Fruit Freshness Detection System

Solomon Javed (1912135)
Muslih Uddin (1912126)

Supervised by: Mr. Khwaja Bilal Hassan

In partial fulfillment of requirement for the degree
Bachelor of Science (Computer Science)
Department of Computer Science
Faculty of Computing and Engineering Sciences
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology
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By

Solomon Javed (1912135)
Muslih Uddin (1912126)

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE (COMPUTER SCIENCE)

(Supervisor) Mr. Khwaja Bilal Hassan	(FYP Committee Head) Mr. M. Nadeem Khokhar

(Program Manager BS(CS))
Dr. Shahzad Latif

Department of Computer Science
Faculty of Computing and Engineering Sciences
Shaheed Zulfikar Ali Bhutto Institute of Science and Technology
Islamabad, Pakistan

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DECLARATION

We, the candidates of Bachelor of Science (Computer Science) at Shaheed Zulfikar Ali Bhutto Institute of Science and Technology, Islamabad do hereby certify that this report titled **Fruit Freshness Detection System**, submitted as partial fulfillment of Bachelor of Science (Computer Science) degree requirements, is our original work and we are its sole author. All the employed materials, references to the literature and the work of others have been referred to and duly cited. This report has not been presented for examination anywhere else.

Solomon Javed
(1912135)

Muslih Uddin
(1912126)

Project Overview

Classification and detection of fresh fruits are included in the supply chain for fresh fruit. Due to the demand for fresh fruit, this industry is expanding globally. It is more important now than ever to preserve our health from such hazardous substances and to expand the sale of fruits. Fresh fruit gets spoiled and wasted while being transported and distributed. Such drawbacks in this scenario can be avoided by using this to continuously monitor fresh fruit. Fruit-borne illnesses quickly taint fresh fruit. This strategy plus the use of smart logistics for transaction monitoring can get around this. The main objective of the effort was to minimize or eliminate wastes. Here, a convolution neural network (CNN)-based algorithm for fruit recognition is suggested. Deep learning is a more complex form of machine learning that seeks to classify and recognise images with a high degree of accuracy. By creating a convolution neural network, this method may be utilised to forecast what kind of fruit would be present. The most common neural network model used for image classification applications is convolutional neural networks (CNNs).

Convolutional neural networks (CNNs) are widely used in computer vision applications like object identification and image classification. Convolutional and deep neural networks have been utilised in previous research to determine the freshness of perishable commodities like fruits and vegetables. Instead of using the conventional CNN architectures, the suggested approach seeks to investigate the potential of transfer learning with respect to the CNN models in picture categorization of fruits. Here, three different fruit varieties were identified, along with their relative freshness, using a variety of traditional convolutional neural network architectures and a residual convolutional neural network. On the provided set of data, the efficacy of each convolutional neural network model was assessed. According to their test results, the study attempted to rank the top performing model using visual data made up of six distinct varieties of fruits. The findings imply that standard and residual convolutional neural networks may accurately assess the freshness of fruits. On the fruits dataset, which was taken into consideration and evaluated with a test accuracy score better than 99 %, residual networks perform remarkably well. There was also some investigation into the application of the specified algorithm in the food business. In order to complement other computer vision techniques like background removal and picture augmentation approaches, the system makes an effort to choose the CNN model that could be used in the food business.

Dedication

Firstly, we dedicate our project to the creator Allah Almighty and dedicate to whom the world owes its existence Muhammad (Peace Be Upon Him) and dedicate this to our beloved parents, our extremely dedicated and generous teachers, and our supportive friends, their prayers always pave the way to success for us. We dedicate this final year project to all the individuals who have supported and inspired us throughout this journey.

To our families, thank you for your unwavering love, encouragement, and understanding. Your belief in our abilities has been a constant source of motivation, and I am grateful for your endless support.

To our friends, thank you for standing by us and providing both emotional and academic support. Your camaraderie and shared experiences have made this project even more meaningful.

To our professors especially Dr. Danish Mehmood and Mr. Nadeem Khokar and mentors, thank you for your guidance, expertise, and invaluable insights. Your mentorship has shaped our knowledge and skills, and we are grateful for the opportunities you have provided us.

To all the participants and contributors who willingly shared their time, knowledge, and resources for this project, thank you. Your involvement has enriched the project's outcomes and made it more comprehensive and impactful.

Lastly, we dedicate this project to ourselves - for the perseverance, determination, and commitment we have shown throughout this final year. This project represents the culmination of years of hard work, personal growth, and academic pursuit. We are proud of what we have accomplished and the knowledge we have gained.

May this project serve as a testament to the collective effort, dedication, and passion invested by all those involved. May it contribute to the advancement of knowledge and make a positive impact in its intended field.

Thank you all for being a part of this journey and for making this final-year project a reality.

Acknowledgment

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We would like to recognize and give our warmest thanks to our professors, especially Dr. Danish Mehmood and Mr. Nadeem Khokar, thank you for your guidance, expertise, and invaluable insights. Your mentorship has shaped our knowledge and skills, and we are grateful for the opportunities you have provided us

Not forgetting to mention my course mates, for their valuable feedback and time in helping us through any problem we faced in doing the project work.

Last but not least, we would like to thank our family for their love and support through our studies

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Chapter 1

Introduction

Pakistan is one of the countries where agriculture is the main source of economic stability. Pakistan has climatic conditions favorable for the growth of a variety of fruits and vegetables and the country benefits from this by exporting fruits and vegetables. Fruit export being one of them, generates about three hundred and fifty to four hundred million dollars on an average base, as per the Pakistan Bureau of Statistics.

Therefore, fruits have become one of the foods we consume every day because fruits contain vitamins, proteins, etc. Fruit also has a time period for consumption and after the specific time period particular fruit cannot be consumed as bacteria and micro-organisms are developed inside the fruit. There are still many fruit supply companies in Pakistan that use a traditional examination of fruit performed by human specialists, which results in poor examination and heavy losses. The proposed solution uses machine learning techniques to eradicate any kind of human error. This system will be a game changer in the fruit export industry. Apart from that, money and time wastage will be minimized. The proposed system can also be used by fruit exporters, fruit vendors, and the general public. The system will be predicting whether the selected fruit is fresh or rotten. After the prediction, one can easily select the fruit based on its freshness. This results in increased speed and reduced costs when sorting fruit processes because the traditional method is replaced with the latest and most efficient one.

1.1 Chapter Overview

Chapter 1 is about the introduction of the research. Chapter 1 informs about the problem and what solution should be provided to solve the highlighted problem. Chapter 1 is further divided into several sections which further explains the important aspects of the chapter. Section 1.1 highlights the overview of what is done throughout the chapter and what parts are there to explain the overall chapter. Section 1.2 explains about the domain in which the research is based and how significant is the domain to our research. This section also describes the significance of problem encountered and what should be done to solve the problem. Section 1.3 explains the scope of study, the study to be covered and the main focus of study. This section also tell us why the research was done in the first place, also tells what amount of work is already done to solve the problem.

Section 1.4 elucidate the objectives behind the research as to why the research is being done and what benefits will come from doing so. This section helps in defining the questions/objectives which the research will overcome. This section also helps in determining whether the research was a success or not. Section 1.5 describes the report layout which in turn tells about the chapters included in the whole research and what those chapter explain. Every chapter covers different aspect of the research e.g chapter 2 cover literature reviews i.e study of previous work done in the selected problem and chapter 3 covers methodology that includes proposed model and algorithm etc. Section 1.6 gives an overall summary of the chapter completed above, which includes the brief introduction

of sections that are covered in the chapter and what those sections includes. This is basically a brief of the covered sections and what was done in the sections.

1.2 Introduction

Pakistan is one of the countries where agriculture is the main source of economic stability. Pakistan has climatic conditions favourable for the growth of variety of fruits and vegetables and the country benefits from this by exporting fruits and vegetables.Fruit export being one of them, it generates about three hundred and fifty to four hundred million dollars on an average base, as per the Pakistan Bureau of Statistics [1]. Many people have invested and generated millions in revenue and are continuing to do so. Pakistan is a country blessed with different climatic regions which can be used for plantation of almost every kind of fruit. Due to this, it is a great business choice for new entrepreneurs to invest and get in. According to FAO, fruit production reached nine million tons in 2018 alone. Mangoes had the highest production rate of two million three hundred thousand tons, followed by oranges with one million five hundred thousand tons [2]. Fruit also has a time period for consumption and after the specific time period particular fruit cannot be consumed as bacteria and micro-organisms are developed inside the fruit. There are still many fruit supply companies in Pakistan that use the traditional examination of fruit performed by human specialists, which results in poor examination and heavy losses. The proposed solution uses machine learning techniques to eradicate any kind of human error. This system will be a game changer in the fruit export industry and also money and time wastage will be minimized.

The suggested system aims to eliminate fruit wastage that occurs when the fruit is shipped to other countries without systematic checking that results in losses worth millions. This project will be a game changer for industries having business concerning fruits. The proposed system will be allowing fruit exporters to digitize the fruit-checking process, which will result in the eradication of fruit spoilage. The system will be also financially affordable to implement. The proposed system because of its affordable nature can be used by everyone. The users can be businessmen dealing with the export of fruits normally examining using traditional and destructive methods which can also lead to losses. The general public can also use the product for automating the fruit-checking process because human checking can lead to errors and properly trained models/systems can be revolutionary in that scenario. The significance of the proposed system is very vast. As plantation is a very important aspect of economic development. Planters are very cautious about their products and it is essential to supply fresh fruits in the markets as they are highly demanded. So, with the proposed system's help, the fruits' freshness can easily be predicted. In case, the fruits get tainted the planters have to face major financial problems. To overcome the mentioned situation we proposed a system that can work efficiently and effectively to detect the freshness of fruit. By adopting the given solution human error can be eradicated efficiently.

The suggested system will detect the freshness of fruits irrespective of the shape and size which has little to zero effect on the freshness of fruits. This will minimize fruit wastage which is eliminated on the basis of shape and size. Around thirty-six million tons of food is wasted in Pakistan during parties, weddings, and hotels. Global Hunger Index has declared Pakistan as one of those countries where an alarming level of hunger exists. United Nations (UN) has released a statement that states that thirty percent of the fruits

worth forty-eight billion dollars are wasted yearly. Fruit wastage contributes about half of the mentioned figure. Fruit wastage is an issue that cannot be ignored and due to partial ignorance of such a serious issue losses are being occurred. Thus to eliminate wastage, Fruit Freshness Detection System is introduced to be used in industries to minimize wastage as much as possible. The available solutions are the one that either predicts freshness based on shape and size or is not available for fruits native to Pakistan which are exported worldwide. The fruit Freshness Detection System will be a revolutionary product for businessmen/fruit exporters as their losses will be minimized and with less cost compared to a traditional examination done by human specialists. Therefore, an experimentation plan is proposed to develop a deep-learning model for fruit freshness detection.

1.3 Scope of Study

The scope of the study refers to the boundaries and limitations of a research project. It defines what the study will and will not cover. In the case of a fruit freshness detection project, the scope of the study would include the specific types of fruits that the detection algorithm or tool will focus on, the geographical area or region where the study will be conducted, and the type of data sources that will be used to train and test the algorithm [1,2].

The suggested system aims to eliminate fruit wastage that occurs when the fruit is shipped to other countries without systematic checking that results in losses worth millions. Fruit freshness detection system will be a game changer for industries having business concerning fruits. The proposed system will be allowing fruit exporters to digitize the fruit-checking process, which will result in the eradication of fruit spoilage. The system will be also financially affordable to implement. The proposed system because of its affordable nature can be used by everyone. The users can be businessmen dealing with the export of fruits normally examining using traditional and destructive methods which can also lead to losses. General Public can also use the product for automating the fruit-checking process because human checking can lead to errors and properly trained models/systems can be revolutionary in that scenario. The significance of the proposed system is very vast. As plantation is a very important aspect of economic development. Planters are very cautious about their products and it is very essential to supply fresh fruits in the markets as fresh fruits are highly demanded. So, with the proposed system's help, the fruits' freshness can easily be predicted. In case, the fruits get tainted the planters have to face major financial problems. To overcome the mentioned situation we proposed a system that can work efficiently and effectively to detect the freshness of fruit. By adopting the given solution human error can be eradicated efficiently. As explained above Pakistan is one of the countries where climatic conditions are favorable for the plantation of a variety of fruits and most of Pakistan's economic stability depends on agriculture. So, the proposed system is the best fit for an agricultural country like Pakistan.

1.4 Research Objectives

The research objectives for the study project lay out its objectives. Research objectives should serve as a guide for each step of the research process, including data

collecting, argument development, and conclusion creation. Though they might change slightly as you go along, your research objectives should always be consistent with the actual research you conduct and the content of your article [3].

The main reason behind the study was to develop a system, beneficial for businessmen having a business of exporting fruits and any individual dealing with fruits. The losses that fruit exporters/sellers/buyers had to face because of the poor examination of fruits. The goal is to eradicate losses that occur due to poor/traditional examination of fruits. The fruit export companies have to face losses because of this issue and the suggested aims are to minimize/eliminate these problems. The objectives of this study are as follows:

1. To eliminate fruit wastage.
2. To predict the freshness of fruits native to Pakistan.
3. To eliminate traditional fruit examination techniques.

Research Questions

The Research Questions (RQs) are as follows:

1. RQ.1: Does the system eliminate fruit wastage?
2. RQ.2: What are the most effective image processing algorithms for identifying and quantifying fruit freshness indicators?
3. RQ.3: What are the key visual features and characteristics that correlate with fruit freshness, and how can they be measured objectively?
4. RQ.4: How can the fruit freshness detection system be integrated into existing supply chain processes to enable real-time monitoring and decision-making?
5. RQ.5: Does the system predicts freshness on fruits native to Pakistan?
6. RQ.6: Is the proposed system better than traditional techniques?

1.5 Report Layout

The study must necessarily be sufficiently described in the research report layout for the reader to be able to put it in its larger scientific context, assess the effectiveness of the study's procedures, and determine how seriously the results should be considered. The report must be laid out properly for this purpose. The format of the report indicates what information the research report should include. The introduction, the body of the report, and the conclusion should all be included in the layout. Let's handle each of them independently.

1. Chapter 1: Introduction. The introduction to the research, the study's scope, its goals, and its questions are all provided in this chapter.
2. Chapter 2: Literature review. This chapter offers information about the study's history, current state of the art, review of the literature, issue statement, target audience for the study and users, software process model, and high-level features.

3. Chapter 3: Methodology. This chapter provides an insight of the methods used to achieve the goal. Flowchart is used to brief the whole flow of working and also tells about the model used for training the machine. Proposed algorithm is also described. In the end, sequence diagram is shown to explain how will the system work in a sequence.
4. Chapter 4: Interfaces and Physical Design. This chapter includes user interfaces, how your system will look, and how it can be accessed. The chapter also includes the user table.

Figure 1.1 gives the pictorial representation of the report layout.

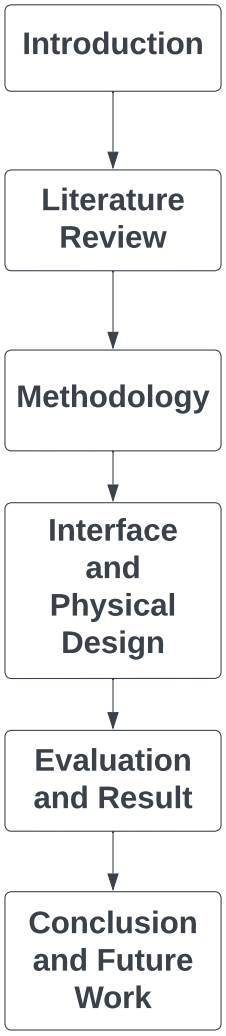

Figure 1.1: Report Layout

1.6 Summary of the chapter

Chapter 1 includes a variety of different aspects and contains different sections to further explain the work done in the chapter. Introduction was given first to give an overall introduction of the domain and why this research is being done and what good

will it provide and why is there a need to do research in the particular domain. In this, Pakistan's climatic conditions were explained and how much Pakistan earns from agriculture alone, and how the proposed system will help change the business processes for the betterment. Some issues were discussed with the existing techniques and what harm the current techniques provide to the businessmen.

Some research papers were reviewed and their detection techniques were observed there were some drawbacks in the above research papers which are mentioned in this chapter. The chapter overview section gives an overview of what is being done in each section. The chapter further explored the domain and the significance of the research and how many losses are faced yearly based on poor examination and how that affects the overall economy of Pakistan. The problems with the existing systems were discussed and how those problems affect the overall system. Research objectives were explained to check whether the developed system is up to mark or not. And by setting some objectives, the end result can easily be concluded based on whether the developed system meets those objectives or not. The report layout further explains what is done in each individual chapter and an explanation was provided regarding that particular chapter and what that chapter included. This helps in getting an overview of the chapters and what should be expected from those chapters.

Chapter 2

Background and Literature Review

The background and literature review of a research study provides context and support for the research objectives. The background section typically includes a general overview of the topic, explaining why it is important and relevant. The literature review, on the other hand, is a comprehensive examination of existing research on the topic, including previous studies, theories, and findings. The purpose of the literature review is to identify gaps in the current knowledge and to build a strong foundation for the proposed research [4].

The background and literature review play an essential role in providing context and justification for a research study. In the case of the Fruit freshness detection project, the background section includes a general overview of the topic, explaining the significance of detecting fresh fruits. This includes information on the economic impact of spoiled fruits and the importance of sustainable agricultural practices.

The literature review for the fruit freshness detection project is a comprehensive examination of existing research on the topic, including previous studies, theories, and findings related to fruit freshness detection methods, and preventive measures.

2.1 Chapter Overview

Chapter 2 is about background and literature review. This chapter includes background or previous work that has been done with the chosen topic. It enlists all the state of art research papers and includes both features and limitations. Chapter 2 is further divided into several sections which further explain the important aspects of the chapter. Section 2.1 is the chapter overview and informs about what are all the things listed and explained in the chapter. By reading the chapter overview one can get the main idea of what to expect from the chapter. Section 2.2 tells about the background of your study and informs about the techniques that will be used in the proposed system and what techniques are already available and how they are used in each research. Section 2.3 is the literature review is basically the work previously done on the given topic. This section also explains what has been done and why. It tells about different work done on the topic, its features, and its limitation. This section also provides a critical evaluation and lists all the features and makes a comparison as to why the suggested system is better than the rest.

Section 2.4 is the problem statement in which the problem that the suggested system is going to solve is stated. This sections explains why the problem is significant that it needs a solution and what work has been done and what are the limitations of those solutions. Section 2.5 includes the targeted audience which the proposed system aims to facilitate and how the suggested system is going to change their working processes for the betterment. Section 2.6 is the software process model which explains why the process model is used and why is there a need for process model, includes the selected model and how is that model going be useful with the suggested system and how those steps are

modeled in the system. It includes all the high level features and the time required to perform each task. Section 2.7 is the summary of what is done in the whole chapter and briefs all the the things done in each section.

2.2 Background

The background is a section that provides the context and background information on the research topic. It explains the relevance and importance of the topic and summarizes the key findings, theories, and concepts related to the topic. The background section aims to give readers a clear understanding of the research problem and its significance by highlighting the current state of knowledge in the field [5].

The background section of the fruit freshness detection system research project provides a context and overview of the current state of knowledge related to detecting the freshness of fruits. This section highlights the prevalence and economic impact of fresh and spoiled fruits on the fruit industry and the importance of early detection and timely treatment to prevent losses. It summarizes the existing literature and research on the topic, including the traditional methods and recent advancements in computer vision and machine learning algorithms for automated freshness detection.

The suggested system uses a CNN approach for training the machine. Neural networks with shared parameters are known as covnets or convolution neural networks. Consider that you have an image. It can be visualized as a cuboid with the dimensions of length, width, and height (as images often comprise red, green, and blue channels). Think about applying a small neural network, say, with k outputs, to a small area of this image and displaying the results vertically. Moving the neural network across the entire image will result in the appearance of a new image with modified width, height, and depth. We now have extra channels, however, they are narrower and taller than the original R, G, and B channels. This process is known as convolution. If the patch size is the same as the image size, the neural network will be a typical one. Because of the little area, we have less weight.

2.3 Literature Review

A thorough summary of past research on a subject is called a literature review. Scholarly books, journals, and other sources that are relevant to a particular topic of study are examined in the literature review. This earlier study ought to be mentioned, summarized, objectively assessed, and clarified in the review. It must give the study a theoretical foundation and let you, the author, define its parameters. The literature review reassures the reader that your work has been carefully thought out by recognizing the contributions of prior scholars. It is assumed that the author has read, evaluated, and incorporated any references to prior studies in the field into the current work [6].

For the suggested project, the literature review will be an essential part of the research process. It will involve conducting a comprehensive review of existing studies, theories, and findings related to fruit freshness detection.

2.3.1 Literature

Literature is a portrayal and investigation of the writing pertinent to a specific field or subject. it gives an outline of what work previously had been completed, who are the vital specialists and who accomplished that work, which of the inquiries are now responded to in regards to a specific area of examination interests, what strategy and procedure were utilized to respond to the specific inquiries and what are the predominant speculations and theory.

Here are five relevant applications that are closely related to the proposed system:

Fruit Disease Identifier [7] is a mobile application designed to help farmers and gardeners identify fruit diseases using computer vision and machine learning tools. The app allows users to take a photo of a fruit and receive an immediate diagnosis of the disease, as well as recommended treatment options. The app covers 3 different fruit diseases, including common ones like an early blight in tomatoes, black rot in apples, and a bacterial spot in peppers. It uses a large database of images to ensure accurate identification with high precision. One of the key features of the Apple Disease Identifier app is its simplicity and ease of use. Farmers and gardeners can quickly identify and treat fruit diseases, saving time, money, and resources. The app provides clear instructions for treatment and care, helping users to prevent further damage and maintain healthy plants and fruits. Another benefit of the app is its accessibility. Farmers and gardeners can use it from anywhere, at any time, and it is available in multiple languages to reach a wider audience. However, there are a few limitations to the app. It relies on the user's ability to take clear photos of the fruits, which can be difficult in certain lighting conditions. Additionally, the app may not cover all fruit diseases and their variations, and it is not a substitute for professional advice from an agricultural specialist. Overall, the Fruit Disease Identifier app is a valuable tool for farmers and gardeners to quickly and accurately identify Fruit diseases and take action to protect their agricultural products.

The Features of the application are listed below.

- Computer vision and machine learning
- 3 Fruit diseases
- Treatment options
- Available in multiple languages
- Quick and accurate diagnosis

The limitations of the application are listed below.

- Limited fruits coverage
- Inaccuracy of identification
- Restricted to mobile platforms
- Subscription-based service
- Not substitute for professional advice

Apple Disease Detection [8] is a mobile application that can have significant impacts on the agricultural industry, leading to reduced crop yields and lower-quality

produce. This is particularly true for countries like Pakistan, which exports a wide variety of fruits including oranges, apples, mangoes, and grapes. Identifying and managing fruit diseases is an important task for farmers and other stakeholders, but it can be challenging and time-consuming to do so manually. The Apple Disease Detection project is a web-based application that enables users to easily detect the disease of an apple plant by simply uploading an image of the apple leaf. The underlying model used in the application is a Convolutional Neural Network (CNN), which has been trained to identify various diseases that affect apple plants. The model has been extensively trained using a large dataset of apple leaves to achieve an accuracy of 94 percent. This high accuracy ensures that the results obtained through the web application are reliable and can be trusted by users. The web-based interface is user-friendly and straightforward, making it accessible to a wide range of users, including both expert and non-expert individuals. With this innovative tool, users can quickly and easily detect the disease affecting their apple plants, enabling them to take timely and appropriate action to control its spread and protect their crops.

The Features of the application are listed below.

- Computer vision
- Machine Learning
- Multiple disease detection
- Cross-platform availability
- Accurate disease identification

The limitations of the application are listed below.

- Restricted to Apple only
- Inaccuracy of identification
- Requires internet connection for use
- Needs expert analysis for confirmation
- Relies on image quality

Identify Apple Tree Diseases [**9**] is a cutting-edge mobile application that utilizes artificial intelligence (AI) to help farmers and agricultural professionals detect and diagnose diseases in apple trees. This app is designed to assist farmers in quickly identifying and treating apple tree diseases, which can lead to significant crop losses if left untreated. The app works by analyzing images of apple tree leaves captured by the user's smartphone camera. The AI algorithms behind the app have been trained on a large image database of thousands of apple tree leaf images, enabling the app to accurately identify common diseases such as apple scab, cedar apple rust, and powdery mildew. Once a disease is detected, the app provides the user with detailed information about the disease, including symptoms, causes, and recommended treatments. This information is based on current best practices in agricultural research and is regularly updated to ensure the most accurate and up-to-date advice. One of the key advantages of the Identify Apple Tree Diseases app is its ability to provide quick and accurate diagnoses, enabling farmers to take action before the disease spreads further and causes irreparable damage. By catching diseases early, farmers can prevent yield losses and maintain healthy, productive apple trees.

The Features of the application are listed below.

- Accurately diagnoses apple tree diseases (AI)
- Provides detailed disease information
- Prevents disease spread, reduces crop loss
- Offers valuable agricultural information
- Regularly updated information

The limitations of the application are listed below.

- Relies on clear, accurate pictures
- Requires smartphone access
- Can not detect rare diseases
- Smartphone camera required
- Potential for misdiagnosis or false positives.

Plants Disease Identification [**10**] is a mobile application that uses artificial intelligence to detect and diagnose plant diseases based on images of leaves, stems, and fruits. This app is designed to help farmers, gardeners, and agricultural professionals identify and treat plant diseases accurately and quickly. The app uses a deep learning algorithm to analyze images uploaded by users and compare them to a large database of plant diseases, symptoms, and treatments. The app can detect diseases in a wide variety of crops, including vegetables, fruits, and ornamental plants. One of the most significant advantages of Plants Disease Identification is its accuracy. The AI technology used in the app can accurately identify plant diseases with a high degree of precision, reducing the risk of misdiagnosis and ensuring that the correct treatment is applied. Additionally, the app is user-friendly and accessible, allowing anyone to use it regardless of their level of expertise. Moreover, Plants Disease Identification provides a range of information and resources related to plant diseases, including detailed descriptions of symptoms and recommended treatments. The app also includes a feature that allows users to track the progress of their plants over time and monitor the effectiveness of the treatments they have applied. However, there are some limitations to this app. The accuracy of the app depends on the quality of the images uploaded by users. Poor-quality images may lead to misdiagnosis, resulting in the application of the wrong treatment. Furthermore, the app may not be able to detect rare or uncommon diseases that are not included in the database. Finally, the app may require an internet connection, which may not be available in all areas, making it less useful in remote or rural locations. Despite these limitations, Plants Disease Identification is a valuable tool for anyone involved in plant cultivation and management.

The Features of the application are listed below.

- Uses AI to detect plant diseases from images
- Accurate disease identification
- Analyze leaves, stems, and fruits

- Detailed symptom descriptions
- Treatment recommendations

The limitations of the application are listed below.

- Dependent on image quality
- Limited to certain plant species
- It is not suitable for all regions
- Constrained to specific disease categories.
- Requires smartphone access

PlantVision AI [**11**] is an application designed to quickly and accurately identify plant diseases through images of plant leaves. The identification of plant diseases is critical to the agricultural industry, as it helps to prevent crop loss and improve the quality of yields. The app uses Artificial Intelligence and has been trained on a large dataset of nearly 70,000 images, ensuring an accuracy rate of approximately 95 percent. The app provides information about the identified disease, including potential treatments and the source of the information. It supports various plant types, including Apple, Corn, Grape, Peach, Potato, Tomato, Strawberry, Cherry, and Bell Pepper. The diseases that are currently supported for each plant type are also listed in the app, such as Bacterial Spot, Early Blight, Late Blight, and more. The app is easy to use, allowing farmers to quickly and accurately identify diseases in their crops. By identifying plant diseases early, farmers can take appropriate actions to prevent the spread of the disease and reduce crop loss. This helps to save time, money, and resources for both the farmer and the world. One of the key features of PlantVision AI is its use of Artificial Intelligence, which helps to ensure accurate and efficient identification of plant diseases. The large database of images that the app uses for training also adds to its accuracy. Additionally, the app provides users with information about the identified disease, which helps farmers to take appropriate actions to manage the disease.

The Features of the application are listed below.

- 91 Percent accuracy in plant disease identification
- Uses Artificial Intelligence
- Provides information on disease and treatments
- Supports various plant types
- Efficient disease management

The limitations of the application are listed below.

- Limited number of supported plant types
- Relies on image quality for accuracy
- Potential for misidentification
- Requires internet connection for use
- Needs expert analysis for confirmation.

Here are 10 Research papers reviews that are closely related to the proposed system:

Fu et al. [**12**] have in their study, attempted to deal with software that analyzes a safe and economical way to determine fruit freshness based on size, shape, and color. Testing of fruits should be done using non-destructive methods as the items are very fragile and are to be dealt with delicately. In determining fruit size, a key physical characteristic is a color which provides visual characteristics. Fruit characteristics such as shape and color are key to perceived controls. A system-independent structure for sorting fruit based on freshness must be able to effectively identify both parameters. The system can easily get the shape of the fruit from a digital image and can perform predictions based on that image. However, color recognition involves many psychological and physical concepts, making it difficult to accurately model and process the colors in the image. There are many classes of color systems that are present for sorting fruits based on color. In this classification based on the color, software development is very important. The complete solution is designed through a neural network concept to control the color, size, and shape of the fruit. The most important factor in classifying fruits is the color, but many fruits are similar in color, so their size helps us solve this kind of problem. This is a completely automated project to eradicate any kind of human error on a commercial scale, but it has some shortcomings such as predicting freshness based on shape and size is not commercially efficient.

Chen et al. [**13**] have in their study, attempted to deal a software developed by students of Masters of Computer Science, Bina Nusantara University, Jakarta, Indonesia in which, it is stated that Indonesia is a country with a climate favorable for the plantation of different types of fruits and vegetables. Indonesia being one of the world's leading exporters of agricultural items/goods and this particular industry contributes to a lot of job opportunities as well. But fruit also has a time period in which it is consumed, after which it undergoes a series of chemical reactions which leads to the formation of enzymatic reaction. This reaction transforms fresh fruit into rotten by going through a series of molecule transformations, if not consumed in that particular time period. During this particular time, many companies still ship deteriorated fruits for consumption due to the lack of precision in the fruit sorting process at fruit collection. From the plantation and entry of other fruit into inappropriate packaging. This lack of precision results in losses worth millions because no company accepts rotten fruits. Therefore, the process is very important to detect fruit spoilage from the stage of production to consumption. The system proposed a CV-based design along with CNN Model to detect freshness. The proposed system is applicable only to fruits native to Indonesia and not applicable to fruits grown in Pakistan.

Shital et al. [**14**] have in their study, attempted to develop a solution to find fruit from a given digital image, and automatically evaluate its result depending on the condition of the sample. Since most of the fruits have a unique appearance when the background is clear or solid in color, a simple threshold can be used to segment the fruit object from the image. Areas of the image within the thresholds will be selected while others will be masked. This process will enable the system to get the particular fruit image while the rest of the image is ignored. An outline of the selected image areas is displayed to determine the bounding boxes for object detection. The data set used for training consists of four fruit classes: apple, dragon fruit, pear, and kiwi, derived from a wide variety of images with different noises and unfavorable conditions, which will also

help in predicting a result if the image is already exposed to noise. First, we analyze the connection between fruit appearance and freshness and how they are co-related and can be used for prediction. The YOLO neural network in the classification of fruits is considered for a hierarchical deep learning model, outcomes will be used in regression CNN for prediction. A linear model based on the look and color of the images tells us the reason behind the selection deep learning technique. The setback is that the project calculates freshness based on half-cut and digital images rather than real-time images.

Kumar et al. [**15**] have in their study, attempted to develop a model which is used in agriculture. The recognition of damaged fruits becomes pivotal. As usual, this crucial work is carried out by humans on a routine basis to identify fresh and tainted fruits, which fruit agriculturalists find effective. After a certain time, fruits undergo biochemical reactions and their shape start going yellowish and the fruit gets deteriorated. The model focuses on three different fruit kinds in either fresh or decomposed forms. It is challenging to categorize fruits because of their wide range of sizes, colors, textures, shapes, and other properties. Therefore, to overcome this problem a model is proposed to identify whether the fruit is rotten or fresh. In this model, many fruits were studied which includes apples, bananas, and oranges. The system's main objective is to employ CNN for detection. Likewise, machine learning has become a helpful hand in minimizing food wastage in many different ways. Due to the vast variety of fruits available, it theoretically is impossible to classify fruits by their pictures. By using CNN, deep learning is made possible. In doing so, the CNN model outperforms current approaches and can distinguish between fresh and rotting fruits with accuracy. As a result, the suggested CNN model will automate the ability of the human brain to discern between fresh and rotting fruits, decreasing the possibility of human error in fruit classification. CNN models for binary classification prefer sigmoid and softmax functions, whereas softmax is utilized for multiclass classification and is used to classify the pictures into fresh and decaying fruits, whereas CNN is used to get the fruit image properties. A dataset was taken from Kaggles and was used to demonstrate the model's performance, and the model achieved an accuracy rate of 97%. Comparing the suggested model to different current models, it is discovered that the performance can be improved. Apart from that, the dataset is pre-trained using models like Alexa, GoogleNet, ImageNet, VGG16, and VGG19 to recognize food images.

Jayasankar et al. [**16**] have in their study, used Deep Learning techniques to attempt to explain the developments in the agricultural sector. Fruit ripeness estimation methods are now extensively used in digital picture processing. In order to remove features from acquired digital photographs, the research set out to investigate the various feature extraction algorithms and techniques already in use. The quality of the fruits must therefore be marked on the packaging by the vendors. Based on the fruit's weight, size, form, and color, the research evaluates the fruit's quality. All of these algorithms are implemented on the RASPBERRY PI development board, which will eventually become a stand-alone and reasonably-priced gadget. A cost-effective embedded system prototype will be created by carrying out all of the component interfaces. The system explains how the Raspberry Pi may be used to assess the freshness of the fruit. As we all know, food is essential for human survival. The handling and storage of food improperly might lead to food poisoning. This happens because most germs go unnoticed and undiscovered. Additionally, the flavor, scent, or look of fruit is typically unaffected by these bacteria.

Therefore, we should examine the strategies for avoiding food poisoning and promoting the use of fresh foods. The Raspberry Pi is used in this project's detector system, which checks the freshness of fruits. When fruit is gathered, it should be put on a conveyor belt so that it can travel through a sensor device that can determine the fruit's full freshness state and display it. Images are important sources of information and data in the field of agricultural science. Emphasis is placed on the core concepts and procedures used by computer vision systems, automatic vision-based tools, image analysis software, and automated sorting and grading systems. The Raspberry Pi is used to capture the fruit image as the first step in the proposed system. The features of the fruit, such as color, shape, and size of fruit samples, are then retrieved before the image is sent to the processing stage. Fruit image processing using an artificial neural network then moves on to the training and testing phase. In the suggested model, neural networks are used to determine the fruit's shape, size, and color. The results are improved when these three features are combined.

Cheah Ui Shaun [**17**] have the paper proposes a portable application that can recognize newness in organic products. Organic products assume a critical part in our eating routine as they contain supplements that are fundamental for our well-being. These supplements are significant as they assist us with safeguarding against ongoing sicknesses. Organic products that are not new won't contain as numerous supplements as when it was new. Along these lines, it is vital to guarantee that main new and ready organic products are consumed. In any case, there exist an enormous number of customers that don't have the foggiest idea how to choose natural products that are new while buying. Other than that, the organic product industry in Malaysia involves unsafe synthetic compounds to perform organic product reviews which makes the organic product lose its supplements. To do this, the venture uses Profound Learning advances related to a portable application to foresee the newness of organic products. In spite of the fact that there are a few applications that can perform natural product newness expectations, they require the client to have a few outer gadgets to foresee its newness precisely. Subsequently, this task will zero in on fostering an application that can precisely forecast the natural product's newness without requiring additional gadgets.

Jayasinghe and Sammani [**18**] have in the paper that products of the soil have been a huge piece of the feasts that people take every day. Since the rate of sicknesses has expanded in present-day times, individuals have become more inquisitive and mindful about regular and natural items: particularly leafy foods. Among them, individuals focus closer on the newness of the natural products they eat. Consequently, it infers the need to distinguish the nature of organic products since it has been demonstrated to influence human well-being. Essentially, the nature of organic products relies upon the newness of the fruits. The natural products that a poor person has handled in any way are viewed as new organic products.

They are brimming with fundamental nutrients, minerals, cell reinforcements, fiber, and different supplements that can work on human well-being and are viewed as vital for keeping up with great well-being. New organic products enjoy many benefits to the human body, for example, giving 10-20 times more fiber consumption quite easily. Many new natural products contain fundamental strands that are uncommonly expected to keep up with body well-being. The fundamental target of this research is to gauge the freshness of organic products by noticing their CO2 discharge, water fume discharge, and

O2 assimilation in the wake of collecting for the papaya and watermelon. They were classified into three gatherings (500g-1kg, 1kg-1.5kg, 1.5kg2kg) and tried on 4 chosen days including the collection day, three days after reap, seven days later, and fourteen days after to notice the progressions in these three elements (CO2, O2, and dampness). A CO2 sensor, an O2 sensor, and a dampness sensor were set up to distinguish the changes. The gathered information was utilized to prepare the AI model (Keras Successive Model). Subsequent to entering the sort of the organic product, weight, the distinction of oxygen, and water fume fixation following 45 minutes, as contributions for the model, the model will anticipate the newness of the natural product as a rate. The Accuracy of the created model was viewed as 98 percent. The consequences of the examination suggested that the pace of O2 assimilation slowly increments in the wake of gathering and the water fume discharge steadily diminishes. It is recommended to utilize higher awareness sensors to acquire exact outcomes.

Kuriakose et al. [**19**] have programmed fruits acknowledgment and freshness recognition framework with audio output by utilizing machine vision is presented. Here, organic product acknowledgment calculation in light of a Convolution Neural Network (CNN) is proposed. Profound learning is a high-level AI that plans to accomplish high exactness in picture acknowledgment and arrangement. This framework can be utilized to foresee the sort of organic product by building a convolution brain organization. Convolutional Neural Networks (CNNs) are the most well-known neural network model being utilized for picture arrangement assignments. Here, VGGnet which is a CNN design, is used to distinguish the kind of picture.

Here, the data set comprises of Apple types (Apple A, Apple B, Apple C, Apple D, Apple E, Apple F). A technique for distinguishing the freshness of apples is likewise included. Subsequent to recognizing the apple type, we use YOLOv3 a deep neural network model to identify the newness of the apple. YOLOv3 is a pre-trained model for picture division. The system utilizes this model for distinguishing the newness of organic products. The result of the framework will be in the structure sound. Here, proposed a superior YOLOv3-based neural network for conceal. The current YOLOv3 is an organization with quick speed and execution as of late. Most observation frameworks utilizing CCD cameras at the same time store pictures from cameras introduced in various areas. In such a climate, the utilization of deep learning requires a technique for identifying objects through a solitary derivation motor in a majority of pictures. In the event that the surmising motor equipment is utilized for every camera channel, the expense of building a reconnaissance framework increments essentially. Hence, in the field of reconnaissance frameworks, an organization structure with a high discovery speed is required regardless of whether the recognition execution is somewhat corrupted. This paper proposes a technique to speed up by lessening the current YOLOv3 network Architecture.53 feature extractors, Darknet-53, is diminished to 24 layers.

Harsh et al. [**20**] have dissected a protected and financial method for identifying natural product freshness in view of size, shape, and variety. Testing of natural products ought to be finished with non-harming techniques in light of the fact that these are extremely delicate things. While natural product estimating, the key actual property is its color, which gives the visual property. The reviewing of organic products depends on investigations, encounters, and through perceptions. The recommended framework uses machine learning strategies to grade the freshness of fruits. 2D fruit depictions are

reviewed on the shape and variety-based breaking down techniques. Perhaps various fruit pictures could have comparable variety, size as well as shape values. In this manner, utilizing variety or shape property examination strategies are not exceptionally compelling to distinguish and separate natural product pictures. Subsequently, the researchers utilized a procedure to expand the accuracy and flawlessness of the fruit freshness identification with the assistance of size, shape, and variety-based strategies with the association of a Convolutional Neural Network (CNN). The recommended framework starts the technique by tapping the fruit's picture. Then, at that point, the picture is moved to the filtration level where the properties like size, shape, and shade of natural product tests are removed. Hereafter, with the utilization of convolutional neural network, the fruit pictures are going through preparing and testing process. In this proposed paper, the convolutional neural network is utilized to draw out the size, shape, and shade of foods grown from the ground and the association of these three elements, the got results are extremely reassuring.

Mukhiddinov et al. [**21**] have studied that classification of fruit and vegetables assumes a fundamental part in the food business. Newness is a major proportion of leafy foods quality that straightforwardly influences the physical well-being and buying inspiration of purchasers. What's more, it is a critical determinant of market cost; in this manner, concentrating on the newness of foods grown from the ground is basic. Inferable from likenesses in variety, surface, and outside ecological changes, like shadows, lighting, and complex foundations, the programmed acknowledgment, and grouping of leafy foods utilizing machine vision is testing. This review presents a profound learning framework for multiclass products of the soil classification in light of a superior YOLOv4 model that initially perceives the article type in a picture prior to group it into one of two classes: new or spoiled. The proposed framework includes the improvement of an enhanced YOLOv4 model, making a picture dataset of products of the soil, information argumentation, and execution assessment. Moreover, the foundation of the proposed model was improved by involving the Mish enactment capability for a more exact and quick location. Contrasted and the past Consequences be damned series, a total exploratory assessment of the proposed strategy can get higher typical accuracy than the first YOLOv4 and YOLOv3 with 50.4 percent, 49.3 percent, and 41.7 percent, separately. The proposed framework has remarkable possibilities for the development of independent also, ongoing products of the soil arrangement framework for the food business and commercial centers that can likewise assist outwardly hindered individuals with picking new food and staying away from food contamination.

2.3.2 Critical Evaluation

A critical evaluation table is a tool used in the literature review to help organize and synthesize information from previous studies and findings related to the research topic. It is a table that lists the studies, authors, and key information and concisely summarizes the study's results, strengths, and limitations.

For the proposed system, critical evaluation will be an essential part of the research process. It evaluates the system's ability to accurately detect and classify fruit freshness levels. Assess the system's precision, recall, and F1 score to measure its effectiveness in differentiating between fresh and spoiled fruit.

Table 2.1 gives a comparison of the app reviewed. The parameters selected for the comparison are listed below:

Table 2.1: Applications Comparison

Features	Applications					
	Fruit Disease Identifier [7]	Apple Disease Detection [8]	Identify Apple Tree Diseases [9]	Plant Disease Identification [10]	PlantVision AI [11]	Proposed System
Machine Learning	✓	✓	✗	✓	✓	✓
Detection based on color	✗	✗	✗	✗	✗	✓
Image Processing	✓	✓	✓	✗	✓	✓
CNN based prediction	✓	✓	✓	✗	✗	✓
Detection based on shape	✗	✗	✗	✗	✗	✓
Real-time Detection	✓	✓	✗	✗	✗	✓

Table 2.2 provides a correlation of the exploration papers evaluated. Despite the fact that there are numerous arrangements accessible, however, the thought behind the proposed arrangement is to consolidate the elements structure of of different arrangements into one so the client can have all offices without going for various methodologies.

Table 2.2: Papers Comparison

Paper	Features	Limitations
Fu et al. [12]	Detection based on color	Not applicable on every color.
Chen et al. [13]	Computer vision based predication.	Not applicable to fruits native to Pakistan.
Shital et al. [14]	CNN based prediction freshness.	Detection based on color
Kumar et al. [15]	Test accuracy 97.14 percent.	Time consuming task
Jayasankar et al. [16]	Detection on the Basis of size.	Need for regular monitoring.
Cheah Ui Shaun. [17]	No hardware included.	Software dependency.
Jayasinghe and Sammani. [18]	Accuracy of 0.989.	Initial cost of equipment.
Kuriakose et al. [19]	YOLOv3 to detect freshness.	Applicable on apple only.
Harsh et al. [20]	Accuracy of 0.93.	Applied on Jonagold apples.
Mukhiddinov et al. [21]	Detects fruits and vegetables.	Lack behind in accuracy.

2.4 Problem Statement

The suggested system will detect the freshness of fruits irrespective of the shape and size which has little to zero effect on the freshness of fruits. This will minimize fruit wastage which is eliminated on the basis of shape and size. Around thirty-six million tons of food is wasted in Pakistan during parties, weddings, and hotels. The global

hunger index has declared Pakistan as one of those countries where an alarming level of hunger exists. United Nations (UN) has released a statement that states that thirty percent of the fruits worth forty-eight billion dollars are wasted yearly.

Fruit wastage contributes about half of the mentioned figure. Thus to eliminate wastage, Fruit Freshness Detection System is introduced to be used in industries to minimize wastage as much as possible. The available solutions are the one that either predicts freshness based on shape and size or is not available for fruits native to Pakistan which are exported worldwide. The fruit Freshness Detection System will be a revolutionary product for businessmen/fruit exporters as their losses will be minimized and with less cost compared to a traditional examination done by human specialists. Therefore, an experimentation plan is proposed to develop a deep-learning model for fruit freshness detection.

2.5 Intended Users of the Product

As we know that transportation and distribution of fruits have to face spoilage and wastage. Such disadvantages can be avoided by continuous monitoring of fresh fruits using the proposed system. The project is very important in the agricultural industry to ensure the freshness of the fruits at a particular time without any error and human specialist supervision. Since the agile model divides the tasks into smaller modules, that is why this particular model is opted for because it will create ease in development. Due to this large numbers of fruits from Pakistan can be checked in a very short span of time and the cost will also be less because there will be no human labor and machine maintenance. Our exporters are in dire need of the project because if shipments of the fruits to other countries are once done and the fruits turn out to be spoiled, then the entire consignment can be rejected. As a result money, hard work, and time all are wasted. As mentioned above, the proposed system will be a game changer in the agricultural industries in identifying tainted and fresh fruit.

Fruit Exporter: Fruit exporters are the main user of the project because the companies have to face losses worth millions every year due to the rejection of sent consignments because of fruits being rotten.

Local Fruit Seller: Local fruit seller can use the suggested product to check the fruits before buying them so that the seller only buys those fruits which are fresh and does not face any loss.

Fruit Buyers: Fruit buyers (general public) can use this product to minimize wastage of fruits and money. Since, the suggest system is easily accessible so can be used anywhere to check the freshness of fruits.

2.6 Software Process Model

Software process models make it simple for developers to sketch out each stage of their projects. In terms of process planning, cost estimation, problem-solving, and team and customer communication, they assist project managers. By using a software process model, everything becomes organized. By applying a software model, it becomes easy to backtrack because one can easily identify from which phase the issue was detected [22].

In the proposed system, a software process model could refer to the systematic framework or representation of the steps involved in developing a software tool or algorithm for detecting fruit freshness. The purpose of the software process model in this context would be to provide a roadmap for the development of the software tool and to ensure that the development process is consistent, repeatable, and predictable.

2.6.1 Introduction

In order to manage a project, the Agile methodology separates it into several phases. Continuous cooperation with stakeholders and improvement at every stage is necessary. Once the job is underway, teams cycle through a process of planning, performing, and evaluating. There must always be continual communication between team members and project stakeholders [23].

The Agile model, also known as Agile software development, is an iterative and flexible approach to project management and software development. With the help of agile methodologies, teams may work more effectively and efficiently while delivering the highest-quality product within the constraints of the budget. Agile teams, however, work well together and can react to changes in the majority of projects more swiftly. Agile teams can improve their capacity for successful collaboration by using visual management to communicate data visually rather than in list form on a spreadsheet or wiki. This makes it easier to handle change and comprehend the nuances of a project. One of the key areas of focus for Agile teams is their ability to work in iterations. During iterative work, which is completed in brief cycles, a tiny portion of the overall project is completed at a time. The main benefit of iterative work is that less work is wasted. That is, when something about the project changes, the amount of rework needed is minimised. In other words, teams won't have to go very far down a particular path before realising that they need to turn back and start from the beginning. One technique to extend the use of iterative work beyond projects is to divide any amount of work into manageable units that are simple to visualise. Figure 2.1 gives a pictorial view of the agile methodology.

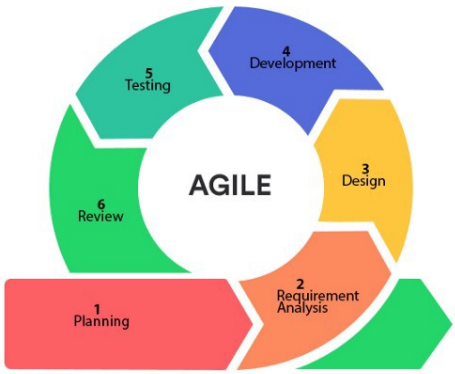

Figure 2.1: Agile Model [24]

2.6.2 Justification

The agile methodology is the main methodology used by the proposed system. Teams can operate more productively and efficiently while providing the highest-quality product

within the parameters of the budget with the aid of agile approaches. Agile teams, on the other hand, get along well and can respond to changes in most projects more quickly. Agile teams can employ visual management to communicate data graphically on a spreadsheet or wiki rather than in list form, which will increase their capacity to successfully cooperate. This makes it simpler to deal with change and understand a project's complexities. Agile teams place a lot of emphasis on their capacity to work in iterations as one of their main focuses. A small percentage of the entire project is finished at a time while working iteratively, which is accomplished in brief cycles. Less work is wasted when working iteratively, which is its main advantage. That is, the amount of rework required is minimized when something about the project changes. To put it another way, teams won't have to travel very far down a certain path before realizing that they need to turn around and start over. By breaking down any amount of labor into small, easily recognizable parts, iterative work can be used outside of projects.

For the proposed system, the agile model is a suitable software development process. This model allows for repeating a sequence of steps, known as iterations until the desired outcome is achieved. The agile model is designed to be flexible and adaptive, accommodating changes and feedback from stakeholders. It provides early and frequent opportunities for stakeholders to review and provide feedback on the software, which helps ensure that the end product meets their needs and expectations. The agile model is well-suited for the fruit freshness detection project because it enables the development team to respond to new requirements or changes in technology and incorporate user feedback into the product design, which is critical for developing a successful software solution for plant pathology. By using the iterative model, the development team can achieve their objectives efficiently while creating a flexible and adaptive system that meets the needs of stakeholders.

2.6.3 Steps

The agile model is a flexible and adaptive software development process that involves repeating a sequence of steps until the desired outcome is achieved. It is designed to accommodate changes and feedback from stakeholders, allowing for a collaborative and continuously improving development process. The steps involved in the agile model include planning, analysis and design, implementation, testing and evaluation, and deployment. The agile model enables the development team to prioritize and manage risks, incorporate user feedback into the product design, and deliver a working version of the software at the end of each iteration.

The agile model is a software development approach that involves building and improving upon a software system through a series of cycles, or iterations. Each iteration begins with the implementation of a small set of requirements and ends with the review and analysis of the completed work. This process is then repeated, with each iteration resulting in an updated version of the software. The agile model differs from traditional software development approaches in that it does not try to fully specify all requirements at the beginning of the project. Instead, it focuses on developing and delivering functional pieces of the software in a series of small, manageable increments. This allows the team to adapt to changing requirements and incorporate feedback from stakeholders as the project progresses.

Sprint 1: The team will define the project goals and objectives. Dataset will be selected and the data will be cleaned using the appropriate techniques. In the end the dataset will be cleansed and normalized.

Sprint 2: The team will be preprocessing the cleansed dataset from previous sprint. The research and identifying relevant datasets for fruit freshness detection are carried out here. Collect and curate the required data, including images and sensor readings. Establish a data pipeline for efficient data handling during the development process.

Sprint 3: It evaluates various machine learning or deep learning models for fruit freshness detection. Select the most suitable model based on performance and requirements. Develop the chosen model architecture, considering factors such as image processing, feature extraction, and classification. Train the model using the preprocessed data and optimize its hyperparameters.

Sprint 4: Model training focus on the development and refinement of machine learning or deep learning models. Many parameters will be taken into action to train the model. The primary objective is to train models using labeled data and optimize their performance.

Sprint 5: Integrate the trained model with the data acquisition component. Develop algorithms for real-time fruit freshness detection using the model and sensor inputs. Implement mechanisms for continuous monitoring and updating of freshness scores. Validate the real-time detection system against a variety of fruits and conditions.

Sprint 6: The teams will design an intuitive user interface for the fruit freshness detection system, and implement the UI components to allow users to interact with the system. Integrate real-time freshness scores and sensor readings into the UI. Develop visualizations and charts to present freshness data effectively.

Sprint 7: First, gather the requirements as per the necessity. During a hardware development sprint, the focus is on designing, prototyping, and refining the physical components of a system or device.

Sprint 8: Prepare the system for deployment, ensuring compatibility with target platforms. Optimize the system for efficiency and performance. Create documentation and user guides for the fruit freshness detection system. Conduct a final review and ensure that all requirements have been met. Deploy the system to the intended environment and provide the necessary support.

2.6.4 High-level Features

High-level features are the key functionalities or capabilities that define the core value and purpose of a software product. They represent the most important aspects of the software from the user's perspective and provide the foundation for the software's design and development [25].

For the Fruit freshness detection system: High-level features are the core functionalities or capabilities that define the purpose and value of the detection system. These features are essential from the user's perspective and form the basis for the system's design and development. Some of the high-level features of the proposed system include:

Responsive design: The application is designed to be responsive and adaptable to different screen sizes and devices, making it easy to use on desktop computers, laptops, and mobile devices.

Fruit image upload: The application allows users to upload images of fruits that are to be classified. Freshness classification: The proposed system uses advanced machine learning algorithms to classify the freshness in the uploaded fruit image, providing accurate and reliable results.

Unlimited usage: Users can use the application for unlimited time, allowing them to classify as many fruit images as they need.

User-friendly interface: The application has a user-friendly interface that is easy to navigate and use, making it accessible to people of all skill levels.

2.6.5 Time Frame

A time frame refers to the length of time or period of time during which a project is scheduled to be completed. It is a critical aspect of project management and helps to define the project's schedule, budget, and resources. The time frame is a key factor in determining the feasibility of a project and establishing realistic expectations for the project's outcomes [26].

The requirements engineering phases that will be used in making this project are shown in 2.3 along with the time needed to carry out each phase. The table shows a timeline of the time needed for the project to complete.

Table 2.3: Time Frame

Phase	Duration
Sprint 1: Data Collection and Cleaning	30 days
Sprint 2: Preprocessed Images	30 days
Sprint 3: Model Selection and Development	30 days
Sprint 4: Model Training	30 days
Sprint 5: Real-Time Fruit Freshness Detection	30 days
Sprint 6: User Interface and Visualization	30 days
Sprint 7: Hardware Development	30 days
Sprint 8: Deployment and Finalization	30 days

2.7 Summary of the chapter

A concise recall or account of the key elements of a written work, activity, or event is known as a summary. Usually, it stays brief and to the point and steers clear of superfluous details. Children can retain key details of a section of literature by using a variety of summarizing approaches. For older kids, having this ability is perfect for helping them prepare for assignments or exams, but it's also a helpful skill that will help them communicate more assuredly and clearly in general.

Chapter 2 includes a variety of different aspects and contains different sections to further explain the work done in the chapter. Firstly, we have chapter overview which gives an insight of what is going to be in the chapter and what to expect from it. Then,

there is background and literature review (which helps view existing solutions) in which the techniques that will be used in the suggested system and all the previous work that has been done in the given topic and what techniques were used and what was the unmet need/requirement in those researches. The suggested system is critically evaluated from the all the previous work and shows what features your system have that existing do not. This helps in further understanding why your system is better than the rest. Problem statement tells us about the issue which motivated the research and how much significant that problem is and what are the consequences being faced because of that problem not being solved and what is the missing part in all of the previous work. Intended users are entities which the suggested system aims to help and who are they exactly and how significant is the solution to them. Software process model is an important part in developing a project as it organises the project and without it the project becomes scrambled. Developing a project with the right process models help in backtracking and maintaining changes when required and identify which part caused the error. Then the used model is defended as to why it is being used instead of other available models and what qualities does the chosen model has that the others do not have. Steps are there to show how the model's steps are being used in the proposed system and its features are listed to further justify the choice of the model. Time frame shows the time duration required to perform each step which includes performing different task in the model.

Chapter 3

Methodology

The methodology section of a research project is a critical component that outlines the approach, methods, and procedures used to carry out the study. This section provides a detailed explanation of the steps taken to answer the research questions and achieve the research objectives. It is crucial to ensure that the methodology is clearly defined and structured to ensure that the research is conducted effectively and efficiently [27].

For the proposed system of fruit freshness detection, the methodology section is essential as it outlines the approach, methods, and procedures that will be used to develop the system. The methodology will involve a systematic approach that includes several stages, starting from literature review to user testing. The first step will be to collect a dataset of fresh and rotten fruit images and preprocess it for machine learning algorithms.

3.1 Chapter Overview

Here, the methodology of the suggested system will be discussed. Before getting into it we should know about research methodology. A research methodology gives research authenticity and gives experimentally sound discoveries. It likewise gives a nitty gritty arrangement that assists with keeping scientists on target, making the interaction smooth, powerful, and reasonable. A specialist's system permits the reader to comprehend the methodology and techniques used to reach conclusions. Research methodology basically alludes to the useful "how" of some random piece of exploration. All the more explicitly, it's about how a researcher deliberately plans a review to guarantee substantial and dependable outcomes that address the examination points and targets.

The methodology involves in the suggested system is the agile method. Agile is the way to manage the work of the project by breaking it up into several phases. First, the system will capture the image of the fruit. the fruit than will pass through a data set that will split the data set into training, testing, and validation set. In data preparation, the data set comprising both fresh and rotten samples was used, which in turn was classified as training and testing data. The next process is training by designing the model that is planned to be used and a list of special parameters, such as the learning level and the number of training epochs. In this process, the accuracy is calculated using a loss function. The chapter includes a flowchart of the proposed system, the architecture of the proposed model, and the sequence diagram.

3.2 Methodology

The suggested system, Gathers a diverse dataset of images representing different types of fruits at various freshness levels. Collect images under controlled conditions, ensuring consistent lighting, background, and camera settings. Include a sufficient number of samples for each freshness category.

The data used in this assessment is natural items new and ruined for the gathering

dataset which is gotten from Kaggle and has been planned by gathering, segregating, and thereafter stamping. The dataset consolidates 10,200 pictures of 3 kinds of organic products with 6 classes of new foods grown from the ground natural product. In this audit, disconnecting the photos by making names into 6 classes. The created model can be utilized as a pre-trained model for the fruits dataset to work on the exhibition. In setting up the information, the public dataset of new and spoiled fruits for the order has been gathered and the dataset has been separated into two sections, in particular training and testing data. The next process is pre-processing information by editing, and resizing the information as needed. The next process is training by planning a model that is wanted to be utilized and a rundown of determined boundaries, for example, the degree of learning and the quantity of preparing epochs. In this cycle, accuracy is determined involving the misfortune function. The restriction for training data is restricted to new apples, new oranges, new bananas, spoiled apples, spoiled oranges, and spoiled bananas so the arranged model can foresee these 6 classes. In testing, the information that has been trained with the CNN model which is planned is saved into a graph with the configuration (.h5) then, at that point, the chart is made into a Programming interface so the application can get to the graph. The application for testing is a web-based application that worked with python cup. The web-based application was picked on the grounds that it tends to be gotten to by means of a cell phone or PC with the assistance of a program. Grouping is accomplished by launching the application and uploading the image. Once the image is uploaded, the application will provide the predicted results in response.

The following is flowchart of the proposed system is shown in the Fig. 3.1.

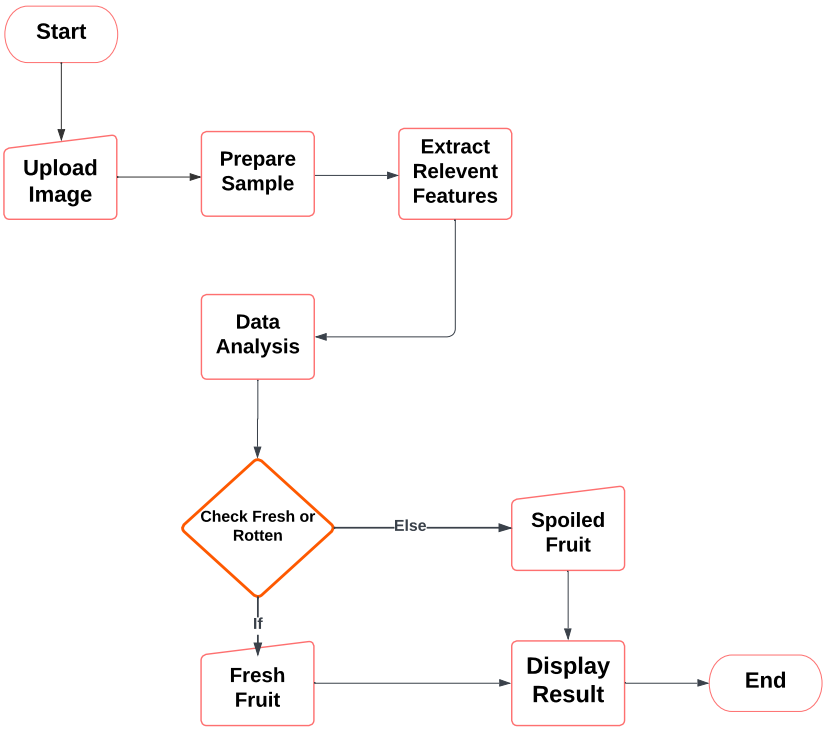

Figure 3.1: Proposed system flowchart

3.3 Proposed Model

The information used in the examination is fruit freshness and spoiled for the grouping dataset which is gotten from Kaggle and has been designed by gathering, isolating, and afterward marking. The dataset incorporates 10,200 pictures of three types of fruit with six classes of fresh fruit and rotten fruit. In this review, isolating the pictures by making names into 6 classes.

The developed model can be utilized as a pre-trained model for fruit dataset analysis in the exhibition. The process begins with gathering a public dataset of fresh and spoiled fruits, which is then divided into training and testing data. The next step involves preprocessing the data by editing and resizing it as required. Training is carried out by designing a desired model and specifying parameters such as learning rate and the number of training epochs. Accuracy is determined by evaluating the loss function during this process. The training data is limited to fresh apples, fresh oranges, fresh bananas, spoiled apples, spoiled oranges, and spoiled bananas, enabling the model to predict these six classes. For testing, the data trained with the designed CNN model is saved as a configuration (.h5) file and converted into API access to the application. The testing application is a web-based application built using Python. This choice was made because it can be accessed via a browser on smartphones or computers. To perform grouping, the user simply opens the application and uploads the image. After the image is uploaded, the application provides the predicted results.

The following is the diagram of the architecture as shown in Fig. 3.2

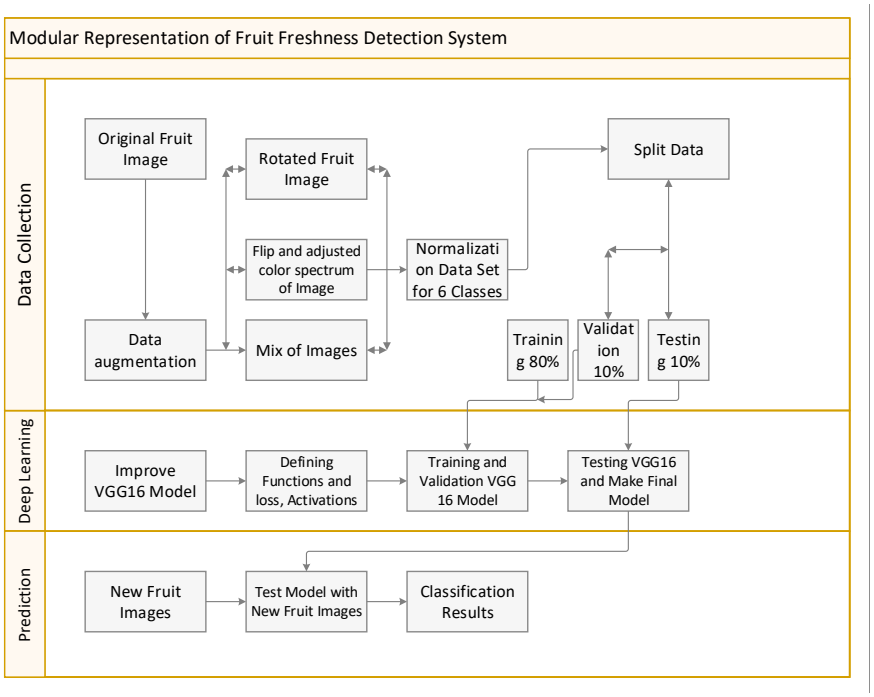

Figure 3.2: The Architecture of the Proposed Model

3.4 Proposed Algorithm

The proposed algorithm refers to the computational procedure or mathematical formula that is being proposed for a specific problem or task. The proposed system is

targeting three types of fruits such as apple, banana and orange. The system will be used by farmers to classify these diseases using machine-learning approaches

The system will use Inception V3. Inception-v3 is a convolutional neural network architecture developed by Google that has succeeded in several image classification tasks. It is based on the concept of inception modules, which are blocks of layers that are designed to extract features from the input using a combination of different sizes and types of filters.

The mathematical equation for an inception module in Inception-v3 can be expressed as:

$$f_i = Conv(x, k_i) + MaxPool(x, k_i)$$

where:

f_i is the output feature map from the inception module. $Conv(x, k_i)$ is the output feature map from a convolutional layer with kernel k_i applied to the input x. $MaxPool(x, k_i)$ is the output feature map from a max pooling layer with kernel k_i applied to the input x.

The proposed algorithm for fruit freshness detection begins by taking an input image of the fruit to be assessed. The image undergoes preprocessing to improve its quality and make it suitable for analysis. Relevant features are then extracted from the preprocessed image, capturing attributes that signify fruit freshness, such as color, texture, and shape. A trained machine learning or deep learning model is employed to predict the freshness level of the fruit based on the extracted features. By setting appropriate thresholds, the predicted freshness level is categorized into classes like fresh, ripe, or spoiled. The algorithm outputs the predicted freshness level, which can be presented through a user interface or stored for further analysis. The algorithm can be refined and improved iteratively through feedback, validation, and updates to the model and feature extraction techniques. It is important to customize the algorithm based on the dataset and specific requirements of the fruit freshness detection system.

The algorithm 1 involves preprocessing an input image, extracting relevant features, and utilizing a trained model to predict the freshness level. By setting appropriate thresholds, the predicted freshness level is categorized, and the algorithm provides the output. Iterative refinement and customization based on the dataset and system requirements are crucial for optimizing the algorithm's performance.

Algorithm 1 Fruit Freshness Detection System

Require: *Basemodel (Input), X (Output)*

```
for each layer in basemodel.layers:
        set layer.trainable to False
        X = Flatten(basemodel.output)
        X = Dense(units=6, activation='sigmoid')(X)
        model = Model(input=basemodel.input, output=X)
        model.compile(optimizer='adam', loss=keras.losses.binarycrossentropy,
        metrics= ['accuracy']) model.summary()

    traindatagen = ImageDataGenerator(featurewisecenter=True,
                rotationrange=0.4,
                widthshiftrange=0.3,
                horizontalflip=True,
                preprocessingfunction= preprocessinput,
                zoomrange=0.4,
                shearrange=0.4)

    traindata = traindatagen.flowfromdirectory(directory="MyFiles",
                targetsize=(150, 150),
                batchsize=64)

    from keras.callbacks import ModelCheckpoint, EarlyStopping
        mc = ModelCheckpoint(filepath="./bestmodel.h5",
                monitor="accuracy",
                verbose=1, savebestonly=True)

        es = EarlyStopping(monitor="accuracy",
                mindelta=0.01,
                patience=5,
                verbose=1)
        cb = [mc, es]

    his = model.fitgenerator(traindata,
        stepsperepoch=10,
        epochs=10,
        callbacks=cb)
```

3.5 Sequence Diagrams

A sequence diagram is a type of UML (Unified Modeling Language) diagram that shows the interactions between objects or components in a system. It is used to describe the flow of messages or events between objects over time and is often used to model the behavior of an object-oriented system. Sequence diagrams are used in software engineering and systems design to document and communicate the design of a system [28].

In proposed system sequence diagram helps to visualize the interactions between objects and provides a clear understanding of how a system works, making it easier to identify potential problems and make improvements. Sequence diagrams are particularly useful for documenting the interactions between objects in real-time systems, such as web applications and interactive software. Figure 3.3 shows the sequence diagram of the proposed system.

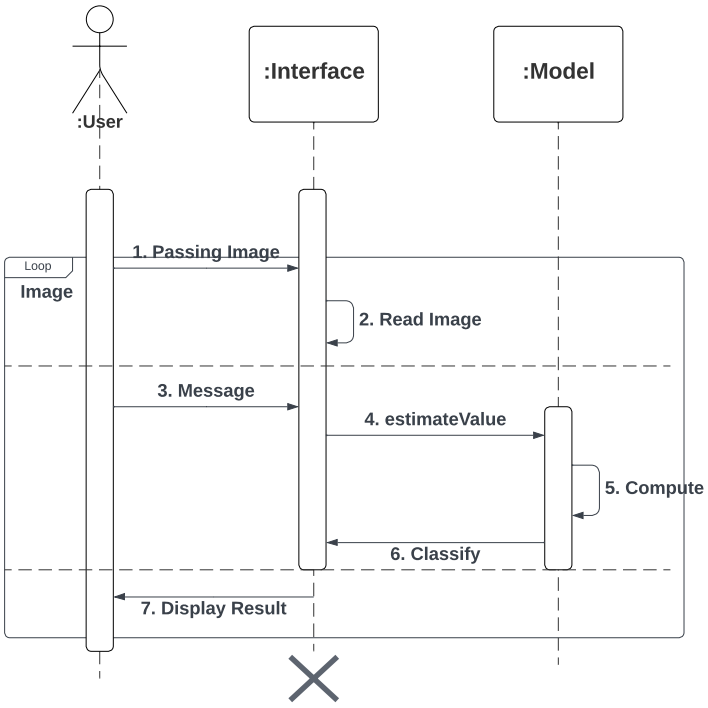

Figure 3.3: Sequence Diagram of The Proposed System

In the sequence diagram for the proposed system, the process begins with the user interacting with the system, whether through a user interface. The user then captures or selects an image of the fruit and uploads it to the system. The system performs preprocessing on the uploaded image, including resizing, normalization, and noise reduction, to prepare it for analysis. Next, relevant features are extracted from the preprocessed image, capturing attributes like color histograms, texture descriptors, or shape characteristics that indicate fruit freshness. Using a trained machine learning or deep learning model, the system predicts the freshness level of the fruit based on the extracted features. The predicted freshness level is then classified into categories such as fresh, ripe, or spoiled, using predefined thresholds or ranges. The system displays or communicates the predicted freshness level to the user through a user interface.

Chapter 4

Interfaces and Physical Design

Interfaces and physical design are two important concepts in software engineering. Interfaces define the way objects or components communicate with each other, while physical design refers to the arrangement of software components on a hardware platform. Interfaces specify the methods, inputs, and outputs of an object or component, and are an important aspect of software design as they allow different parts of a system to work together seamlessly [29,30].

They define the contract between two components and ensure that the components can interact with each other without introducing bugs or errors into the system. Physical design, on the other hand, deals with the placement and organization of software components on the hardware platform. It involves the selection of hardware components, such as servers and storage devices, and the design of the network architecture to ensure that the system can operate efficiently and reliably.

The level of human contact and interaction in a device is the user interface (UI). This can include desktop displays, keyboards, mouse, and other pointing devices. It also refers to the manner in which a user engages with a website or application. Through contrasting graphics, simple design, and responsiveness, a well-done user interface allows successful interaction between the individual and the system, app, or machine.

4.1 User Interfaces

A user interface (UI) is the part of a software application that allows users to interact with the system. It is the bridge between the user and the software, providing users with a visual and intuitive way to access and manipulate the system's functions and data. The design of a user interface is crucial for the success of a software application as it directly affects the user's experience and satisfaction. A well-designed UI should be intuitive, efficient, and visually appealing, providing users with a clear and straightforward way to accomplish their tasks [31].

There are various types of user interfaces, including graphical user interfaces (GUIs), command-line interfaces (CLIs), and web-based interfaces. GUIs are the most commonly used type of UI and are characterized by visual elements, such as windows, buttons, and icons, that allow users to interact with the system using a mouse and keyboard.

Figure 4.1 shows the main mobile screen, here the user can see the appearance of the application. Users can see the application and can get access by just tapping on it.

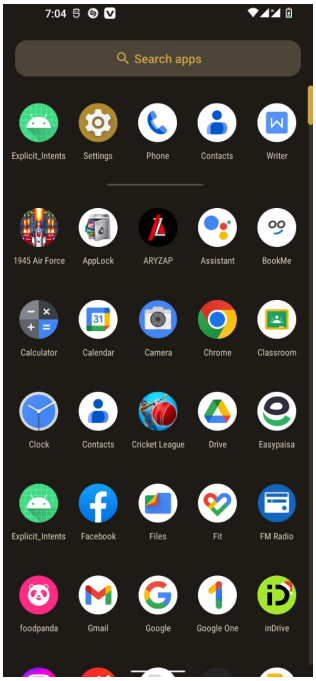

Figure 4.1: Main Mobile Screen

Figure 4.2 is the home interface. This is the interface user sees before signing in. An introduction to the system is given on it. In order to perform classification and other actions the user must upload an image. Home and About can be used to navigate the page. The home page interface is the first page a user sees when they visit a website or application. It serves as the starting point for users to navigate the site and access its various features and services. A well-designed home page interface should be visually appealing, easy to navigate, and provide users with a clear understanding of what the site or application offers.

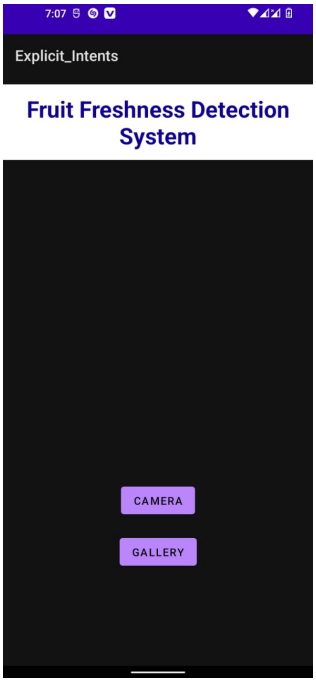

Figure 4.2: Home Screen

Figure 4.3 shows the camera screen, When the user clicks on the camera option the user can get access to the camera to capture a picture of the specific fruit. The camera would allow users to take a picture of the fruit they want to test. The screen could include instructions on how to position the fruit in the frame and a button to capture the image.

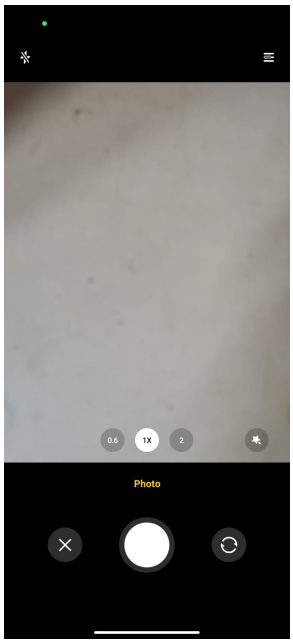

Figure 4.3: Camera Screen

Figure 4.4 shows the gallery screen, when the user clicks on the gallery option the user can access the gallery from which the user can upload a picture of the specific fruit. The gallery screen would allow users to take a picture of the fruit they want to test from the gallery.

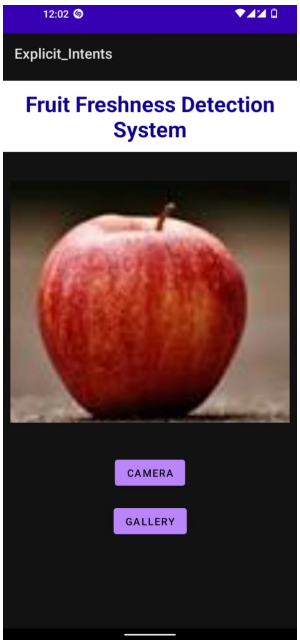

Figure 4.4: Gallery Screen

Figure 4.5 shows the output screen. The output screen of the proposed system provides

visual feedback and information about the freshness of the scanned fruit. It serves as the user interface for interacting with the system and understanding the freshness assessment results. The output screen typically displays information such as classified as rotten or fresh and confidence.

Figure 4.5: Output Screen

4.2 User Tables

A user table is a data set table that stores information well-defined for the clients of a framework. User tables are utilized to deal with the verification and approval of clients inside a framework. User tables are ordinarily made and overseen by information base chairmen utilizing SQL. User tables store data, for example, client names, passwords, and other individual subtleties [32].

In the suggested model, the system does not use a database. The system will process the data in real-time and provide output without the need to store the data long-term.

Chapter 5

Evaluation and Results

Evaluation and results are crucial components of any software development project. Evaluation is the process of measuring the performance and effectiveness of the software, while results refer to the outcome of the evaluation process [33].

Evaluation is conducted to determine if the software meets the requirements and expectations set out in the project plan. It involves testing the software to verify that it functions correctly and that it provides the desired level of performance. The results of the evaluation process provide important feedback on the strengths and weaknesses of the software and can be used to make improvements or modifications to the software.

5.1 Overview

Convolutional neural networks (CNNs) are a type of deep learning model that is particularly effective for image recognition and classification tasks. They are called "convolutional" because they use convolutional layers, which apply a convolution operation to the input data. These layers are designed to automatically learn spatial hierarchies of features from the input data, which makes them well-suited for image recognition tasks [34]

The evaluation process involves conducting experiments on a set of fruit samples with varying levels of freshness, using the fruit freshness detection system to classify them, and comparing the results with the actual freshness levels of the samples. The methodology used for evaluation should be clearly described, including details such as the equipment and software used, the number and types of fruit samples tested, and the conditions under which the tests were conducted. The dataset used for testing the system should also be described in this chapter, including details such as the dataset's source, the number and types of fruit samples included, and any pre-processing steps taken to prepare the dataset for testing.

Performance metrics used to assess the system's accuracy in detecting fruit freshness may include metrics such as accuracy, precision, recall, and F1-score. These metrics will be used to evaluate the performance of the system on the test dataset, and the results will be presented in the form of tables and graphs.

The results chapter will also include a discussion of the findings, highlighting the strengths and weaknesses of the fruit freshness detection system. This discussion will also consider any limitations of the study and potential areas for future research. Overall, the evaluation and results chapter of a fruit freshness detection system project is critical in demonstrating the effectiveness of the system in accurately detecting fruit freshness and providing valuable insights into its performance .

5.2 Experimental Setup

An experimental setup refers to the detailed description of the experimental procedures and protocols used to conduct a scientific experiment or study. It typically includes information on the materials, equipment, and methods used, as well as any controls, variables, or parameters that were tested or measured. The experimental setup is a crucial part of the project because it allows other researchers to understand and replicate the experiment. By providing detailed information on the experimental setup, researchers can ensure that their findings are valid and reliable. Additionally, the experimental setup can also be used to troubleshoot any issues or problems that may have arisen during the experiment [35].

The proposed model is The experimental setup for a fruit freshness detection system project that typically involves the following steps:

The first step is to collect a dataset of fruit samples with varying levels of freshness. This dataset can be collected from local markets or grocery stores. Ensure that the dataset is diverse and includes a range of fruit types and levels of freshness. Once the dataset has been collected, it needs to be cleaned and prepared for testing. This may involve removing any defective or damaged fruit samples, as well as labeling each sample with its corresponding freshness level. The equipment and software used for the experiment are critical. A digital camera or a smartphone camera can be used to capture images of the fruit samples, and image processing software like OpenCV can be used for image analysis. The fruit samples need to be arranged on a flat surface, and multiple images of each sample should be captured from different angles and under different lighting conditions.

The captured images need to be pre-processed before analysis. This can include operations such as noise reduction, color correction, and image enhancement. Once the images are pre-processed, features need to be extracted that can be used to train the machine learning model. This can include texture features, color features, and shape features. Model Training: The extracted features are used to train a machine learning model using an appropriate algorithm such as a support vector machine (SVM) or convolutional neural network (CNN). After the model is trained, it needs to be tested on a separate set of images that were not used for training. This helps to evaluate the accuracy of the model in detecting the freshness of the fruit samples. Finally, the performance of the fruit freshness detection system is evaluated using performance metrics such as accuracy, precision, recall, and F1-score. Table 5.1 summarises the parameters used in the suggested model and experimentation along with the set values.

Table 5.1: Model Parameters

Model Parameters	**Value**
Epochs	30
Dataset	12000 Pictures
Activation Function	Sigmoid
Learning Rate	Default
Shear Range	0.4
Horizontal Flip	True

Continued on next page

Table 5.1 – *Continued from previous page*

Model Parameters	**Value**
Rotation Range	0.4 %
Width Shift Range	0.3 %
Target Size	256,256
Batch Size	65
Steps per Epoch	10
Execution time	25 min

5.2.1 Dataset

A dataset is a collection of data that is treated by a computer as a single unit. This indicates that although a dataset consists of a large number of distinct pieces of data, it can be used to train an algorithm with the intention of locating observable patterns throughout the dataset as a whole [36,37].

In the suggested model, the dataset is extracted from Kaggle which contains approximately 12,000 pictures. The pictures are classified into six classes i.e. Fresh Apple, Fresh Banana, Fresh Orange, Rotten Apple, Rotten Banana, and Rotten Orange. Table 5.2 summarises the dataset used in the suggested model and experimentation along with the set values.

Table 5.2: Dataset

Dataset	**Value**
Fresh Apple	1465
Fresh Banana	1465
Fresh Orange	1465
Rotten Apple	1465
Rotten Banana	1465
Rotten Orange	1465

5.3 Experimental Evaluation

Experimental evaluation is a research methodology used to determine the effectiveness or impact of an intervention or treatment under controlled conditions. It involves designing and conducting experiments in which one or more variables are manipulated while holding all other factors constant, to determine their effect on the outcome of interest [38].

In an experimental evaluation, a hypothesis is developed and tested through the manipulation of the independent variable, with the dependent variable being measured before and after the intervention. The results are then analyzed to determine whether the intervention had a significant effect on the dependent variable, and to what extent.

The experimental evaluation of a fruit freshness detection system involves several steps.

The first step would be to clearly define the objective of the project. In this case, the objective would be to evaluate the effectiveness of the fruit freshness detection system

in accurately detecting the freshness of fruits. The next step would be to define the experimental setup. This would involve identifying the fruits to be used in the experiment, the sensors and other hardware to be used, the conditions under which the fruits would be stored, and the criteria for determining freshness. The next step would be to conduct the experiment. The fruits would be stored under different conditions, and the sensors would be used to detect their freshness. The results would be recorded, and statistical analysis would be performed to determine the accuracy of the system. The results of the experiment would be analyzed to determine the accuracy of the fruit freshness detection system. This would involve comparing the readings from the sensors with the criteria for freshness and calculating the accuracy, precision, and other metrics. Based on the analysis of the results, conclusions would be drawn about the effectiveness of the fruit freshness detection system. This would involve identifying the strengths and weaknesses of the system, determining areas for improvement, and making recommendations for future research. Finally, the findings of the experiment would be reported in a formal report or presentation. The report would include a description of the experimental setup, the results of the experiment, the analysis of the results, and the conclusions and recommendations.

5.3.1 F1 Score

The F1 score is a common evaluation metric used in machine learning for binary classification tasks. It is the harmonic mean of precision and recall, two metrics that evaluate the performance of a classification model [39].

In the suggested system, the F1 score is used to measure how well the system is able to correctly classify fruits as fresh or not fresh. The F1 score takes into account both precision and recall, which are metrics that measure how accurate and complete the system's classifications are, respectively. Fig.5.1 shows the F1 score of the proposed system.

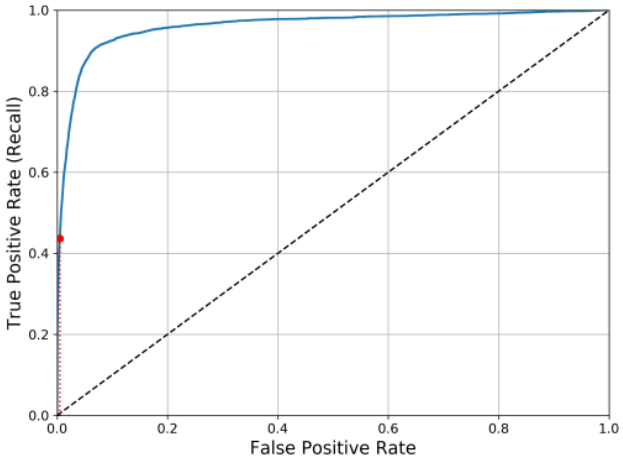

Figure 5.1: F1 Score of the Model

5.3.2 Accuracy

Accuracy is a commonly used evaluation metric in machine learning that measures the overall correctness of a model's predictions. It calculates the percentage of correctly classified instances out of the total number of instances in the dataset. It is evident from the model in Fig.5.2 that the accuracy of the suggested system is 95 Percent. Accuracy in fruit freshness detection system refers to the degree to which the system can correctly identify the freshness level of fruits. In order to determine accuracy, the system's readings are compared to a set of pre-determined freshness criteria or standards [40].

The accuracy of a fruit freshness detection system can be evaluated using statistical measures such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and receiver operating characteristic (ROC) curves. These measures are used to evaluate the system's ability to correctly identify true positive (fresh fruits) and true negative (spoiled fruits) samples, as well as false positive and false negative results. Figure 5.2 show the accuracy of the model.

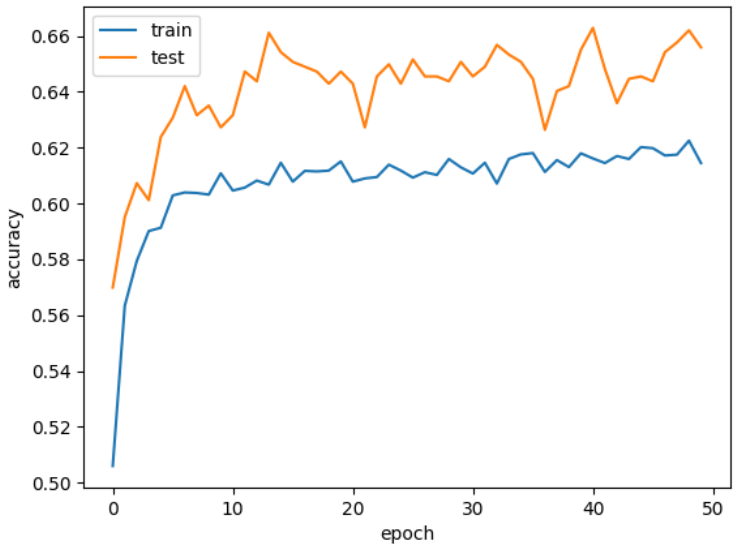

Figure 5.2: Accuracy of the Model

5.3.3 Precision

Precision refers to the ability of the system to produce consistent and reliable results. In other words, if the system were to measure the freshness of a fruit multiple times, it would produce similar results each time [41].

Achieving precision in the suggested system requires careful calibration of the sensors used to collect data, as well as the algorithms used to analyze the data. The system would need to be designed to minimize measurement errors and account for any variability in the fruit's physical and chemical properties. To ensure precision, the system could be calibrated using a set of known fresh and spoiled fruits, with their corresponding freshness levels. The system could then be tested and adjusted until it consistently produces accurate and reliable results.

5.3.4 Loss Function

A loss function, also known as a cost function or objective function, is used to quantify the discrepancy between the predicted output of a model and the true target values. It measures how well the model is performing in terms of minimizing errors or maximizing accuracy. In the system, loss refers to the discrepancy between the predicted freshness labels generated by the system and the true freshness labels of the fruits in the dataset. The goal of the system is to minimize this loss, which is typically achieved by adjusting the parameters of the model during the training process [42].

During training, the model updates its parameters based on the gradients of the loss function with respect to the parameters. The optimization process aims to minimize the loss function over the training set, resulting in a model that can accurately classify the freshness of new fruits that it has not seen before. The loss function is a crucial component of the system, as it provides a quantitative measure of the model's performance and guides the optimization process to improve the accuracy of the system. as shown in Fig. 5.3.

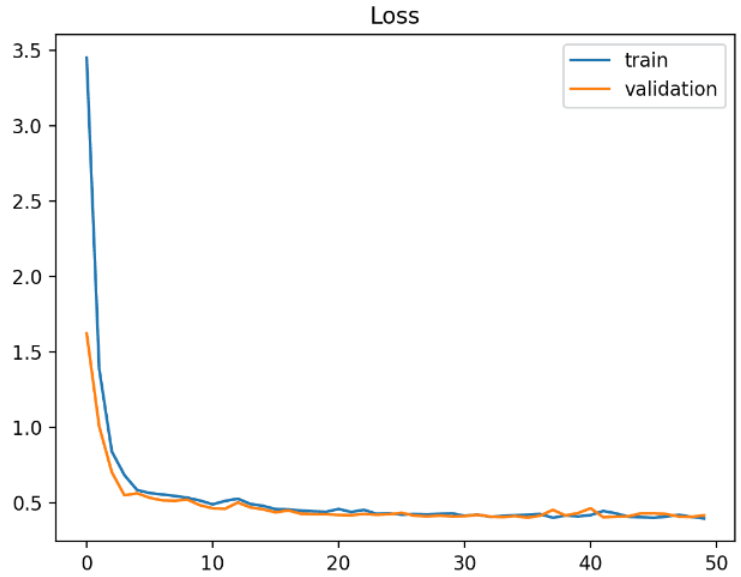

Figure 5.3: Loss Function

5.4 Summary

The evaluation and results chapter is critical for determining the effectiveness and accuracy of the system in detecting the freshness of fruits. Through experimental evaluation, the project team can test the system's ability to accurately measure and detect freshness based on predefined criteria. In this chapter, the project team will report on the experimental setup, data collection process, analysis of the results, and conclusions drawn from the findings. The accuracy and reliability of the system will be evaluated using statistical measures and compared to pre-established standards. The results of the evaluation and testing will provide insights into the strengths and weaknesses of the fruit freshness detection system, identify areas for improvement, and provide recommendations for future research.

Chapter 6

Conclusion and Future Work

6.1 Conclusion

The fruit freshness detection system is an innovative solution that aims to provide an accurate and reliable method of assessing the freshness of fruits. By combining advanced imaging technology with machine learning algorithms, this system can analyze various physical properties of fruits to determine their freshness level. This system has the potential to revolutionize the fruit industry by enabling farmers and distributors to ensure that only fresh and high-quality fruits are delivered to consumers. Moreover, the system can be further developed and expanded to include additional features such as scalability, expanded fruit types, mobile applications, and environmental factors. The fruit freshness detection system is a valuable tool that utilizes technology to assess the quality and freshness of fruits. By employing various sensors, image processing techniques, and machine learning algorithms, this system can accurately determine the freshness level of fruits based on their physical characteristics such as color, texture, and aroma.

The implementation of a fruit freshness detection system brings numerous benefits. Firstly, it enables fruit suppliers, distributors, and retailers to ensure that only fresh and high-quality fruits reach consumers, reducing waste and enhancing customer satisfaction. The system provides an objective and consistent measure of fruit freshness, eliminating subjective judgments and human error.

Moreover, the fruit freshness detection system plays a crucial role in food safety. It can detect signs of spoilage, decay, or contamination in fruits, helping to prevent the consumption of potentially harmful or unsafe products. This contributes to maintaining public health and reducing the risk of foodborne illnesses. The integration of this system into the fruit supply chain also improves overall efficiency. Automating the fruit quality assessment process saves time and resources compared to manual inspection methods. Additionally, the system enables real-time monitoring, allowing prompt action to be taken when freshness issues are detected, such as adjusting storage conditions or initiating faster delivery.

However, it is important to acknowledge that the fruit freshness detection system may have limitations. Factors like variations in fruit types, ripeness stages, and external conditions can affect the accuracy of freshness assessments. Continuous refinement and calibration of the system are necessary to ensure reliable results across different scenarios. Furthermore, this system can also help reduce food waste by detecting fruits that are about to spoil and removing them from the supply chain. Overall, the fruit freshness detection system is a promising technology that has the potential to benefit both the fruit industry and consumers alike.

6.2 Future Work

Future work refers to the potential areas of research that could be pursued in the future based on the findings and limitations of the current study. It typically includes suggestions for further research, which may include new hypotheses, research questions, or experimental designs that could help to expand upon or refine the findings of the current study. Future work is an important component of a research paper, as it highlights the potential for further investigation and discovery in a particular field. By identifying areas for future research, authors can help to guide and inspire other researchers who may be interested in pursuing similar topics or questions. Future work can also help to build upon the existing literature and contribute to the development of new theories or approaches within a particular field.

In the future, the development of fruit freshness detection systems can focus on several areas of improvement. One key aspect is enhancing the accuracy and precision of the freshness detection algorithms. This can involve researching and implementing advanced machine learning or deep learning techniques, incorporating diverse datasets, and refining feature extraction and classification methods. Additionally, integrating advanced sensors such as hyperspectral or multispectral imaging can enable more detailed and accurate assessments of fruit freshness by capturing additional spectral information. Real-time monitoring and feedback mechanisms can be developed to continuously assess freshness levels, provide immediate feedback, and enable timely interventions to maintain or enhance fruit quality.

The project fruit freshness detection system has great potential for future development and expansion. Here are a few possible avenues for future work:

- Enhance accuracy: One potential area of future work is to improve the accuracy of the system. This could involve testing the system on a larger dataset, refining the algorithms used for image processing and analysis, or incorporating additional features that can help to detect freshness more accurately.
- Increase scalability: Another area of future work is to increase the scalability of the system. This could involve developing a more efficient hardware platform that can process images faster, or creating a cloud-based system that can handle large volumes of data and support multiple users.
- Expand to other fruits: The current system is designed to detect the freshness of specific types of fruits, but it could be expanded to include other types of fruits as well. This could involve training the system on additional datasets or developing new algorithms to detect freshness in different types of fruits.
- Develop a mobile application: Another potential area of future work is to develop a mobile application that can be used by consumers to determine the freshness of fruits they purchase. This could involve developing a user-friendly interface that integrates with the existing system or developing a separate system specifically for consumers.
- Incorporate environmental factors: Finally, the system could be expanded to take into account environmental factors that can impact the freshness of fruits. This could involve integrating sensors to measure temperature and humidity.

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