GROWTH PREDICTION, DISEASES DETECTION & CLASSIFICATION SYSTEM FOR ANTHURIUM PLANTS

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Abstract

Anthurium holds an important place as an economically beneficial flower in export market due to its consumer demand. However, it has become a challenging task for large scale Anthurium growers to identify diseases in Anthurium plant with naked eye observation in its early stages. Failing the same can lead to a situation where the plant will remain untreated and the diseases might spread rapidly across the entire plantation. This will lead to a huge loss of revenue.

The purpose of this report is to provide an understanding about the challenges that farmers face when maintaining their plantations, the existing solutions and the new beneficial solution proposed to overcome the challenges. The report mainly focuses on functions such as disease classification, measuring the severity and providing with necessary causes and treatments to minimize the disease.

The final output of this research is a stand-alone application named “Agro”, designed to assist large scale Anthurium growers to maintain a healthy plantation inside a greenhouse environment. The application performs tasks such as warning the user about the risk, classifying the disease identified, measuring the severity, providing causes and necessary treatments to minimize the diseases and predicting the growth of the plantation considering external environmental factors. Therefore, after the successful implementation of the application, it can be adapted for other crops as well.

ACKNOWLEDGMENT

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LIST OF ABBREVIATIONS

Abbreviation	**Description**
Agro	Name of the application
SRS	Software Requirement Specification
IDE	Integrated Development Environment
OpenCV	Open Source Computer Vision
BPNN	Backward Propagation Neural Network

1 INTRODUCTION

Agro is an efficient solution proposed to minimize the obstacles that large scale Anthurium growers face when monitoring plantations. Every aspect that is needed to be considered in monitoring a plantation like growth prediction, diseases detection and disease outbreak prediction are performed through the application with minimum user involvement. The purpose of this report is to provide an understanding about Agro, the output of our final year research. The report focuses mainly on diseases detection functionality. All the facts related to the function are discussed in detail throughout the document.

1.1 Research Problem

Anthurium holds an important place as an economically beneficial flower in export market due to its consumer demand. This attractive flowering plant is mostly grown in mild climates inside greenhouse environments. But a major problem that large scale Anthurium growers in Sri Lanka face when monitoring their plantations is protecting the plants from various bacterial and fungal diseases and knowing the outbreak of a disease due to changes in environmental conditions such as sunlight, temperature and humidity. They also cannot keep an accurate record about the growth of a plantation.

Among above problems, a major threat which bothers growers constantly are diseases. The mechanism they currently follow in identifying diseases is the traditional naked eye observation. Growers often complain about the difficulty in identifying diseases efficiently in huge plantations using the above method as sometimes when they do not notice a certain disease and not properly treat that plant, the disease might spread rapidly across the entire plantation and cause huge loss of revenue, time and effort. Also some novice growers may find it complicated to identify a particular disease, causes and treatments specific to the disease. Therefore, there is a necessity of a proper guidance system to minimize the loss caused due to lack of knowledge regarding monitoring a healthy plantation.

1.2 Background Context

Floriculture in Sri Lanka started as an industry in 1970. It has grown substantially during the last few years to become one of Sri Lanka's major foreign exchange generating ventures. Cut flowers grown in the country can be divided into two main categories based on their temperature requirements. They are Temperate Cut Flowers and Tropical Cut Flowers. Anthurium and Orchid are the most popular tropical cut flowers which are being grown commercially for exports as well as for the local market. Anthurium can be grown at elevations up to 1500 meters above sea level, with texture remarkably enhanced with increase in elevation. Annual production of Anthurium is around 3 million [1].

Anthurium plants need a shady and moist environment to grow well. The average temperature of Sri Lanka usually ranges from 28 – 32 degrees Celsius which may differ due to global weather conditions as a whole [2]. According to agricultural experts in Sri Lanka, because of the hot and dry climate prevailing nowadays, various diseases that harm the plants spread rapidly.

There are few major diseases that bother Sri Lankan growers very much. They are Flea disease, Early leaf spot disease, Fungal diseases and Bacterial diseases. They often worry about the huge amount of money spent on treating these diseased plants. Therefore, accurate identification of diseases plays a vital role in monitoring plantations in order to obtain the maximum harvest.

There are some inbuilt applications to detect the diseases of various plants such as potato, palm oil and grapes.

Potato Leaf Diseases Detection and Classification System:

Girish Athanikar et al. have proposed neural network based detection and classification of potato leaf disease. Images are filtered using Gaussian filter technique followed by segmentation using K-means clustering algorithm. In addition to color features and area, the texture features are extracted by GLCM followed by classification using neural network classifiers. The neural network is trained using most commonly used with the back propagation algorithm. The proposed method has received an accuracy of 92% [3].

Real Time Grape Leaf Diseases Detection:

Nivedita.R. Kakade et al. have proposed an image-processing-based solution for the automatic grape leaf diseases detection and classification. The proposed method classified five diseases which effects on the plants are: Black rot, Downy mildew, powdery mildew, Leaf Roll and Normal Leaf. The digital images are acquired from the environment using a digital camera. Gaussian filter is applied followed by Edge detection using canny algorithm further Gray Level Co-occurrence Matrix (GLCM) method is adopted for extracting second order statistical texture features followed by classification using Back Propagation Neural Network (BPNN). Experimental result shows that the proposed system is effective with the classification rate above 92.94% [4].

Detection of Palm Oil Leaf Disease with Image Processing and Neural Network Classification on Mobile Device:

Alham F. Aji et al. have proposed the application of image processing and machine learning for identifying palm oil diseases based on visual appearances. They designed a method with the linear complexity process in order to maximize the processing time which is implemented to mobile device. First step in classifying palm leaves disease is classifying all pixels in the image. Every pixel will be classified as one of the three categories, which is background pixel, spot pixel, and leaf pixel. The identification result that represent background pixel or leaf pixel will be removed from image. Then all remaining adjacent spot pixel will be joined to form a spot image. Breath First Search or BFS algorithm is used to form all spot pixels. Further the following features namely median of RGB value, quartile 1 of RGB value, quartile 3 of RGB value, average brightness, standard deviation, and shape are extracted. Neural network is used to learn the pattern and generate a classification model [5].

1.3 Research Gap

When studying the existing researches, we found out that there are researches done for various crops such as mango, potato and grapes. But there are no existing applications built to monitor Anthurium plantations. At the same time in most of the existing applications, external factors which affect a plantation like humidity, sunlight and temperature are not considered.

In existing applications, all the aspects such as disease detection, growth prediction and predicting disease outbreak are not considered in one single research. Therefore, the existing applications do not provide the comfort of monitoring a whole plantation. Another point noted was the possibility of using existing applications in a real plantation is weak.

When considering diseases detection function, many research papers have not provided the causes and treatments for a disease. It would be beneficial to novice farmers and growers if the necessary treatments and causes for a particular disease are provided so that they do not want to contact agricultural experts to treat the diseases.

Table 1.1: Comparison of proposed system and existing researches.

Title	Crop/Plant	Consider growth of a plant	Possibility to use in a real plantation	External factors considered
Potato Leaf Diseases detection and classification system	Potato	No	Weak	No
Real time grape leaf diseases detection	Grape	No	Average	No
Detection of Palm Oil Leaf Disease with Image Processing and Neural Network Classification on Mobile Device	Palm oil	No	Weak	No
Agro	Anthurium	Yes	Excellent	Yes

1.4 Research Objectives

The objectives of a research project summarize what is to be achieved by the study. There are two types of research objectives called general and specific.

1.4.1 General objectives

General Objectives are broad goals to be achieved. The general objectives of the study state what the researcher expects to achieve by the study in general terms.

In project Agro, developing a user friendly stand-alone application for diseases detection, growth prediction and disease outbreak prediction can be considered as a general objective.

This application is targeted on large scale Anthurium growers who have a less amount of knowledge about technology. To minimize the user's interaction with the system, we have implemented a warning system. Therefore, the application is very user friendly when considering Anthurium growers as target audience.

1.4.2 Specific objectives

Specific objectives are short and narrow in focus. When general objectives are broken into small logically connected parts, specific objectives are formed. There are few specific objectives in the project.

1. Detection of diseases, quantification and providing with causes and treatments

   This is the most important feature in the entire application. When a spot appears, the user will be warned using an alarm. Then causes and treatments are also given through the alarm so that user does not have to contact agricultural experts to treat the plants properly.

2. Growth prediction

   This function warns the owner about the effective climate changes in harmful manner. So the owner can take measure to avoid the problem before it affects. Indirectly this helps the owner to get a good profit from the harvest he gains through the plantation as well as helping the owner to manage the work easily.

3. Predicting the outbreak of a disease

   The user can know the environmental conditions affecting a certain disease through this function. If those environmental conditions are available, he can know that a certain disease is appearing. Environmental conditions like humidity, sunlight and temperature are taken into consideration to predict the outbreak of a disease and warn using an alarm.

2 METHODOLOGY

2.1 Methodology

Research methodology describes the way that the research is carried out. This may include the surveys, interviews and research techniques followed during the period of research. The methodology of developing the application “Agro” is described below.

Agro is a stand-alone application developed in order to assist large scale Anthurium growers in Sri Lanka to monitor their plantations efficiently. As developers, our main aim was to design and implement the application using the latest technology which will help them to save their time, effort and revenue.

The software runs on an embedded platform, a raspberry pi which is a tiny affordable computer popularly used in developing countries for building applications. The sensors and the camera are connected to the raspberry pi in order to get necessary data. The whole system is situated inside a greenhouse environment.

Identification of diseases is done using an artificial neural network included in the raspberry pi. When an image captured through the camera is input to the raspberry pi, disease name, causes and treatments for a particular disease are given as outputs. According to the severity of the disease, planters can adjust on the pesticides they use to treat diseased plants. All the outputs are given as warnings using an alarm.

2.1.1 Approach

The system is developed using incremental model available under software development life cycle models. In incremental model the whole requirement is divided into various builds. Multiple development cycles take place here, making the life cycle a "multi-waterfall" cycle. Cycles are divided up into smaller, more easily managed modules. Incremental model is a type of software development model like V-model, Agile model etc. In this model, each module passes through the requirements, design, implementation and testing phases. A working version of software is produced during the first module, so you have working software early on during the software life cycle. Each subsequent release of the module adds function to the previous release. The process continues till the complete system is achieved. [6]

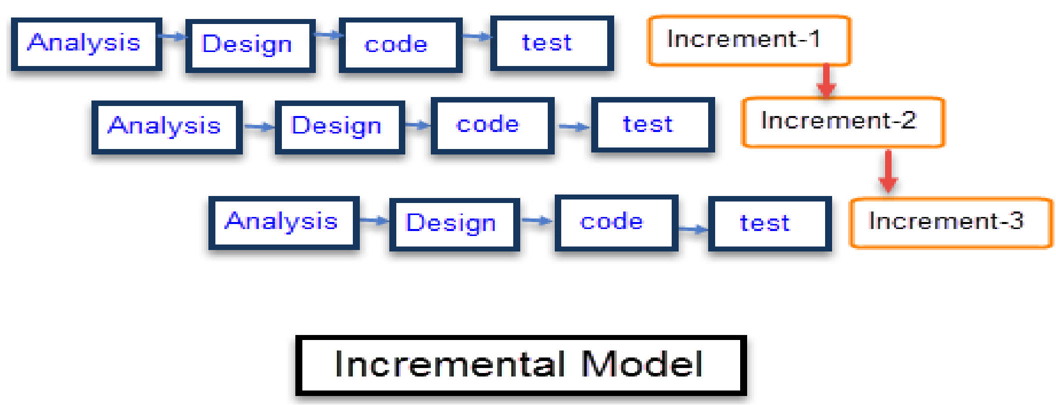

Figure 2.1: Incremental Model

Source: https://www.guru99.com/what-is-incremental-model-in-sdlc-advantages disadvantages.htm

2.1.1.1 Advantages of incremental model

- Generates working software quickly and early during the software life cycle.
- This model is more flexible – less costly to change scope and requirements.
- It is easier to test and debug during a smaller iteration.
- Lowers initial delivery cost.

Incremental model was used to develop Agro because;

- Major requirements of the complete system were clearly defined and understood.
- The system is broken down into independent parts and the parts are incrementally implemented, tested and delivered. Then the core system is delivered to the customer.

2.1.2 Requirement Analysis

The main intention of the project is to build a user-friendly, accurate and efficient application. Therefore, requirement phase is a pivotal phase in developing the system. In this phase, requirement and specification of the software are collected.

The aim of requirement gathering is to understand the needs of the customer exactly. Requirements were gathered using the following methods.

- Interviewing few large scale Anthurium growers in order to gather information about the problems that they face when monitoring the plantations.
- Reading research papers and journals on plant leaf disease detection and classification using neural network techniques.

- Gathering information with the help of materials like e-books, web articles and tutorials that are available online.

Requirements are documented in Software Requirements Specification (SRS). This document is the legal contact between the customer and the developers. All requirements collected by above methods were documented in order to identify the functional, performance, operational, interface requirements separately. When implementing Agro, all the requirements were identified clearly in the SRS level.

2.1.3 Design

This is the phase where requirements specification is transformed into a suitable form for implementation in a programming language. Requirements gathered are simplified to estimate the resources and timeline of the project. The system is designed following object-oriented concepts.

Functions were clarified further using use case diagrams and use case scenarios. There are no any user interfaces to minimize the user interaction with the system. All the outputs are given using warnings so that a user with minimum technological background can also interact with the system efficiently.

2.1.4 Implementation

This phase describes how the system is implemented. This is also known as the coding phase. Agro is implemented to run on an embedded platform. Raspberry pi 3 is being used for this purpose. Camera and sensors used for data gathering are connected to the raspberry pi. For the process of image acquisition, digital camera (Fuji film Fine Pix S8300 compact camera) is used. It provides the captured image to the system for further analysis. This compact camera has a high quality lens which provides zooming. DHT 11 sensor was used to get humidity and the temperature readings and light-dependent resistor (LDR) to get the sun light intensity.

2.1.4.1 System interfaces

Following are the system interfaces used in the process of system implementation.

Python:

The language used for implementation is python. Python is an open source programming language used for general purpose programming. Python has extensive support libraries. It is also easier to learn and has user friendly data structures. Python is widely used in GUI based desktop applications like image processing and graphic design applications [7]. Python 2.7 version was used in Agro because of above reasons.

OpenCV:

Necessary features to train neural networks were obtained using the library OpenCV. It has a Python interface and supports Windows, Linux, Mac OS, iOS and Android. OpenCV was designed for computational efficiency and with a strong focus on real-time applications [8]. OpenCV was used in Agro because it is free of charge and the RAM usage is low.

PyCharm:

IDE used is PyCharm (JetBrains PyCharm Community Edition 2014.1.4). It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems. PyCharm is cross-platform, with Windows, macOS and Linux versions [9].

Raspberry Pi 3:

The Raspberry Pi is a series of small single-board computers. The Raspberry Pi 3, with a quad-core Cortex-A53 processor, is described as 10 times the performance of a Raspberry Pi 1. Benchmarks showed the Raspberry Pi 3 to be approximately 80% faster than the Raspberry Pi 2 in parallelized tasks [10].

2.1.4.2 System diagram

The whole system is being implemented according to the system diagram below. There are three neural networks running inside the raspberry pi for diseases classification, growth prediction and disease outbreak prediction.

According to the system diagram, when an image is captured from the camera it goes through three processes named image preprocessing, image segmentation and feature extraction. Colour features are input to the neural network for disease classification. Leaf area along with sensor readings are input to growth prediction neural network and spot size along with sensor readings are input to disease outbreak prediction neural network. Necessary inputs are taken separately and outputs are given as warnings to the user through an alarm.

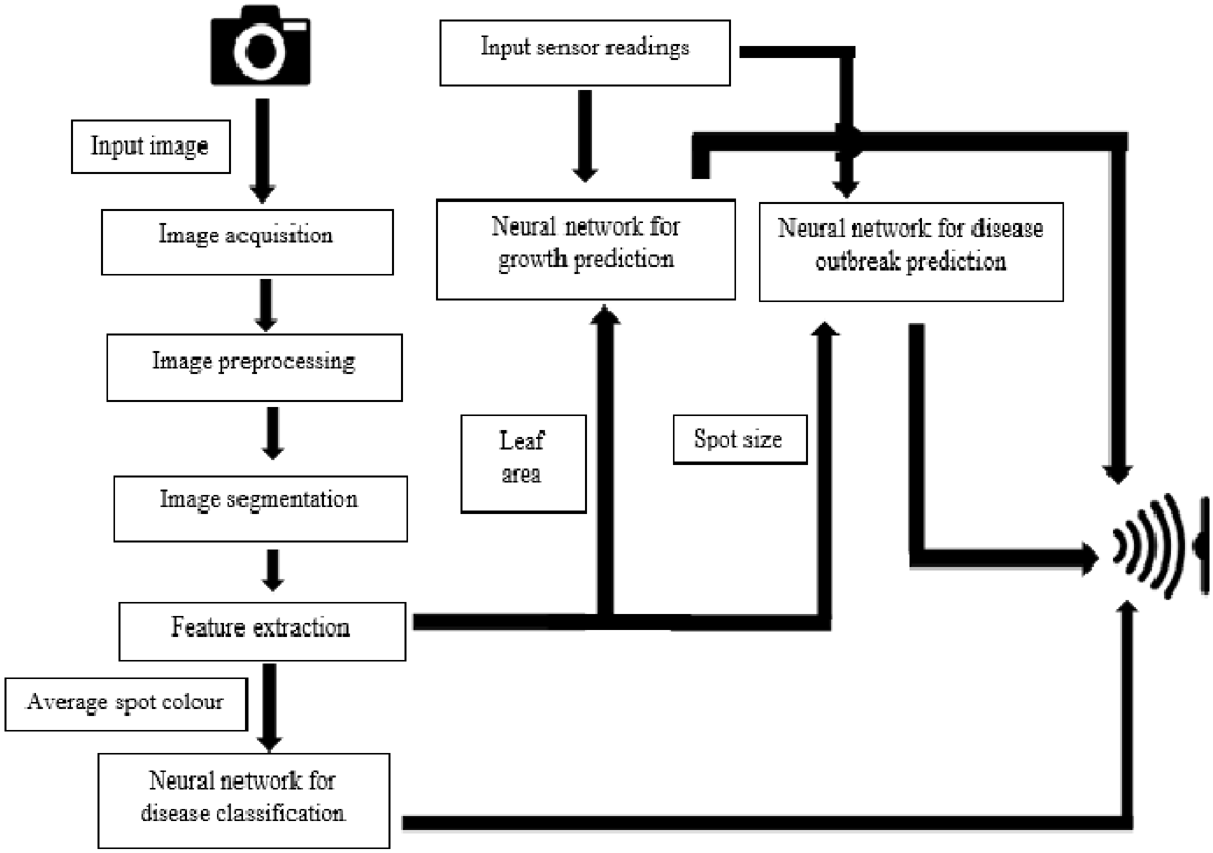

Figure 2.2: System diagram of Agro

2.1.4.3 Implementation of diseases detection

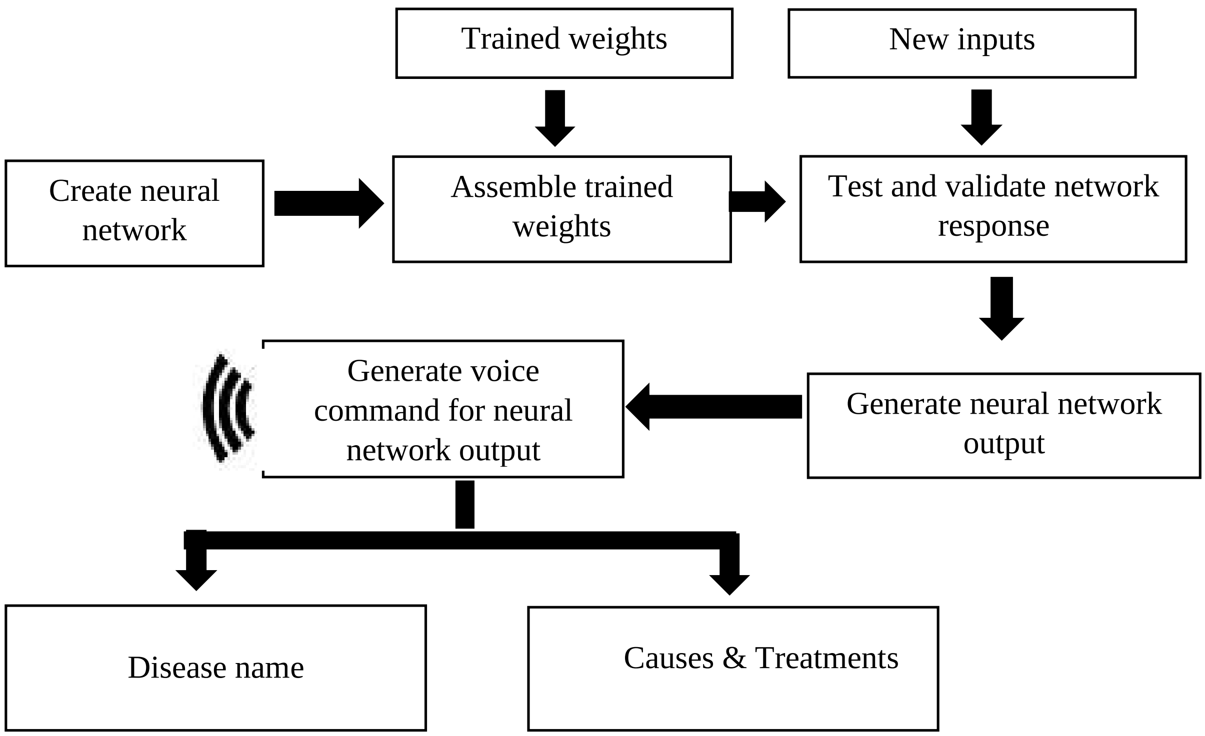

Figure 2.3: System diagram for identification of diseases

Following are the steps followed in the process of implementing diseases identification functionality.

Step 1: Implementing an artificial neural network

Artificial neural network

An artificial neural network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns, in a sense

- based on that input and output. ANNs are considered nonlinear statistical data modeling tools where the complex relationships between inputs and outputs are modeled or patterns are found. ANN is also known as a neural network. ANNs have three layers that are interconnected. The first layer consists of input neurons. Those neurons send data on to the second layer, which in turn sends the output neurons to the third layer [11].

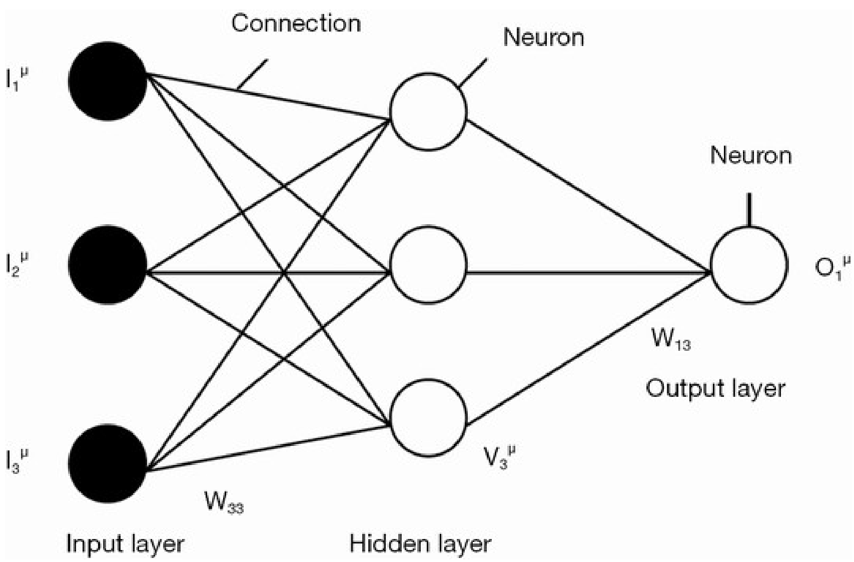

Figure 2.4: A three-layer artificial neural network

Source: Journal of Thoracic Disease - AME Publishing Company

For the process of disease detection, an artificial neural network of three layers was implemented using python language. Numpy, a library for python programming language that supports multi-dimensional arrays and matrices was used for the implementation.

```
import numpy as np
import pygame

class Neural_Network(object):
    def __init__(self):
        # parameters

        self.inputSize = 5
        self.outputSize = 1
        self.hiddenSize = 10


def forward(self, X):
    # forward propagation through our network
    self.z = np.dot(X, self.W1)  # dot product of X (input) an
    self.z2 = self.sigmoid(self.z)  # activation function
    self.z3 = np.dot(self.z2, self.W2)  # dot product of hidde
    o = self.sigmoid(self.z3)  # final activation function
    return o

def sigmoid(self, s):
    # activation function
    return 1 / (1 + np.exp(-s))

def sigmoidPrime(self, s):
    # derivative of sigmoid
    return s * (1 - s)

def backward(self, X, y, o):
    # backward propgate through the network
    self.o_error = y - o  # error in output
    self.o_delta = self.o_error * self.sigmoidPrime(o)  # appl

    self.z2_error = self.o_delta.dot(self.W2.T)  # z2 error: h
    self.z2_delta = self.z2_error * self.sigmoidPrime(self.z2)

    self.W1 += X.T.dot(self.z2_delta)  # adjusting first set (
    self.W2 += self.z2.T.dot(self.o_delta)  # adjusting second
```

Figure 2.5: Python neural network

Step 2: Train the neural network inputs through Matlab

Then the same neural network was implemented and trained through Matlab using backward propagation algorithm.

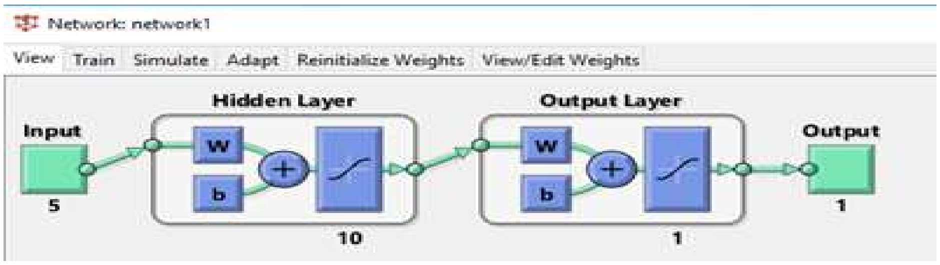

Figure 2.6: Neural network implemented for disease identification using Matlab

The advantage of using Matlab to implement the neural network is that there is a user interface which helps to easily understand how neurons of the artificial neural network are connected. For the implementation number of hidden layer neurons were taken as ten and output layer neurons are equal to the number of outputs. Since there is only one output, output layer has only one neuron. Inputs are RGB values of the colour features and the output is the class which the disease belongs to.

The neural network was trained using BPNN algorithm. Backpropagation is a method used in artificial neural networks to calculate the error contribution of each neuron after a batch of data (in image recognition, multiple images) is processed. This is used by an enveloping optimization algorithm to adjust the weight of each neuron, completing the learning process for that case [12].

Step 3: Export trained weights to the python neural network

Then trained weights were exported to the neural network implemented using python. Colour features extracted from various diseased plant images were the input to the neural network. Then the network was tested for new inputs. Outputs are given to the user as warnings.

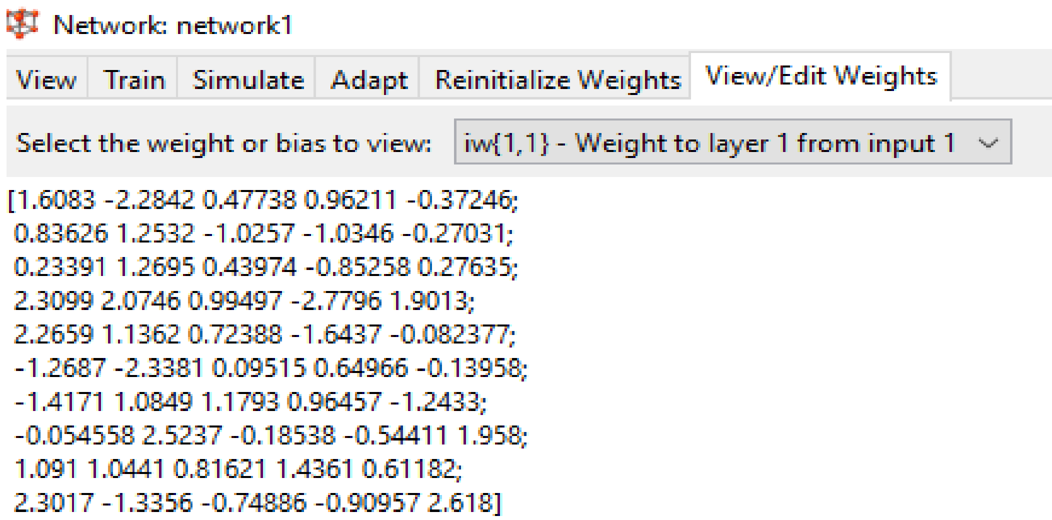

Figure 2.7: Weights of the neural network

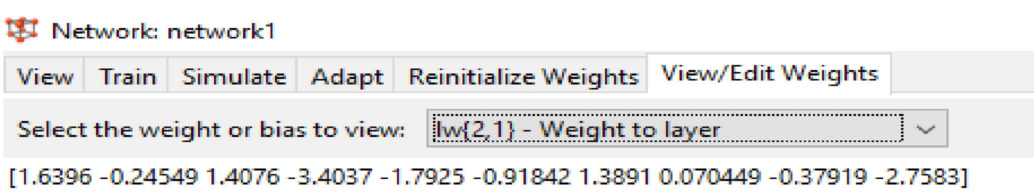

Figure 2.8: Weights of the neural network

Exported values from Matlab to python neural network are assigned to an array.

```
        # weights
        self.W1 = np.array([[1.8994, -1.9036, 0.58063, 0.85967, -0.12757],
[0.85723, 1.1449, -1.103, -1.1265, -0.31784],
[-1.2511, 1.1382, 1.0708, -0.44781, 0.76534],
[2.9987, 1.2808, 0.98558, -1.5679, 1.8782],
[0.87069, 1.0099, 0.54876, -1.4356, -0.79484],
[-2.365, -1.8158, 0.76965, 0.93298, -0.57956],
[-1.6031, 1.5126, 3.2874, 1.5943, -1.3166],
[1.265, 2.4654, -0.41674, -0.34579, 1.5453],
[1.2786, 0.77237, 0.48828, 1.5293, 0.53275],
[1.1627, 0.79528, -0.99503, -1.2224, 0.76123]]).T  # (5x10) weight matrix from input to hidden layer

        self.W2 = np.array([[1.25],[0.021185],[-0.11778],[-2.6928],[0.45181],[1.6343],[3.754],[-0.33022],[-0.18872],[0.3807
```

Figure 2.9: Neural network weights exported from Matlab

Step 4: Implementing the warning system

The warning system was implemented by using a library called pygame in python.

```
def predict(self):
    A = np.array([0.96472879])
    #out = str(self.forward(xPredicted))
    print("Predicted data based on trained weights: ")
    print("Output after training: \n" + str(self.forward(X)))
    print("Input: \n" + str(xPredicted))
    print("Output: \n" + str(self.forward(xPredicted)))

    if(A==[0.96472879]):

        pygame.mixer.init()
        pygame.mixer.music.load("../audioFile/Flea_disease.wav")
        pygame.mixer.music.play()
        while pygame.mixer.music.get_busy() == True:
            continue
            A = 0
```

Figure 2.10: Python code for the warning system

Step 5: Testing in the raspberry pi

The same result was achieved when testing the system using the raspberry pi. The diseases were classified and the output was given.as warnings.

2.1.5 Testing

Testing was done in three steps as unit testing, integration testing and system testing.

- Unit Testing

Unit testing is the first stage of testing. Each and every individual unit should be tested under unit testing. Since there are four functions in Agro, each function was tested separately and obtained the result.

- Integrated Testing

In integration testing, the individual modules are combined and tested. Objective of this testing is to make sure that the interaction of two or more components produces results that satisfy the functional requirement.

- System Testing

Testing the entire system is known as system testing. When all the individual modules are integrated to the system, the whole system needs to be tested to ensure that it is working properly without any errors. When Agro was integrated and tested in the Raspberry pi, it executed without any errors by giving correct outputs.

- User Acceptance testing

This is the last phase of testing. The final integrated software is given to the users to make sure that it is up to user requirements. We hope to give this software to a large scale Anthurium grower in order to check whether they are satisfied with the functionality of the product.

2.2 Research Findings

This section describes the principal outcomes of the research. The document mainly focuses on the diseases detection function of the application built to assist large scale Anthurium growers on how to monitor their plantations efficiently. In order to continue this research, first we had to find out about the available applications similar to Agro and the defects in them. For that we read many research papers, searched the internet and contacted responsible persons to gather information. Principal outcome of diseases detection functionality is that the growers do not need to observe plants separately as we implemented the application to capture the image of the entire plantation, check whether there is a spot and detect the disease among the three different diseases that are identified by this application.

3 RESULTS AND DISCUSSION

3.1 Results

Results are a very important section in any product associated with technology. To understand the concept behind the project development, evidences and results are used. This section includes the results of the study based upon methodology that we applied to implement the system.

Three diseases are targeted to be identified at the end of this research. Only two diseases are identified till now. Identification of other disease is in progress. Three major diseases that are very popular among growers are Flea disease, Early Leaf Spot disease and Fungal disease.

Flea disease:

Figure 3.1: Flea disease

1. Symptoms of the disease

Small yellow dots can be seen on the surface of leaves at the initial stage. When the disease becomes more severe, the spots become white in colour. When examined thoroughly, the leaves seem to be like pierced by a needle. This disease spreads rapidly within few days across the entire plantation.

2. Causes and treatments

In order to control the spread of the disease, growers must reduce the temperature inside the greenhouse.

Early leaf spot disease:

Figure 3.2: Early leaf spot disease

1. Symptoms of the disease

Medium sized white spots usually surrounded by a yellow halo can be seen on the surface of leaves at the initial stage. When the disease becomes more severe, the spots become dark brown in colour.

3. Causes and treatments

In order to control the spread of the disease, growers must control the humidity inside the greenhouse.

Fungal disease:

Figure 3.3: Fungal disease

1. Symptoms of the disease

Small brown spots usually surrounded by a yellow halo can be seen on the surface of leaves at the initial stage.

2. Causes and treatments

This might be because the plant is too close to a source of heat. There is also a possibility of this plant being exposed to dry air. In order to control the spread of the disease, growers must move the plant to a cooler place with bright but not direct sunlight.

Table 3.1: Results of disease identification

Disease Identified	Number of images taken for training	Number of images taken for testing
Flea Disease	15	5
Early Leaf Spot Disease	16	6
Fungal Disease	14	4

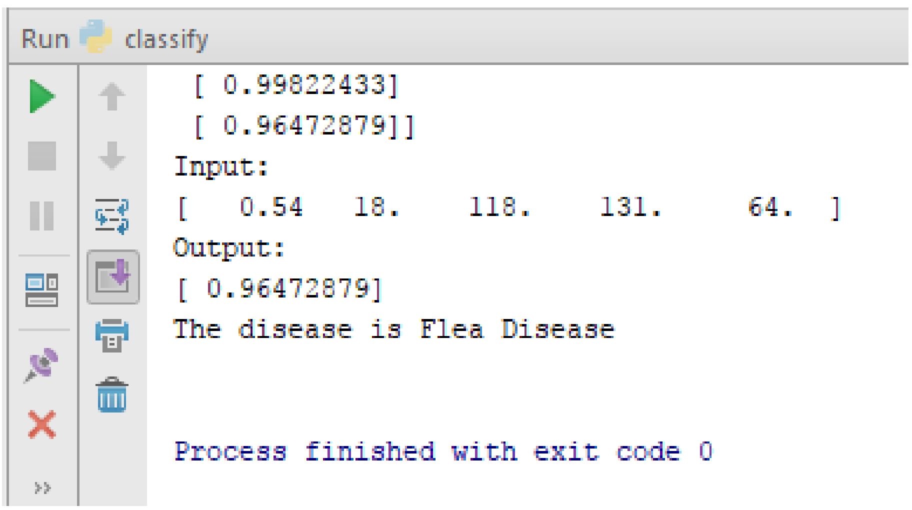

Figure 3.4: Sample result of disease classification

3.1.1 User interfaces

The software does not include any user interfaces. User interaction with the system is minimal as all the outputs are delivered as warnings using an alarm. It will be easier for users with less amount of knowledge about technology. Users do not have to worry about the execution of the system after a power failure because the system runs automatically even after a power failure.

3.1.2 Test cases

Table 3.2: Test case for disease identification

Test Case ID	1
Description	Identifying a disease
Steps	Image is captured through the camera Features of the image are extracted using the application Features are fed to the neural network inside the raspberry pi Output is generated in audio format
Input Data	Colour features extracted from diseased leaf images
Expected Output	Voice output" The disease is a flea disease. The causes for the disease are high temperature. Reduce the temperature inside the greenhouse"
Actual Output	Voice output" The disease is a flea disease. The causes for the disease are high temperature. Reduce the temperature inside the greenhouse"

3.2 Discussion

The discussion part mainly focuses on the problems and difficulties we faced during the research and how we overcame them. When we were searching for a real world problem, we found out that although the technology is advanced, still conventional methods are used in monitoring huge Anthurium plantations.

Then we collected information through blogs, websites and contacting large scale Anthurium growers about the problems they face. We contacted some agricultural experts as well as IT experts to confirm whether this research is possible or not. Finally, we came up with a research topic worth exploring for our final year research and technological approach that is very helpful to the growers.

The most crucial part was to find a data set of diseased Anthurium plants. Although there are many large growers who plant Anthurium around Sri Lanka, they do not keep diseased plants inside the greenhouses with other plants because the diseases spread rapidly. Then we contacted the staff of Gampaha Botanical Garden. But none of them provided us with diseased plants. Then we contacted some botany researchers to check whether there is a dataset available for us to train the neural networks. But all those attempts were unsuccessful. Finally, we contacted some small scale planters and they helped us in giving diseased plants.

Then we set up a plantation in our own house to continue the research. The other challenge was capturing images. As instructed by our supervisor we had to capture images at least four times a day. Since it was difficult and time consuming, we on somedays we could not take pictures four times a day. However, we were able to collect about thousand images of various infected and non-infected plants which are necessary to train the neural networks.

Finally, we overcame the above challenges as a group and in order to develop a product which meets user’s requirements.

4 CONCLUSION

Over the last few years the demand for cut flowers has increased and keeps on increasing annually at a rate of 15-18%. The annual worth of cut flower consumption is approximately $27 million in Europe and about $40 billion worldwide. Netherlands is the biggest exporter 59%. Other exporters are Thailand, Singapore, Malaysia, China and Indonesia. Sri Lanka's share is a paltry Rs. 750 million in this high value market [13].

The following table shows that the income gained by exporting cut flower has increased by the end of 1995. According to agricultural experts, Anthurium has contributed hugely for the increase of income.

Table 4.1: Export of Floriculture Products from Sri Lanka (1990-1995)

Product	**Value (Million Rupees)**					
	1990	**1991**	**1992**	**1993**	**1994**	**1995**
Bulbs, Corms, Tubers	0.5	0.71	21.2	21.6	10.03	6.1
Live Plants	99.5	123.1	132.4	120.3	162.4	179.0
Cut Flowers	31.0	29.7	21.7	34.5	45.3	54.8
Cut Foliage	60.3	77.74	106.9	111.0	189.1	190.2
Total Rs. Million	191.3	231.25	282.2	287.4	406.83	430.1

Source: http://www.fao.org/docrep/005/ac452e/ac452e08.htm#fnB8

Western, North Western and Central Provinces in Sri Lanka are the major areas where cut flowers are grown commercially. The most attractive cut flower grown in Sri Lanka is Anthurium. There are thousands of different species available around the world with numerous colour variations.

Since Anthurium is a very expensive flower, it needs proper care and maintenance throughout its growth in order to get the maximum harvest. There are various aspects that should be considered when monitoring a plantation. They are detecting a disease when it appears at the initial stage and treating carefully without letting it to spread across the whole plantation, monitoring the growth of a plantation considering the environmental conditions that affect the Anthurium plantation like humidity, sunlight and temperature, Predicting the outbreak of a disease by considering the above environmental conditions. Unfortunately, currently there are no proper mechanisms to monitor large Anthurium plantations.

The mechanism growers use currently to monitor plantations is the traditional naked eye observation. This method is sometimes inaccurate and inefficient. Large scale Anthurium growers often complain that it is a difficult task to observe the plants separately one by one, whether a disease has appeared or not since Anthurium is planted in huge nurseries. They waste a lot of effort, time and money when they use the conventional method.

Therefore, we thought of introducing a solution through technology where they can keep track of the entire plantation tirelessly. This research provides an efficient solution considering all the aspects of maintaining a healthy plantation. This automatic system running inside the raspberry pi can detect three major diseases affecting large scale plantations. Growth of the plantation is predicted so that they can control the environmental conditions like temperature inside the greenhouse if they see a reduction of growth. The application also provides the outbreak of a disease so that user can know the environmental conditions that affect the diseases. All the outputs are provided as warnings using an alarm so that user does not have to directly interact with the system.

4.1 SWOT Analysis

4.1.1 Strength

This application focuses on all the aspects that are needed to consider in monitoring a large plantation. Therefore, this can be adapted to other crops as well. Also a person with a minimum technological background can use this although the application is developed using the latest technology.

4.1.2 Weakness

The language application uses to interact with the users is English. But Sinhala is the language used commonly in Sri Lanka. Therefore, users might feel a little bit unfamiliar till they get used to the application.

4.1.3 Opportunities

Although Anthurium is a very expensive flower that contributes hugely to the income of Sri Lanka, there is no such application implemented to monitor a plantation considering external environmental factors.

4.1.4 Threats

Since our target users are Anthurium growers they might not be having a considerable knowledge to setup the system in their own plantation. Therefore, a person familiar with technology should support in setting up the system including cameras, sensors and raspberry pi in the plantations.

4.2 Business Proposition

The application can be marketed and sold to large scale Anthurium growers in Sri Lanka by explaining them the benefits of using the application. Also the application is helpful to the people maintaining botanical gardens. Botany related researchers who are interested can use this application for their studies. The application can be advertised online to be sold to the foreign market.

4.3 Main Nonfunctional Requirements of the System

- User-friendliness
- Less Complexity
- Reliability
- Availability

4.4 Assumptions and Limitations

- User has to have a considerable amount of English knowledge
- Only three diseases can be identified.
- Anthurium leaves are facing upwards and not turned downwards.

4.5 Future Work

- Since the application is built targeting Sri Lankan large scale Anthurium growers, implement the application in Sinhala.
- Application can be modified to identify more diseases.
- Application can be adapted to other crops by doing necessary changes.

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