PLANT GROWTH MONITORING SYSTEM USING ARTIFICIAL INTELLIGENCE

PLANT GROWTH MONITORING SYSTEM USING ARTIFICIAL INTELLIGENCE

B.E. SENIOR DESIGN PROJECT REPORT
AI Specialization

Prepared by
Hasnain Hussain

Project Advisor
Dr Arsalan Jawed

College of Engineering

PAF – Karachi Institute of Economics and Technology
Karachi

PAF - Karachi Institute of Economics & Technology

PAF Base Korangi Creek, Karachi-75190, Pakistan

SDP COMPLETION DECLARATION

We the students of College of Engineering, batch **Spring 14** hereby declare that we have completed our final year project titled **PLANT GROWTH MONITORING SYSTEM USING ARTIFICIAL INTELLIGENCE** and have achieved all targets set forth in the project proposal.

It is requested that we may be examined.

NAME	REGISTRATION ID	SIGNATURE
Hasnain Hussain	**7299**	Hasnain Hussain

Confirmation by Project Supervisor:

I Dr Arsalan Jawed, as project supervisor for the above-mentioned group confirm that they have completed all requirements of the final project including the number of minimum visits for supervision, submission of all deliverables etc.

They may now be allowed to present and defend their work.

____

Date & signature

FOR OFFICE USE ONLY

Remarks (If any)

1. **Report submitted** ☑ **Yes** ☐ **No** ______________________
2. **Project hardware & software fully functional** ☑ **Yes** ☐ **No** ______________________
3. **All other deliverables received** ☑ **Yes** ☐ **No** ______________________
4. **Presentation Date & Time** ______________________

Approved by Project Committee ☑ **Yes** ☐ **No**

Approved by the Dean/Director:

I certify, to the best of my knowledge, that the required procedures have been followed and the preparation criteria have been met for this project work.

____

(Dean/Director CoE)

ABSTRACT

Plant growth monitoring and protection are the key elements in the plant production industry. These factors influence the quality and productivity of the plant and its yields. Diseases are the major factor that vitiates the plant health. More often they harm plant parts like fruit, flower, leaf or stem, but quite often the severity of diseases may even result in plant death. In recent years, computer vision techniques, machine learning algorithms and deep learning models have gained importance due to their capability of dealing with complex data with precision. These techniques are well known for pattern recognition and classification problems. Therefore, in this work, a multilayer convolutional neural network is proposed for the classification of diseased plant leaf images. The real-time images of plant in healthy and diseased condition are collected for validating the performance of the proposed model. If the plant leaf is unhealthy, necessary precaution will be displayed.

TABLE OF CONTENTS

LIST OF FIGURES

Chapter 1

INTRODUCTION

Agriculture is the backbone of human existence on earth. For any civilization to prosper, agriculture has to be healthy and sustainable. Agriculture provides nourishment to the world population and holds the badge of being the source of income for India and other developing nations. Also, the demand for food is expected to continue to grow as a result both of population growth and rising incomes. It results in great pressure on agriculture industry to secure the growing demands for the food. Innovations in agriculture are increasingly needed to secure a growing world demand for food, in order to conserve and optimize the use of limited natural resources and to sustain the environment's ability to provide economic, social, and environmental services to society. So, to maintain the growth and food production properly we are working on the Plant Growth Monitoring System using Artificial Image Processing. Direct measurement of plant growth, for example, on plant weight measurement is usually destructive. We live in a world where everything can be controlled and operated automatically, but there are still a few important sectors in our country where automation has not been adopted or not been put to a full-fledged use, perhaps because of several reasons one such reason is cost. One such field is that of agriculture. Agriculture has been one of the primary occupations of man since early civilizations and even today manual interventions in farming are inevitable. Plant monitoring form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. Automating a plant monitoring and controlling of the climatic parameters which directly or indirectly govern the plant growth and hence their produce. Automation is process control of industrial machinery and processes, thereby replacing human operators.

Direct measurement causes partial or whole plant damage. Some plant growth analysis required that plant can be measured again after data collection to determine the trend of growth for a certain time. Lack of direct measurement due to plant damage can be avoided by indirect measurement. This is one of the reasons for using image processing techniques on agricultural research. In image processing techniques, data is obtained only from the image of the object, so this method is nondestructive and does not damage plant. Plant image area plays a role in predicting plant growth parameters. It is based on the change of plant appearance as a result of plant growth. The appearance of these plants would be captured and processed for predicting plant growth parameters. The complexity of the plant object becomes a problem, especially when measuring the whole plants. A whole plant is a complex object because there are parts of the plant which are covered by other parts. This object complexity will reduce the accuracy of prediction. The development of image processing techniques to overcome this problem is combining several cameras in one object observation. Some cameras are placed around the object so that all parts of plant surface image can be captured. The implementation of multi-camera in image processing techniques has been proven to increase the accuracy of measurement results. The mathematical model has been applied in image processing techniques for improving the accuracy in predicting based on the image feature extraction.

The plant growth monitoring and plant protection are the key concepts for agriculture. The production from a field is completely depended on how healthy is the plant being evolved. This in turns further imitates on the quality and quantity of the plant yields. There are several factors responsible for influencing the plant health, some of them are soil type, moisture level, humidity level, nutrient content, weed, and diseases, etc. Among them, plant disease is the major factor that decreases plant production. These diseases can occur in any part of the plants including stem, flowers, fruits, leaves, stem, etc. More often a severe loss to the plants is observed when a disease is diagnosed in the plant leaves. Since leaves are the main source of producing food for the plants, therefore, entire plant life is depended on them. There is the number of factors responsible for affecting the plant health, but majorly those are categorized among two knowns as abiotic factors and biotic factors. The abiotic factor is the non-living entities that include temperature, humidity, climate, etc. whereas biotic factors are the living organisms that include fungus, bacteria, or virus. We cannot countermeasure the environmental factors but on the other hand, while espousing suitable mechanisms abiotic factors can be counter-measured. Generally, the conventional way of diagnosing a disease from the plant is done with the help of an expert. The samples of the plant have been gathered and observations have been made based on both physical and laboratory investigations. The functional part of these systems requires an expert known to be a plant pathologist to make decisions and also physical intervention. Usually, this entire process is time consuming and often ends up with a high cost. With the increasing demand for food production, it has become essential to adopt some real-time and automated measures to overcome the old-fashioned means of diagnosing plant diseases. Computer vision methodologies have been used in the number of applications for pattern recognition classification, object segmentation, etc. Images and image processing techniques are to the core for all the computer vision applications. They play a key role in storing and analysing the useful and important information from a scene. Nowadays, it has been observed that a number of methods based on Machine Learning (ML) and Deep Learning (DL) has been used for processing an image. These methods are known for their capability of handling complex images and also for their higher accuracy. Deep learning models are the subpart of machine learning well well-known for their layered structures. These networks simulate the conventional artificial neural networks that map the functional capability to simulate the thinking process of the human brain. These networks are unsupervised in nature generally compromised of the stack of layers over one another. Deep learning is also termed as deep neural networks or convolutional neural network having the capacity of learning from unstructured data. In recent years, deep neural networks have been extensively used for the purpose of classification. Therefore, in this study, we present a deep neural network for the classification of healthy and diseased leaves images. The real-time images of the leaf have been acquired for this purpose. This dataset compromises of both the healthy and diseased leaf images. The images are then labelled for their classes. Then the entire dataset is divided among training and testing datasets. Three cross fold strategy has been adopted to validate the performance of our proposed multilayer convolutional neural network. The network is first trained with the help of the training database and then the trained model is then validated with the help of testing database for its accuracy.

The agriculturist in provincial regions may think that it’s hard to differentiate the malady which may be available in their harvests. It's not moderate for them to go to agribusiness office and discover what the infection may be. Our principle objective is to distinguish the illness introduce in a plant by watching its morphology by picture handling and machine learning. Pests and Diseases results in the destruction of crops or part of the plant resulting in decreased food production leading to food insecurity. Also, knowledge about the pest management or control and diseases are less in various less developed countries. Toxic pathogens, poor disease control, drastic climate changes are one of the key factors which arises in dwindled food production. Various modern technologies have emerged to minimize postharvest processing, to fortify agricultural sustainability and to maximize the productivity. Various Laboratory based approaches such as polymerase chain reaction, gas chromatography, mass spectrometry, thermography and hyper spectral techniques have been employed for disease identification. However, these techniques are not cost effective and are high time consuming. In recent times, server based and mobile based approach for disease identification has been employed for disease identification. Several factors of these technologies being high resolution camera, high performance processing and extensive built-in accessories are the added advantages resulting in automatic disease recognition. Modern approaches such as machine learning and deep learning algorithm has been employed to increase the recognition rate and the accuracy of the results. Various researches have taken place under the field of machine learning for plant disease detection and diagnosis, such traditional machine learning approach being random forest, artificial neural network, support vector machine (SVM), fuzzy logic, K-means method, Convolutional neural networks etc.… Random forests are as a whole, learning method for classification, regression and other tasks that operate by constructing a forest of the decision trees during the training time. Unlike decision trees, Random Forest overcome the disadvantage of over fitting of their training data set and it handles both numeric and categorical data. The histogram of oriented gradients (HOG) is an element descriptor utilized as a part of PC vision and image processing for the sake of object detection.

Here we are making utilization of three component descriptors:

1. Hu moments
2. Haralick texture
3. Color Histogram Hu moments is basically used to extract the shape of the leaves.

Haralick texture is used to get the texture of the leaves and color Histogram is used to represent the distribution of the colors in an image.

Machine learning (ML) is a field of inquiry devoted to understanding and building methods that 'learn', that is, methods that leverage data to improve performance on some set of tasks. It is seen as a part of artificial intelligence. Machine learning algorithms build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so. Machine learning algorithms are used in a wide variety of applications, such as in medicine, email filtering, speech recognition, and computer vision, where it is difficult or unfeasible to develop conventional algorithms to perform the needed tasks. A subset of machine learning is closely related to computational statistics, which focuses on making predictions using computers, but not all machine learning is statistical learning. The study of mathematical optimization delivers methods, theory and application domains to the field of machine learning. Data mining is a related field of study, focusing on exploratory data analysis through unsupervised learning. Some implementations of machine learning use data and neural networks in a way that mimics the working of a biological brain. In its application across business problems, machine learning is also referred to as predictive analytics.

As a scientific endeavor, machine learning grew out of the quest for artificial intelligence. In the early days of AI as an academic discipline, some researchers were interested in having machines learn from data. They attempted to approach the problem with various symbolic methods, as well as what was then termed "neural networks"; these were mostly perceptron’s and other models that were later found to be reinventions of the generalized linear models of statistics. Probabilistic reasoning was also employed, especially in automated medical diagnosis. However, an increasing emphasis on the logical, knowledge-based approach caused a rift between AI and machine learning. Probabilistic systems were plagued by theoretical and practical problems of data acquisition and representation. By 1980, expert systems had come to dominate AI, and statistics was out of favor. Work on symbolic/knowledge-based learning did continue within AI, leading to inductive logic programming, but the more statistical line of research was now outside the field of AI proper, in pattern recognition and information retrieval. Neural networks research had been abandoned by AI and computer science around the same time. This line, too, was continued outside the AI/CS field, as "connectionism", by researchers from other disciplines including Hopfield, Rumelhart and Hinton. Their main success came in the mid-1980s with the reinvention of backpropagation. Machine learning (ML), reorganized as a separate field, started to flourish in the 1990s. The field changed its goal from achieving artificial intelligence to tackling solvable problems of a practical nature. It shifted focus away from the symbolic approaches it had inherited from AI, and toward methods and models borrowed from statistics, fuzzy logic, and probability theory. The difference between ML and AI is frequently misunderstood. ML learns and predicts based on passive observations, whereas AI implies an agent interacting with the environment to learn and take actions that maximize its chance of successfully achieving its goals. As of 2020, many sources continue to assert that ML remains a subfield of AI. Others have the view that not all ML is part of AI, but only an 'intelligent subset' of ML should be considered AI.

Supervised learning algorithms build a mathematical model of a set of data that contains both the inputs and the desired outputs. The data is known as training data, and consists of a set of training examples. Each training example has one or more inputs and the desired output, also known as a supervisory signal. In the mathematical model, each training example is represented by an array or vector, sometimes called a feature vector, and the training data is represented by a matrix. Through iterative optimization of an objective function, supervised learning algorithms learn a function that can be used to predict the output associated with new inputs. An optimal function will allow the algorithm to correctly determine the output for inputs that were not a part of the training data. An algorithm that improves the accuracy of its outputs or predictions over time is said to have learned to perform that task. Types of supervised-learning algorithms include active learning, classification and regression. Classification algorithms are used when the outputs are restricted to a limited set of values, and regression algorithms are used when the outputs may have any numerical value within a range. As an example, for a classification algorithm that filters emails, the input would be an incoming email, and the output would be the name of the folder in which to file the email. Similarity learning is an area of supervised machine learning closely related to regression and classification, but the goal is to learn from examples using a similarity function that measures how similar or related two objects are. It has applications in ranking, recommendation systems, visual identity tracking, face verification, and speaker verification.

Supervised learning algorithms build a mathematical model of a set of data that contains both the inputs and the desired outputs. The data is known as training data, and consists of a set of training examples. Each training example has one or more inputs and the desired output, also known as a supervisory signal. In the mathematical model, each training example is represented by an array or vector, sometimes called a feature vector, and the training data is represented by a matrix. Through iterative optimization of an objective function, supervised learning algorithms learn a function that can be used to predict the output associated with new inputs. An optimal function will allow the algorithm to correctly determine the output for inputs that were not a part of the training data. An algorithm that improves the accuracy of its outputs or predictions over time is said to have learned to perform that task. Types of supervised-learning algorithms include active learning, classification and regression. Classification algorithms are used when the outputs are restricted to a limited set of values, and regression algorithms are used when the outputs may have any numerical value within a range. As an example, for a classification algorithm that filters emails, the input would be an incoming email, and the output would be the name of the folder in which to file the email. Similarity learning is an area of supervised machine learning closely related to regression and classification, but the goal is to learn from examples using a similarity function that measures how similar or related two objects are. It has applications in ranking, recommendation systems, visual identity tracking, face verification, and speaker verification.

A convolutional neural network (CNN) is a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data. CNNs are powerful image processing, artificial intelligence (AI) that use deep learning to perform both generative and descriptive tasks, often using machine vison that includes image and video recognition, along with recommender systems and natural language processing (NLP). A neural network is a system of hardware and/or software patterned after the operation of neurons in the human brain. Traditional neural networks are not ideal for image processing and must be fed images in reduced-resolution pieces. CNN have their "neurons" arranged more like those of the frontal lobe, the area responsible for processing visual stimuli in humans and other animals. The layers of neurons are arranged in such a way as to cover the entire visual field avoiding the piecemeal image processing problem of traditional neural networks. A CNN uses a system much like a multilayer perceptron that has been designed for reduced processing requirements. The layers of a CNN consist of an input layer, an output layer and a hidden layer that includes multiple convolutional layers, pooling layers, fully connected layers and normalization layers. The removal of limitations and increase in efficiency for image processing results in a system that is far more effective, simpler to trains limited for image processing and natural language processing. VGG19 is a variant of VGG model which in short consists of 19 layers (16 convolution layers, 3 Fully connected layer, 5 MaxPool layers and 1 SoftMax layer). There are other variants of VGG like VGG11, VGG16 and others. VGG19 has 19.6 billion FLOPs. Alex Net came out in 2012 and it improved on the traditional Convolutional neural networks, so we can understand VGG as a successor of the Alex Net but it was created by a different group named as Visual Geometry Group at Oxford's and hence the name VGG, It carries and uses some ideas from its predecessors and improves on them and uses deep Convolutional neural layers to improve accuracy. Let's explore what VGG19 is and compare it with some of other versions of the VGG architecture and also see some useful and practical applications of the VGG architecture. Before diving in and looking at what VGG19 Architecture is let's take a look at ImageNet and a basic knowledge of CNN. Convolutional Neural Network (CNN)-First of all let’s explore what ImageNet is. It is an Image database consisting of 14,197,122 images organized according to the WordNet hierarchy. this is an initiative to help researchers, students and others in the field of image and vision research. ImageNet also hosts contests from which one was ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) which challenged researchers around the world to come up with solutions that yields the lowest top-1 and top-5 error rates (top-5 error rate would be the percent of images where the correct label is not one of the model’s five most likely labels). The competition gives out a 1,000-class training set of 1.2 million images, a validation set of 50 thousand images and a test set of 150 thousand images. and here comes the VGG Architecture, in 2014 it out-shined other state of the art models and is still preferred for a lot of challenging problems.

Plant disease forecasting is a management system used to predict the occurrence or change in severity of plant diseases. At the field scale, these systems are used by growers to make economic decisions about disease treatments for control. Often the systems ask the grower a series of questions about the susceptibility of the host crop, and incorporate current and forecast weather conditions to make a recommendation. Typically, a recommendation is made about whether disease treatment is necessary or not. Usually, treatment is a pesticide application. Forecasting systems are based on assumptions about the pathogen's interactions with the host and environment, the disease triangle. The objective is to accurately predict when the three factors – host, environment, and pathogen – all interact in such a fashion that disease can occur and cause economic losses. In most cases the host can be suitably defined as resistant or susceptible, and the presence of the pathogen may often be reasonably ascertained based on previous cropping history or perhaps survey data. The environment is usually the factor that controls whether disease develops or not. Environmental conditions may determine the presence of the pathogen in a particular season through their effects on processes such as overwintering. Environmental conditions also affect the ability of the pathogen to cause disease, example a minimum leaf wetness duration is required for grey leaf spot of corn to occur. In these cases, a disease forecasting system attempts to define when the environment will be conducive to disease development. Good disease forecasting systems must be reliable, simple, cost-effective and applicable to many diseases. As such they are normally only designed for diseases that are irregular enough to warrant a prediction system, rather than diseases that occur every year for which regular treatment should be employed. Forecasting systems can only be designed if there is also an understanding on the actual disease triangle parameters. Agriculture is one of the important sources of income for farmer. Farmers can grow variety of plants but diseases hamper the growth of plants. One of the major factors that leads the destruction of plant is disease attack. Disease attack may reduce the productivity plants from 10%-95%. At present there are different strategies to get rid of plant diseases such as removing the affected plants manually, mechanical cultivation and last is using different pesticides. The easy method to detect to plant disease is taking help of agricultural expert. But this method of manual detection of diseases takes lot of time and is laborious work. Next method is using pesticide but excess use of pesticide may increase growth of plants but it reduces the quality of plant. But using more pesticide for plants without analyzing how much quantity of pesticide is needed for particular crop because excess use of pesticide may lead adverse effect on environment and human health.

1.1 MOTIVATION

Technology has redefined farming over the years and technological advances have affected the agriculture industry in more ways than one. Agriculture is the main occupation in many countries worldwide and with rising population, which as per UN projections will increase from 7.5 billion to 8.7 billion in 2051, there will be more pressure on land as there will be only an extra 5% of land, which will come under cultivation by 2050. This means that farmers will have to do more with less. According to the same survey, the food production will have to increase by 70% to feed an additional two billion people. However, traditional methods are not enough to handle this huge demand. This is driving farmers and agro companies to find newer ways to increase production and reduce waste. As a result, Artificial Intelligence (AI) is steadily emerging as part of the agriculture industry's technological evolution. The challenge is to increase the global food production by 50% by 2050 to feed an additional two billion people.AI-powered solutions will not only enable farmers to improve efficiencies but they will also improve quantity, quality and ensure faster go-to-market for crops. Every day, farms produce thousands of data points on temperature, soil, usage of water, weather condition, etc. With the help of artificial intelligence and machine learning models, this data is leveraged in real-time for obtaining useful insights like choosing the right time to sow seeds, determining the crop choices, hybrid seed choices to generate more yields and the like. AI systems are helping to improve the overall harvest quality and accuracy – known as precision agriculture. AI technology helps in detecting disease in plants, pests and poor nutrition of farms. AI sensors can detect and target weeds and then decide which herbicide to apply within the region. This helps in reduced usage of herbicides and cost savings. Many technological companies developed robots, which use computer vision and artificial intelligence to monitor and precisely spray on weeds. These intelligent AI sprayers can drastically reduce the number of chemicals used in the fields and thus improve the quality of agricultural produce, and bring in cost efficiency.

1.2 STATEMENT OF THE PROBLEM

Plant growth plays a key role in getting a good yield for the farmer. The factors that affect plant growth are light, water, temperature and nutrients. These four elements affect the plant's growth hormones, making the plant grow more quickly or more slowly. Changing any of the four can cause the plant stress which stunts or changes growth, or improves growth.

1.3 OBJECTIVES

- To design an effective and appropriate plant growth monitoring system.
- Use Artificial Intelligence for image processing to find the Growth of the Plant.
- To analyze the growth and to predict the health condition of the plant using leaves.
- To Identify the Plant Disease using Machine learning algorithm.

1.4 OUTLINE OF THE REPORT

- Chapter 1 introduces us to the project and highlights the need for maintain the good plant health. It also gives a brief understanding of the artificial intelligence and CNN algorithm.
- Chapter 2 of this report deals with the study of already existing systems. Pages related to the project have been studied and the observed drawbacks have been overcome.

- Chapter 3 is in regards to the methodology and the blocks involved in the project. It also tells us the functioning and explains each of the blocks. The flowcharts and the algorithm of the project have been discussed here.
- Chapter 4 deals with the hardware and software components involved. It also briefs us about the specifications of the components used.
- Chapter 5 gives us the results of the project.
- Chapter 6 gives us the advantages and applications of the project. It also gives us the future scope by telling us how the developed project can be improved in several ways. It also states the ways in which it can be improved.

1.5 CHAPTER SUMMARY

Chapter 1 deals with the introduction to Agriculture, Machine Learning and how AI is involved in Agriculture to check Plant health. It also contains motivation which helps to build the above system. It also describes the problem statement and the objectives of the project.

Chapter 2

LITERATURE SURVEY

Plant image area plays a role in predicting plant growth parameters. It is based on the change of plant appearance as a result of plant growth. The appearance of these plants would be captured and processed for predicting plant growth parameters. The complexity of the plant object becomes a problem, especially when measuring the whole plants. A whole plant is a complex object because there are parts of the plant which are covered by other parts. This object complexity will reduce the accuracy of prediction. The development of image processing techniques to overcome this problem is combining several cameras in one object observation. Some cameras are placed around the object so that all parts of plant surface image can be captured. The implementation of multi-camera in image processing techniques has been proven to increase the accuracy of measurement results. According to this, Data is collected for every 3 days during 21 days of observation. The images are taken from each plant and repeated through three times. It means that in every plant it will have 15 plant images. The next step is to take the observation data using digital scales to measure plant fresh weight. The development of a model using 1050 plant images is divided into 700 plant images for model development and 350 plant images for model validation [1].

The image analysis and processing system has a high potential for evaluating plant growth and health with high accuracy. Automatic image analysis system is flexible to use. In the development of automated inspection tools for plant growth and health assessments. The image analysis is often included in mechanical equipment to replace manual assessments by humans. Also, to control the operation of the machine. There are 5 main steps in image analysis: image recording, reanalysis, segmentation, detection and classify Image processing can reduce the total data of the image to a manageable level. By adding edges and making geometric corrections before analysis, measurement, and specifying some specific details such as size, area, and shape. The most important benefit of image analysis is able to see specific areas and contrasting colors. This helps with visual explanation and interactive analysis by computer. The images that are analyzed can also be stored in a large memory. When computers are connected to the internet, it becomes very easy to transfer data between scientists from cities or countries [2].

A system to monitor temperature, humidity, moisture levels in the soil was designed and the project provides an opportunity to study the existing systems, along with their features and drawbacks. Agriculture is one of the most water consuming activities. The proposed system can be used to switch the motor (on/off) depending on favorable condition of plants i.e., sensor values, thereby automating the process of irrigation. which is one of the most time efficient activities in farming, which helps to prevent over irrigation or under irrigation of soil thereby avoiding crop damage. The farm owner can monitor the process online through Front End Structure. By this work, the wastage of water and the consumption of power by motor can be reduced so that they are conserved for the future use. Through this project it can be concluded that there can be considerable development in farming with the use of IOT and automation [3].

A plant disease is any abnormal condition that alters the appearance or function of a plant. A plant disease takes place when an organism infects a plant and disrupts its normal growth habits. Symptoms can range from slight discoloration to death. Diseases have many causes including fungi, bacteria, viruses, and nematodes. In this work, the dataset of various plants has been collected. Features have been extracted for these leaves and are classified using RF classifiers. The texture-based features; Shape and Color have been looked upon. The feature set has been formed using all the extracted features. This feature set has been given as the input for the classification part. The Random Forest also shows misclassification results. So, the future work is mainly on normalizing the feature values and reduces the misclassification errors. Further this work can be extended into an application that can be installed in the smart phones and educate people about the existence of the medicinal plants around them and make them aware of its therapeutic values. It also helps the common people, researchers and doctors to easily discriminate between the various medicinal plants without the help of experts [4].

Recently, improving the quality of life of farmers through the application of ICT in agriculture has attracted active attention. Smart farming refers to a system that cultivates or manages crops by integrating various sensors and cameras with computer and communication technologies. In this study, we developed a plant growth measurement system and designed a series of devices to increase system performance. Moreover, to improve the performance analysis based on environmental information and images, we used not only the faster R-CNN network to detect the location and size of pests but also a powerful tool to estimate the likelihood of identified pests. Furthermore, through this study, we have successfully advanced the existing artificial intelligence technology, thereby laying the foundation for AI in agricultural automation [5].

Agriculture is the foundation of the world economy, 75% of nations rely upon agriculture. Agriculture has gotten substantially more than essentially a way to bolster consistently developing populaces. It is significant wherein over 70% populace relies upon agriculture in India. In image processing, an acknowledgment system equipped for recognizing plants by utilizing the images of their leaves has been created and with the assistance of the utilization of the images of pesticides can be controlled. The proposed system estimates measurements of the plant by utilizing an infrared sensor and creates most extreme stature, width and distance across the stem of the plant as plant growth parameters, utilizing estimated information. The proposed plant growth monitoring system has been executed by structuring a mechanized examining system. At last, the system execution is contrasted and checked and the estimation information that has been gotten by down to earth field tests [6].

Agriculture is the backbone of our Indian economy and almost 80 percentage of our population depend on it, but it is becoming a strenuous practice due to irregular weather pattern and over usage of underground water. So, there is a need for automatic monitoring and advisory system for increase in productivity. Image processing is a powerful technique that has now been widely used in various fields for solving complex problems and its application in the field of agriculture has been proved a useful contribution. Thus, the proposed work aims at extracting plant color or texture using image processing technique and the resultant image is subjected to virtual height measurement scheme. Then plant height is verified for normal growth in comparison with the plant growth chart. If plant growth is not well, an advisory system may be created which can alert the user [7].

In classifying various plant diseases, Great success has been achieved through deep learning with convolutional neural networks (CNNs). This paper offers an overview analysis of current plant-based disease detection systems. In this analysis, using a CNN, equipped with a bell pepper plant image dataset, a variety of simulation approaches for neurons and layers were used. Plant diseases cause significant growth and economic losses, as well as a reduction in the quality and quantity of agricultural products. In monitoring large crop fields, the detection of plant diseases in a day has received increasing attention. Good plant health and disease identification data through effective management strategies may promote disease control. This approach would increase the production of crops. Bugs known as aphids spread viruses. That's why control of insects is so important to control pepper plant problems. Pepper-related diseases will devastate your entire garden like a virus or wilt. When you find issues with the pepper crop, the best thing to do is destroy the infected plant before it infects the entire garden. As it is understood Once trained on larger datasets, convolutional networks may learn features, there is no need to worry about image quality [8].

Infected areas and damage levels due to pest and disease have been growing seriously according to the global climate changes. The government department of plant protection normally collects the crop pest and disease information by manual inspection, which is unable to provide timely and spatially continuous crop growth status and pest / disease development over large areas. The manuscript aims to bring together and produce cutting edge research to provide crop pest and disease monitoring and forecasting information, integrating multi-source (Earth Observation-EO, meteorological, entomological and plant pathological, etc.) to support decision making in sustainable management of pest and disease. Taking national disease a fungal disease of wheat rust and national pest a serious insect pest locust as the experimental object, we conducted the following research: 1) the sensitive spectral features of rust and locust with the capability of stresses differentiation would be identified or formed based on field hyperspectral data and UAV hyperspectral images for detection, 2) multi-sources of data that are composed by remote sensing images and meteorological observations would be integrated to evaluating habitat of rust and locust in farmland level, 3) multi-temporal remote sensing images and vegetation ecological dataset are combined to provide environmental information of rust and locust dispersion, and forecast the damaged areas and levels in regional scales. Moreover, an automatic system is developed to do the disease and pest time-series monitoring and forecasting, also the visual display of the thematic maps and analysis reports. The system is constructed based on the WebGIS platform. It selected Browser/Server (B/S) architecture, access the system interface through a web browser, simple, quick and easy to operate. And, it could timely, efficiently, and quantitatively do the extraction and analysis of crop pest and disease occurrence and developing information, also produce pest and disease thematic maps and scientific reports. The crop pest and disease monitoring and forecasting system, can provide effective information of pest and disease developing for our agricultural sector, provide a scientific basis to formulate pest and disease prevention and control measures, and also provide data basis and technical support for the crop network management. Based on the system, we analyzed the damaged situation and changes of national wheat rust in 2019, and locust in Tianjin 2019. The results would not only promote the efficacy of pest and disease management and prevention by improving the accuracy of monitoring and forecasting but also help to reduce the number of chemical pesticides, which could thus guarantee the food security and sustainable development of agriculture in China [9].

Computational modelling is becoming increasingly significant in improving our understanding of natural systems, and in making predictions to manage them. Many computational models have been used in various areas for these purposes. However, it has been suggested that models should not be either too simple or too complex, if they are to be useful. Thus, it is of importance to construct models with an optimized model structure that sufficiently well represents their real-world counterparts. To do that, better modelling strategies are needed. The pattern-oriented modelling (POM) strategy is an approach that has been proposed to address these issues. It has been used widely to develop agent-based models, aiming to make the models more comprehensive and rigorous, and increasing their predictive power. Functional-structural plant models can be identified as ABMs, if organs/growth units of a plant are considered as agents. To test the feasibility and demonstrate the value of using the POM strategy for functional-structural plant modelling, this study focuses on modelling of avocado because of its clear modular construction and its economic significance to subtropical and tropical horticulture world-wide. Our study focuses on the systematic development of techniques to apply the POM strategy to functional-structural plant modelling. The overall objective was to determine whether the POM strategy could be used to construct FSPMs in order to increase their predictive power. In the present study, a functional-structural plant model of the annual growth module of avocado was constructed using the POM strategy. The model was able to reproduce multiple observed patterns of architecture and shoot growth simultaneously, and to make independent predictions providing insights into branching architecture, which were consistent with independently generated findings of other studies. Comparison of model outcomes to multiple observed patterns of modular construction at different scales, example metamer level, growth unit level and branch level, increases our confidence that the model performed well. Those independent predictions can be strong indicators that the model is structurally realistic [10].

2.1 CHAPTER SUMMARY

Chapter 2 deals with the study of existing work, we’re able to use various technologies in each work, combined them with growth detection and overcome all drawbacks seen in the extensive study. Hence, we would like to conclude by saying that by doing the extensive literature survey we have gained enormous knowledge on already existing research.

Chapter 3

METHODOLOGY

3.1 BLOCK DIAGRAM

The plant growth monitoring system estimates measurements of the plant by utilizing Artificial intelligence to check whether the plant is healthy or unhealthy. This system is helpful for monitoring plant growth using a few parameters. The block diagram of the Plant Growth Monitoring System is shown in below figure 3.3.

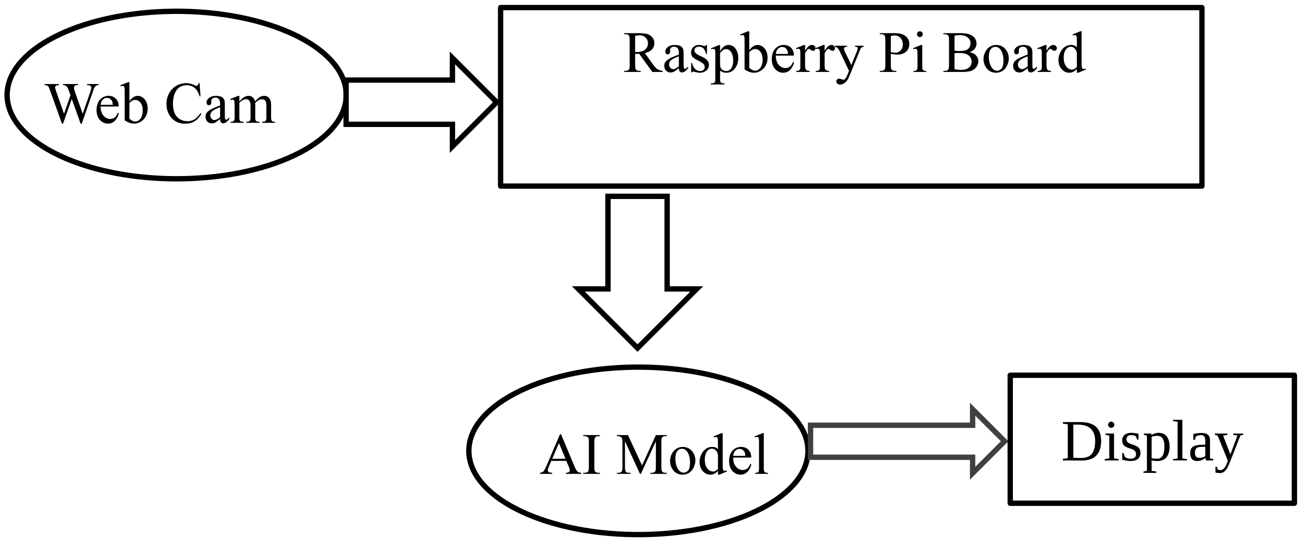

Figure 3.1: Block Diagram of Plant Monitoring System

The Block diagram consists of mainly 3 components:

1. Webcam
2. Raspberry pi board
3. AI model.
4. Display

- Raspberry pi Board: The Raspberry Pi is a low-cost, credit-card-sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. We are using a Raspberry pi board because we will be able to interface a camera to the board.
- Webcam: A webcam is a video camera that feeds or streams an image or video in real-time to or through a computer network, such as the Internet. We are using a webcam to capture of leaf image of the plant. Then the Captured image is made to store, which is further used for detecting a plant condition using a machine learning algorithm.

- AI model: The collected data that is an image from the Raspberry-pi is pre-processed and stored it Google drive and further implemented in the AI Algorithm model to predict whether the plant is healthy or not. The AI model output is displayed on Monitor screen.

4.2 FLOWCHART

The object of this project is on some plants. The plant growth monitoring system starts by capturing the image of the plant leaves and storing it in the drive. The image is captured by the webcam connected to the raspberry pi board. After storing it in the drive, further, it will be taken by the machine learning model to predict whether the plant is healthy or unhealthy. Here we are using a CNN (Convolution Neural Network) model which is used for object recognition for prediction based on few parameters such as size, shape, texture, Colour etc.

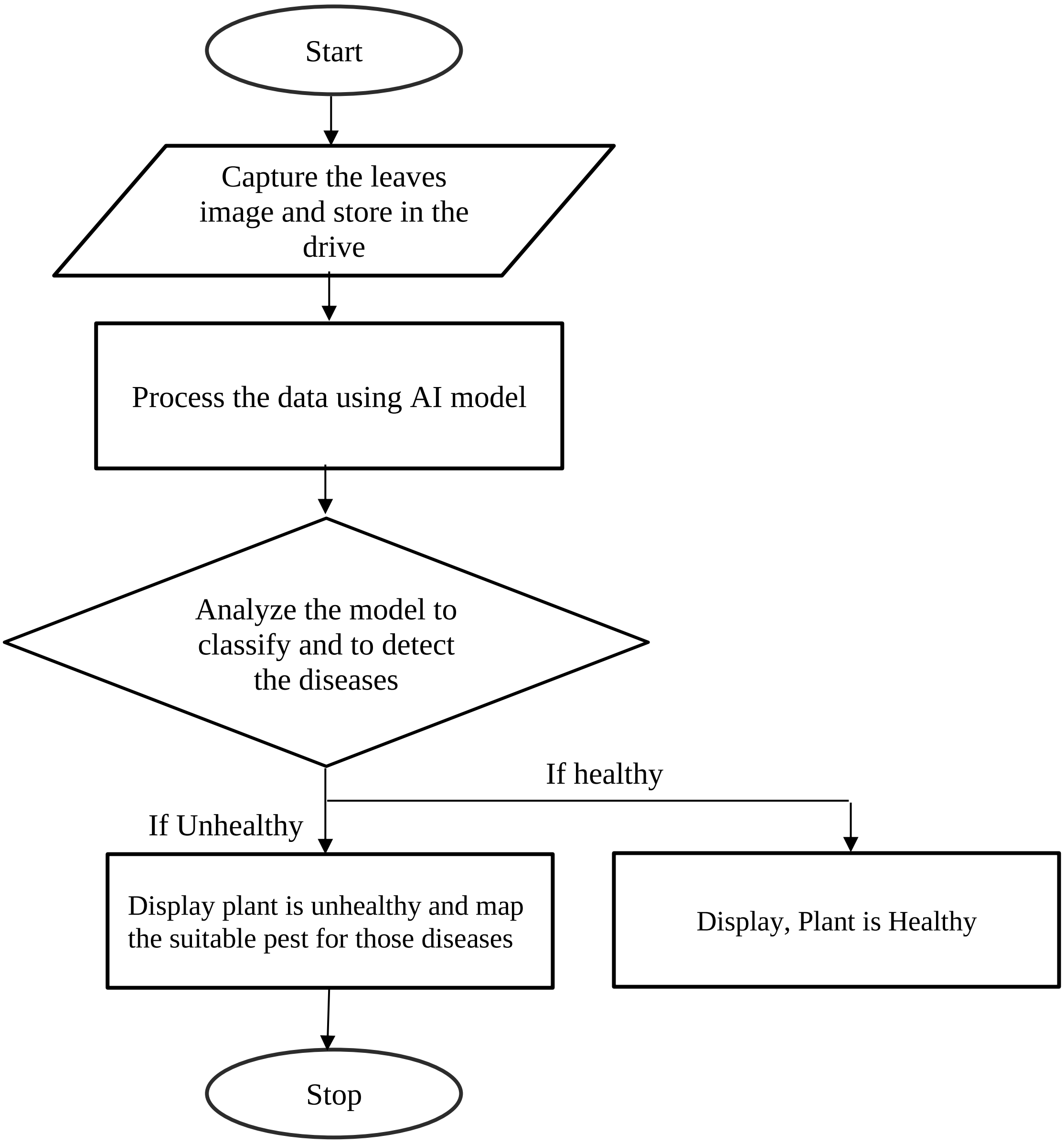

Figure 3.2: Flow diagram of Plant Growth Monitoring system using Artificial Intelligence

If plant leaves have some of the changes in the parameter, it will be scanned and based on the algorithm it will check that plant is healthy or unhealthy. If its unhealthy, model will map to the corresponding class number and that precaution will be showed.

Fig 3.2 shows the flow diagram of plant growth monitoring system. Fig 3.3 shows the process of training and testing the plant growth image. Here the image of plant growth is captured by web camera and the captured image is Pre-Processed using Histogram Equalization and Denoising on whole image datasets. Then Apply Color and Cluster Based Combine Segmentation approach. Extract Shape, Color and Texture Features for all images and applying the machine learning classification approach VGG19 using database. During this process it will take the one cluster (shape, texture, color) and then detect weather it is normal or affected by disease.

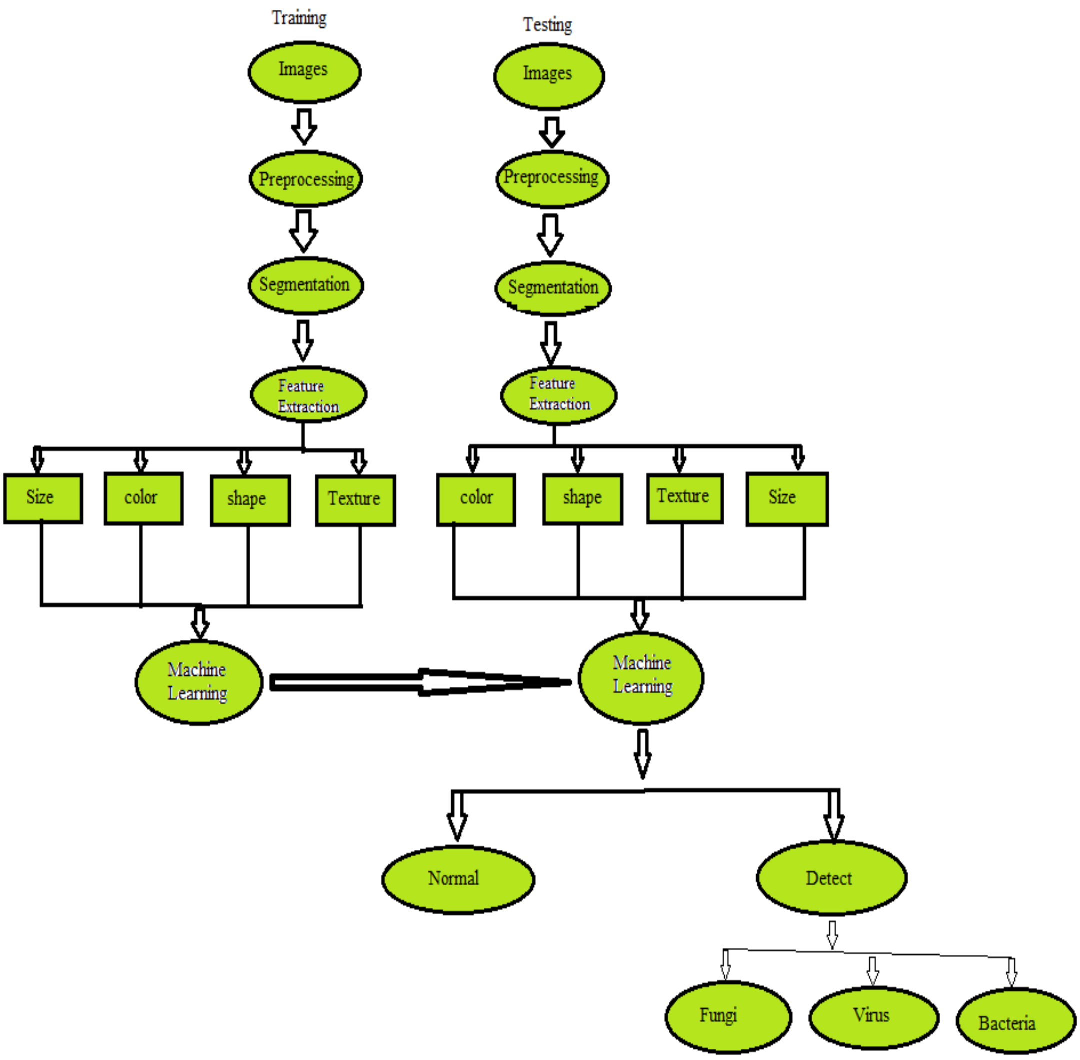

Figure 3.3: Flowchart of AI model of Plant growth monitoring system

3.3 ALGORITHM

In the last few years of the IT industry, there has been a huge demand for one particular skill set known as Deep Learning. Deep learning is a subset of Machine Learning which consists of algorithms that are inspired by the functioning of the human brain or the neural networks. These structures are called as Neural Networks. It teaches the computer to do what naturally comes to humans. In Deep learning, there are several types of models such as the Convolutional Neural Networks (CNN) and Reinforcement Learning. But there has been one particular model that has contributed a lot in the field of computer vision and image analysis which is the Convolutional Neural Networks (CNN) or the Conv Nets. CNNs are a class of Deep Neural Networks that can recognize and classify particular features from images and are widely used for analysing visual images.

Their applications range from image and video recognition, image classification, medical image analysis, computer vision and natural language processing. The term 'Convolution" in CNN denotes the mathematical function of convolution which is a special kind of linear operation wherein two functions are multiplied to produce a third function which expresses how the shape of one function is modified by the other. In simple terms, two images which can be represented as matrices are multiplied to give an output that is used to extract features from the image.

Training

Step 1: Select or upload images and its Label.

Step 2: Apply Pre-Processing using ML model in Google Colab.

Step 3: Apply Colour and Cluster Based Combine Segmentation approach.

Step 4: Extract Shape, Colour and Texture Features for all images.

Step 5: Apply machine Learning Approach CNN, and make database.

Testing

Step 1: Select or upload image.

Step2: Apply Pre-Processing using Histogram Equalization and Denoising.

Step 3: Apply Colour and Cluster Based Combine Segmentation approach.

Step 4: Extract Shape, Colour and Texture Features.

Step 5: Apply machine Learning classification Approach.

3.3.1 INTRODUCTION TO DEEP LEARNING & NEURAL NETWORKS

1. BASIC ARCHITECTURE

There are two main parts to CNN architecture.

A convolution tool that separates and identifies the various features of the image for analysis in a process called as Feature Extraction.

A fully connected layer that utilizes the output from the convolution process and predicts the class of the image based on the features extracted in previous stages. Fig 3.4 represents CNN architecture.

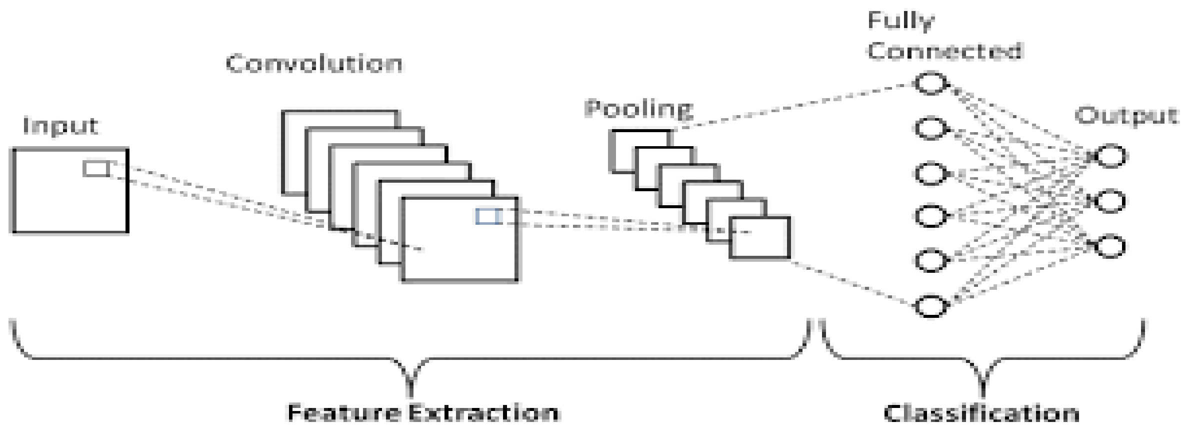

Figure 3.4: CNN Architecture

There are three types of layers that make up the CNN which are convolutional layers, pooling layers, and fully-connected (FC) layers. When these layers are stacked, a CNN architecture will be formed. In addition to these three layers, there are two more important parameters which are the dropout layer and the activation function which are defined below.

1. CONVOLUTIONAL LAYER

This layer is the first layer that is used to extract the various features from the input images. In this layer, the mathematical operation of convolution is performed between the input image and a filter of a particular size MxM. By sliding the filter over the input image, the dot product is taken between the filter and the parts of the input image with respect to the size of the filter (MxM).

The output is termed as the Feature map which gives us information about the image such as the corners and edges. Later, this feature map is fed to other layers to learn several other features of the input image.

2. POOLING LAYER

In most cases, a Convolutional Layer is followed by a Pooling Layer. The primary aim of this layer is to decrease the size of the convolved feature map to reduce the computational costs.

This is performed by decreasing the connections between layers and independently operates on each feature map. Depending upon method used, there are several types of pooling operations. In Max Pooling, the largest element is taken from feature map. Average Pooling calculates the average of the elements in a predefined sized Image section. The total sum of the elements in the predefined section is computed in Sum Pooling. The Pooling Layer usually serves as a bridge between the Convolutional Layer and the FC Layer.

3. FULLY CONNECTED LAYER

The Fully Connected (FC) layer consists of the weights and biases along with the neurons and is used to connect the neurons between two different layers. These layers are usually placed before the output layer and form the last few layers of a CNN Architecture. In this, the input image from the previous layers is flattened and fed to the FC layer. The flattened vector then undergoes few more FC layers where the mathematical functions operations usually take place. In this stage, the classification process begins to take place.

4. DROPOUT

Usually, when all the features are connected to the FC layer, it can cause overfitting in the training dataset. Overfitting occurs when a particular model works so well on the training data causing a negative impact in the model's performance when used on a new data. To overcome this problem, a dropout layer is utilized wherein a few neurons are dropped from the neural network, of 0.3, 30% of the nodes are dropped out randomly from the neural network.

5. ACTIVATION FUNCTIONS

Finally, one of the most important parameters of the CNN model is the activation function. They are used to learn and approximate any kind of continuous and complex relationship between variables of the network. In simple words, it decides which information of the model should fire in the forward direction and which ones should not at the end of the network. It adds non-linearity to the network. There are several commonly used activation functions such as the ReLU (Reactivation Function), Softmax, tanH and the Sigmoid functions. Each of these functions have a specific usage. For a binary classification CNN model, sigmoid and softmax functions are preferred and for a multi-class classification, generally softmax us used.

3.3.2 PHASES IN IMAGE PROCESSING

The steps for image processing are given below:

Step 1: Image acquisition is the process of capturing an image with a sensor (such as a camera) and converting it into a manageable entity (for example, a digital image file). One popular image acquisition method is scraping.

Step 2: Image enhancement improves the quality of an image in order to extract hidden information from it for further processing.

Step 3: Image restoration also improves the quality of an image, mostly by removing possible corruptions in order to get a cleaner version. This process is based mostly on probabilistic and mathematical models and can be used to get rid of blur, noise, missing pixels, camera miscues, watermarks, and other corruptions that may negatively affect the training of a neural network.

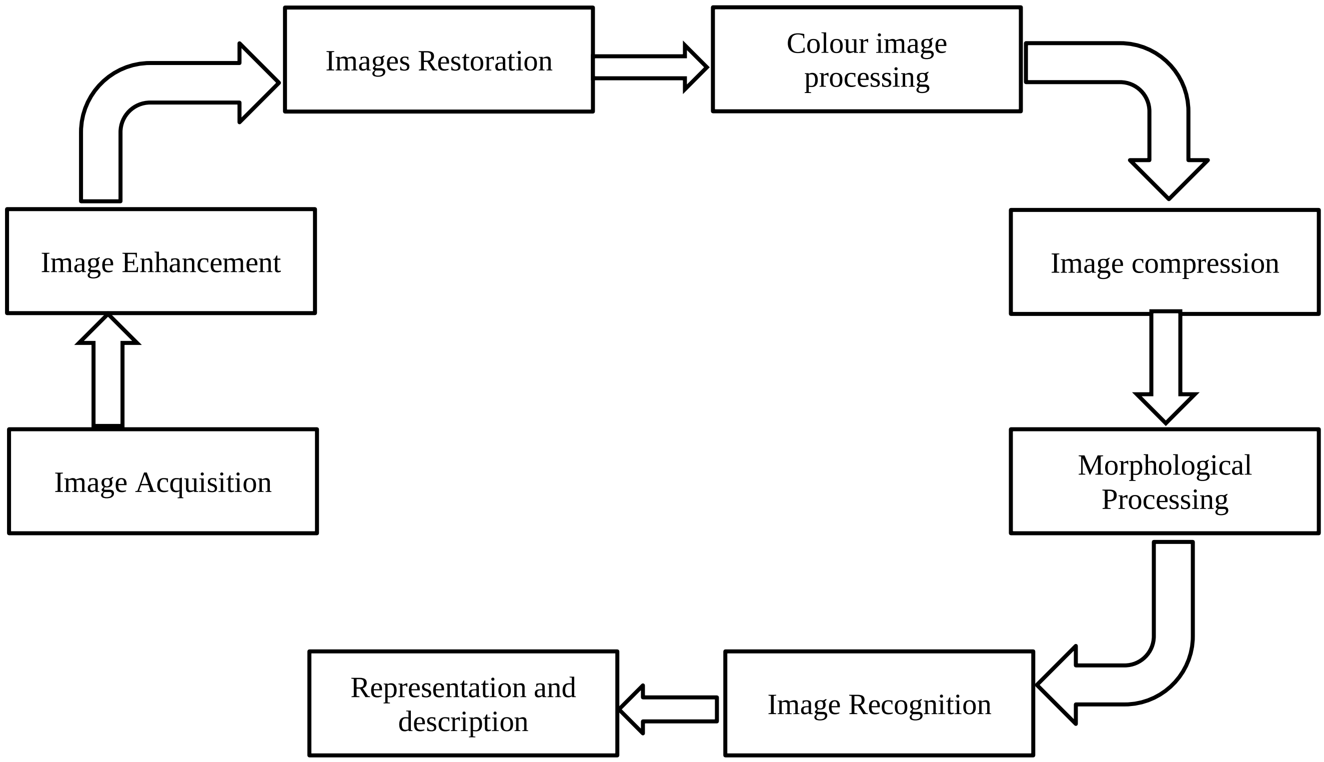

Figure 3.5: Flowchart of image processing

Step 4: Colour image processing includes the processing of coloured images and different colour spaces. Depending on the image type, we can talk about pseudo colour processing (when colours are assigned grayscale values) or RGB processing (for images acquired with a full-colour sensor).

Step 5: Image compression and decompression allow for changing the size and resolution of an image. Compression is responsible for reducing the size and resolution, while decompression is used for restoring an image to its original size and resolution. These techniques are often used during the image augmentation process. When you lack data, you can extend your dataset with slightly augmented images. In this way, you can improve the way your neural network model generalizes data and make sure it provides high-quality results.

Step 6: Morphological processing describes the shapes and structures of the objects in an image. Morphological processing techniques can be used when creating datasets for training AI models. In particular, morphological analysis and processing can be applied at the annotation stage, when you describe what you want your AI model to detect or recognize.

Step 7: Image recognition is the process of identifying specific features of particular objects in an image. Image recognition with AI often uses such techniques as object detection, object recognition, and segmentation. This is where AI solutions truly shine. Once you complete all of these image processing phases, you're ready to build, train, and test an actual AI solution. The process of deep learning development includes a full cycle of operations from data acquisition to incorporating the developed AI model into the end system.

Step 8: Representation and description are the process of visualizing and describing processed data. AI systems are designed to work as efficiently as possible. The raw output of an AI system looks like an array of numbers and values that represent the information the AI model was trained to produce. Yet for the sake of system performance, a deep neural network usually doesn't include any output data representations. Using special visualization tools, you can turn these arrays of numbers into readable images suitable for further analysis. However, as each of these phases requires processing massive amounts of data, you can't do it manually. Here's where AI and machine learning (ML) algorithms become very helpful. The use of AI and ML boosts both the speed of data processing and the quality of the final result. For instance, with the help of AI platforms, we can successfully accomplish such complex tasks as object detection, face recognition, and text recognition. But of course, in order to get high-quality results, we need to pick the right tools and methods.

3.4 VISUAL GEOMETRIC GROUP-19 (VGG-19)

The system is machine learning based approach to detect the plant disease. It uses convolution neural network built on vgg 19 architecture to detect disease.

The layers in VGG19 model are as follows:

- Conv3x3 (64)
- Conv3x3 (64)
- MaxPool
- Conv3x3 (128)
- Conv3x3 (128)
- MaxPool
- Conv3x3 (256)

- Conv3x3 (256)
- Conv3x3 (256)
- Conv3x3 (256)
- MaxPool
- Conv3x3 (512)
- Conv3x3 (512)
- Conv3x3 (512)
- Conv3x3 (512)
- MaxPool
- Conv3x3 (512)
- Conv3x3 (512)
- Conv3x3 (512)
- Conv3x3 (512)
- MaxPool
- Fully Connected (4096)
- Fully Connected (4096)
- Fully Connected (1000)

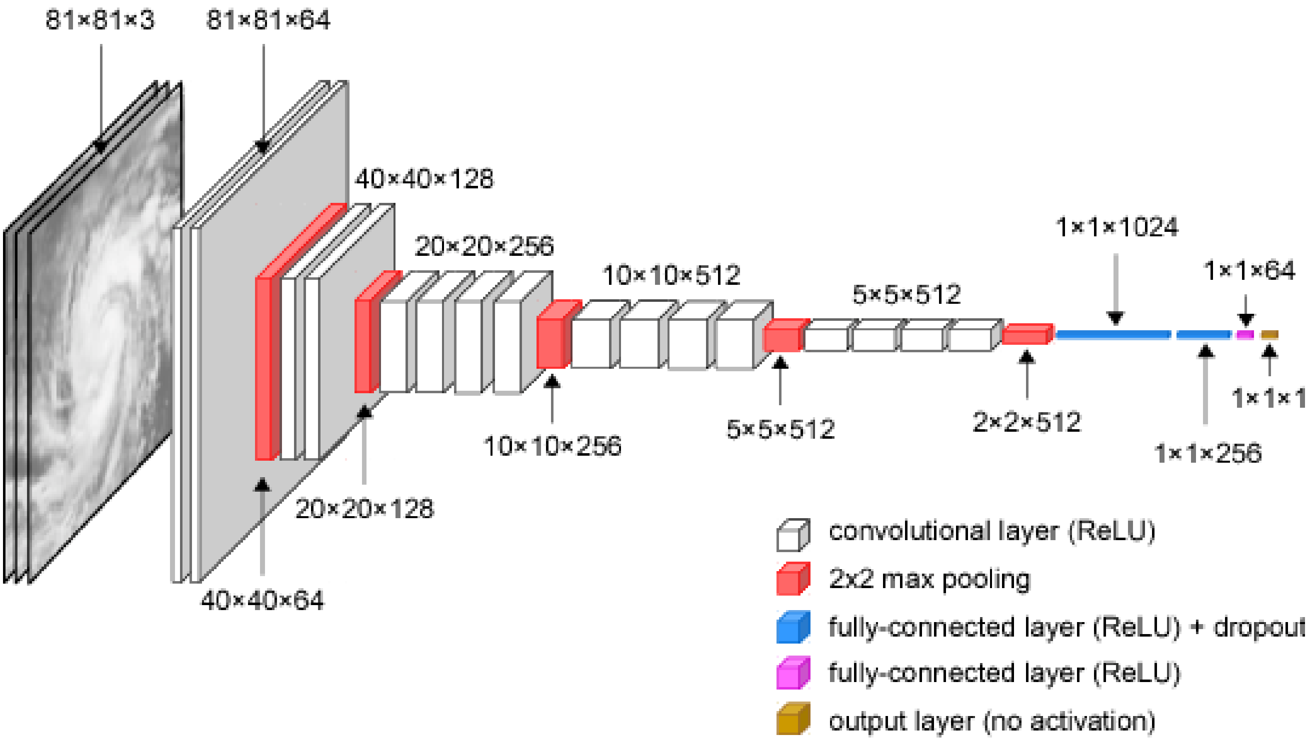

Figure 3.6: VGG19 Architecture

3.4.1 ARCHITECTURE OF VGG-19

The architecture of VGG19 Architecture is shown in Fig 3.6 and is explained below:

- A fixed size of (224 * 224) RGB image was given as input to this network which means that the matrix was of shape (224,224,3).
- The only preprocessing that was done is that they subtracted the mean RGB value from each pixel, computed over the whole training set.
- Used kernels of (3 * 3) size with a stride size of 1 pixel, this enabled them to cover the whole notion of the image.
- spatial padding was used to preserve the spatial resolution of the image.
- max pooling was performed over a 2 * 2-pixel windows with sride 2.
- this was followed by Rectified linear unit (ReLu) to introduce non-linearity to make the model classify better and to improve computational time as the previous models used tanh or sigmoid functions this proved much better than those.
- implemented three fully connected layers from which first two were of size 4096 and after that a layer with 1000 channels for 1000-way ILSVRC classification and the final layer is a softmax function.

3.4.2 USES OF THE VGG NEURAL NETWORK

The main purpose for which the VGG net was designed was to win the *ILSVRC* but it has been used in many other ways.

- Used just as a good classification architecture for many other datasets and as the authors made the models available to the public they can be used as is or with modification for other similar tasks also.
- Transfer learning: can be used for facial recognition tasks also.
- weights are easily available with other frameworks like keras so they can be tinkered with and used for as one wants.
- Content and style loss using VGG-19 network

3.5 CHAPTER SUMMARY

Chapter 3 deals about the detailed introduction and methodology of the system. Mentioned components of the working system in block diagram and explained in detail way. It also describes about the flow diagram, block diagram and architecture used for the system.

Chapter 4

HARDWARE AND SOFTWARE COMPONENTS

4.1 Hardware Requirements

- Raspberry Pi 3
- Web Camera
- Monitor

4.1.1 RASPBERRY PI 3

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processer, 10x faster than the first-generation Raspberry Pi. Additionally, it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs. Raspberry Pi is a development board in PI series. It can be considered as a single board computer that works on LINUX operating system. The board not only has tons of features it also has terrific processing speed making it suitable for advanced applications. PI board is specifically designed for hobbyist and engineers who are interested in LINUX systems and IoT (Internet of Things). The figure indicates the Raspberry pi Board. Fig 4.1 represents the Raspberry Pi 3 Board.

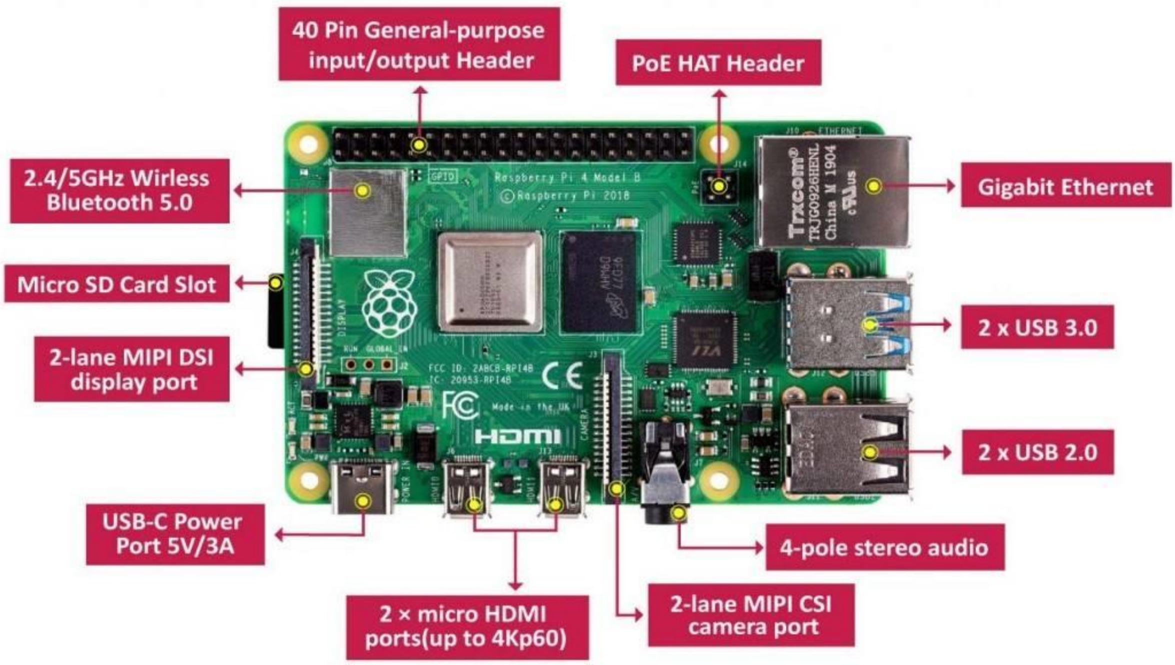

Figure 4.1: Raspberry Pi 3 Board

Raspberry Pi platform is most used after ADRUINO. Although overall applications of PI are less it is most preferred when developing advanced applications. Also, the Raspberry Pi is an open-source platform where one can get a lot of related information so you can customize the system depending on the need.

Here are few examples where Raspberry Pi 3 is chosen over other microcontrollers and development boards:

1. Where the system processing is huge. Most Arduino boards all have clock speed of less than 100MHz, so they can perform functions limited to their capabilities. They cannot process high end programs for applications like Weather Station, Cloud server, gaming console etc. With 1.2GHz clock speed and 1 GB RAM Raspberry Pi can perform all those advanced functions.
2. Where wireless connectivity is needed. Raspberry Pi has wireless LAN and Bluetooth facility by which you can setup WIFI HOTSPOT for internet connectivity. For Internet of Things this feature is best suited.
3. Raspberry Pi had dedicated port for connecting touch LCD display which is a feature that completely omits the need of monitor.
4. Raspberry Pi also has dedicated camera port so one can connect camera without any hassle to the PI board.
5. Raspberry Pi also has PWM outputs for application use.

There are many other features like HD steaming which further promote the use of Raspberry.

How to Use Raspberry Pi? PI is simply a computer on a single board so it cannot be used like Arduino development boards. For the PI to start working we need to first install operating system. This feature is similar to our PC. The PI has dedicated OS for it; any other OS will not work.

The programming of PI is given step by step below.

- Take the 16GB micro-SD card and dedicate it specifically for PI OS.
- Choose and Download OS software. [https://www.raspberrypi.org/downloads/]
- Format the SD card and install OS on to the SD memory card using convenient methods.
- Take the SD card after OS installation and insert it in PI board.
- Connect monitor, keyboard and mouse.
- Power the board with micro-USB connector
- Once the power is tuned ON the PI will run on the OS installed in the memory card and will start from boot.

- Once all drivers are checked the PI will ask for authorization, this is set by default and can be changed.

After authorization you will reach desktop where all application program development starts. On the PI you can download application programs required for your use and can directly install as you do for your PC. After that you can work on developing required program and get the PI run the developed programs.

Specifications: Specification of Raspberry PI 3 board are listed below:

- Processor Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n.
- Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE).
- GPU Dual Core Video-Core IV Multimedia Co-Processor.
- Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode.
- Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure Memory 1GB LPDDR2.
- Operating System Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT.
- Dimensions 85 x 56 x 17mm.
- Power Micro USB socket 5V1, 2.5A.

Pins: A powerful feature of the Raspberry Pi is the row of GPIO (general-purpose input/output) pins along the extreme right edge of the board. Like every Raspberry Pi chipset, it consists of a 40-pin GPIO. A standard interface for connecting a single-board computer or

SPI0: GPIO9 (MISO), GPIO10 (MOSI), GPIO11 (SCLK), GPIO8 (CE0), GPIO7 (CE1).

SPI1: GPIO19 (MISO), GPIO20 (MOSI), GPIO21 (SCLK), GPIO18 (CE0), GPIO17 (CE1), GPIO16 (CE2).

I2C pins: I2C is used by the Raspberry Pi board to communicate with devices that are compatible with Inter-Integrated Circuit (a low-speed two-wire serial communication protocol). This communication standard requires master-slave roles between both devices. I2C has two connections: SDA (Serial Data) and SCL (Serial Clock). They work by sending data to and using the SDA connection, and the speed of data transfer is controlled via the SCL pin.

Data**:** (GPIO2), Clock (GPIO3)

EEPROM Data: (GPIO0), EEPROM Clock (GPIO1)

UART Pins: Serial communication or the UART (Universal Asynchronous Receiver / Transmitter) pins provide a way to communicate between two microcontrollers or the computers. TX pin is used to transmit the serial data and RX pin is used to receive serial data coming from a different serial device. The UART pins areTX (GPIO14) RX (GPIO15)

Connectors: The connectors i.e., external devices that can be connected to ports of Raspberry Pi are listed below:

- Ethernet 10/100 Base T Ethernet socket
- Video Output HDMI (rev 1.3 & 1.4 Composite RCA (PAL and NTSC).
- Audio Output Audio Output 3.5mm jack, HDMI USB 4 x USB 2.0 Connector.
- GPIO Connector 40-pin 2.54 mm (100 mil) expansion header: 2x20 strip Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines.
- Camera Connector 15-pin MIPI Camera Serial Interface (CSI-2).
- Display Connector Display Serial Interface (DSI) 15way flat flex cable connector with two data lanes and a clock lane.
- Memory Card Slot Push/pull Micro SDIO.

4.1.1.1 ADVANTAGES

The advantages of Raspberry Pi 3 are as follows:

- Low cost
- Consistent board format
- 10x faster processing
- Added connectivity

4.1.1.2 APPLICATIONS

The various applications of Raspberry Pi 3 are as follows:

- Low-cost PC/tablet/laptop
- IoT applications
- Media centre
- Robotics
- Industrial/Home automation
- Server/cloud server
- Gaming
- Wireless access point
- Environmental sensing/monitoring (example: weather station)

4.1.2 WEB CAMERA

A webcam is a video camera that feeds or streams an image or video in real time to or through a computer network, such as the Internet. Webcams are typically small cameras that sit on a desk, attach to a user's monitor, or are built into the hardware. Webcams can be used during a video chat session involving two or more people, with conversations that include live audio and video. A camera image is shown in fig 4.2.

Webcam software enables users to record a video or stream the video on the Internet. As video streaming over the Internet requires much bandwidth, such streams usually use compressed formats. The maximum resolution of a webcam is also lower than most handheld video cameras, as higher resolutions would be reduced during transmission. The lower resolution enables webcams to be relatively inexpensive compared to most video cameras, but the effect is adequate for video chat sessions. Webcams typically include a lens, an image sensor, support electronics, and may also include one or even two microphones for sound.

Image sensors can be CMOS or CCD, the former being dominant for low-cost cameras, but CCD cameras do not necessarily outperform CMOS-based cameras in the low-price range. Most consumer webcams are capable of providing VGA-resolution video at a frame rate of 30 frames per second. Many newer devices can produce video in multi-megapixel resolutions, and a few can run at high frame rates such as the PlayStation Eye, which can produce 320×240 video at 120 frames per second. The Wii Remote contains an image sensor with a resolution of 1024×768 pixels. Common resolutions of laptops' built-in webcams are 720p (HD), and in lower-end laptops 480p. The earliest known laptops with 1080p (Full HD) webcams like the Samsung 700G7C were released in the early 2010s.

As the bayer filter is proprietary, any webcam contains some built-in image processing, separate from compression.

Optics: Various lenses are available, the most common in consumer-grade webcams being a plastic lens that can be manually moved in and out to focus the camera. Fixed-focus lenses, which have no provision for adjustment, are also available. As a camera system's depth of field is greater for small image formats and is greater for lenses with a large f-number (small aperture), the systems used in webcams have a sufficiently large depth of field that the use of a fixed-focus lens does not impact image sharpness to a great extent.

Most models use simple, focal-free optics (fixed focus, factory-set for the usual distance from the monitor to which it is fastened to the user) or manual focus.

Compression: Digital video streams are represented by huge amounts of data, burdening its transmission (from the image sensor, where the data is continuously created) and storage alike. Most if not all cheap webcams come with built-in ASIC to do video compression in real-time. Support electronics read the image from the sensor and transmit it to the host computer. The camera pictured to the right, for example, uses a Sonix SN9C101 to transmit its image over USB. Typically, each frame is transmitted uncompressed in RGB or YUV or compressed as JPEG. Some cameras, such as mobile-phone cameras, use a CMOS sensor with supporting electronics "on die", i.e., the sensor and the support electronics are built on a single silicon chip to save space and manufacturing costs. Most webcams feature built-in microphones to make video calling and videoconferencing more convenient.

Interface: Typical interfaces used by articles marketed as a "webcam" are USB, Ethernet and IEEE 802.11 (denominated as IP camera). Further interfaces such as e.g., Composite video, S-Video or FireWire were also available.

The USB video device class (UVC) specification allows inter-connectivity of webcams to computers without the need for proprietary device drivers.

Software**:** Various proprietary as well as free and open-source software is available to handle the UVC stream. One could use Guvcview or GStreamer and GStreamer-based software to handle the UVC stream. Another could use multiple USB cameras attached to the host computer the software resides on, and broadcast multiple streams at once over (Wireless) Ethernet, such as MotionEye. MotionEye can either be installed onto a Raspberry Pi as MotionEyeOs, or afterwards on Raspbian as well. MotionEye can also be set up on Debian, Raspbian is a variant of Debian. Note that MotionEye V4.1.1 can only run-on Debian 10 Buster (old stable) and Python 2.7. Newer versions such as 3.X are not supported at this point of time according to Ccrisan, foundator and author of MotionEye.

Figure 4.2: Web Camera

4.1.3 MONITOR

A computer monitor is an output device that displays information in pictorial or text form. A monitor usually comprises a visual display, some circuitry, a casing, and a power supply. The display device in modern monitors is typically a thin film transistor liquid crystal display (TFT-LCD) with LED backlighting having replaced cold-cathode fluorescent lamp (CCFL) backlighting. Previous monitors used a cathode ray tube (CRT) and some Plasma (also called Gas-Plasma) displays. Monitors are connected to the computer via VGA, HDMI, DisplayPort, USB-C, low-voltage differential signaling (LVDS) or other proprietary connectors and signals. Fig 4.3 shows the image of monitor screen.

Figure 4.3: Monitor

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome.

4.2 SOFTWARE REQUIREMENT

The software requirement for plant growth monitoring system is:

- Raspberry Pi OS
- Google Colaboratory

4.2.1 RASPBERRY PI OS

Raspberry Pi OS (earlier called as Raspbian) is an officially supported operating system for Raspberry Pi. It is a 32-bit Linux base OS that has been optimized to run on Pi systems and has been around since 2013. Raspberry Pi OS was first developed by Mike Thompson and Peter Green as Raspbian, an independent and unofficial port of Debian to the Raspberry Pi. The first build was released on June 16, 2013. As the Raspberry Pi had no officially provided operating system at the time, the Raspberry Pi Foundation decided to build off of the work done by the Raspbian project and began producing and releasing their own version of the software. The Foundation's first release of Raspbian, which now referred both to the community project as well as the official operating system, was announced on October 11th, 2014.

On June 29th, 2020, the Raspberry Pi Foundation announced they were releasing a beta 64-bit version of their official operating system. However, the 64-bit version was not based on Raspbian, instead taking its userland from Debian directly. Since the Foundation did not want to use the name Raspbian to refer to software that was not based on the Raspbian project, the name of the officially provided operating system was changed to Raspberry Pi OS. This change was carried over to the 32-bit version as well, though it continued to be based on Raspbian. The 64-bit version of Raspberry Pi OS was officially released on February 3rd, 2022.

Raspberry Pi OS is highly optimized for the Raspberry Pi line of compact single-board computers with ARM CPUs. It runs on every Raspberry Pi except the Pico microcontroller. Raspberry Pi OS uses a modified LXD as its desktop environment with the Open box stacking window manager, along with a unique theme. The default distribution is shipped with a copy of the algebra program Wolfram Mathematica, VLC, and a lightweight version of the Chromium web browser. Fig 4.4 represents logo of Raspberry Pi OS.

Figure 4.4: Raspberry Pi OS Logo

Features: User interface of Raspberry Pi OS has a desktop environment, PIXEL, based on LXDE, which looks similar to many common desktops, such as macOS and Microsoft Windows. The desktop has a background image. A menu bar is positioned at the top and contains an application menu and shortcuts to a web browser (Chromium), file manager, and terminal. The other end of the menu bar shows a Bluetooth menu, Wi-Fi menu, volume control, and clock. The desktop can also be changed from its default appearance, such as repositioning the menu bar.

Package management: Packages can be installed via APT, the Recommended Software app, and by using the Add/Remove Software tool, a GUI wrapper for APT.

Components: PCManFM is a file browser allowing quick access to all areas of the computer, and was redesigned in the first Raspberry Pi OS Buster. Raspberry Pi OS originally used

Epiphany as the web browser, but switched to Chromium with the launch of its redesigned desktop. Raspberry Pi OS comes with many beginner IDEs, such as Thonny Python IDE, Mu Editor, and green foot. It also ships with educational software like Scratch and Bookshelf.

4.2.2 GOOGLE COLABORATORY

Google Colaboratory is a freemium tool offered by Google Research that allows users to write and execute Python code in their web browsers. Colab is actually based on the Jupyter open source, and essentially allows you to create and share computation files without having to download or install anything. Since Google Colab is cloud-based, it comes preinstalled with just about every library you could need in the cloud. This means that you don't have to separate precious disk space or time to download the libraries manually. The free version also comes with a certain level of GPU, memory and run time, which can fluctuate. If you need more capacity, you can upgrade to one of the paid plans. Google does not disclose limits for any of its Colab plans due to the need for flexibility. Fig 4.5 represents logo of Google Colab.

Figure 4.5: Google Colab Logo

Colaboratory, or "Colab" for short, is a product from Google Research. Colab allows anybody to write and execute arbitrary python code through the browser, and is especially well suited to machine learning, data analysis and education. More technically, Colab is a hosted Jupyter notebook service that requires no setup to use, while providing access free of charge to computing resources including GPUs.

4.2.2.1 LIBRARIES USED

Libraries that are required /used in google Colaboratory are shown below

- Numpy: NumPy is a Python library used for working with arrays. It also has functions for working in domain of linear algebra, Fourier transform, and matrices. NumPy was created in 2005 by Travis Oliphant. It is an open-source project and you can use it freely. NumPy stands for Numerical Python. NumPy is the fundamental package for scientific computing in Python. It is a Python library that provides a multidimensional array object, various derived objects (such as masked arrays and matrices), and an assortment of routines for fast operations on arrays, including mathematical, logical, shape manipulation, sorting, selecting, I/O, discrete Fourier transforms, basic linear algebra, basic statistical operations, random simulation and much more. Fig 4.6 shows the NumPy logo.

Figure 4.6: NumPy Logo

NumPy targets the C-Python reference implementation of Python, which is a non-optimizing bytecode interpreter. Mathematical algorithms written for this version of Python often run much slower than compiled equivalents due to the absence of compiler optimization. NumPy addresses the slowness problem partly by providing multidimensional arrays and functions and operators that operate efficiently on arrays; using these requires rewriting some code, mostly inner loops, using NumPy. Using NumPy in Python gives functionality comparable to MATLAB since they are both interpreted, and they both allow the user to write fast programs as long as most operations work on arrays or matrices instead of scalars. In comparison, MATLAB boasts a large number of additional toolboxes, notably Simulink, whereas NumPy is intrinsically integrated with Python, a more modern and complete programming language. Moreover, complementary Python packages are available; SciPy is a library that adds more MATLAB-like functionality and Matplotlib is a plotting package that provides MATLAB-like plotting functionality. Internally, both MATLAB and NumPy rely on BLAS and LAPACK for efficient linear algebra computations. Python bindings of the widely used computer vision library OpenCV utilize NumPy arrays to store and operate on data. Since images with multiple channels are simply represented as three-dimensional arrays, indexing, slicing or masking with other arrays are very efficient ways to access specific pixels of an image. The NumPy array as universal data structure in OpenCV for images, extracted feature points, filter kernels and many more vastly simplifies the programming workflow and debugging.

- Matplotlib: Matplotlib is a comprehensive library for creating static, animated, and interactive visualizations in Python. Matplotlib makes easy things easy and hard things possible.

  - Create publication quality plots.
  - Make interactive figures that can zoom, pan, update.
  - Customize visual style and layout.
  - Export to many file formats.
  - Embed in Jupyter and Graphical User Interfaces.
  - Use a rich array of third-party packages built on Matplotlib.
- Keras: Keras is an open-source software library that provides a Python interface for artificial neural networks. Keras acts as an interface for the TensorFlow library. Up until version 2.3, Keras supported multiple backends, including TensorFlow, Microsoft Cognitive Toolkit, Theano, and PlaidML. As of version 2.4, only TensorFlow is supported. Designed to enable fast experimentation with deep neural networks, it focuses on being user-friendly, modular, and extensible. It was developed as part of the research effort of project ONEIROS (Open-ended Neuro-Electronic Intelligent Robot Operating System), and its primary author and maintainer is Francois Chollet, a Google engineer. Chollet is also the author of the Xception deep neural network model.

Features of Keras:

Keras contains numerous implementations of commonly used neural-network building blocks such as layers, objectives, activation functions, optimizers, and a host of tools to make working with image and text data easier to simplify the coding necessary for writing deep neural network code. The code is hosted on GitHub, and community support forums include the GitHub issues page, and a Slack channel. In addition to standard neural networks, Keras has support for convolutional and recurrent neural networks. It supports other common utility layers like dropout, batch normalization, and pooling.

Keras allows users to productize deep models on smartphones (iOS and Android), on the web, or on the Java Virtual Machine. It also allows use of distributed training of deep-learning models on clusters of Graphics processing units (GPU) and tensor processing units (TPU).

4.3 CHAPTER SUMMARY

Chapter 4 deals with the hardware and software components of the system. Both software and hardware components explained in detailed manner. It also describes about the libraries used in Google Colaboratory which is required to build project.

Chapter 5

RESULT & DISCUSSION

Innovations in agriculture are increasingly needed to secure a growing world demand for food, in order to conserve and optimize the use of limited natural resources and to sustain the environment's ability to provide economic, social, and environmental services to society.AI based Image processing is the process of implementation, analysis and manipulation of a digitized image, especially in order to improve its quality. Our project deals with the capturing the image of the plant leaf in its growth and then based on appearance of the plants it would be processed for predicting plant growth parameters. After preprocessing the images, it will be classified and trained using some Machine learning algorithm.

The project development is divided into two parts one is hardware part and other is software part. The hardware consists of Raspberry Pi connected to web Cam. Below fig 5.1 shows the hardware model used to capture the image of the leaves. Raspberry pi is a 40-pin micontroller which is interfaced with the Web camera and the python code is written in the backward.

Figure 5.1: Hardware model of capturing image.

After the image is capture, we are going to use this image for testing it on the trained model. The fig 5.2 shows the output that image is captured successfully and stored. Then this stored image is used to train the model for prediction. We have two phases in running the software, one is training and other is testing. Training data is the data you use to train an algorithm to predict the outcome you design your model. Testing the data is used to measure the performance, such as accuracy or efficiency, of the algorithm you using to train the machine. It consists 38 classes of plant disease images labelled respectively. These images will be fed into machine learning module, and trained module is extracted.

- Training of machine learning module with data sets: The neural machine learning module is created using keras library and python in google collab editor The CNN model is built on vgg19 architecture.

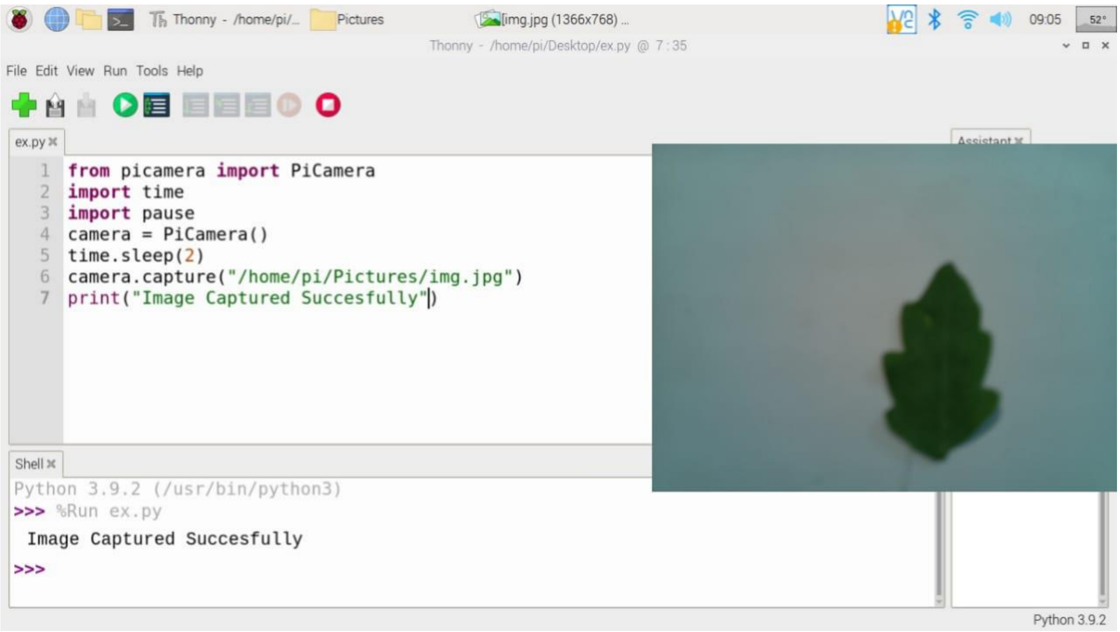

Figure 5.2: Snapshot of the captured image using webcam

- For training the module 1000's of images of plant leaves with disease are collected and stored in a file. The file is divided into two parts training datasets and testing data sets training data sets is used to train the machine learning module. It consists 38 classes of plant disease images labelled respectively. These images will be fed into machine learning module, and trained module is extracted.

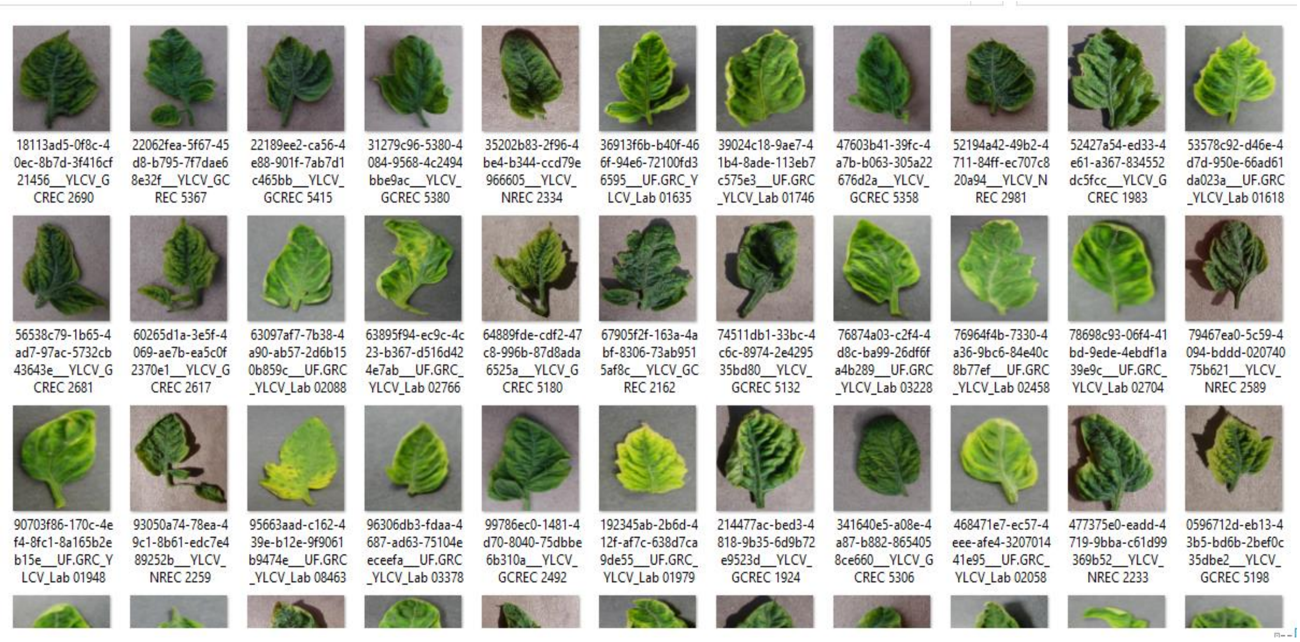

Figure 5.3: Snapshot of the dataset stored in google drive.

Above fig 5.3 shows the snapshots of the dataset stored in the google drive which is used for training the model using ML algorithm.

- Detection of plant disease: The detection of plant disease starts with the collection of plant leaf image sample at the farm, the image is then passed into trained neural module for diagnosis. The trained machine learning module will give output whether the sample image contains any disease and if disease is detected a precaution for that disease will also be displayed.

Here we have used tomato plant leaves as a dataset (approximately 1000 of images), which consist of different pattern, texture, Colour and size. We have used the Convolution Neural Network for leaves recognition and used for prediction of the diseases. After the training of the model, we have to test the model by passing the validation dataset. Here is one of the examples, we have used the tomato leaves to validate the data using ML model.

```
path="/content/drive/MyDrive/livetest/leaveimage.jpg"
prediction(path)
```

```
32
The plant diagnosed asTomato___Septoria_leaf_spot
Tomato_Septoria_leaf_spot

1.       Removal and destruction of the affected plant parts.
2.      Seed treatment with Thiram or Dithane M-45 (2 g/kg seed) is useful in checking seed borne infection.
3.      In the field spraying with Mancozeb 0.2 % effectively controls the disease.
```

Figure 5.4: Snapshot of Output Screen

Above fig 5.4 shows one of the outputs of our prediction, which defines that the plant leaves are unhealthy. If the plant is healthy means it will display 0. Here the output is 32 which means that leave is having a disease which belong to the class 32. We have defined the 38 precaution and stored in the drive. Is the plant being unhealthy means, it will map to that class number and shows the necessary precautions.

Below table 5.1 contain various plant image with the corresponding health conditions. We have defined the necessary precaution on the google drive, if the plant image is tested over the trained image, it will analyze weather the plant is healthy or not. If the plant is unhealthy it will map to the corresponding class and display the precautions for that disease.

Table 5.1: Results obtained during the identification of Disease.

Sl. No	Plant Images	Parameter measured	Diseases Class and Name	Description
1.	 (224 x 224) PX	Shape Size Colour	Class-32 and Tomato Septoria leaf spot	Disease identified and precautions are: Removal and destruction of the affected plant parts. Treatment with Thiram or Dithane ss M-45 is useful in checking seed borne infection. In the field spraying with Mancozed-0.2 effectively controls the disease.
2.	 (224 x 224) PX	Shape Size Colour	No class defined	Plant leaf not detected because we have not trained this plant hence, Not identified.
3.	 (224 x 224) PX	Shape Size Colour	Class-33 and Pepper_leaf	Disease not identified and hence Pepper plant is healthy

4.	 (224 x 224) PX	Shape Size Colour	Class-7 Com_(maize)_ Cercospora_leaf_ spot_gray_leaf spot Gray_leaf_spot	Disease identified and precautions are: Management techniques include crop resistance. Crop rotation. Residue management, use of fungicides, and weed control. The purpose of disease management is to prevent the amount of secondary disease cycles as well as to protect leaf area from damage prior to grain formation.
5.	 (224 x 224)PX	Shape Size Colour	Class-34 and Tomato_Target _Spot	Disease identified and precautions are: Warm wet conditions favour the disease such that fungicides are needed to give adequate control. The products to use are chlorothalonil, copper oxychloride or mancozeb. Treatment should start when the first spots are seen and continue at 10-14-day intervals until 3-4 weeks before last harvest.

5.2 CHAPTER SUMMARY

Chapter 5 deals with the result that we obtained while performing. We have identified and tabulated the different plant disease based on few parameters like size, color, shape and texture of leaves using convolution neural network.

CONCLUSION

Plants are important for nature and as well as equally important for the living being. They are the essential part as they provide us with food, shelter, medicine and many more. Plants are also get affected by the diseases and the disorders as the human being does. So, in this regard, some appropriate, timely, and accurate methods are to be adopted for suitable plant growth monitoring and plant protection. Therefore, in this work, we have proposed a multilayer convolutional neural network for the classification of diseased plant leaf images. The results were validated on the database acquired for four different plant leave images categorized among healthy and diseased.

The proposed system helps in identification of the plant disease and provides remedies that can be used as a defense mechanism against the disease. The database obtained from the internet is properly segregated and the different plant species are identified and are renamed to form a proper database then obtain test database which consists of various plant diseases that are used we will train our classifier and then output will be predicted with optimum accuracy. We use Convolution Neural Network (CNN) which comprises of different layers which are used for prediction. Camera is attached and will capture images of the plants which will act as input for the software, based of which the software will tell us whether the plant is healthy or not.

FUTURE SCOPE

The proposed model has less accuracy in capturing the image of the plant. The time taken for the image processing is comparatively more, hence it can be reduced by using different algorithms. In future, the presented model can be further enhanced for the classification of different plant leave and diseases.

REFERENCES:

[1]. Wahyu Saputra and Rudiati Evi Masithoh, "Development of Growth Monitoring system using Image Processing Technique based on Multiple Image" Vol. 2, No. 5, January 2017.

[2]. Annie Christi and Brijesh Vala, "Plant Health Monitoring System using Image Processing" Volume 6, May 2019.

[3]. Gaurav Patil, Shashank Pathmudi and Akash Patil, "Plant Monitoring System" Vol.10, September 2021.

[4]. Subhanshu Gupta, Ajay Mudgil and Amita Soni, "Plant Growth Monitoring System" Vol.1, June 2012.

[5]. Meonghun Lee, Haeng Kon kim, Hyun Yoe, "Plant Growth Measurement System using Image Processing", December 2020.

[6]. R.Aravind, Dr. D. Maheswari, "Plant Growth monitoring System"Vol.9, APRIL 2020.

[7]. I.S.Akila, A.Shivakumar, S.Swaminathan, "Automation in plant growth monitoring using high precision image classification and virtual height measurement techniques", Vol.10, February 2018.

[8]. Vignesh Dhandapani, S.Remya, T.Shanthi, R.Vidhy, "Plant Health Monitoring using Image Processing", Vol.5, March 2018 .

[9]. Prof.Bhavana Patil, Mr.Hemant Panchal, Mr.Shubham Yadav, Mr.Arvind Singh, "Plant Monitoring using image processing, Raspberry pi and Iot", Vol.4, October 2017.

[10]. Sakshi Gajwani, Rutuja Pande, Nidhi Nagadeve, Archana K,"Monitoring Plant Infection using Soft Computing and Image Processing Techniques" Vol.1, June-2021.

[11]. Annie Christi, Brijesh vala, "Plant Health Monitoring System using Image Processing: A Review" Vol.6, May-2019.

[12]. Arda Aydin, Anil cay, Burak Polat, "Image Analysis Applications in Plant Growth and Health Assessment" Vol.22, May 2017,

[13]. A.Pravin, T.Prem Jacob and P.Asha, "Enhancement of Plant Monitoring using Iot", Vol.3, May 2018.

[14]. Raden Arief Setyawan, Achmad Basuki, Chong yung wey, "Machine Vision Based Urban Farming Growth Monitoring System", Vol.8, December 2020.