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01-235162-002

Identification of Plant Diseases Using ML Model with Mobile Application

Bachelor of Science in Information Technology

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April, 2020

Certificate

We accept the work contained in the report titled “Identification of Plant Diseases Using ML Model with Mobile Application ”, written by Ms. Abeera Naveed Dar as a confirmation to the required standard for the partial fulfillment of the degree of Bachelor of Science in Information Technology.

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April 20th, 2020

Abstract

Plant diseases have been a significant aspect in the decreased crop production over the years. Ultimately they cause the farmers a decline in the profit which they earn from their annual harvest. This problematic scenario can be avoided if the fields are monitored closely right from the beginning, planting stage until the end, harvesting stage. But this method is only applicable if the crops have been planted at a small-scaled farm.

The proposed system in this project is going to assist the farmers in looking out for plant leaf diseases such as black rot, leaf blight or bacterial spot etc among their fields before things get out of hand. The system is based on disease identification and their classification by employing a trained Machine Learning model. This model has been trained using "Plant Disease Data-set" openly available at Kaggle.The model can be called into play via mobile application having access of its camera. Just as the model is done with its pre-processing, it will return its result that will be forwarded to the user via the mobile application. If the result comes out positive the farmer can take precautionary measures before the disease spreads in the whole field.

Acknowledgments

In the name of Allah, Most Beneficial, Most Compassionate. All praises be to Allah Almighty as I cannot thank him enough for the strength and energy that he had given me and the blessings he showered upon me for pointing me in the right direction so I could complete this project. I am also gratified that my supervisor, Syed Hassan Tanvir and co-supervisor, Sajjad Hussain Shah, allowed me to work with them on this emergent technology. I sincerely thank them and acknowledge their efforts in supervising this project and carving the path for me to successfully conclude this project. I am also deeply thankful of my parents who gave me emotional support throughout this project. I am indebted to everybody else who facilitated me in any way during the course of this project. May the blessings of Allah be with them always (Ameen).

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April, 2020

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Acronyms and Abbreviations

ECMA	European Computer Manufacturer’s Association
EXPO	Exponent
GDP	Gross Domestic Product
GLCM	Gray Level Co-Occurrence Matrix
GPR	Gaussian Process Regression
GUI	Graphical User Interface
HIS	Hue, Intensity, Saturation
IoT	Internet of Things
JS	JavaScript
JSX	JavaScript XML
K-NN	K-Nearest Neighbor
ML	Machine Learning
NBNDVI	Narrow Band Normalized Difference Vegetation Index
OS	Operating System
PLSR	Partial Least Square Regression
PRI	Primary Rate Interface
RGA	Region Glowing Algorithm
RGB	Red, Green and Blue
RMSE	Root Mean Square Error
SDK	Software Development Kit
SPI	Spectral Vegetation Indices
SVM	Support Vector Machine
SVR	Support Vector Regression
WLR	Wheat Leaf Rust
WSN	Wireless Sensor Networks
WYR	Wheat Yellow Rust
YUV	Luminance, Blue-Luminance, Red- Luminance

Chapter 1

Introduction

1.1 Introduction

Pakistan is a developing country and like all other developing countries agriculture is the backbone of Pakistan's economy. Besides, Pakistan is also blessed with extraordinary geological position in light of the fact that it provides our farmers with plenty of suitable conditions to grow almost every crop in the country. Therefore, agriculture contributes 18.5 percent to Gross Domestic Product (GDP) of Pakistan [1]. Not just that it is also a vital source of foreign exchange earnings for our country. But even though agriculture is a key to economic growth, its performance, over the last decade, has decreased below the desired level primarily due to unhealthy productivity of crops in Pakistan. Thus, the development of this sector on a long term basis is essential for the growth and prosperity of our country which in turn demands the utilization of modern technologies to prevent contaminated production of crops.

In most of the cases, the contaminated production of crops is due to some disease-causing agents that may either be viruses or pests. They spread diseases within the crops whose symptoms are then observed on the stems or leaves of that affected plant. For that reason identification of diseases in plants and finding out the cause of the disease attack, plays a key role in the successful cultivation of crops. This will not only result in an increased production but will also help in preventing such kind of calamity in the future.

There are huge differences amid acquired and the actual output of our crops. This is because the cultivation of these crops to give an excellent produce as well as an optimal yield is highly technical. And therefore, our crops very much suffer due to the absence of appropriate technology and inadequate education of farmers about plant diseases which ultimately decreases the amount of yield we get from them, hence, detection of these diseases in plants is of vital importance.

Following examples show how plant diseases became the cause of downfall of economy for some nations [2]:

1. Potato blight: It emerged in Ireland between the years 1845 to 1847 with an estimate of about 1.5 million deaths due to starvation. But it didn't just stop there, around same number of people were forced to leave their land and migrate to other parts of the world.
2. Canker: One of the deadliest diseases in Citrus plant. Abolition programs of this disease have been commenced since 1915 in several states that include Florida, Alabama, South Carolina, Georgia, Louisiana, Mississippi and Texas. Studies show that about in the years between 1999 to 2008, citrus nurseries got rid of 2,327,772 canker affected plants. They also lost a huge amount of more than 116 million US dollars while eradicating exposed and infected trees in the past 10 years. But besides all the efforts this canker disease is still predominant in a large area of the United States.

Management of diseases requires a lot of effort and hence is a challenging task. Early and efficient diagnosis of plant diseases is also necessary to guarantee food safety and avoid damages caused by spreading of those contagions. The management of these plants requires close monitoring particularly for the management of diseases which may affect crop yield considerably and later the post-harvest life. But as Pakistani farmers are not well educated they often experience these two problems that create a hindrance in achieving this objective:

1. Continuous monitoring of the entire cultivated area by the people capable to detect diseases is not possible.
2. Retaining the ability of handling wide-ranging diseases which can affect any of the species of a plant.

There is a vast variety of diseases that can outbreak within each species of a plant, and every one of these diseases shows a number of symptoms that are influenced by certain contextual and environmental factors. If these diseases are not treated on time they cause a severe financial and effort loss.

The present method of plant disease detection is simply observation of experts with the naked eye which is time-consuming and an error-prone method. But these problems can be addressed with the help of integration of latest technology such as smart devices. Therefore, we are in desperate need of such a developing technology that automatically detects plant diseases before they get out of hand. This project is all about providing a possible solution to increase our agricultural throughput and lessen the subjectivity ascending from human experts in diagnosing plant diseases.

1.2 Objective

The objectives of this project are stated as follows:

- To develop a smartphone application which will use machine-learning classification techniques to assist the end farmer in detecting plant diseases by uploading leaf images of those plants.
- To employ such a technique that will reduce the chance of error and time consumption in identification of common plant diseases in Pakistan.

1.3 Problem Statement

Diseases in crops pose a threat to food security. They also cause a decline in the petite income of already empty-handed farmers working on small-scale. Therefore the farmers of Pakistan are fairly in need of identifying plant diseases early at hand because these diseases lead to substantial decrease in Pakistan's agricultural products both in quantity and quality, ultimately deteriorating the economy our Pakistan along with the farmer's hard-earned profit.

1.4 Problem Description

Prevention and control of diseases in plants are of utmost importance if we want our agricultural sector to bloom and flourish. Therefore, not just a correct diagnosis is required but it must also be quick as a wink in order to control plant diseases before it is too late; as it is needless to say that safety measures will only be effective after spot-on diagnosis and within short period time.

Management of diseases manually is surely a very challenging task. In most cases the diseases are seen either on stems or the leaves of the plant. But this is also a reality that a precise automatic analysis of these vividly visible symptoms of diseases, traits and pests has not been performed yet due to the snake pit of visual patterns on the diseased area. Henceforth the demand for a much more accurate and refined detection system has readily increased.

Automatic detection of plant diseases can be done by observing pattern changes in their stems, leaves, and flowers but using their leaves for detection purposes is a great approach because of following benefits:

- They are easily and readily visible and available at all times.
- They are not weather-specific like flowers.
- Any change in their appearance can be rapidly noticed.
- They are neither hidden nor hard to reach, like in some cases stems of plants are not visible under a huge pile of leaves and branches.

Detection of plant diseases using machine-learning involves two main objectives i.e. accuracy and speed. The innate ways of detection of plant diseases are not only tedious but also hectic, time-consuming and more prone to errors. Besides, they can only be done in limited areas. On the other hand, automatic disease detection is a lot accurate and requires much less effort as compared to the existing methods [3].

1.5 Methodology

Machine-learning comprises of statistical methods that enable a model to learn how to identify different patterns in huge and complex data-sets. In this project, we will be using Inception V3 as our machine-learning model that will be trained using a vast variety of plant disease data-set. This training will make it possible for the model to identify plant diseases as soon as leaf images of the plants are sent to it. A mobile application will also be developed solely for the purpose of sending leaf images to the model and displaying output to users. To integrate the mobile application with Inception V3, we will utilize cloud based firebase that will be responsible for transferring the data between them.

The design diagram is shown in Figure 1.1

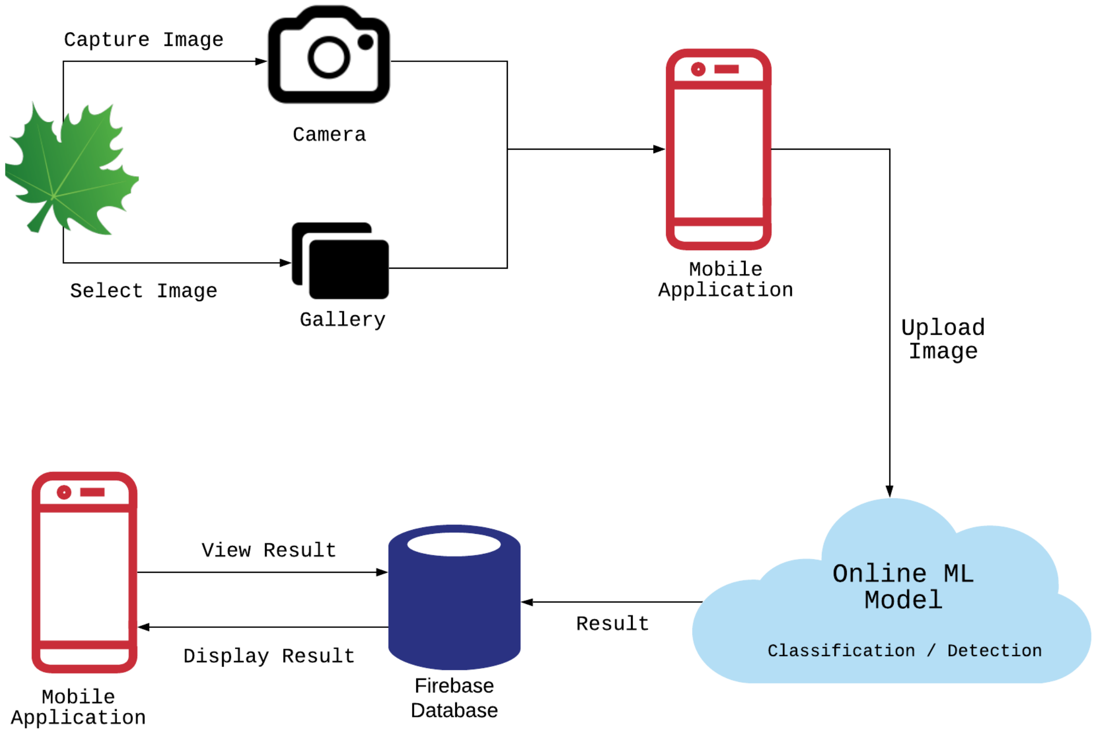


Figure 1.1: System Methodolgy

1.6 Data-set

The dataset which we have selected for conducting this study is freely available online at kaggle [4]. This data-set comprises of 87,000 RGB images of healthy and diseased plant leaves that are further divided into 38 classes. Total data-set is categorized into 80/20 ratio of training and validation set preserving the directory structure. A new directory containing 33 test images is created later for prediction purpose. Total number of images in the dataset along with healthy and diseased is shown in the table below.

Total Leaves	87000
Healthy Leaves	43500
Diseased Leaves	43500
Test leaves	33

Table 1.1: Leaf Dataset

Given next are some of the images that are part of this data-set.

1.6.1 Healthy Leaves of Data-set

(a) Healthy Leaf of Data-set

(b) Healthy Leaf of Data-set

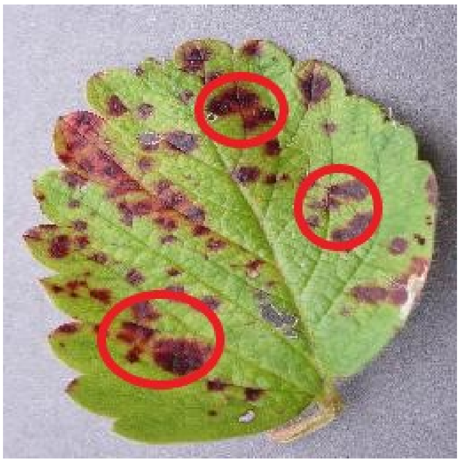
(c) Healthy Leaf of Data-set

(d) Healthy Leaf of Data-set

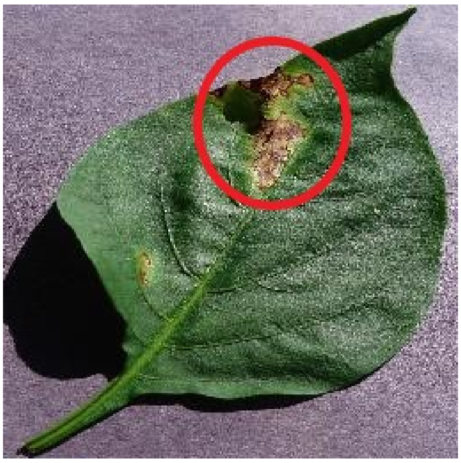
(e) Healthy Leaf of Data-set

(f) Healthy Leaf of Data-set

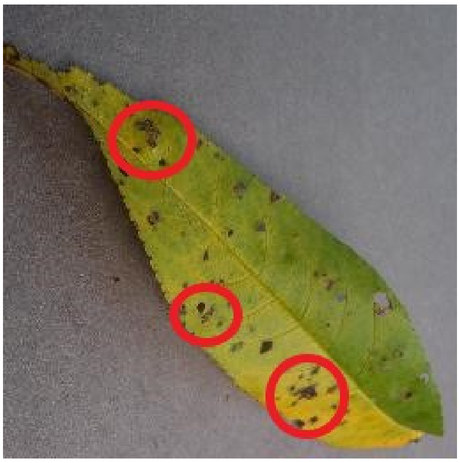
1.6.2 Diseased Leaves of Data-set



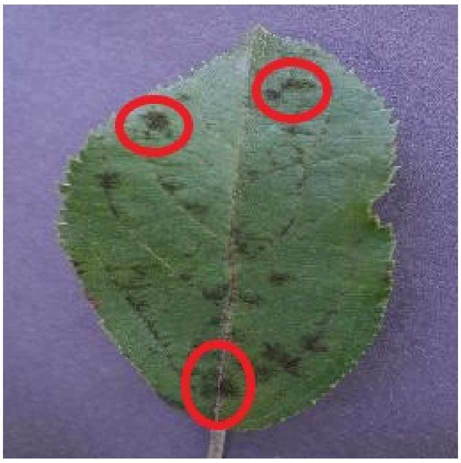
(a) Diseased Leaf of Data-set



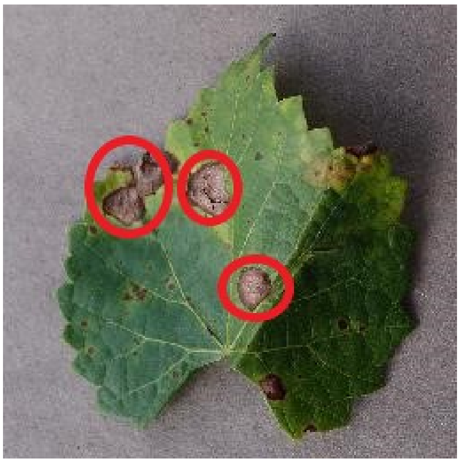
(b) Diseased Leaf of Data-set



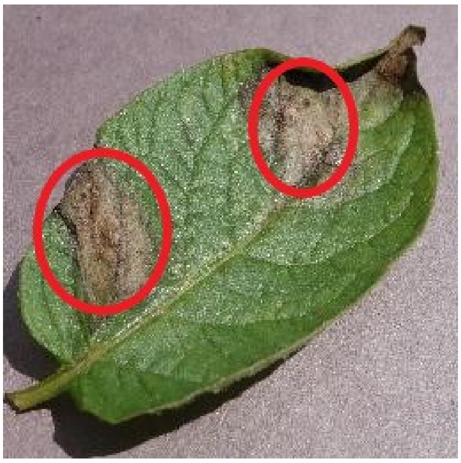
(c) Diseased Leaf of Data-set



(d) Diseased Leaf of Data-set

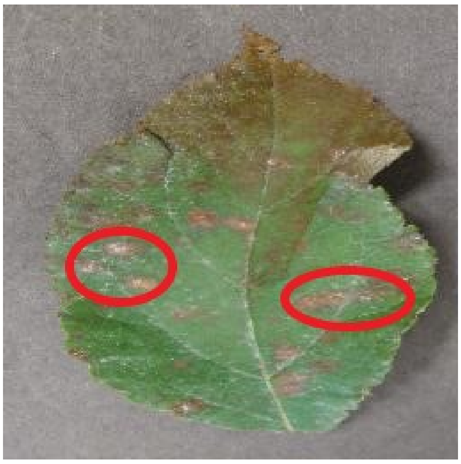


(e) Diseased Leaf of Data-set



(f) Diseased Leaf of Data-set

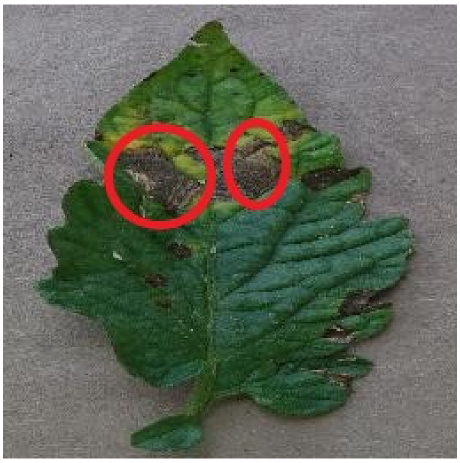
1.6.3 Testing Leaves of Data-set



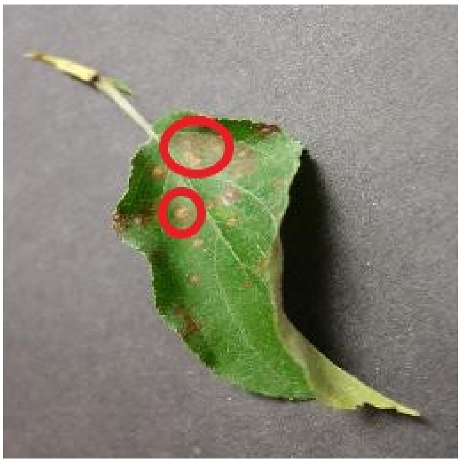
(a) Testing Leaf of Data-set

(b) Testing Leaf of Data-set

(c) Testing Leaf of Data-set



(d) Testing Leaf of Data-set



(e) Testing Leaf of Data-set

(f) Testing Leaf of Data-set

1.7 Project Scope

Scope of this project lies within the range of Machine Learning only and does not fall in the category of Deep Learning.

1.8 Feasibility Study

1. **Risks Involved**

   Primary risk involved in this project is that it will constantly require an active internet connection which certainly can become a problem at crucial times, especially in Pakistan.

   Another risk element is the output that the ML model will provide as it has to be preciously accurate in order to avoid any kind of inconvenience regarding false detection of plant diseases and ultimately becoming the reason behind the eradication of a whole field.

   Not just accuracy, rapid response rate is also a big risk factor involved in this scenario as it will be good-for-nothing if it is going to take much time just like other conventional ways since there is no point creating a mechanism that is not going to be any different than the rest.

2. **Resource Requirement**

   A very important resource without which this application will not be able to function is its connection with the cloud which will store each and every piece of information regarding our ML model as well as the dataset required for its functionality.

   Besides access to cloud, a complete dataset based on different kinds of plant diseases will also be required so to train our machine-learning model to provide any kind of output.

1.9 Solution Application Areas

Our primary target domain would be farmers because they do not have sufficient resources to consult an expert or even have an idea about experts because of which those people charge them even more than their actual amounts. Not only that those professionals also don’t like to go out in the fields or get their hands filthy with mud and thus the poor farmers and their crops pay the price.

1.10 Milestones

Following tasks are to be accomplished in order to develop this project:

1. Research Phase
2. ML Model coding and training
3. Mobile application development
4. Cloud-based ML Model integration with mobile application
5. Documentation
6. Testing
7. Deployment

Chapter 2

Literature Review

2.1 Climatic parameter monitoring of plants using IoT

A paper based on climatic parameters named "Leaf disease Detection and Climatic Parameter Monitoring of Plants Using IoT"was presented by Dr. G. H. Agrawal et al. [5]. In this paper they have represented a basis which points towards practicing of Internet of Things for noticing overall climatic parameter conditions with least effort and effectively available sensing framework. The illustration regarding the assimilated system and the interrelating components for firm assessment of parameters given by sensors and not just that but communicating that information via the web is also demonstrated in their paper in a straightforward vernacular. By conducting surveys rather than just writing down the authors comprehended that the agriculturists have to be guided about the wellbeing state of their fields explicitly through web so that all the results and consequences are forthrightly sent to them through emails by the help of Matlab.

As we all know agriculture and farming have been one of the vital occupations of mankind since early development but still manual practices while cultivating are inevitable. Keeping an eye on the whole cultivated area to prevent any unwanted endeavors is a crucial task for the agriculturists or the farmers since they also have to be on edge constantly in order to achieve increased crop production for better yield. But with the evolutions in Internet and the Wireless Sensor Networks (WSN), same idea as practicing IoT in home automation is being applied for this purpose. The only difference is that instead of homes automation, farming automation is being introduced here. Due to this reason, the proposed system is based on remote assessment and monitoring of various parameters in the field via the web. It allows automation of those parameters by applying some compositional techniques as well as ZigBee correspondence methods. Transmission of information gathered by those sensory gadgets was made possible by connecting a portable PC with wireless ZigBee system.

Diseases create a hindrance for an ordinary plant in performing its basic activities such as fertilization, germination etc. These diseases are not just caused by pathogens but because of unfriendly natural circumstances also. Consequently, it is a crucial need for the cultivators to detect plant diseases at an early stage. In light of these factors, the idea of the Internet of Things has been proposed in this article. IoT is a perfect match for this case because technology is advancing day by day and requires a new area of information for making progressive applications.

It is a challenging task to manage plant diseases. In most cases, plants show symptoms of diseases on their leaves or stems. A detailed study on the causes of these symptoms (whether they are occurring due to pests, disparaging traits or unfavorable natural conditions) has not yet been conducted because of complicated visual patterns. Therefore the demand for more accurate pattern recognition techniques has increased. Hence the three authors suggested an alternate solution based on image processing to assist in detecting leaf diseases automatically and classifying those diseases according to the natural environmental conditions.

Shedding a light on the background of this farming mechanization idea proposed in this article, it was basically influenced by "The Internet's Evolution of Things", white paper composed by Jim Chase who discovered that IoT is capable of making a smart, untraceable system fabric which we can modify by controlling and detecting it because the people working on expansion of IoT are planning to introduce connectivity within different equipment and devices so that they can also be a part of this emerging technology.

In another paper "Leaf Disease Severity Measurement Using Image Processing" published by Sanjay B. Patil in 2011, a picture preparing technique has been proposed to provide proof regarding the infected leaf area of a diseased plant. For that purpose, he has chosen sugarcane poo for experimentation and achieved accuracy of 98.60% proving that image processing is a convenient technology to measure severity of a disease in a plant. It not only eliminates the chance of human errors but also reduces the need to implement traditional methods. This same idea has been utilized in by the three authors of this research article to conduct image processing.

Another framework proposed by Narvekar et al., based on leaves of grape plant, tests the captivating pathway used as a part of diagnosing grape plant sicknesses with the help of its leaf infected area assessment.

Looking into the components of the system proposed by Dr. G. H. Agrawal et al., it is primarily based on three sections i.e. procedures for sensing changes in natural parameters, image processing and lastly IoT.

Basically, the system is composed of numerous sensors that collect a huge variety of data of different aspects about the field under observation. That data from the sensing devices is transmitted by means of the ZigBee network. Diseases on the leaves are detected by a software named matlab and after image processing has been done the results are sent via email. The result report consists of the name of that disease, what were the reasons behind its occurrence and how to control it. Another function performed by this system along with disease detection of a plant in a field is the remote detection and control of various parameters present within that field by utilizing IoT. That data collected by the end devices is then sent to a coordinator via the ZigBee network.

2.2 Detection of plant diseases using IoT

Rajesh Yakkundimath et al., have proposed a system in their recently published article "Plant Disease Detection using IoT"[6]. In this article they developed a system to determine the state of a plant (whether healthy or diseased) based on the quality of that plant's leaves. The suggested methodology makes use of sensor devices to sense parameters like humidity, temperature and color of leaves. These parameters are then subjected to comparison with the dataset in practice to determine if the specified values lie within the stated range of the dataset in use. The suggested model is applicable in a variety of fields such as farmers, botanists, physicians, industrialists and food engineers. Numerous opportunities exist here to contribute towards this field by using image processing techniques alongside the suggested methodology in order to make it more accurate and effective so that the values can be more efficiently determined to decide if the chosen leaf is diseased or not.

The authors of this article also offer to construct a comprehensive form of the already proposed system by using image processing technique which will identify what kind of disease is carried by the leaf and will also distinguish between different kinds of diseases among the leaves of the same plant.

The authors Rajesh Yakkundimath et al., also plan to shape an automated system that will not just be useful in large scale production but also aid in timely detection of diseases which will, in turn, assist the system users in achieving enhanced performance and improved yield of the crops. At this stage, the system only detects if the leaf being examined is diseased or not but it can be further extended to make it recognize the type of disease and its classification. In this article, the three authors have narrowed down their research upon humidity, color and temperature parameters only. But they can further enhance it by using the image processing techniques in combination with various other sensors. One more drawback was that the values determined for these parameters were not accurate therefore the authors decided to take a range of values for the considered parameters keeping in mind that the specified range can differ according to climatic conditions at that moment.

Agriculture is the fundamental basis of economic development of a country and is also responsible for tremendous opportunities of employment to a huge percentage of mankind. In that scenario, health conditions of plants play a very significant role in making good profit for plant cultivators. To prevent plants from getting diseased or infected appropriate measures must be taken during their growth and development stages because otherwise crop yield is substantially reduced due to the presence of infectious bacteria, viruses and other diseases caused by unfavorable natural conditions.

The current system of detecting plant diseases is based on observations by the naked eye and that is unquestionably a time-consuming process and prone to error also. For that reason, a new concept is being introduced here that will assist in the detection of plant diseases automatically during the early stages so that it does not get out of hand costly to be treated also. Farmers also practice a number of strategies to prevent plant diseases at regular intervals.

The term IoT has become a symbol of connectivity among physical devices (home appliances, vehicles, sensors and other electronic devices) with the network that not just allows interchanging of data but also opens more and more ways to directly link the physical world with the computer world ultimately reducing the need of human interference. In the upcoming years, 2050 to be precise, the global population is estimated to rise above 9 billion. Therefore, to sustain the demand of such a vast population, it has become mandatory for the farming industry to implement IoT technology in their day to day errands. In light of the above facts increase in the demand of food must be met no matter what challenges ascend may it be extensive farming or unfavorable natural conditions or bacteria and parasites. Because IoT based farming mechanization can readily enhance the food production hence improving the production of agricultural sector.

It is a paramount requirement of farmers as well as the agricultural experts to detect plant diseases in the early stages. Hence the primary objective of the proposed system is plant disease detection using IoT. In most cases, the beginning of a disease takes its toll on the leaves of plants. Therefore while preparing the proposed system, detection of plant diseases by examining their leaves has been taken into consideration. Identification of an affected leaf from a non-affected leaf can be done by measuring several factors such as variation in color, humidity and temperature.

To comprehend the different computer system applications following papers have been very helpful in the related areas of IoT and computer farming. (Mark Seelye et al., 2011) have demonstrated a color sensor and at an affordable price to enable monitoring growth and development of a plant within a confined lab. That sensor is responsible for keeping an account of the health of the plant under observation by determining its leaf color at different stages.

(Murali Krishnan and Jabert.G, 2013) have utilized image processing techniques to control plant diseases caused by pests with the help of Matlab software. Experimentation is then performed on those images in three steps i.e. pre-processing, transformation and clustering.

(Sushma R. Huddar et al., 2012) have proposed an innovative algorithm that will not only identify plant diseases caused by pests but it will also perform segmentation, all of this by using image processing techniques. Whitefly, which is a major cause of pest diseases in a number of crops was chosen for experimentation purposes while this paper. Several types of leaves were used while testing the algorithm and the results for detection of whitefly disease came out to be 96% accurate. The suggested algorithm utilizes minimal computational complexity. It intends to target pest diseases in both agricultural fields and greenhouse environment.

(Yun Shi et al., 2015) have given an idea of utilizing IoT for monitoring insect pests and plant diseases in this paper. Here they have presented how we can use this kind of technology for gathering information, monitoring plant diseases on an agricultural scale. And afterwards collecting that disease and insect pest facts and statistics with the help of sensor nodes, eventually processing and mining that data.

(Prof. S. G. Galande, et al., 2015) have described in this paper how to implement IoT to monitor agricultural parameters wirelessly. They have developed a wireless system that monitors ecological conditions in the field e.g. pH level of soil, wet level of soil, humidity and temperature alongside detection of plants through their leaves.

(Nimish Gopal, 2016) has described auto-irrigation and plant disease detection using image processing based on micro-controller. These days the image processing technique is being broadly practiced in the field of agricultural sciences to offer as much protection of plants as possible so that we can have better management of crops and thus increased production.

Another innovative idea demonstrated by (Sai Vivek et al., 2017) is pest control based on Arduino and involving environmental monitoring sensors. They have attempted to develop a robot in this paper that will be capable of operating on dispensing pests control agents and to avoid obstacles in the field without any human interference for the sake of self-guidance. It will also make a sterilized environment to enable optimal growth of plants and will also monitor them.

(S. Gavaskar and A. Sumithra, 2017) in their paper have designed a pest monitoring system based on IoT that uses Arduino for noise and temperature monitoring to implement agricultural precision. In a paper presented by (Oliver Schmittmann et al., 2017) a seemingly good assessment algorithm has been introduced to recognize different species of plants. A true colour sensor has been used for that purpose that uses decision models in combination with that algorithm to differentiate individual crops.

(Zhang Chuanlei et al., 2017) have published a paper demonstrating apple plant disease identification through genetic algorithm combined with feature selection method based on correlation. To convert the RGB model of an input image into grey, YUV and HIS models a color transformation structure was put into practice which removed the background of the image under observation and the diseased area was segmented with RGA (region glowing algorithm) so that the SVM classifier would be able to recognize them.

2.3 Transfer Learning Approach for Plant Disease Detection System

It is important for the farmers to get knowledge and collect information about their crops with the help of ICT because it is a valuable resource for their farming. Boikobo Tlhobogang et al., 2018 [7] performed a study in which they explored the problematic conditions such as time constraint or proper farming knowledge for the farmers that are not working on an industrial scale. The goal of their study is to find out how should one manage and deal with emerging plant diseases by examining their leaves. They have presented in their research a mobile solution based on advancing machine-learning capabilities. The prototype for the proposed system was tested under certain experimental conditions to determine whether it is actually what the farmers need i.e. if it is accurate, if it is relevant and if it is timely.

Madibela, states that agriculture has the ability to help a farmer gain wealth and prosperity in his livelihoods and lessen his poverty. The author further emphasizes on animal products as the unrivalled sources of protein with high quality which assist in improving the food security and value of life. In the region of Botswana farming faces a lot of challenges not just because of parasites and diseases but also due to scarcity of feeds, repetitive droughts and non-availability of markets. Plant diseases not only create a risk for marketing of the crop yield but unavailability of sanitation and absence of hygiene can also become the causes of serious diseases to human beings.

Extensive internet connectivity enables the immediate application of the proposed system. This system will help the farmers to know anything they want to know about their crops anywhere and anytime. The increased development in mobile application technology has also enabled the development of apps regarding farming such as MODISAR which has believed to be an exceptional management application for farms. Moreover, it is a software both for web and desktop that can be installed on PCs of farmers so that they will be able to access data concerning their farms.

Another study conducted by Patil and Kulkani suggests an approach to become aware of plant diseases accurately and at an early stage by making use of artificial neural networks and image processing techniques. Based on this methodology they performed experiments and the results turned out to be 91% accurate. In their literature, it has been depicted that evaluating the color and texture of the leaf has proven to give exceedingly good results.

A vital part of information i.e which species a plant belongs to and what kind of disease it is carrying, can be determined by the help of leaves of that plant. To analyze images of leaves for disease detection different kinds of methods have been referenced in the literature. A few researchers have classified using K-NN classifiers, while in some cases feature extraction, segmentation and RGB form of images has been used for disease detection. Suchitra and Badai in their research have applied k-means clustering, spatial filters, support vector machine and GLCM to identify disease in a pomegranate plant and got successful achieving accuracy of 90% for disease detection.

Chapter 3

Requirement Specifications

3.1 Present Scenario

Infectious plants cause intermittent outburst of diseases that ultimately lead to famine and hence large scale deaths. The naked eye observation of experts is the main approach adopted in practice for detection and identification of plant diseases. But, this requires continuous monitoring of experts which might be prohibitively expensive in large farms. Further, in some developing countries, farmers may have to go long distances to contact experts, this makes consulting experts too expensive and time-consuming and moreover, farmers are unaware of non-native diseases.

It is visualized to make appropriate facts and figures available and provide services to both the private sector and the farming community by utilizing advanced technologies for communication and information purposes, to complement the prevailing delivery conduits provided by the government. Helplines are an initiative taken by the government in this direction to bring together a one-stop-shop for the farmers to enlighten them with all the information needs related to their crops. Once connected through the helpline, a farmer will be provided with all the details and information that he requires on specific subjects. Using the helplines these people are able to call the service centers and resolve all their queries. The staff at the service centers is either trained and equipped with all the relevant information or they search in pursuit of the specific information that the farmer wants.

But a disadvantage in this scenario is that the people at the service center are not able to perceive the precise issue that the farmer is facing. The severity of the disease cannot be apprehended completely while sitting in their rooms and thus in certain cases may result in incorrect detection of a diseases which can become the cause of eradication of the whole field.

3.2 Proposed System

Detection of diseases in plants automatically is an imperative research topic these days since it can prove to be beneficial for watching over hefty crop fields and thus automatically detecting the plant diseases by recognizing them with the help of the symptoms appearing on their leaves. This ultimately permits machine vision. Machine vision illustrates image-based automatic detection, robot guidance and process control. As compared to that optical identification of plant diseases is less accurate, labor-intensive and lastly, it can only be done in minor fields of crops.

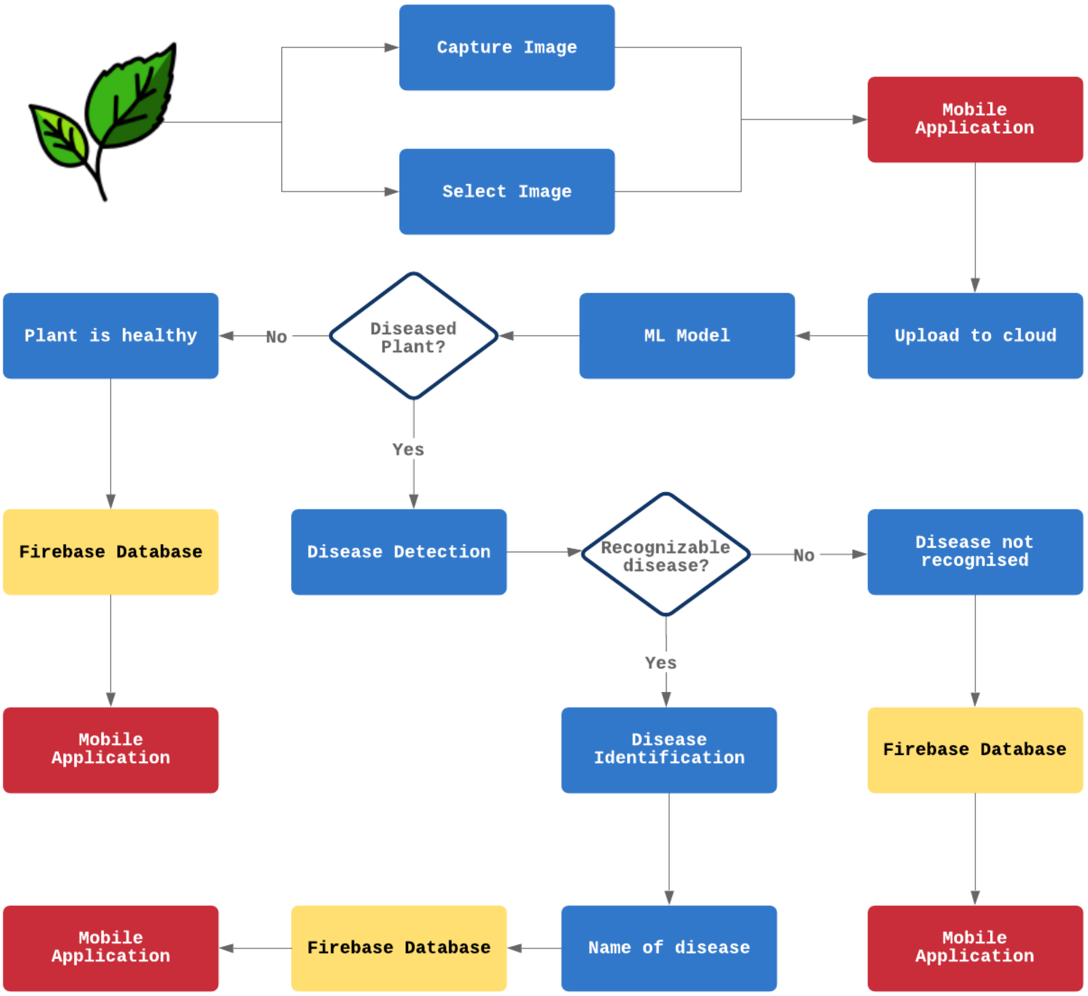


Figure 3.1: Proposed System Diagram

In the proposed system first step is acquiring leaf images of the affected plants. Here farmers are required to capture those leaf images and send them over to the system using the mobile application developed exclusively for this purpose. The uploaded image is then processed by our trained model to mine out suitable features of the affected leaf which will assist in further analysis yet to be conducted for disease identification. Firstly, the model will classify the image whether it categorizes as a diseased leaf or not. If the leaf does not contain any disease symptoms, the model will return the result at that instant to firebase database stating that it is a healthy leaf. But if the leaf is diseased, the model will further process it to identify the kind of disease. Afterwards, when the kind of disease is identified, it will send the resulting details to the database. From the database the farmer will be able to view the result with the help of the previously developed mobile application.

3.3 System Requirements

This project will be employing Inception V3 as the machine-learning model. It will be placed over the cloud from where it will be accessible all the time. The software components include Windows OS, React Native(Expo) and Firebase Database.

3.4 Software Requirements

- Windows OS
- JavaScript (Language)
- JSX (Language)
- Firebase (Database)
- React Native(Expo)

3.5 Hardware Requirements

- Personal Computer
- Smart Phone

3.6 Functional Requirements

1. **Train**

   In this project, the machine-learning model needs to be trained. This training process will be based on the images included in the data-set selected for this whole project, by making the model familiar with the appearance of diseased leaves and their plant types respectively. All of this training process will be done using a laptop and no special hardware is required.

2. **Image Capture**

   Define the characteristics of the camera that will be required to capture images so they will be identifiable by the trained model. It will be used to capture images of leaves so that the system is able to evaluate the current state of that plant.

3. **Label Image**

   After the image is evaluated by the pre-trained ML model it will be sent over to the database and the result will be displayed on the mobile application to enlighten the farmer about the condition of his plant or field.

3.7 Non-Functional Requirements

The non-functional requirements of the system are listed in the following.

1. **Reliability**

   The system should reliably detect diseased area from the given leaf.

2. **Security**

   The system will keep the credentials of farmers safe.

3. **Usability**

   Application will be user friendly, easy to use, and easily understandable due to low literacy rate among our farmers.

4. **Performance**

   The system must offer identification of maximum number of diseases without involving extensive delay.

5. **Maintainability**

   Developer will be responsible for the maintenance of the system.

6. **Availability**

   The system will be available anywhere once the application is installed on a smartphone.

7. **Re-usability**

   Different modules of the system will be developed in such a way so that other similar systems being developed may be able to utilize them.

8. **Scalability**

   The system should be developed in such a way that new modules and functionalities can be added, thereby facilitating system evolution.

3.8 Use Cases

A use case is primarily a blend between several operations and functions defining how an actor will interact with the system to achieve a desired objective. The following diagram depicts our overall system and each use case has been described later on.

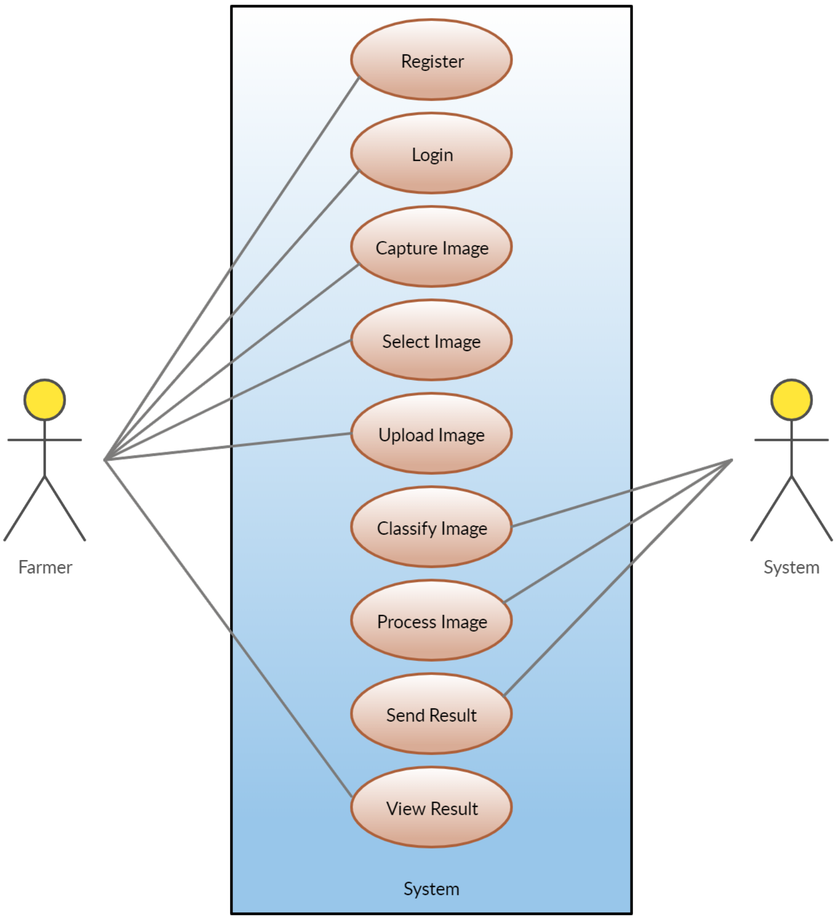


Figure 3.2: Main Use Case Diagram

Table 3.1 describes the use case for user registration. As the user wants to avail the services of the application, he first has to register himself on the application.

Use Case Name	Register
Use Case ID	UC-01
Priority	High
Primary Actor	Farmer
Basic Flow	Credentials will be asked when the user clicks on the register button.
Alternative Flow	User has already made an account.
Pre-condition	Application must be installed.
Post-condition	User will be registered.

Table 3.1: Register Use Case Description Table

Table 3.2 describes the use case for user login. If the user wants to use the application, he will first have to log in to the application.

Use Case Name	Login
Use Case ID	UC-02
Priority	High
Primary Actor	Farmer
Basic Flow	Credentials will be asked when the user clicks on the register button.
Alternative Flow	User has to create a new account.
Pre-condition	Application must be installed.
Post-condition	User will be logged in.

Table 3.2: Login Use Case Description Table

Table 3.3 describes the use case for invalid user login. In case the user tries to login with invalid credentials, he will be denied access to use the application.

Use Case Name	Invalid Login
Use Case ID	UC-03
Priority	Medium
Primary Actor	Farmer
Basic Flow	User will provide his wrong email and/ or password and after validation from the database, he will be denied to use the application.
Alternative Flow	User provides correct email and/ or password.
Pre-condition	Application must be installed.
Post-condition	User will not be logged in.

Table 3.3: Invalid Login Use Case Description Table

Table 3.4 describes the use case for capturing an image. The user can capture a real-time image that he wants to be processed.

Use Case Name	Capture Image
Use Case ID	UC-04
Priority	High
Primary Actor	Farmer
Basic Flow	Capturing image will be initiated when the user clicks the camera button.
Alternative Flow	Image is already captured.
Pre-condition	User must be logged in and camera must be functional.
Post-condition	Image will be captured.

Table 3.4: Capture Image Use Case Description Table

Table 3.5 describes the use case for selecting an image. User has the choice of either capturing real-time image or choose an already captured image from the device's memory.

Use Case Name	Select Image
Use Case ID	UC-05
Priority	Medium
Primary Actor	Farmer
Basic Flow	Application will direct the user to the device's memory to enable him to select an existing image.
Alternative Flow	Capture image at real-time.
Pre-condition	Image must have been captured before.
Post-condition	Image will be selected.

Table 3.5: Select Image Use Case Description Table

Table 3.6 describes the use case for uploading the image. After capturing the image or selecting one from device memory, the user must upload that image on the cloud.

Use Case Name	Upload Image
Use Case ID	UC-06
Priority	High
Primary Actor	Farmer
Basic Flow	Application will send the captured image or the selected image by the user over to the cloud.
Pre-condition	Internet availability and the image must have been captured or selected before.
Post-condition	Image will be uploaded to the cloud.

Table 3.6: Upload Image Use Case Description Table

Table 3.7 describes the use case for classifying the image. The trained model must classify the uploaded image as a healthy or diseased one.

Use Case Name	Classify Image
Use Case ID	UC-07
Priority	High
Primary Actor	System
Basic Flow	The model will match the uploaded image with the pre-existing images to detect if it contains any disease or not.
Pre-condition	Image must be sent over to the cloud and the plant type must be one of those included in the training data.
Post-condition	Image will be classified as healthy or diseased.

Table 3.7: Classify Image Use Case Description Table

Table 3.8 describes the use case for processing the image. The ML model must analyze the image to identify which plant image it is and what kind of disease it contains.

Use Case Name	Process Image
Use Case ID	UC-08
Priority	High
Primary Actor	System
Basic Flow	The model will match the uploaded image with its training data to identify the kind of plant and the type of disease it carries.
Pre-condition	The disease type must be one of those included in the training data.
Post-condition	Image will be labelled with plant name and disease type.

Table 3.8: Process Image Use Case Description Table

Table 3.9 describes the use case for sending result of the image. After performing analysis the model must send the resulting data along with treatment recommendation to the database for record-keeping and for viewing purposes by the user.

Use Case Name	Send Result
Use Case ID	UC-09
Priority	High
Primary Actor	System
Basic Flow	The model will send the analyzed data to the database where it will be stored and will be vied by the user.
Pre-condition	Analysis must be performed before sending the resulting data.
Post-condition	The result will be stored and the user can view it.

Table 3.9: Send Result Use Case Description Table

Table 3.10 describes the use case for viewing result of the image. When the model is done performing analysis and sending its result, the user will then view it from the database to have a know-how regarding the disease.

Use Case Name	View Result
Use Case ID	UC-10
Priority	High
Primary Actor	Farmer
Basic Flow	The model will send the data to the database to let the user know what result came out of the analysis.
Pre-condition	Result must be sent to the database so that the user may be able to view it.
Post-condition	User will become aware of the disease and how he may be able to treat it.

Table 3.10: View Result Use Case Description Table

Chapter 4

Design

This chapter focuses on technical aspects of the project, especially the project's design both visual and technical in detail. The design phase of this project involves GUI design, database design and the navigation path in working across the system. A GUI draft will also be shown to introduce the initial design at the start of the project. As a whole, this chapter will mostly feature diagrams and schematics related to the project and its various sub-components.

4.1 Design Methodology

The design methodology for this project takes into account the aspects of main technology being used i.e Machine Learning along with the main method of deployment Mobile Application. For clarity, the design methodology has been kept modular and hierarchal. Most of the ideas presented have already been discussed in Chapter 1 of this document.

Figure 4.1 demonstrates the design methodology of this project.

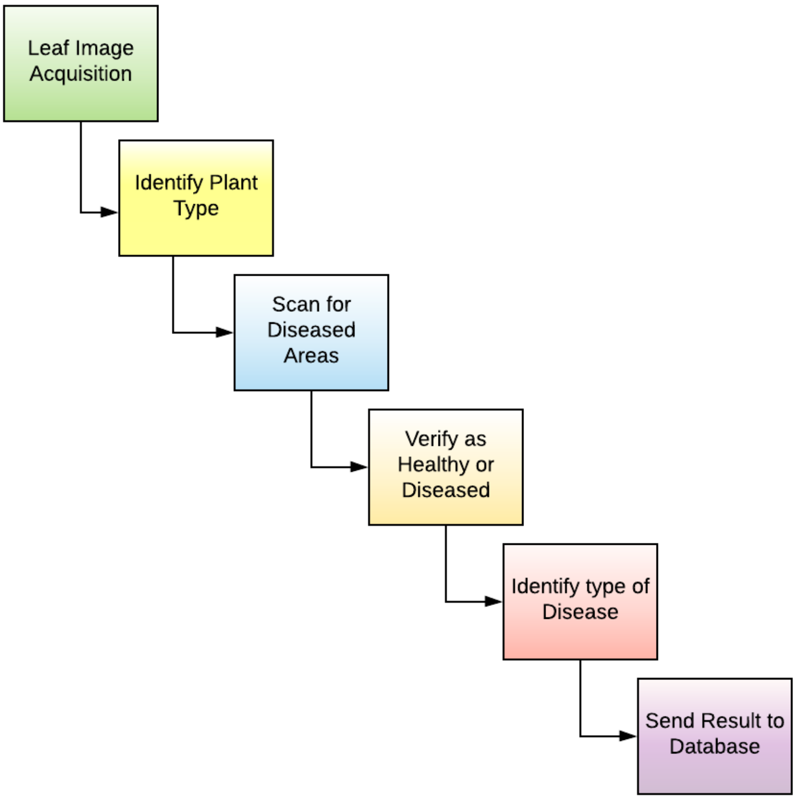


Figure 4.1: Design Methodology

1. **Leaf Image Acquisition:** The starting phase involves acquiring an image of the leaf to be examined via a camera present in the end user's device.

2. **Identify Plant Type:** Upon receiving the image the system will identify what type of plant, the image under consideration belongs to.

3. **Scan for diseased areas:** The system will then scan the image for any special spots or areas which will indicate that the leaf possess a particular disease.

4. **Verify as healthy or diseased:** After scanning, the system will categorize the leaf as healthy or diseased depending upon the presence of diseased areas.

5. **Identify disease:** If the leaf is not categorized as healthy then the system will match the trained disease images with that of the scanned image and verify the type of disease present.

6. **Send result to database:** When it is all done with classifying of plant leaf and identifying of its disease, it will then send its result to the firebase database.

4.2 Navigation Path

A diagram is given below to develop an idea regarding the pages in the mobile application and the sub processes involved:

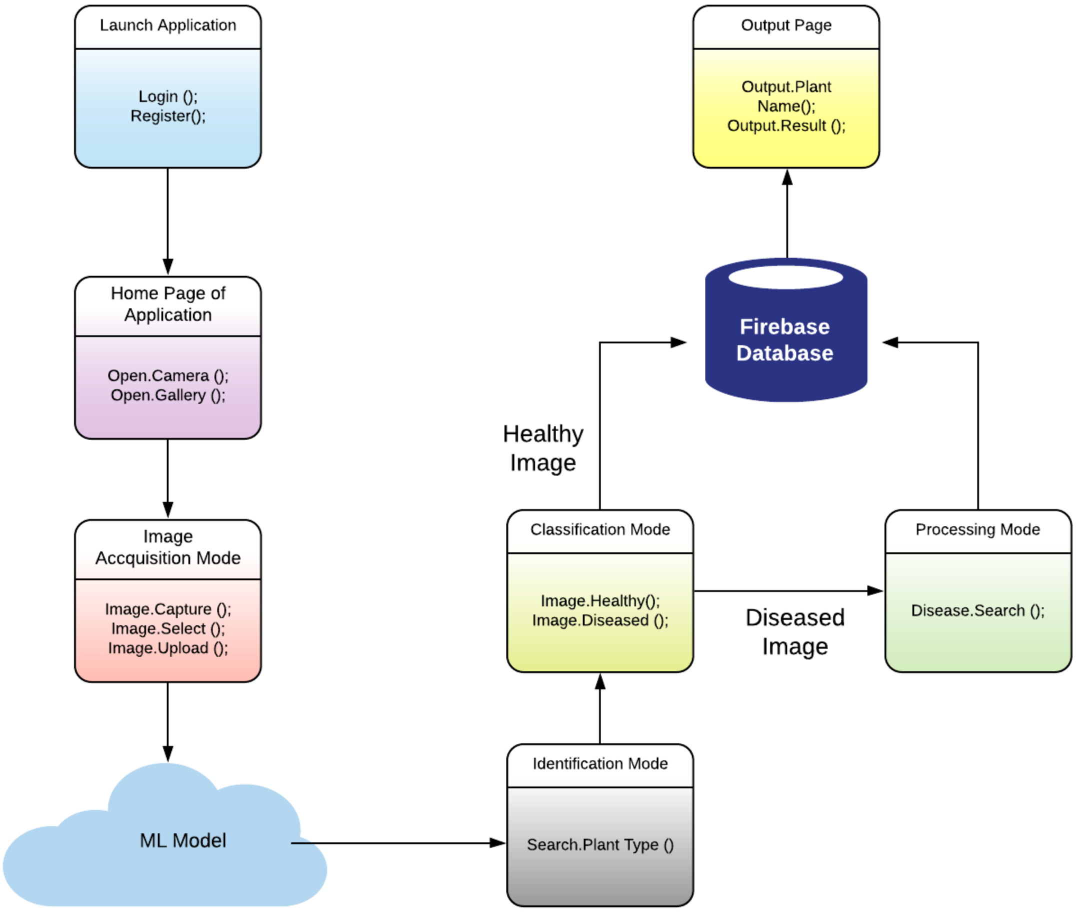
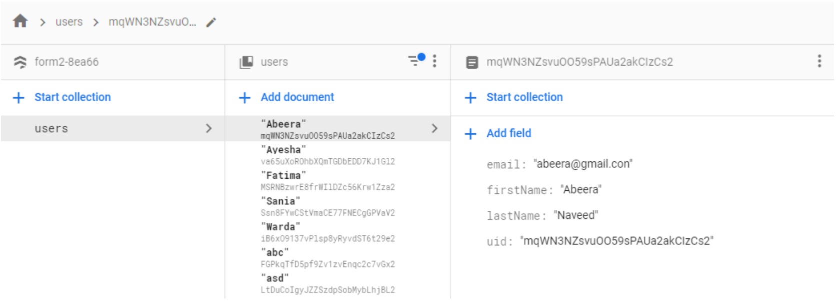


Figure 4.2: Navigation Path

Figure 4.2 shows the modelling of the actual pages of the application along with the sub-processes that will be carried. It shows how the user will be able to access and navigate between different pages. Not only that, the diagram also depicts the various commands, tasks that will be carried out on the loading of each page.

4.3 Database Design

The database design for this project is cloud-based (Firebase). The purpose of this database is to store the results of classification which will have to be displayed later via the mobile application on the end user's device. The developed mobile application will retrieve the data of classification from the database and it will notify the user if there is any positive disease-presence result. Figure 4.3 shows the schema design of firebase database.



users > mqWN3NZsvuO...

form2-8ea66

+ Start collection

users

users

+ Add document

"Abeera"
mqWN3NZsvu0059sPAUa2akCIzCs2
"Ayesha"
va65uXoROhbXQmTGDbEDD7KJ1G12
"Fatima"
MSRNBzwrE8frWI1DZc56Krw1Zza2
"Sania"
Ssn8FYwCStVmaCE77FNECgGPVaV2
"Warda"
iB6x09137vPlsp8yRyvdST6t29e2
"abc"
FGPkqTfD5pf9Zv1zvEnqc2c7vGx2
"asd"
LtDuCoIgyJZZSzdpSobMybLhjBL2

mqWN3NZsvuOO59sPAUa2akClzCs2

+ Start collection

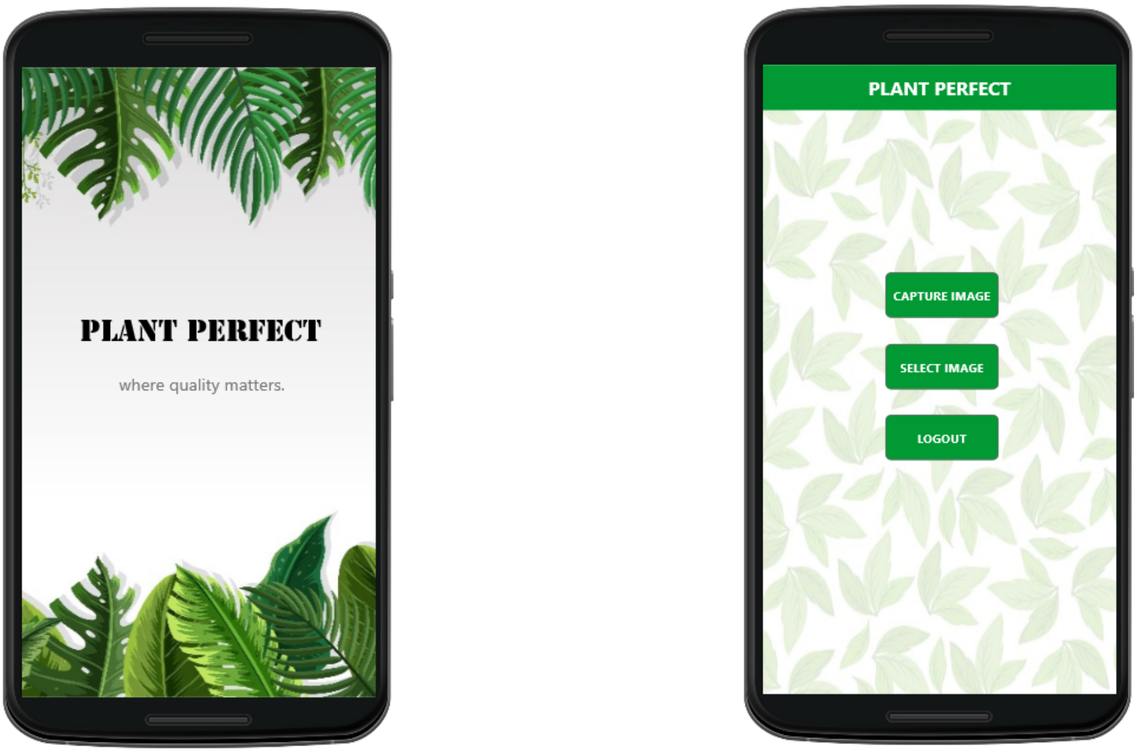
+ Add field

email: "abeera@gmail.con"
firstName: "Abeera"
lastName: "Naveed"
uid: "mqWN3NZsvuOO59sPAUa2akClzCs2"

Figure 4.3: Database Schema

4.4 GUI Design

Figure 4.4a shows the graphical user interface draft of the mobile application that will be developed for the end-user to interact with the system. The design of the introductory screen of the application is shown in the figure given next.



(a) GUI Design of Splash Screen

(b) GUI Design of Home Page

4.5 Sequence Diagrams

Sequence diagrams of a system show how the objects inside the system collaborate with each other to carry out a certain instruction.

4.5.1 Registration Sequences Diagram

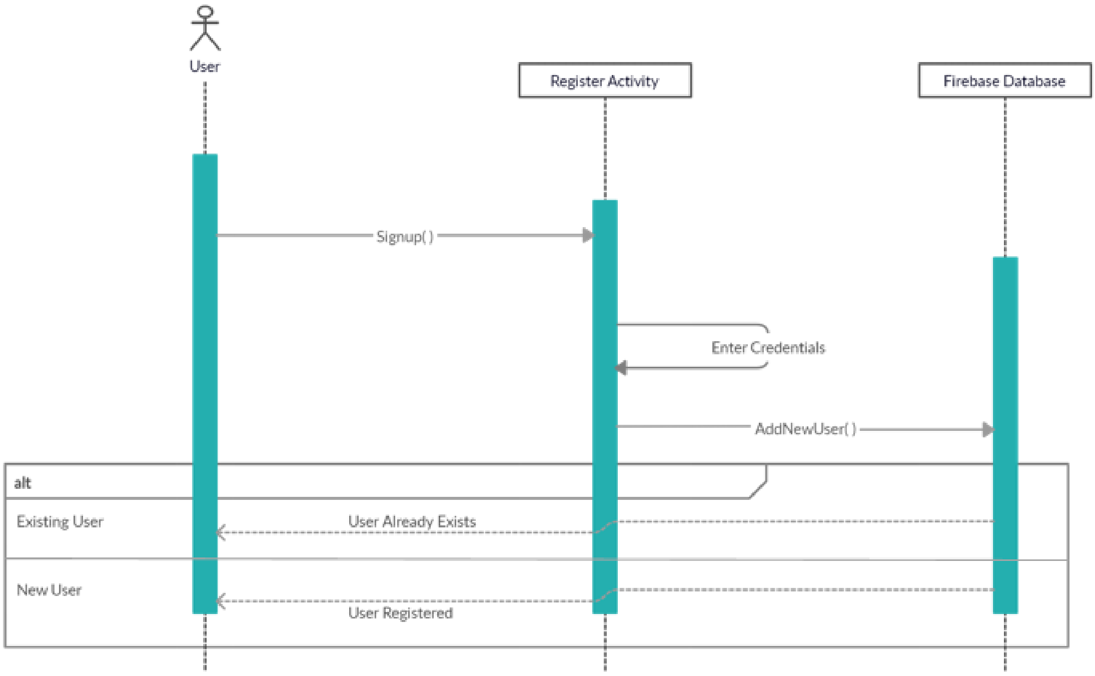


Figure 4.5: Registration Sequence Diagram

User first has to register to avail the services of the application when using it for the first time. For that purpose he fills in the information required for registration and the request is then sent to the firebase database to add a new user. The firebase checks the data and responds back with an affirmative message that user has been registered but if there is already someone in the database existing with the same credentials then the database will prompt that a user with the given credentials is already present in the database.

4.5.2 Login Sequence Diagram

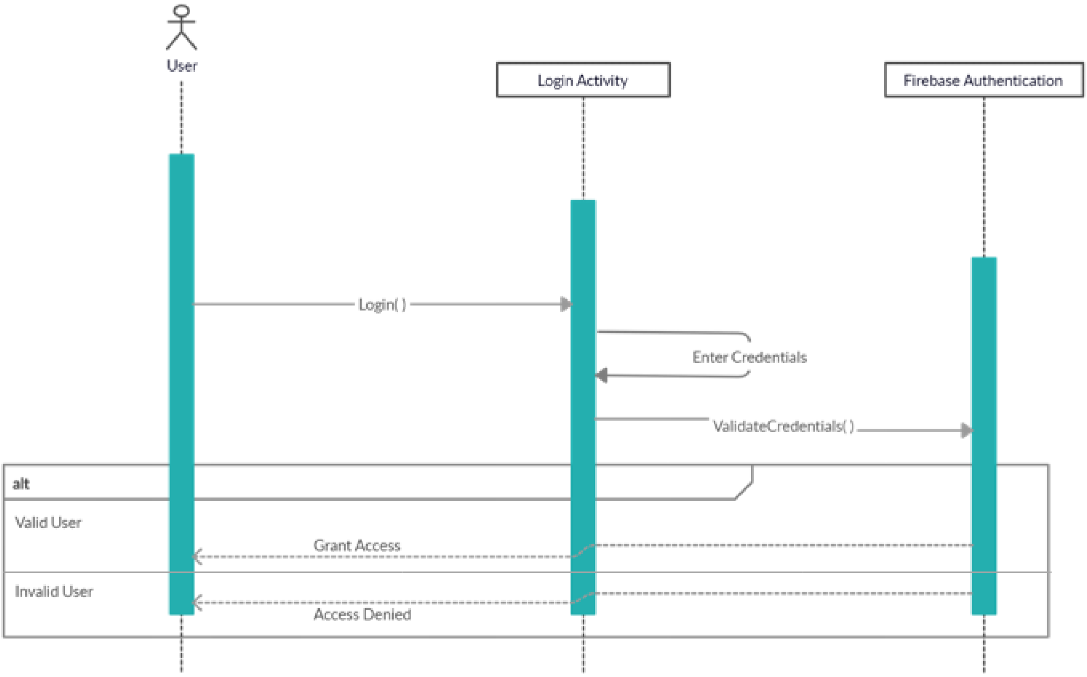


Figure 4.6: Login Sequence Diagram

If a user has already signed up before then he will only have to enter his email and password, the next time he uses the application. Once the data is entered it will be validated from the database and if it matches with the previously provided data at the time of registration then he will be granted access to use the application or else the user will be prompted with the message as access denied.

4.5.2.1 Capture Image Sequence Diagram

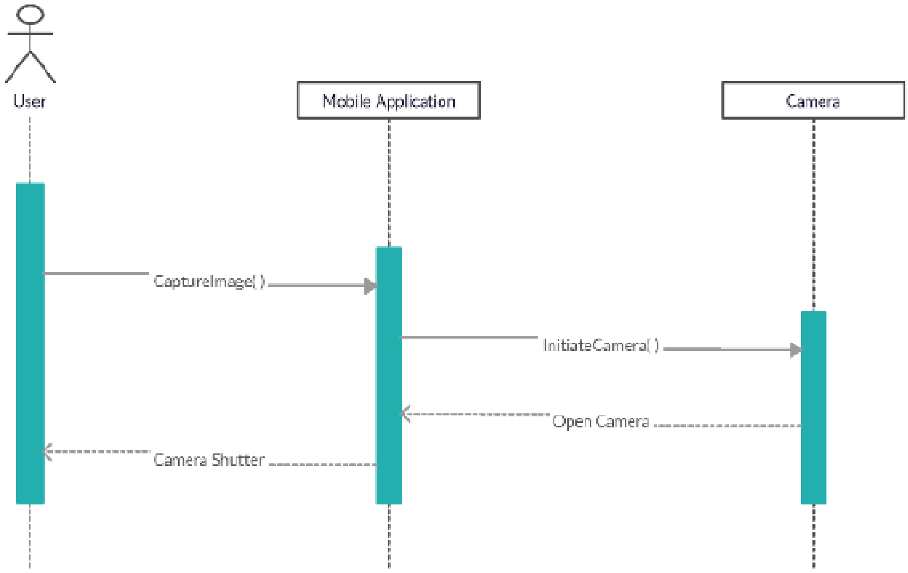


Figure 4.7: Capture Image Sequence Diagram

If the user wants to capture real-time image then he will have to click on the capture button which will initiate an instruction to open the camera app. The camera screen will then be visible to the user where he can click images using the shutter.

4.5.2.2 Select Image Sequence Diagram

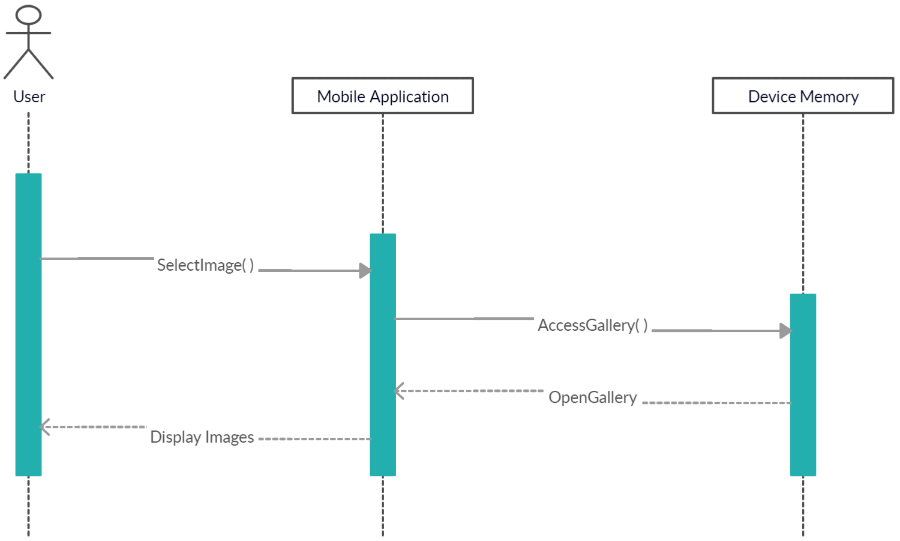


Figure 4.8: Select Image Sequence Diagram

In case the user wants to use an image that has already been taken, he will click on the select button which will cause the device's memory to grant access to its gallery and so the images residing in the memory will be visible to the user for him to choose from.

4.5.3 Upload Image Sequence Diagram

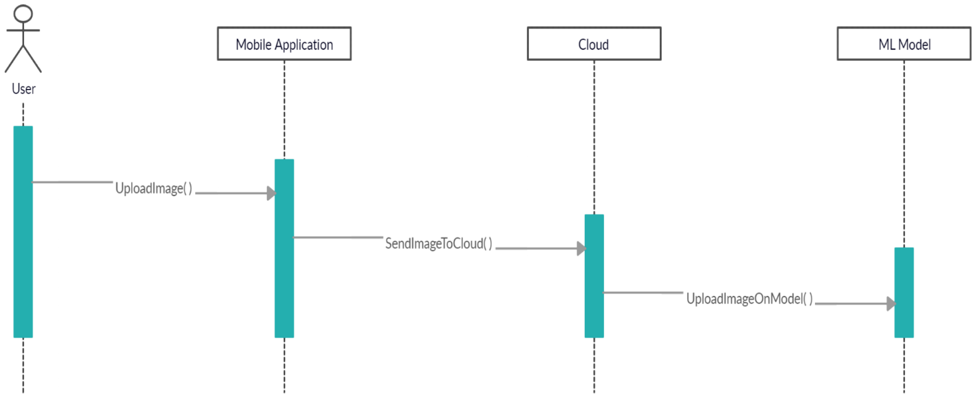


Figure 4.9: Upload Image Sequence Diagram

Once the user has finalized an image he will then upload it to the cloud with the help of the mobile application. From there the image will be sent to the machine learning model for its processing and classification.

4.5.4 Classification Result Sequence Diagram

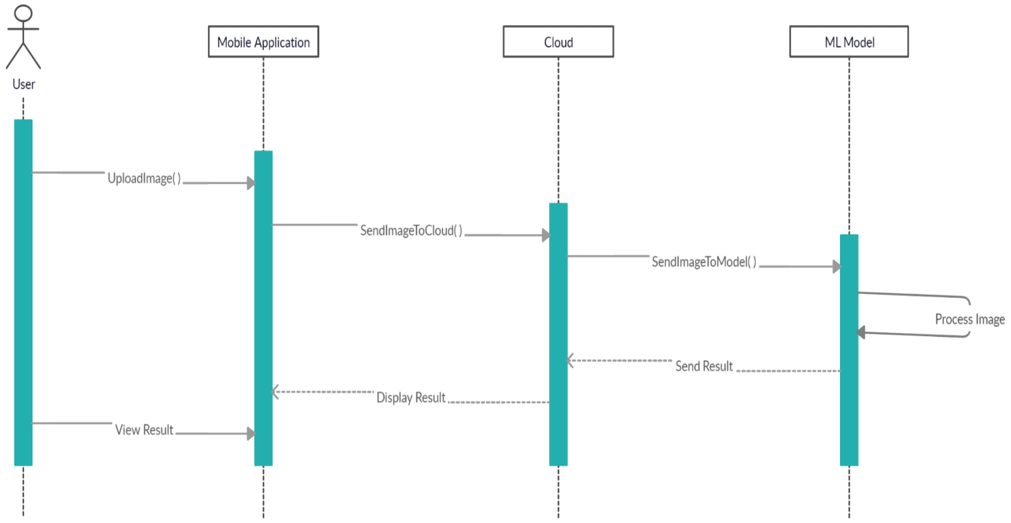


Figure 4.10: Classification Result Sequence Diagram

After the image has been sent to the ML model it will then start processing that image as to whether the plant is healthy or diseased or if it is even included in the list of leaves of plants incorporated into the training data of the model. In the end, when the whole procedure is completed, the result is sent back to the mobile application where he can view it from afterwards.

Chapter 5

System Implementation

Implementation is the act of transforming an idea into reality. It can primarily be defined as putting a plan or an agreement to effect. It is the process through which the lowest level system elements are actually yielded as the sole purpose of implementation is to fabricate a system element in accordance with that element's requirements and/or design properties to bring that system into production.

5.1 System Architecture

Architectural design of a system is a conceptual model that defines the overall system. With its help, a reader can easily understand and have a clear view of how a system actually works. Figure 5.1 shows how different components of the system designed in this project will coordinate together to make the whole system function. So as to simplify the documentation, verification and implementation, the system may be divided into three parts based on their functionalities.

The smartphone application in this project has been developed using Expo, one of the latest technologies that are trending these days which helps it in being both effective and productive. The application is free of any expense and easy to understand since while designing the GUI of this application it had been strictly kept in mind that a majority of users of this application are going to be farmers living in rural areas and they are not well equipped with using complex features.

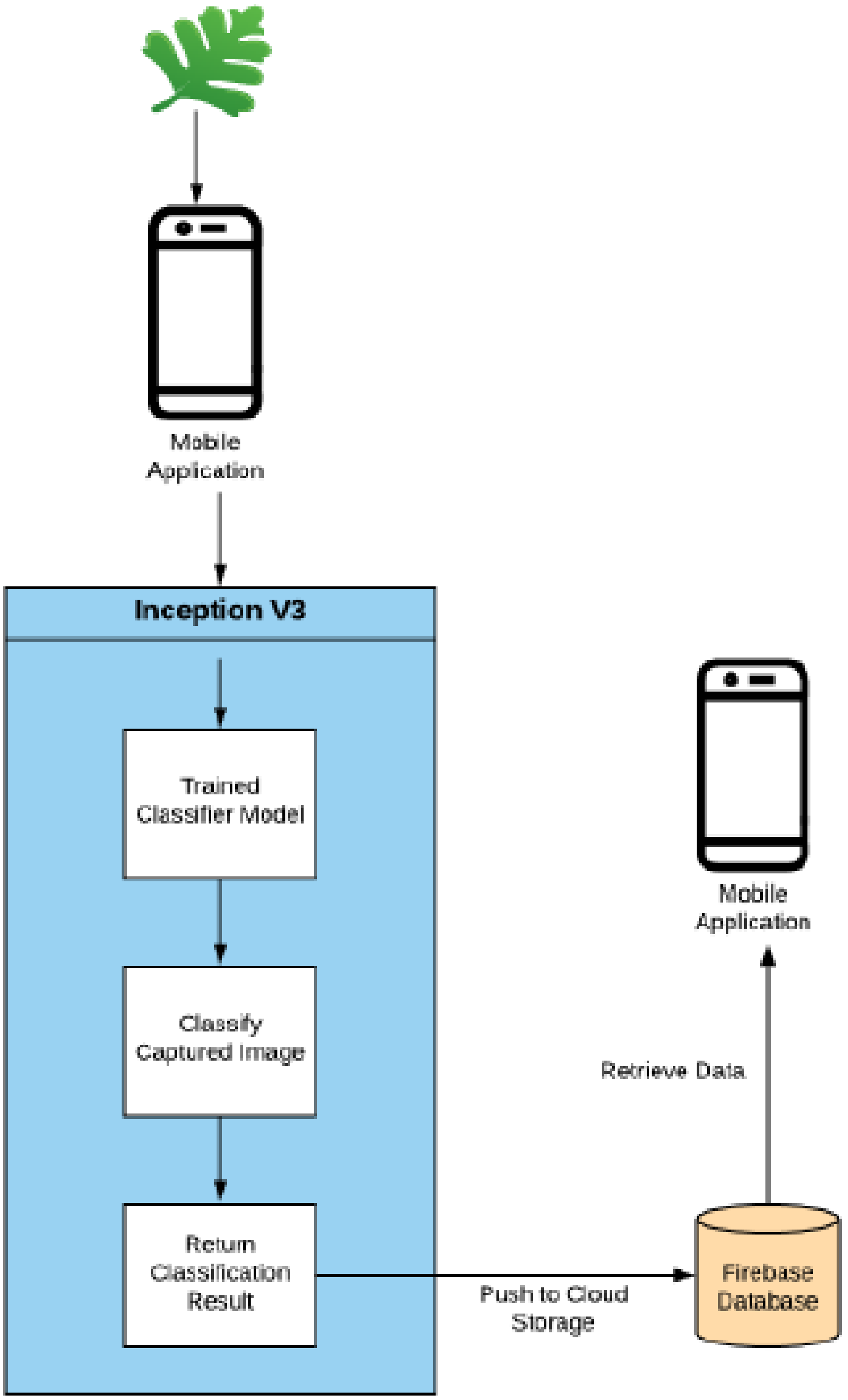


Figure 5.1: System Architechture

5.1.1 Processing Logic

The principle logic of this system comprises of three parts and these are input, processing and output. The first part i.e. input involves plant images whereas the second part (processing) is dependent upon the model for classification of those images. Figure 5.2 explains the basic logic behind this system:

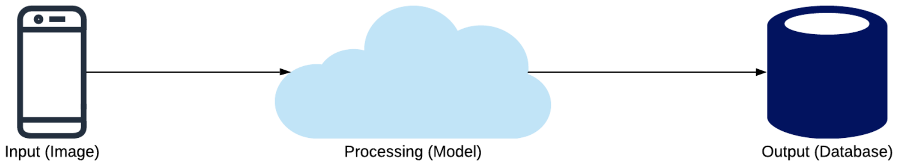


Figure 5.2: Processing Logic of the System

1. The application takes an image either by capturing or by selecting one from the device's memory as input.

2. The input is taken by the ML model. At this stage the model executes all of the project's backend operations such as classifying image, identifying plant type and detecting diseases. Once all of the processing has been done, the model then sends an output.

3. The output is received by the database from where the user can access it via the smartphone application to view the result.

5.2 System Internal Components

5.2.1 Application Components

1. **Register:** One of the processes is to create a new account in the database via the smartphone application. Once the user signs up, he can then exploit the further functionality of the application. The user must provide his full name and his email address to register for a new account.

2. **Login:** In order to login to the application, the person will have to provide a valid email address with which he/she registered previously into the system along with a password that must be at least eight characters in length.

3. **Capture Image:** To inquire what kind of a disease a certain crop has the farmer will then have to capture an image of one of its leaves through the capture image feature of the smartphone application.

4. **Select Image:** If in case a farmer does not want to capture a real-time image, he also has the choice of selecting one of the previously captured images from the devices's memory using this feature of the application.

5. **Upload Image:** When an image has been finalized it should then be handled over to the system so it can be processed and that function of handling over is performed by upload image feature.

6. **Show Result:** Lastly when all the processing has been done and the result has been generated, the user may view it with the help of show result feature of the mobile application.

5.2.2 Software Components

1. **Firebase:** To store user credentials along with the data-set images to be used for training and testing of the ML model and for storing the resulting data coming from that model, cloud based database, Firebase has been employed.

2. **ML Model:** To identify plant images as to which species they belong or what kind of disease they carry, a machine learning model has been utilized to perform that function.

5.3 Development Environment

The main development environment used in this project is Expo, a more advanced type of React Native as it lets to develop applications which can run on both Android and iOS platforms. The backend of the whole project as well as frontend of the mobile application has been developed using Expo-CLI. It is a developer tool that creates projects and also provides support for opening projects on other devices along with viewing their logs. Another feature of Expo that has been utilized during the developmental phase is Expo-Client. It is an app for mobile phones that allows programmers to open their in-progress projects on their mobile devices to see how they will behave in reality without the need to use Android Studio or XCode. Another plus point is that multiple people can view my project by sharing the same ID and that's exactly how my supervisor was able to keep an eye on what I was doing and how we were able to communicate with each other during this pandemic.

5.3.1 Languages

The development languages used are JS and JSX both for frontend and the backend. This involves the integration of Firebase and the ML model also along with the interface of the smartphone application. While for designing purposes of the app react native stylesheets have been applied to make it look appealing.

5.3.2 Libraries

Following are the libraries that aided in completing this project:

1. **React**

   Basic front end library for rendering components on the screen. Also required for JSX (react language).

2. **React-Native**

   Native library for operating system abstraction and generalizing code for all operating systems.

3. **Redux**

   Persisting application state across different UI components.

4. **React-Redux**

   Bindings for redux state management library to react's front end UI through properties.

5. **Redux-thunk**

   Run asynchronous code between actions and action dispatches.

6. **Expo-Camera**

   Expo module to access device's camera in real time and snap pictures.

7. **Expo-Font**

   Load custom fonts asynchronously.

5.4 Tools and Technology

5.4.1 Visual Studio Code

For source-code editing, visual studio code has been used since it allows code-refactoring and also provides support for code completion and debugging.

Figure 5.3: Visual Studio Code

5.4.2 Genymotion

In addition to Expo-Client genymotion has also been used for exploring the application in its running state and for testing purposes as it is a cross-platform Android emulator. It is also faster than other Android SDK's emulators and thus genymotion was preferred over other emulators.

Figure 5.4: Genymotion

5.4.3 Mockplus

For both designing purposes of the application and its prototyping, this all in one prototyping tool Mockplus was used to aid in faster progression of this project.

Figure 5.5: Mockplus

5.4.4 Firebase

Firebase being a real-time database management system has been used in this project for storing the information provided by the farmers along with the images of diseased plants that are used for training and testing purposes of the ML model.

Figure 5.6: Firebase

Chapter 6

System Testing and Evaluation

In this chapter, various testing techniques have been discussed to evaluate the performance of the developed system. Testing is an essential part of software development and is a very crucial phase. The techniques performed during this phase and play a vital part in evaluating the working and performance and validating the requirements of the software under consideration.

6.1 Graphical User Interface Testing

While testing for GUI of the application, its behaviour with respect to the user was checked out closely. Each screen was checked for its controls as if whether the buttons are clickable or not, button sizes are constant or not, button background is same or not, the text is of same height and font-weight. Application's navigation was also checked to see if a specified button was navigating to the right screen or performing the right action and if the navigation is easily understandable for new learners. The interface has been made as much user-friendly as possible.

6.2 Usability Testing

Usability testing is evaluated by the target audience of this project i.e. farmers. It gives an insight on how long will it take to carry out a particular task. A farmer is well pleased by executing the Plant Perfect application. It tells us whether the respected system is performing the required task that it is intended to do or not. Concerns of farmers were addressed and were also incorporated into the proposed application. Usability testing has some rules for testing. These rules are listed below:

1. **Easy to learn**
   Plant Perfect is quite a simple application hence, it is pretty easy and convenient to learn for beginners.

2. **Easy to use**
   The buttons of Plant Perfect UI were placed in position by focusing on ergonomic design concepts and by making sure that the end-user does not require any technical previous knowledge to use the application since the majority of users are going to be farmers.

6.3 Software Performance Testing

The system requires no exceptional capabilities just an active internet connection. Also, it has minimal device hardware utilization which shows ground for substantial overall performance of Plant Perfect. If in case the application stops responding (a rare chance that is) the user will just have to restart the application and it will start functioning properly as though nothing had happened. Error log will be shared with the admin in case the application doesn't respond.

6.4 Compatibility Testing

The mobile application is compatible with version 5(Lollipop) and above of Android and version 6.1.6 and above of iOS with a minimum of 2GB RAM of the device. Application in its running state does not drain the battery of that device and in addition, the device also does not heat up upon running the application.

6.5 Load Testing

Load testing was performed on both operating systems i.e iOS and android but no such issue in time or load balancing was detected that a load testing variation could be performed on the application. But on the other hand, some nominal changes were shown by the application in its performance that were hardly noticeable at all. Overall the application did not lag and performed without any errors.

6.6 Test Cases

Table 6.1 describes the test case to verify application is installing properly.

Test Case ID	TC-01
Test Setup	Mobile device and internet avalibility.
Input	Open the apk file. Run it to install the application.
Expected Result	Application should install without any error.
Actual Result	Application installed successfully.
Test Status	Pass.

Table 6.1: Test Case for Installing Application

Table 6.2 describes the test case to verify application is not installing under improper conditions.

Test Case ID	TC-02
Test Setup	Mobile device and internet availability.
Input	Run the apk file. Forcefully close it while the application is being installed.
Expected Result	Application should not install.
Actual Result	Application was not installed.
Test Status	Pass.

Table 6.2: Test Case for Not Installing Application

Table 6.3 describes the test case to verify application is launching properly.

Test Case ID	TC-03
Test Setup	Mobile device.
Input	Tap on the application to open it.
Expected Result	Application should launch without any error.
Actual Result	Application launched successfully.
Test Status	Pass.

Table 6.3: Test Case for Launching Application

Table 6.4 describes the test case to verify application is not launching under improper conditions.

Test Case ID	TC-04
Test Setup	Mobile device.
Input	Forcefully kill the application while opening it.
Expected Result	Application should not launch.
Actual Result	Application did not launch.
Test Status	Pass.

Table 6.4: Test Case for Not Launching Application

Table 6.5 describes the test case to verify new user is being registered.

Test Case ID	TC-05
Test Setup	Mobile device and internet availability.
Input	Enter valid credentials and click on register.
Expected Result	New user should be registered.
Actual Result	User registered successfully.
Test Status	Pass.

Table 6.5: Test Case for Registering New User

Table 6.6 describes the test case to verify new user is not being registered under improper conditions.

Test Case ID	TC-06
Unit of Test	Test
Test Setup	Mobile device and internet availability.
Input	Enter already registered credentials and click on register button.
Expected Result	New user should not be registered.
Actual Result	User was not registered.
Test Status	Pass.

Table 6.6: Test Case for Not Registering New User

Table 6.7 describes the test case to verify user can login.

Test Case ID	TC-07
Test Setup	Mobile device and internet availability.
Input	Enter registered email and password.
Expected Result	User should be logged in.
Actual Result	User logged in successfully.
Test Status	Pass.

Table 6.7: Test Case for User Login

Table 6.8 describes the test case to verify new user cannot login.

Test Case ID	TC-08
Unit of Test	Test
Test Setup	Mobile device and internet availability.
Input	Enter unregistered email and/or password.
Expected Result	User should not be logged in.
Actual Result	User could not login.
Test Status	Pass.

Table 6.8: Test Case for New User Login Denied

Table 6.9 describes the test case to verify registered user cannot login under improper conditions.

Test Case ID	TC-09
Test Setup	Mobile device and internet availability.
Input	Enter invalid email and/or password.
Expected Result	User should not be logged in.
Actual Result	User could not login.
Test Status	Pass.

Table 6.9: Test Case for Registered User Login Denied

Table 6.10 describes the test case to verify user can log out.

Test Case ID	TC-10
Test Setup	Mobile device and internet availability.
Input	Click on log out button.
Expected Result	User should be logged out.
Actual Result	User logged out successfully.
Test Status	Pass.

Table 6.10: Test Case for User Logout

Table 6.11 describes the test case to verify image is being captured.

Test Case ID	TC-11
Test Setup	Mobile device.
Input	Click on capture image button to open camera and capture image.
Expected Result	User should be able to capture image.
Actual Result	User captured image successfully.
Test Status	Pass.

Table 6.11: Test Case for Image Capture

Table 6.12 describes the test case to verify user can cancel image.

Test Case ID	TC-12
Test Setup	Mobile device.
Input	Click on camera shutter.
Expected Result	User should be able to discard image.
Actual Result	Image could not be discarded and user remained on the same screen.
Test Status	Fail.

Table 6.12: Test Case for Image Cancellation

Table 6.13 describes the test case to verify user can use both cameras.

Test Case ID	TC-13
Test Setup	Mobile device.
Input	Click on camera button to open camera.
Expected Result	Flip camera button should be displayed alongside camera shutter.
Actual Result	Only camera shutter was displayed.
Test Status	Fail.

Table 6.13: Test Case for Flip Camera

Table 6.14 describes the test case to verify image can be selected.

Test Case ID	TC-14
Test Setup	Mobile device.
Input	Click on select image button to open device memory and select image.
Expected Result	Device memory should be opened and display images.
Actual Result	Device memory opened and displayed images.
Test Status	Pass.

Table 6.14: Test Case for Image Selection

Table 6.15 describes the test case to verify user can select image after opening the camera.

Test Case ID	TC-15
Test Setup	Mobile device.
Input	Click on camera button to open camera.
Expected Result	Select image icon should be displayed alongside camera shutter.
Actual Result	Only camera shutter was displayed.
Test Status	Fail.

Table 6.15: Test Case for Image Selection from Camera Screen

Table 6.16 describes the test case to verify images are being recognized with correct plant type.

Test Case ID	TC-16
Test Setup	Mobile device and internet availability.
Input	Click on upload image button to upload it on the system.
Expected Result	Image should be recognized with its specific plant type.
Actual Result	Image recognized with correct plant type.
Test Status	Pass.

Table 6.16: Test Case for Plant Species Recognition

Table 6.17 describes the test case to verify images are being recognized with correct disease type.

Test Case ID	TC-17
Test Setup	Mobile device and internet availability.
Input	Click on upload image button to upload it on the system.
Expected Result	Image should be recognized with specific type of disease.
Actual Result	Image recognized with correct type of disease.
Test Status	Pass.

Table 6.17: Test Case for Plant Disease Recognition

Table 6.18 describes the test case to verify multiple leaves are being recognized correctly.

Test Case ID	TC-18
Test Setup	Mobile device and internet availability.
Input	Click on upload image button to upload a group of leaf images on the system.
Expected Result	Image should be recognized with specific plant type.
Actual Result	Image not recognized.
Test Status	Fail.

Table 6.18: Test Case for Multiple Leaves Recognition

Table 6.19 describes the test case to verify image can be recognized in low light.

Test Case ID	TC-19
Test Setup	Mobile device and internet availability.
Input	Click on upload image button to upload it on the system.
Expected Result	Image should be recognized with its plant type.
Actual Result	Image was not recognized.
Test Status	Fail.

Table 6.19: Test Case for Low Light Image Recognition

Table 6.20 describes the test case to verify user can view result.

Test Case ID	TC-20
Test Setup	Mobile device and internet availability.
Input	Click on show result button.
Expected Result	Result should be displayed.
Actual Result	Result was displayed.
Test Status	Pass.

Table 6.20: Test Case for Viewing Result

Chapter 7

Conclusions

Through this project a mobile application was developed capable of distinguishing diseased plants out of healthy plants along with their species. The basic idea is to bring the hardworking farmers some level of comfort by making the hectic task of monitoring a huge number of plants in a whole field somewhat easy for them by offering a very handy solution in the form of Plant Perfect. The anticipated benefits of this project are utterly aimed towards lessening the loss of agriculture sector of Pakistan, because this app is remarkably going to assist the farmers of our country.

7.1 Perspectives

This project is going to overlay the path for using technology in the near future as a tool for enhancing the contribution of agricultural sector in the country's economy by signifying how rather simple yet vigorous technologies, such as Machine Learning can be altered to assist various kinds of professions related to plants may it be farmers, garners, botanists or anybody else. Our country is lagging behind currently in this era of embracing new technologies in different fields of life, especially when it comes to rural areas where people are not aware of how advanced the world has gotten. They are scared of practicing new things and leaving behind their old ways. The application Plant Perfect is simple enough to be easily understood by the users yet its potential for demonstrating the use of technology to aid in increasing the productivity of plants is colossal. This application can be readily set up on play-stores and app-stores, in light of the fact that a single smartphone can support in safeguarding a whole field.

7.2 Future Work

Pakistan is Alhamdulillah blessed with a huge variety of crops and other species of plants too that are useful in one way or another but currently, this project is only beneficial for some crops out of numerous others. In future I want to expand the scope of this whole project so much that a person working with any kind of a plant will be able to enjoy its services and will make the most out of his collection of plants.

Appendix A

User Manual

A user manual helps in giving an idea to the user regarding how to use the system. User guide of Plant Perfect is given below:

A.1 Splash Screen

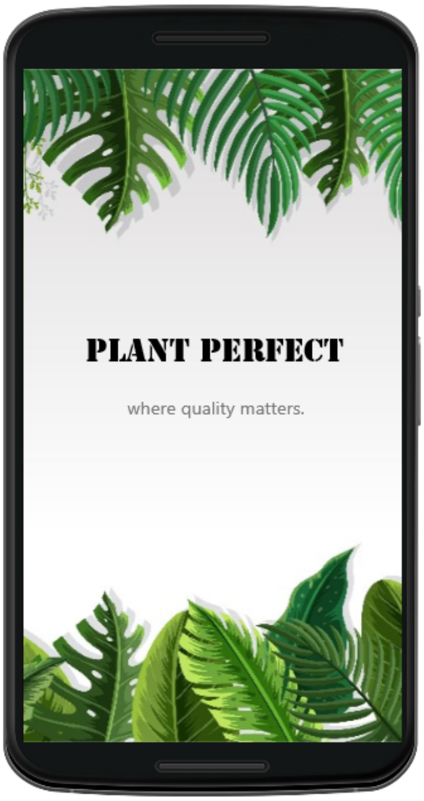


Figure A.1: Splash Screen of Plant Perfect

A.2 Login Screen

Enter valid email and password to log in to the application.

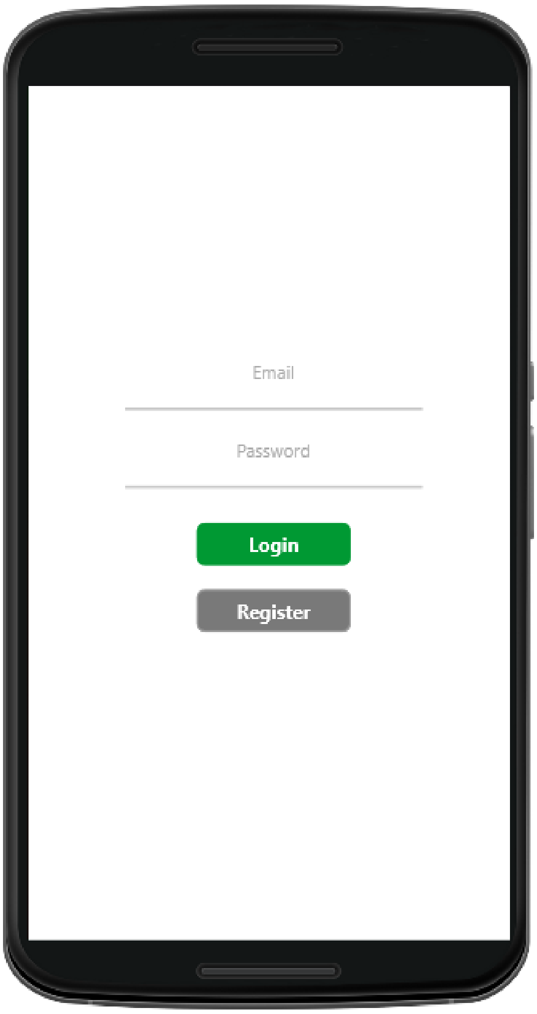


Figure A.2: Login Screen of Plant Perfect

A.3 Home Screen

Select the Capture Image button or more to navigate the home screen.

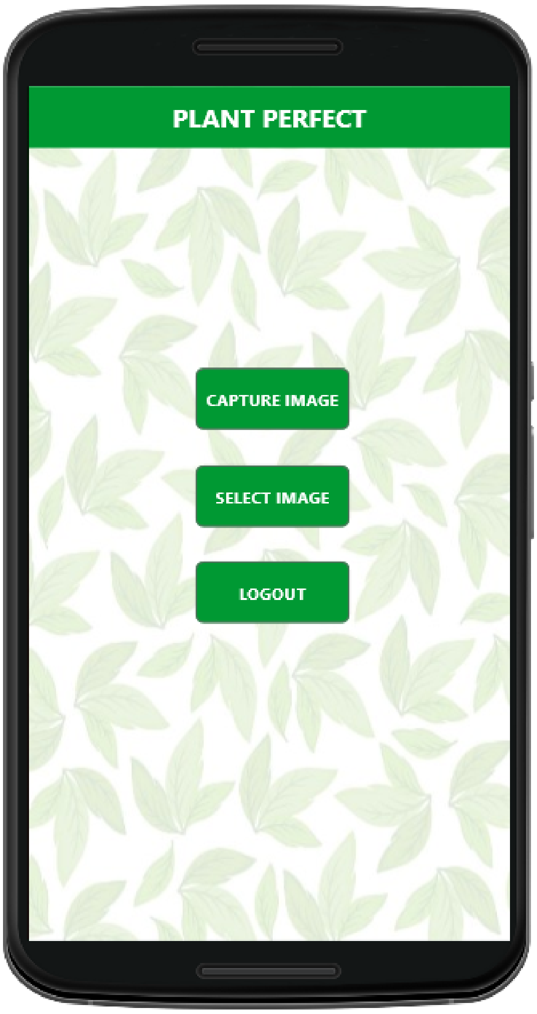


Figure A.3: Home Screen of Plant Perfect

A.4 Camera Screen

On this screen user can capture images of his own choice.

Figure A.4: Camera Screen of Plant Perfect

A.5 Select Screen

Here the user will be able to select one of previously taken images from the device's memory.

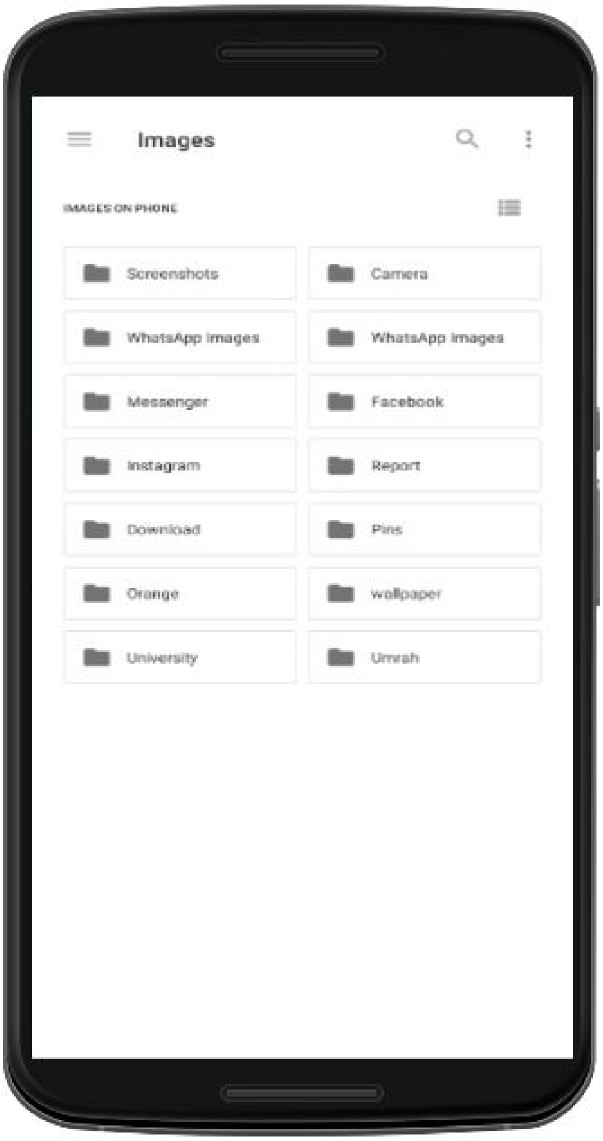


Figure A.5: Select Image Screen of Plant Perfect

A.6 Result Screen

On this screen user will be able to view the result of his uploaded leaf image.

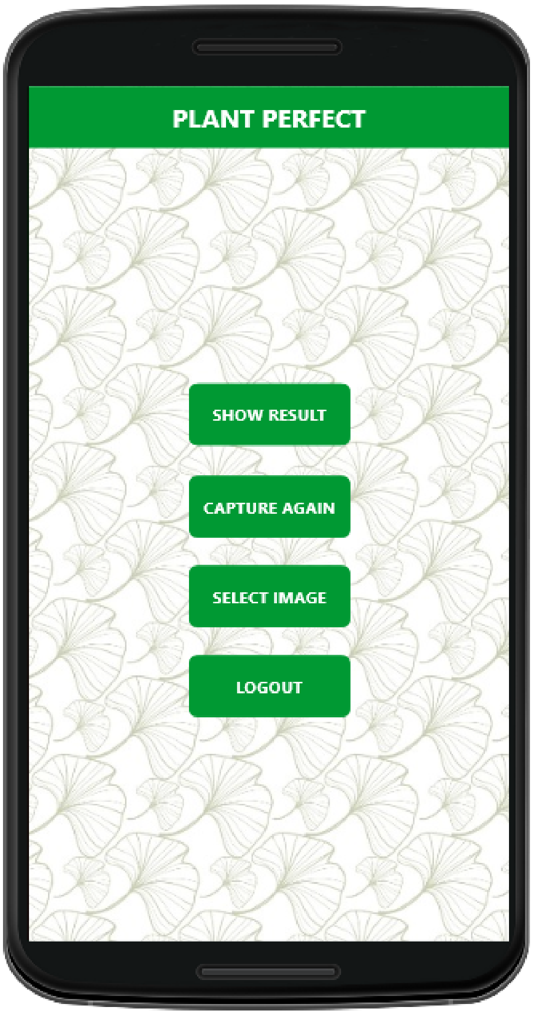


Figure A.6: Result Screen of Plant Perfect

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