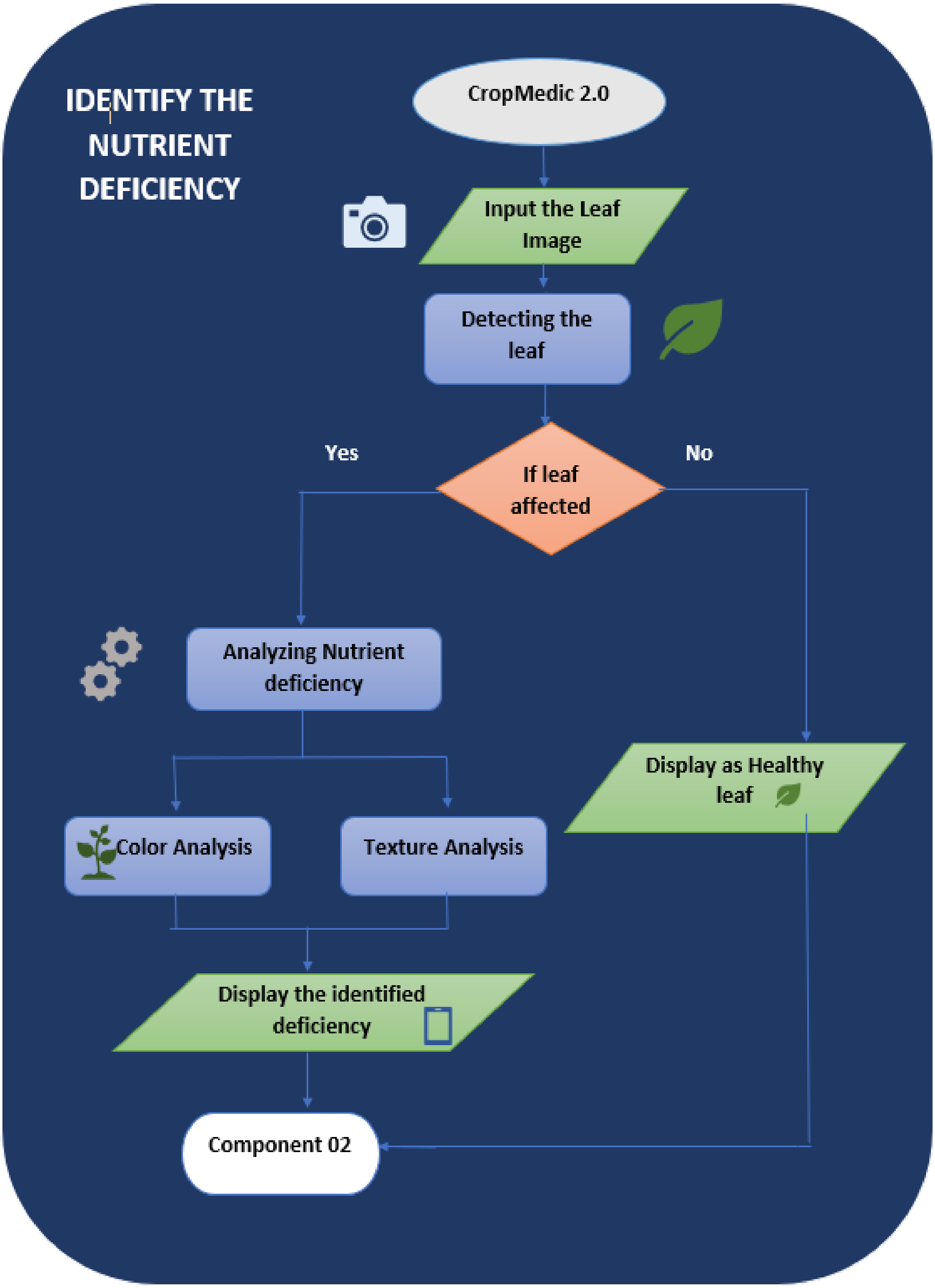

Figure 3.9: Flowchart

4. PROJECT REQUIREMENTS

For the outcome of this component, when user captures and upload the picture of the leaf which is affected by the nutrient deficiency, “CropMedic 2.0” expected to detect the affected nutrient deficiency accurately. It was listed out what are the requirements need to be implemented with the application. Requirement are divided as follows

4.1 User requirements

1. User should be able to capture an image from the mobile phone camera
2. User should be able select the image from gallery.
3. User should able to see the identified nutrient deficiency of the image captured in the previous step through the application.
4. The user should be able to retake the test

4.2 System requirements

1. Hardware requirement: Minimum i7- 7th gen with 8GB Ram
2. Software requirements: Android studio, Tensorflow, Python , Tensorflow, Django

4.3 Functional Requirements

1. System should be able to capture the image through the mobile app.
2. System should be able to select the image from the gallery / smartphone’s memory.
3. System should be able to identify the nutrient deficiency in the captured image.
4. System should display the result of identified nutrient deficiency.

4.4 Non-Functional Requirements

1. System should be able to identify the nutrient deficiency with speed and accuracy
2. Image extraction and classification should be able do with less processing time.

5. DESCRIPTION OF PERSONAL AND FACILITIES

Table 5.1: Description of Tasks

Name	Task
Identification nutrient deficiency using Image processing and machine learning	• Carrying out an extensive study on nutrient deficiencies and symptoms • Develop the Mobile Application using the Android native • Selection of suitable neural network to train – CNN • Setting up the Python 3.5 and Tensorflow through Anaconda distribution • Pulling the Docker Image for tensorflow • Using Transfer Learning to Retrain the CNN model • Testing the whole system • Maintenance

6. CONCLUSION

This proposed system is a mobile application which is going to be implemented as a smart disorder identification system. The main intention of this sub component of system is to identify the nutrient deficiency according to their early symptoms.

The agriculture fields currently possess a high market for the application of ICT [20]. This component is going to be implemented with the image processing techniques and CNN, which is capable of training datasets on their own to predict nutrient deficiency in a leaf. In order to evaluate the CNN, Google Inception V3 model will be trained using 3000 images of healthy leaf and 6000 images of deficient leaf approximately.

REFERENCES

[1] Sachin.B, Jadhav, Vishwanath R. Udupi, Sanjay B.Patil, “Identification of plant diseases using convolutional neural networks,” International Journal of Information Technology, pp 1-10, February 2020. [Abstract]

[2] Sumit Saha, “A Comprehensive guide to Convolutional Neural Networks- the ELI5 way,” December 15, 2018. [Online]. Available: https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53 [Accessed Jan 04, 2020].

[3]N.Minni, N.Rehna ,“Detection of nutrient deficiency in plants using image processing techniques,” Department of Computer Science ,College of women Karaikkal, Puducherry, India Dong-A University, ISSN 2278-2397

[4] J. G. A. Barbedo, “Detection of nutrition deficiencies in plants using proximal images and machine learning: A review,” *Computers and Electronics in Agriculture*, 02-May-2019. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0168169918318957. [Accessed: 02-Feb-2020].

[5] Song, K., Liu, Z., Su, H. and Guo, C. (2011). A research of maize disease image recognition of corn based on BP networks. 3rd International conference on measuring technology and mechatronics automation. 1(1). pp. 246-249.

[6] Hairuddin, M. A Tahir, N. M., and Baki, S. R., (2011) "Overview of image processing approach for nutrient deficiencies detection in Elaeis Guineensis," IEEE International Conference on System Engineering and Technology, pp. 116-120.

[7] Ibm, “The Neural Network Model,” IBM Knowledge Center. [online] Available at: https://www.ibm.com/support/knowledgecenter/en/SS3RA7_15.0.0/com.ibm.spss.modeler.help/neuralnet_model.htm [Accessed 16 Feb. 2020].

[8] Ann McCauley, Clain Jones, Jeff Jacobsen, “Plant Nutrient Functions and deficiency and Toxicity Symptoms”, College of Agriculture Dean Nutrient Management module No.09.

[9] Oxford Business Group, “Plantation and Agriculture from – The Report: Srilanka 2018,” [Online] Available at: https://oxfordbusinessgroup.com/sri-lanka-2018/plantations-agriculture [Accessed 15 Feb. 2020]

[10] Google cloud documentation, “Advanced guide to inception V3,” [online] Available : https://cloud.google.com/tpu/docs/inception-v3-advanced [Accessed 20 Jan, 2019]

[11] Sanjay B. Dhaygude and Nitin P. Khumbhar, “Agriculture Plant Leaf Disease Detection using Image Processing”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, No. 1, pp. 599-602, 2013.

[12] Sanjay B. Patil and Shrikant K. Bodhe, “Leaf Disease Severity Measurement using Image Processing”, International Journal of Engineering and Technology, Vol. 3, No. 5, pp. 297-301, 2011.

[13] V.K. Tewari, Ashok Kumar Arudra, Satya Prakash Kumar, Vishal Pandey and Narendra Singh Chandel, “Estimation of Plant Nitrogen content using Digital Image Processing”, Agricultural Engineering International: CIGR Journal, Vol. 15, No. 2, pp. 78-86, 2013.

[14] Amruta Ambatkar, Ashwini Bhandekar, Avanti Tawale, Chetna Vairagade and Ketaki Kotamkar, "Leaf Disease Detection using Image Processing", Proceedings of International Conference on Recent Trends in Engineering Science and Technology, Vol. 5, pp. 333 -336, 2017

[15] H. Muhammad Asraf, M.T. Nooritawati and M.S.B. Shah Rizam, "A comparative Study in Kernal-based Support Vector Machine of Oil Palm Leaves Nutrient Disease", Procedia Engineering, Vol. 41, pp. 1353-1359, 2012.

[16] Jie Hang, Dexiang Zhang, Peng Chen, Jun Zhang and Bing Wang, "Classification of Plant Leaf Diseases Based on Improved Convolutional Neural Network," [online] Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6806268/ [Accessed 20 Jan, 2019]

[17] Melvin Wong, Department of Tropical Plant and Soil Sciences, Visual Symptoms of Plant Nutrient Deficiencies in Nursery and Landscape Plants. University of Hawai'i at Manoa, Soil and Crop Management: SCM-10, Jan. 2005.

[18] J. Sugano, J. Uyeda, S. Fukuda, T. Radovich and K. Wang, "*Basic Crop Nutrition,"* University of Hawai'i at Manoa, College of Tropical Agriculture and Human Resources.

[20] Ferentinos K.P," Deep learning models for plant disease detection and diagnosis," Comput. Electron. Agric. 2018, 145, 311–318.

[21] Mrityunjaya V latte, Sushila Shidnal, "Multiple nutrient deficiency detection in paddy leaf images using color and pattern analysis," International Conference on Communication and Signal Processing (ICCSP), April 2016.

[22] Jonilyn A. Tejada, Glenn Paul P. Gara,"LeafcheckIT: a banana leaf analyzer for identifying macronutrient deficiency," 3rd International Conference on Communication and Information Processing (ICCIP), November 2017

[23] Xu, G., Zhang, F., Shah, S., Ye, Y. and Mao, H. (2011). "Use of leaf color images to identify nitrogen and potassium deficient tomatoes," Elsevier, 32(11), pp.1584-1590.

[24] S.Sivagami, S.Mohanapriya,"Automatic Detection of Tomato leaf deficiency and its Result of Diseases Occurrence through Image Processing," International Journal of Innovative Technology and Exploring Engineering (IJITEE), vol 8 issue-11, September 2019

[25] Milton-Barker,Adam,"Incption v3 Deep Convolutional Architecture for classifying acute Myeloid/Lymphoblastic Leukemia," Intel AI Developer Program [Online] Available : https://software.intel.com/en-us/articles/inception-v3-deep-convolutional-architecture-for-classifying-acute-myeloidlymphoblastic [Accessed 15, Feb 2020]

[26] Aakanksha, R., Arora, R. and Sharma, S. (2015). Leaf disease detection and grading using computer vision technology and fuzzy logic," International conference on signal processing on integrated networks , IEEE, pp. 500-505.

[27] Latte, M., Shidnal, S. and Anami, B. (2017). Rule Based Approach to Determine Nutrient Deficiency in Paddy Leaf Images. International Journal of Agricultural Technology, [online] 13(2), pp.227-245. Available at: http://www.ijat-aatsea.com [Accessed 13 Feb. 2020]

[28] Jayamala, k., Patil., and Kumar, R. (2011). "Advances in Image Processing for Detection of Plant Diseases," Journal of Advanced Bioinformatics Applications and Research, 2(2), pp.135-141.

[29] Dipanjan Sarkar, "A Comprehensive Hands-on guide to Transfer Learning with Real-World Applications in Deep," November 15, 2018. [Online]. Available: https://towardsdatascience.com/a-comprehensive-hands-on-guide-to-transfer-learning-with-real-world-applications-in-deep-learning-212bf3b2f27a [Accessed Feb 02, 2020].