Detection of Artificially and Naturally Ripened Bananas

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A Project Report on

DETECTION OF ARTIFICIALLY AND NATURALLY RIPENED BANANAS.

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A Report submitted to MIT Academy of Engineering, Alandi(D), Pune, An Autonomous Institute Affiliated to Savitribai Phule Pune University in partial fulfillment of the requirements of

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CERTIFICATE

It is hereby certified that the work which is being presented in the BTECH Project Report entitled **"DETECTION OF ARTIFICIALLY AND NATURALLY RIPENED BANANAS."**, in partial fulfillment of the requirements for the award of the Bachelor of Technology in Electronics Engg.and submitted to the **School of Electrical Engineering** of **MIT Academy of Engineering, Alandi(D), Pune, Affiliated to Savitribai Phule Pune University (SPPU), Pune**, is an authentic record of work carried out during Academic Year **2022–2023**, under the supervision of **Mrs. Vinaya Tapkir**, **School of Electrical Engineering**

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DECLARATION

We the undersigned solemnly declare that the project report is based on our own work carried out during the course of our study under the supervision of **Mrs. Vinaya Tapkir**.

We assert the statements made and conclusions drawn are an outcome of our project work. We further certify that

1. The work contained in the report is original and has been done by us under the general supervision of our supervisor.
2. The work has not been submitted to any other Institution for any other degree/diploma/certificate in this Institute/University or any other Institute/University of India or abroad.
3. We have followed the guidelines provided by the Institute in writing the report.
4. Whenever we have used materials (data, theoretical analysis, and text) from other sources, we have given due credit to them in the text of the report and giving their details in the references.

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Abstract

India produced 99.07 million metric tons of fruits according to the National Horticulture Board in 2019-2020. For a country like India which is reliant heavily on its agriculture produce and export, the quality of fruits and the authenticity of their ripening are very important. Ripening is highly coordinated irreversible phenomenon which Artificial aids in transportation, packaging, and overall appeal to the costumer which increases sales. However, artificially ripened bananas are induced with chemicals which have hazardous effect on the human body and can prove threatening to the health of an individual. Hence a consumer-friendly method needs to be introduced and explored to distinguish between naturally ripened bananas from the artificially ripened bananas. The system to be explored must be relatively simpler than the existing laboratory methods and should be available on the user's mobile device. The aim of the system should be introducing an efficient, time consuming, userfriendly and low complexity system for the reliable differentiation of artificial bananas from the ripened ones.

Acknowledgment

We want to express our gratitude towards our respected project guide Mrs. Vinaya Tapkir for their constant encouragement and valuable guidance during the completion of this project work. We also want to express our gratitude towards respected School Dean Dr. Dipti Sakhare for her continuous encouragement. We would be failing in our duty if we do not thank all the other staff and faculty members for their experienced advice and evergreen co-operation.

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Chapter 1

Introduction

1.1 Background

One of the most important factors that most people are concerned about today is their health. Individuals consume a lot of fruits, which are higher in nutrition and help people stay active, to maintain their health. However, these fruits are now ripened artificially by using chemicals like calcium carbide as a ripening agent, which may even be carcinogenic.

When utilised for the ripening process, unsaturated hydrocarbons like ethylene and acetylene encourage ripening and cause colour changes in fruits. Calcium carbide may increase the quantity of chemicals required for fruit ripening if used on very unripe fruit. It may also make the fruit bland, unhealthy, and extremely toxic. Customers must be cautious when purchasing fruits and look out for those that have been artificially ripened in order to avoid these negative consequences. With human eye observation, it is difficult to identify fruits that have been artificially ripened. We have created a tool that employs image processing to discover the fruits that have been artificially ripened to help with detection. The suggested device receives an input image of a banana that is being tested, compares the features (histogram values) with one that has ripened naturally, and identifies fruits that have been artificially ripened. This technique use a smartphone running an Android application, which does visual processing to identify fruits that have been artificially ripened.

Figure 1.1: Difference between artificially ripened and naturally ripened bananas

An elective procedure that has been connected to address the issue of limited hub lifetime is the utilization of energy gathering. Energy collecting alludes to bridling energy from the earth or other energy sources (body warm, foot strike, finger strokes) and changing over it to electrical energy. The outfit electrical energy controls the sensor hubs. Further, in light of the periodicity and size of have stable energy, framework parameters of a hub can be tuned to expand hub and system execution. Therefore, energy collecting systems can possibly address the trade off between execution parameters what's more, lifetime of sensor hubs. The test lies in assessing the periodicity and greatness of the have stable source and choosing which parameters to tune and all the while maintaining a strategic distance from untimely energy exhaustion before the following revive cycle.

In detection processing the taken image using MATLAB and distinguished the artificial ripened fruits from the naturally ripened fruits using a histogram threshold value. The proposed system thus makes usage of the Smartphone which runs android application that is installed in it and the image processing is executed to detect the artificially ripened fruits. MATLAB was used for detection processing, and a histogram threshold value was used to differentiate between artificially and naturally ripened fruits. The suggested system therefore makes use of the smartphone, which is equipped with an Android application, and to identify the fruits that have been artificially ripened, image processing is carried out.

1.2 Project Idea

A consumer-friendly method needs to be introduced and explored to distinguish between naturally ripened bananas from the artificially ripened bananas. The system to be explored must be relatively simpler than the existing laboratory methods and should be available on the user's mobile device. The aim of the system should be introducing an efficient, time consuming, userfriendly and low complexity system for the reliable differentiation of artificial bananas from the ripened ones.

1.3 Motivation

The basic aim of this project is that the artificial ripening fruits are extremely harmful to human being and continuous consumption of these kinds of fruits will even lead to extremely harmful diseases like cancer. Thus, this method helps out the users to stay healthy and consume fruits which are nutritious by avoiding the intake of artificially ripened fruits which are ripened with the chemical like calcium carbide. The project identifies the fruits ripened by artificial means and keep people healthy by intake of these healthy fruits. The project aims in developing an application for detecting the artificially ripened and naturally ripened fruits. There is an urgent need for the detection of artificially ripened banana to safe guard the genuine farmers. If the proposed method and design is implemented practically, it is a great tool and big boon to the farmers, traders and scientific community.

1.4 Project Challenges

1. Collecting number of different banana samples.

2. Lack of dataset of bananas.

3. Difficulty in identifying ripening stages for bananas which leads to problems in image processing operations.

1.5 Proposed Solution

We have created a tool that employs image processing to discover the fruits that have been artificially ripened to help with detection. The suggested device receives an input image of a mango that is being tested, compares the features (histogram values) with one that has ripened naturally, and identifies fruits that have been artificially ripened. MATLAB was used for detection processing, and a histogram threshold value was used to differentiate between artificially and naturally ripened fruits. Thus, the proposed method takes use of a smartphone that runs an installed Android application and uses image processing to identify fruits that have been artificially ripened.

1.6 Major Contribution

Providing an approach in the detection of artificial ripening fruits using image processing. We aim to propose a method which does not require chemical processes or physical handling of fruits to find the ripening procedure they have underwent. We also introduce a new aspect in image processing by using physical exterior appearances to determine temperature and heat points of a given fruit which can be used to predict what the interior state of the fruit will be.

1.7 Project Report Organization (Chapter wise summary)

Chapter 1: Chapter one encompasses the introduction, the motives and the goals we have placed in mind while beginning the construction of this project. It gives a brief introduction to why the project has been chosen and the problem which it aims to overcome. This chapter encapsulates the starting fundamentals we have kept in mind while embarking tith the project. This chapter also discusses the challenges we face and the solutions we aim to propose while going further with the project. Lastly, it gives a detail on the major contributions. Chapter 2: This chapter shows the literature review that has been done to gather more and more information about the project. This firstly discusses the state of art work, that is the latest work done in the project. We also mention the synopsis of the various journals and paper published in this field of work and aim to draw some inspiration from them. We also put forth the discussions we have after this research work was done. Then we aim to gather a direction on how this project will fare in future. We also discuss the shortcoming we face in this research and the constraints we might enocunter as we move forward in the concluding remarks.

Chapter 2

Literature Review

2.1 Related work And State of the Art (Latest work)

[1] "Multi Spectral imaging to detect artificially ripened bananas: A comprehensive empirical study" by Narayan Vetrekar, Raghuvendra Ramchandra, Kiran B. Raja, R.S. Gaud in 2019 International Conference on Intelligent Computing and Control (I2C2), IEEE2019. Abstract—Although naturally ripened fruits contain critical nutrients, artificial fruit ripening has become more common in recent years due to rising consumer demand and consumer benefits. Artificial ripening lowers fruit quality greatly as compared to natural ripening while also raising health hazards. A common ripening agent is Calcium Carbide (CaC2), which is well known for its carcinogenic effects. We provide a multi-spectral imaging strategy in this study to acquire the spatial and spectral eight narrow spectrum bands over VIS and NIR wavelength range in order to detect the artificially ripened banana. This approach takes into account the significance of the problem. We introduced our newly created multi-spectral pictures collection for naturally and artificially ripened banana samples to present this study. The broad set of experimental results calculated on our sizable database of 5760 banana samples further shows the significance of applying multi-spectral imaging to identify artificially ripened fruits with classification accuracy of 94.66% on average. Artificial ripening, multi-spectral imaging, fusion, feature extraction, and classification are some index terms. [2] M. Adeyemi, M. Bawa, and

B. Muktar, "Evaluation of the effect of calcium carbide on induce ripening of banana, pawpaw and mango cultivated within kaduna metropolis, nigeria"," 2018. Abstract - TIn this study, calcium carbide was given to 12 samples of banana, mango, and pawpaw at three different concentrations (1 g/kg, 5 g/kg, and 10 g/kg of calcium carbide per kilogramme of fruit) and as a control (0 g/kg) in order to assess the effects of calcium carbide as a fruit ripening agent. The results showed that among all the fruits (mango, banana, and pawpaw at 10 g/kg), calcium carbide is a very effective ripening agent with a ripening time of 2 days (48 hours). The moisture, vitamin C, and protein contents of the fruits showed that calcium carbide administration results in reduction of these nutrients, while the administration of calcium carbide resulted in increased of ash, fibre and lipids in the fruits studied. These results showed that even though calcium carbide may have significant fruit ripening ability, it also causes significant reduction in the fruit nutrients for the Kaduna populace. Keywords: Banana, Calcium carbide, Fruits, Mango, Pawpaw.According to the proximate analysis of the fruits, the administration of calcium carbide may increase some food contents like ash B3 (10 g/kg) 9.48%, fibre M3 (10 g/kg) 2.4%, and lipid B3 (10 g/kg) 8.8% while decreasing others like moisture M3 (10 g/kg) 78.34%, vitamin C M1 (10 g/kg) 50.14%, protein M2 (5 g/kg) 3.76%, and carbohydrate P1 (1 g/kg) 44.96% were found to decrease with increased calcium carbide administration. [3] "Identification of Artificially Ripened Fruits Using Smart Phones" by Dr. S. Maheswaran in 2017 International Conference on Intelligent Computing and Control (I2C2), IEEE2017. Abstract -One of the most important factors that most people are concerned about today is their health. Individuals consume a lot of fruits, which are higher in nutrition and help people stay active, to maintain their health. Consuming fruits consistently is believed to reduce the risk of developing chronic diseases and give a number of health advantages. The nutrients that fruits give are essential for the body's optimal maintenance. However, these fruits are now ripened artificially by using chemicals like calcium carbide as a ripening agent, which may even be carcinogenic. An essential piece of information that is shown on television during the mango season is that the fruit stores sell fruits that have been artificially ripened, which are very dangerous to your health. The significant information that was highlighted in the news concerned the artificial ripening of mangoes using calcium carbide. Chemically ripened fruits are overrunning the market despite repeated warnings, raids, and seizures. Health experts claim that eating mangoes that have been ripened using calcium carbide causes a number of negative side effects, including nausea, diarrhoea, stomach and throat ulcers, overall weakness, and occasionally irreversible eye damage and breathing difficultiesConsumers must be cautious when purchasing mangoes and look out for those that have been artificially ripened in order to avoid such negative consequences. With human eye observation, it is difficult to identify fruits that have been artificially ripened. We have created a tool that employs image processing to discover the mangoes that have been artificially ripened to help with detection. The suggested device receives an input image of a mango that is being tested, compares the features (histogram values) with one that has ripened naturally, and identifies fruits that have been artificially ripened. This technique use a smartphone running an Android application, which does visual processing to identify fruits that have been artificially ripened. The proposed technology has a 91 percent accuracy rate for identifying fruits that have been artificially ripened. [4] Dadwal, Meenu, and V. K. Banga. (2012) "Color Image Segmentation for Fruit Ripeness Detection: A Review." 2nd International Conference on Electrical, Electronics and Civil Engineering (ICEECE'2012), Singapore]. Abstract - In this essay, we discuss many methods for determining the rate of maturity in fruits and vegetables. The techniques covered in this work include histogram matching, clustering algorithm-based picture segmentation, and relative parameter value-based segmentation. Fruits and vegetables of various colours are used as input data for each procedure. With these methods, we establish some threshold levels. The maturity level of the provided fruits and vegetables can be determined by comparing the input data image with these threshold values. [5] M. B.S., S. Shinde, K. Bhavsar, A. Chowdhury, S. Mukhopadhyay, K. Gupta, B. Bhowmick, and S. Kimbahune, "Non-destructive method to detect artificially ripened banana using hyper spectral sensing and rgb imaging," in Proc. SPIE 10665, Sensing for Agriculture and Food Quality and Safety X, vol. 10665, May 2018. Abstract - The most natural type of basic nutrients for humans is provided by fruits. They ripen naturally the best. However, technology has made it possible for fruits to ripen quickly and have a longer shelf life. Artificial ripening could be identified using complex techniques like laboratory chemical analysis or professional eye assessment, which may not always be practical. The banana is the fruit that people consume the most of everywhere in the globe. Banana adulteration can be extremely harmful to large populations. It is estimated that carcinogens like calcium carbide may be used to ripen bananas (CaC2). The classification of naturally and artificially ripened bananas using spectral and RGB data is what we propose and create in this research. Our findings demonstrate that we can get up to 90% accuracy utilising a Deep Learning (Neural Network) on RGB data. Additionally, we may get accuracy rates of up to 98.74 percent and 89.49 percent, respectively, utilising Random Forest and Multilayer Perceptron (MLP) feed forward Neural Networks as classifiers on spectral data. [6] M. N. Islam, M. Y. Imtiaz, S. S. Alam, F. Nowshad, S. A. Shadman, and M. S. Khan, "Artificial ripening on banana (musa spp.) samples: Analyzing ripening agents and change in nutritional parameters," Cogent Food Agriculture, vol. 4, no. 1, p. 1477232, 2018. Abstract - Artificial fruit ripening agents have gained popularity in recent years, largely for commercial reasons. It has been stated that several ripening agents are employed to start the ripening process in fruits during the off-seasons. However, further research is needed to completely understand how these chemicals affect the nutritional content of fruits. The nutritional value of fruits that have been ripened naturally and artificially will be measured, analysed, and compared in this study. Bari-1 hybrid banana (Musa Spp.; local name: Sagor Kola) was chosen to carry out the experimental study.Samples that were at full ripeness were taken straight from the markets or orchards. Additionally, unripe green samples were gathered and artificially ripened in the lab using ethylene glycol, calcium carbide, and kerosene stove smoke as artificial ripening agents. For these banana samples, various nutritional characteristics including moisture content, total titratable acidity, vitamin C concentration, and sugar level were evaluated. In order to evaluate and contrast the assessed parameters of naturally and artificially ripened fruits, as well as to identify any changes in their nutritional values and related health risks associated with them.Additionally, the chemical make-up of artificial ripening agents was examined, and potential health hazards associated with ripening agent impurities were evaluated. In order to help consumers, nutritionists, doctors, and other shareholders, the primary goal of this study is to address the changes in nutritional values and health hazards connected with the artificial ripening. Food Laws & Regulations, Fruit & Vegetables, Nutrition, Food Additives & Ingredients, Food Analysis Keywords: Calcium carbide, ethylene glycol, kerosene fume, artificial fruit ripening [7] “Determination of Ripeness and Grading of Tomato using Image Analysis on Raspberry Pi” by Ruchita R. Mhaski in 2015 International Conference on Communication, Control and Intelligent Systems (CCIS), 978-1-4673-7541-2/15/$31.00 it 2015 IEEE. Abstract - The market for fruits and vegetables is the topic of choice. Therefore, it is crucial that providers label the quality of their products before dispensing them. Although some commercially accessible fruit sorting and grading systems have been established, the small and medium fruit processing industries find them to be nearly too expensive. Currently, human specialists rate agricultural products based on attributes that are based on vision, which results in accuracy, consistency, and efficiency issues when determining the quality of agricultural products. In this essay, we will evaluate the tomato's quality based on its size, shape, and level of maturity. The form and size of the tomato are estimated using an edge detection technique, and the level of ripeness is determined using a colour detection algorithm. These algorithms have all been implemented on the Raspberry Pi development board, making for an autonomous and economical system. Conveyor belt, motors, a Pi camera, and a Raspberry Pi development board are all part of our system. The above instruments will all be interfaced, creating a cost-effective embedded system for determining tomato shape, size, and degree of ripeness. Other fruits and vegetables can also be prepared using the same approach. [8] Asif, Mohammad. (2012) ”Physico-chemical properties and toxic effect of fruit-ripening agent calcium carbide.” Annals of tropical medicine and public health Vol.5.No.3 pp 150. Abstract - RThe fruit changes colour, softens, and develops the flavour, texture, and scent that make up ideal eating quality during the final stage of maturation, known as ripening. The purpose of this study was to examine the hazardous consequences on human health of using subpar calcium carbide to ripen crops for home markets. Calcium carbide, acetylene, ethylene, propylene, ethrel (2-chloroethyl phosphonic acid), glycol, ethanol, and a few more substances are among the regularly used ripening agents. One of the most widely utilised ripening agents for fruits is calcium carbide, but local fruit companies also use calcium salts such calcium ammonium nitrate, calcium chloride, and calcium sulphate to postpone fruit ripening.Due to the potential health risks, the usage of calcium carbide is being discouraged worldwide. Because calcium carbide includes quantities of arsenic and phosphorus and creates acetylene gas when dissolved in water, treating food with it is exceedingly dangerous. The effects of arsenic, phosphorus, and acetylene gas on various human organs can result in a variety of health issues, including headache, vertigo, mood swings, fatigue, mental disorientation, memory loss, cerebral edoema, seizures, and chronic hypoxia. Thresholding is the technique used to distinguish foreground pixels from background pixels. The Otsu's method, put out by Nobuyuki Otsu, is one of the various methods for obtaining optimal thresholding. The threshold value where the weighted variance between the foreground and background pixels is the least is found using Otsu's variance-based method. The important thing is to measure the distribution of background and foreground pixels while iterating over all conceivable threshold settings. Locate the threshold at which the dispersion is the smallest. The algorithm iteratively seeks the threshold that reduces the within-class variance, which is determined by the weighted sum of the variances for the two classes (background and foreground). Grayscale typically has hues between 0-255. (0-1 in case of float). Therefore, if we select a threshold of 100, all pixels with values below 100 form the image's background, while all pixels with values at or above 100 become its foreground. The formula for finding the within-class variance at any threshold t is given by:

$$\sigma^2(t) = \omega_{bg}(t)\sigma^2_{bg}(t) + \omega_{fg}(t)\sigma^2_{fg}(t) \tag{2.1}$$

2.2 Limitation of State of the Art techniques

If we were to propose to create an application which can be uses image processing to detect various heat intensity points and then determine the ripening procedure, we have to consider the wide range of irregularities we are prone to get in our results. This state of the art method, normally used in MATLAB functions to calculate the threshold of the system, is mathematically ideal to our using conditions, however it is not completely reliable. Therefore, we propose to add yet another deterministic parameter which will help in ripening detection. This is the mean pixel intensity value. The Otsu's method which is the current state of the art, also has some downsides to it which is the underwhelming precision results in heavy noise, problems with performing in object with small sizes, in-homogeneous lighting and larger intra-class than inter class variance.

2.3 Discussion and future direction

Resizing, reshaping and filtering operations can be done as the initial step when taking the fruit under testing which would ensure uniformity between the samples taken as standard values and also for the samples under testing. Multiple object detection should be added for identifying multiple samples in the bunch of banana samples. This offers efficiency for the users and also does not interfere with segmentation and processing of a single sample. The most effective method would be to introduce machine learning and feature detection. One of the methods would be to take a large number of naturally ripened and artificially ripened bananas and plot them on the scale which has image processing intensity parameters. With this data we can use KNN classification to differentiate naturally ripened and artificially ripened bananas. CNN and SVM methods offer a reliable and low error detection and determination of extracted features from the given samples. Hence the accuracy of prediction increases and the system is less prone to false triggering and failed detection.

2.4 Concluding Remarks

After going through the current state of art and analysing the different journals and papers that have been published regarding this topic, we can fairly assess the objectives in our hand regarding image processing and its application in ripening detection. The intensive work gone through the similar technology that we have been working on has mainly been on perfecting the segmentation operations and establishing a machine learning model which can closely predict the ripening given the evidences based on image processing. However the algorithms that have been used in direct deployment in apps, gives us several downsides in accuracy. Thus we have to come up with a solution which provides an additional parameter of differentiation.

Chapter 3

Problem Definition and Scope

3.1 Problem statement

To design a system for detection of artificially and naturally ripened bananas from a given sample.

3.2 Goals and Objectives

1. To build an application using MATLAB which performs image processing to differentiate between an artificially or naturally ripened bananas .

2. To build a user friendly system for the detection application .

3. To build an automatic system which continuously takes different samples and points out the artificially ripened bananas.

4. To make the detection system less complex and easily accessible.

3.3 Scope and Major Constraints

Scope of the project is to introduce a new method of detection of ripening procedure which can be done by users with basic technology like their mobile phone. It aims to provide an non-physical and non-chemical method of ripening detection by the means of forming patterns and inferences from their outward appearance and texture. Major constraints: The work on the field of ripening detection using image processing has been fairly untouched and hence finding determining factors for ripening differences fairly on the basis of imaging is quite challenging. The image processing algorithms and tools are also not quite yet advanced to provide high precision in finding values like threshold and pixel intensities. Various factors might affect the accuracy of image processing values like the ripening stage they are under, lighting conditions, the image resolution of the users mobile phone and the miscibility of the background with the sample in detection. We aim to work and provide improvements to overcome the major constrains.

3.4 Hardware and Software Requirements

1. MATLAB tool for image processing.
2. End device with camera.
3. Visual studio code and Jupyter notebook.

3.5 Expected Outcomes

The expected outcomes are that a program be first developed and run for establishing a data set which takes mathematical operation of variance and deviation to detect an artificial or naturally ripened bananas, after its image processing values are extracted. A data-set be formed with these values which would be used to develop a Machine learning model for enhanced prediction and accuracy values.

Chapter 4

System Requirement Specification

4.1 Overall Description

A user device which has above par resolution and graphics tolerance capabilities. A boot-able device which incorporates different environments and lets a.mlapp or .apk file to function. A stream hosting capability, however not a necessity, but provides supports to the build of the application. The product is aimed to be a user friendly application which can be shareable to either an android device or a windows device which has a working and above par level of image resolution. The camera should be integrated and permissions be allowed for the application to take images and perform operations on them.

4.1.1 Product Perspective

The product is developed with a motive of being very less complex and user friendly. It should work with minimum to none adjustments and settings needed in the phone to optimize the working of the application. It should also take into consider the different resolutions of the images and segment the image in image processing algorithms on the code simultaneously.

4.1.2 Product Function

The product is developed to determine the ripening procedure it was underwent by using image processing and other algorithms to give the user a final result whether the fruit is naturally ripened or artificially ripened.

4.1.3 User Characteristics

The user range is widespread and limitless. The concerned user who has to determine whether the fruit they have purchased or about to purchase is ripened by artificial harmful methods which can be toxic to the body, can use the application for a better judgement in their decision. Also, wholesalers and dealers, supermarkets and stores can also use the product to provide better and safer services to the consumers.

4.2 Specific Requirements

A camera with a resolutions of the newest compatible android specifications for users using android application for the detection system is important and significant in attaining more accurate values.

4.2.1 User Requirements

The product is developed by keeping in mind that it is very less complex and very easy to use and understand for casual user of mobile phones or laptop devices. Hence the user requirements are little to none for this product.

4.2.2 External Interface Requirements

The user end device may require external libraries and interface requirements like python, java, c, c++. No function specific libraries be needed for the application.

4.2.3 Functional Requirements

The project is integrated with python libraries hence the device which shall be used to run the application be integrated with python compatibility and be capable of hosting python related programs and

4.2.4 Performance Requirement

An updated version of android going further above from android version 9 is recommended for the android users. For functioning in windows, windows 7 and above is satisfactory however version of windows 10 and above is considered optimal. MATLAB version from MATLAB 2020 and upwards is required for the development of MATLAB apps.

4.3 Project Planning

Categories banana samples (artificially ripened bananas and naturally ripened bananas) using image processing. The image processing based method to differentiate between naturally and artificially ripened fruits involve feature extraction from segmented gray image of bananas followed by feature analysis of the coefficients of KNN Algorithm. To extract the identical area from banana bunches; a uniform portion of the image was segmented from the whole image. From this segmented gray scale image of bananas, different imaging features are extracted in spatial and in KNN Algorithm. These features are analyses to find the discriminatory behavior between the different categories of bananas.

Chapter 5

Methodology

5.1 System Architecture

We first take a look at the block diagram which shows the flow of the functionality process of the MATLAB programs through which we further develop the application. The digital camera captures fixed resolution images of the fruit under testing. These images are transferred to an external peripheral device where image processing and further computation are done. The MATLAB tool performs basic image processing operation and the intensity points are plotted to a matrix which can be then expressed as an histogram. Histogram depicts the varying intensity level of the captured image through different data points. We can identify the regions of higher intensity and lower intensity and find the threshold value. After comparison statement in coding, we can yield the final output which concludes if the banana is artificially ripened or naturally ripened.

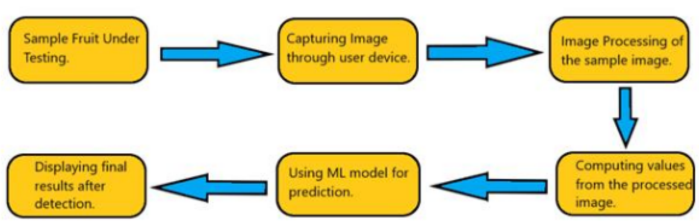

Figure 5.1: block diagram.

5.2 Mathematical Modeling

The segmentation was carried out using the CIELAB colour space scale. CIELAB being a three dimensional scale, closely depicts the range of entire human vision. It is based on the opponent colour model where red and green form an opponent pair and blue and yellow form an opponent pair. The L* dimension is for perceptual lightness, a* and b* dimensions are for unique colours of human vision. The dimension of perceptual lightness helps in narrowing out concentrated colours and brighter spots. By adjusting the colour space values, the darker spots are also segmented out of the image. Thresholding is the technique used to distinguish foreground pixels from background pixels. The Otsu's method, put out by Nobuyuki Otsu, is one of the various methods for obtaining optimal thresholding. The threshold value where the weighted variance between the foreground and background pixels is the least is found using Otsu's variance-based method. The important thing is to measure the distribution of background and foreground pixels while iterating over all conceivable threshold settings. Locate the threshold at which the dispersion is the smallest. The algorithm iteratively seeks the threshold that reduces the within-class variance, which is determined by the weighted sum of the variances for the two classes (background and foreground). Grayscale typically has hues between 0-255. (0-1 in case of float). Therefore, if we select a threshold of 100, all pixels with values below 100 form the image's background, while all pixels with values at or above 100 become its foreground. The formula for finding the within-class variance at any threshold t is given by:

$$\sigma^2(t) = \omega_{bg}(t)\sigma^2_{bg}(t) + \omega_{fg}(t)\sigma^2_{fg}(t) \tag{5.1}$$

where bg(t) and fg(t) represents the probability of number of pixels for each class at threshold t and 2 represents the variance of color values. To understand what this probability means, Let, P(all) be the total count of pixels in an image, PBG(t) be the count of background pixels at threshold t, PFG(t) be the count of foreground pixels at threshold t.

5.3 Objective Function

For the initial testing based on intensity differences, another parameter we would like to take into consideration in determining the varied intensity values in naturally ripened and artificially ripened bananas is the mean pixel value. It is simply put, the mean of all the values the pixels hold. For a grey-scale image, the pixel values are binary. Calculating the overall mean of the image would yield an intensity measure which is instrumental in finding the higher intensity or luminescent image in inspection. The higher would be the mean pixel value, higher would be the intensity of the image. The lower the mean of the image, it implies it has dark spots and irregularities on the peel of the banana and more brownish spots, which are of course, the characteristics of a naturally ripened banana. Yet again following the same procedure for a numerous banana samples, and performing statistical operations, a standard limit for the comparison for banana under testing could be established and then compared to yield a result. The emphasis on irregularities in colour and texture of a naturally ripened banana holds the basis of these differentiation which we carry out by these two parameters: threshold and mean pixel intensity values.

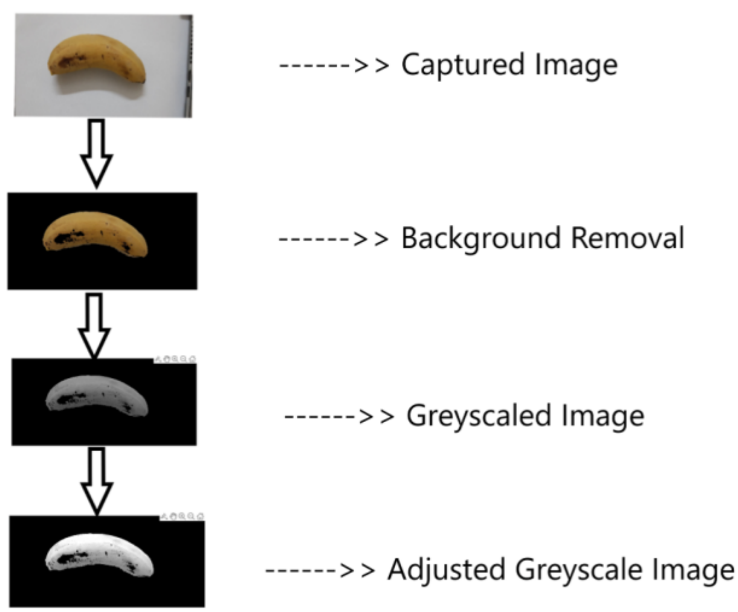

Figure 5.2: Image Processing Stages.

5.4 Approach/Algorithms

For a fruit under testing, the most initial step is capturing of the image which then can be processed to yield desirable values.

1.The image capturing does have varied values on the RGB graph depending on the environment the image is captured, analyzing the captured image under such circumstances might give is inconsistent results. For a proper calculation and finding the desired values, the captured image need to be processed for further processed.

2. A captured image from a digital camera has varying RGB values i.e., a three-dimensional tonal spreading in histogram. The combination of colors which yield yellow color in even consistency on the RGB scale is difficult to decipher and even harder to use for input values. Artificial bananas have a higher consistency of yellow on its peel and the natural banana has uneven consistency on the peel with bumps and darker spots which vary the RGB graph values only by the slightest. A further step of image processing is done which converts the image into grey-scale.

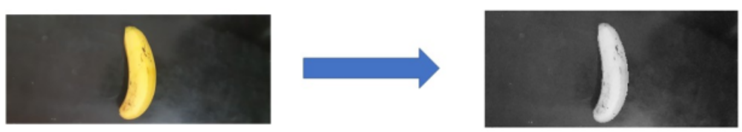

Figure 5.3: RGB to Greyscale.

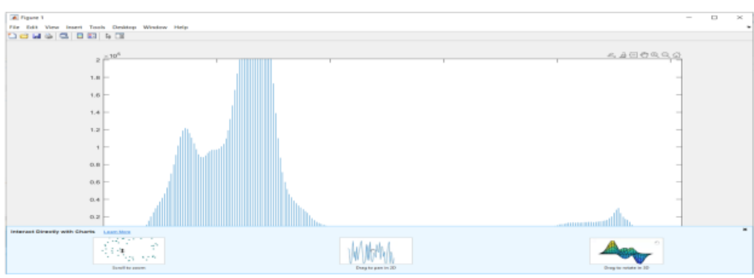

Figure 5.4: Histogram Computation.

3. The analysis and computation of values can be further simplified by converting the captured image in greyscale. The higher intensity points yield a brighter shade of white and the less intense point yield a darker shade. The RGB image values depicts a three dimensional tonal spreading. Converting into the grey-scale image format,

the tonal spreading is two-dimensional and hence the saturation on the histogram can be used to depict the consistency of the color and also compare the intensity of the acquired image histogram. The pixels takes values according to the comparison with the threshold values. The threshold is decided by the Otsu's method. Any intensity values is compared with the threshold values and the final pixel values is assigned as per the comparison with threshold. If the intensity values exceeds the threshold then the pixel is given a brighter shade of white.

4. Hence the overall computation of histogram values and in turn the threshold can be simplified by Grey-scale conversion. We can observe the tonal spreading on the histogram for consistency in the colors and saturation of the intensity values.

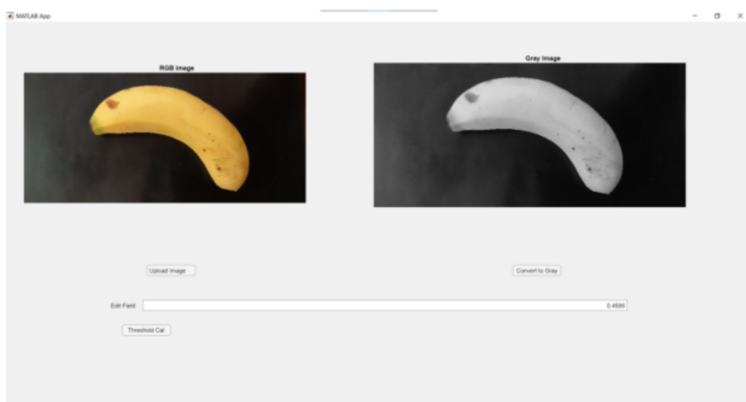

Figure 5.5: Computation of threshold

5. Then we proceed to develop the machine learning algorithms of these values. The dataset can be formed by considering the two parameters which are:- 1. Image Thresholding and 2. Mean Pixel Intensity values. The dataset formed by these can be used to put in a Machine Learning Algorithm which then can be used to integrate the data into an user friendly environment. To establish the Machine learning algorithm to be used, we have tried and tested various algorithms whose output of accuracy, precision and f1 score are as follows.

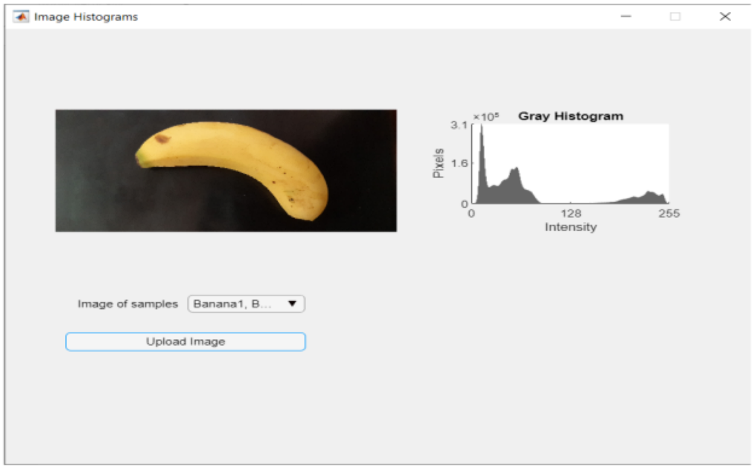

Figure 5.6: Histogram Values

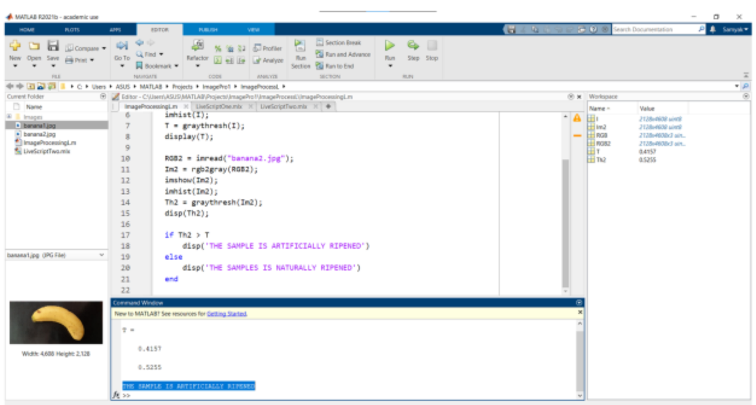

Figure 5.7: Histogram Values

Algorithm	Accuracy(%)	Precision	Recall
KNN	87	0.7	0.73
Logistic Regression	78	0.62	0.65
SVM	80	0.67	0.68

Chapter 6

Implementation

6.1 System Implementation

The system is first implemented using MATLAB app designer. Here we begin by building the basic functionality of taking the images from a certain directory of the users choice. In this particular function, we began by allowing the users to select images from their device. The obtained image would then undergo image processing operations, which then can find us optimal parameters after performing segmentation. The other functionality which we intend to add is capturing the image by camera which is the user-friendly and the most efficient way of detection. Here we integrate the camera of the device and obtain the image from the camera and fit it into our resolutions.

6.2 Experiment/Implementation Parameters

We have chosen two defining parameters for our applications. Various image processing parameters offer properties which can be used to differentiate on the basis of heat detection and intensity detection of an image which can henceforth be used to detect the temperature and external qualities of peel of the banana. The parameters we have gone for are :- 1.Image threshold and 2. Mean Pixel Intensity

1. Image Threshold:- Thresholding is basically an effective way of partitioning an

image, based on its characteristics. It is widely used to separate the foreground from the background. The threshold process is used in our particular application for a purpose which would help us obtain the intensity of the image. In the Otsu's method that we discussed, the threshold of the image can be also used to determine when the pixel would change colours in grey-scale in accordance to the RGB scale. A high intensity i.e. a picture with high amount of brightness would be considered white if it surpasses the threshold of the image. For an image under inspection, the threshold of the image would determine the intensity of the fruit based on what the threshold value yields. This would mean that images with higher threshold values will yield greater intensity which can then show us the consistency in the physical features of the objects. The artificial ripened fruits, from our understanding and literature survey, yield more consistent values of physical features. Therefore Image threshold for a large amount of data taken into consideration can be taken into consideration as our implementation parameter.

2. Mean Pixel Intensity:- Pixel intensity is considered an important parameter when it comes to find the intensity of an image under inspection. Therefore, the use of mean pixel intensity over a body of processed greyscale image is taken to be an important factor in determining the intensity and hence distinguish between natural and artificially ripened bananas. The mean pixel intensity or pixel intensity is on a surface just the brightness of a particular pixel, therefore, we can see many possibilities of obtaining temperature and heat points through the pixel intensity of the image. Taking the overall mean of the intensity of the image can give us a measure of total "brightness" or a very reliable measure of excess heat points in the image which is instrumental in finding the artificial ripened banana. This also shows us how consistent the outer peel of the fruit would be therefore the cosmetic features of the image would be obtained giving us a satisfactory measure for distinguishing images based on their ripening procedure.

6.3 User Interface

The first user interface is made by taking the images from the directory and using them for ripening detection. This provides option for taking images from the directory and using the mathematical and algorithms, then computes the ripening process of the sample. The initial design, like our goals, is very simple and easy to access. This provides user-friendly experience.

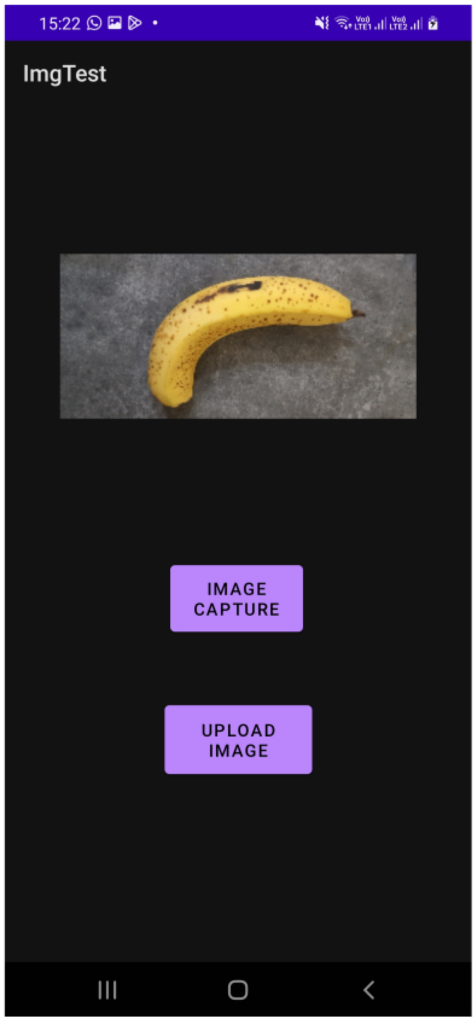

Figure 6.1: User App interface

6.4 Data Description

The basic app design was made in MATLAB software for app designer. The file generated is a .mlapp file which can be made shareable via packaging and full filling compatibility requirements. The image format is jpeg usually however different image formats can be used like jpeg, jpg, png, bmp, etc. The dataset is created by taking multiple entries of samples and recording them in a dataset. This dataset can be used to develop and build the Machine learning mdoel algorithm which predicts the ripeness of the given banana sample.

6.5 Functional Implementation

Coding in MATLAB environment for the beginning of the testing and segmentation process were done. The program developed in the MATLAB environment can then be packaged and its required files be compiled to make a shareable app. This design is integrated with the Machine learning algorithms to achieve accuracy. Below is the code of functional implementation of MATLAB program.

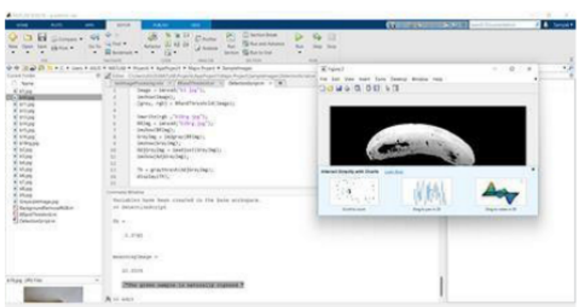

Figure 6.2: funtional implementation

6.6 Output

The output of the system should yield whether the given sample is naturally ripened or artificially ripened. The output of these can be represented through the initial design we had developed using the Graphical user interface on the MATLAB developed app.

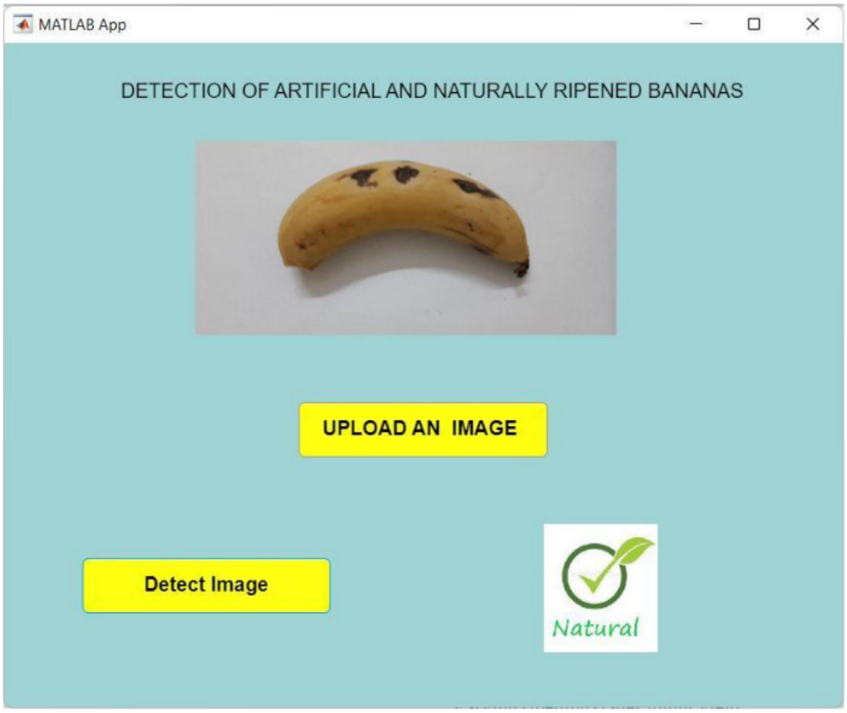

Figure 6.3: GUI output for naturally ripened banana

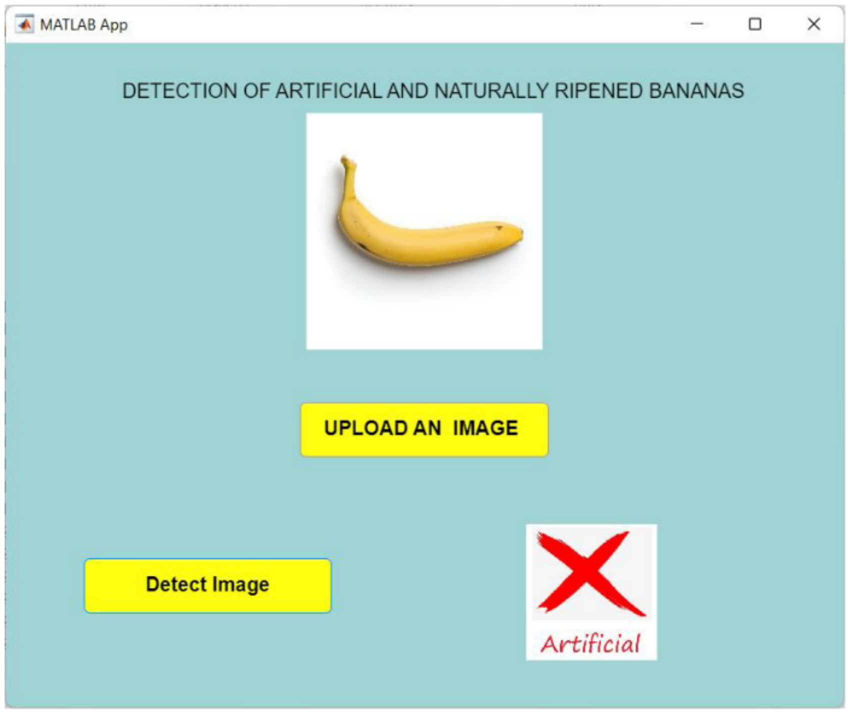

Figure 6.4: Output for artificially ripened banana

```
Th =

    0.3745          <<<----- Threshold Value
                    Calculation.

meanGrayImage =

   30.3509           <<<------ Mean Pixel Intensity
                     Calculation.
    "The given sample is naturally ripened "
```

Figure 6.5: Output after basic threshold detection

Chapter 7

Result Analysis/Performance Evaluation

7.1 Result Analysis of Objective

Initial testing under as low as 16 samples, we use the MATLAB processing and computation to form a set of grey- scale threshold and mean intensity values and tabulate it to perform further statistical operations that establish a limit to compare with a random sample under testing. With the given data, we can perform statistical operation that will help in finding the standard limits and range for the mean pixel intensity and threshold values. The drawback of the given dataset is that itholds only 16 samples which is far less for computation of accurate and reliable standard values. The mean of all the mean pixel intensity values for the 16 samples given is = 31.4855 . The standard deviation of Mean pixel intensity for the 16 samples given is = 1.6088. Similarly, the mean of threshold values for the given 16 samples comes out to be 0.3755. And the standard deviation of the threshold values for the given 16 samples comes out to be 0.001414. For the working using a very constrained sample size for the initial design and testing, we can use these statistical value for computing limits and range for comparison for the new data under testing. For the initial testing based on intensity differences, another parameter we would like to take into consideration in determining the varied intensity values in naturally ripened and artificially ripened bananas is the mean pixel value. It is simply put, the mean of all the values the pixels hold. For a grey-scale image, the pixel values are binary. Calculating the overall mean of the image would yield an intensity measure which is instrumental in finding the higher intensity or luminescent image in inspection. The higher would be the mean pixel value, higher would be the intensity of the image. The lower the mean of the image, it implies it has dark spots and irregularities on the peel of the banana and more brownish spots, which are of course, the characteristics of a naturally ripened banana. Yet again following the same procedure for a numerous banana samples, and performing statistical operations, a standard limit for the comparison for banana under testing could be established and then compared to yield a result. Deploying the steps mentioned above for a given MATLAB code and observing it for a set of samples we can note the parametric values of Mean pixel intensity and grey threshold calculation. We can observe the workflow of the system we intend to develop to detect the ripening of the fruits. First, we began by taking the sample under question by two of the methods. The two different methods that we have proposed in the system are taking the real time picture of the sample via user device camera and the second one being to upload the image file from teh directory of the user. Let us consider first, capturing an image from the user device:- The user camera in their end device, i.e. a mobile or laptop must be permitted and integrated with the program in order for the camera to capture images. In the depiction in Figure 7.1, we have used the MATLAB app to provide the user with the option of using the camera for instant and efficient detection of ripeness stage. The user has to click on 'capture image' option and a camera window opens which turns on the webcam (as is the case for laptop run apps) and we have installed a momentary delay of ten seconds which then snapshots the image and runs it for further image processing and machine learning algorithms.

The next step is if we click on the option for capturing image, the app would turn on the camera of the laptop and a window pops out which garners the live feed for about ten seconds, then captures the image of the sample, as shown in Figure 7.2. This method was adopted to increase the pace of the process and yield the outcome as quickly as possible. The captured image then gets displayed on the window and

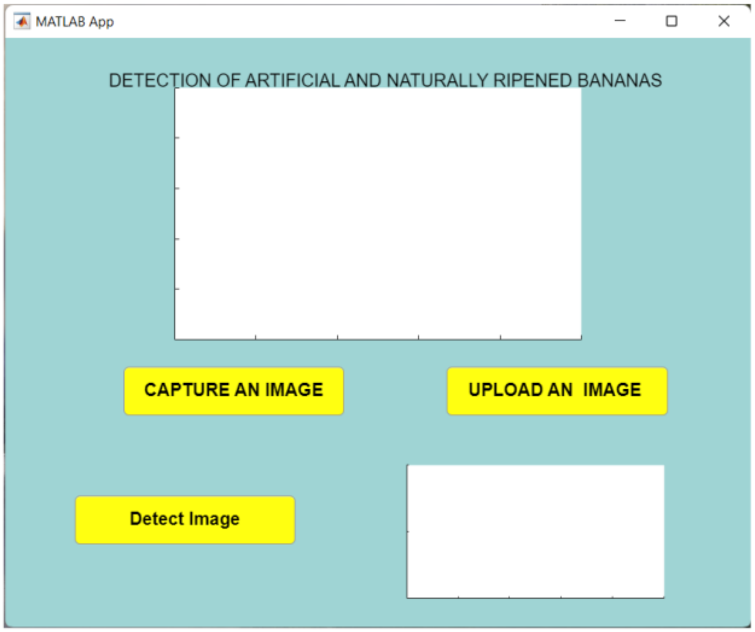

Figure 7.1: The interface for MATLAB app

if the user is satisfied with the image, he can proceed with the detection process by clicking on the detect button or could re-click on the button and run the process of capturing again.

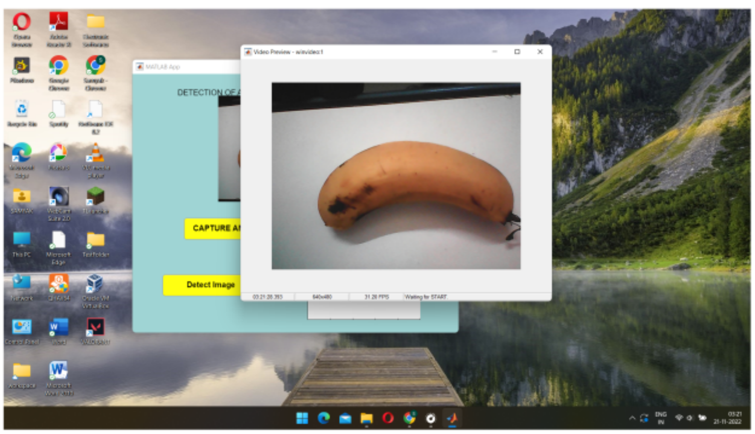

Figure 7.2: Camera opening window to capture the Natural sample)

Now we can use the 'detect' which will callback the function that has two major units in its code. The first one being the image processing operations. The image processing program will have the first step of segmenting the image in different forms and then passing the image for grey scale conversion. In the next process, the RGB image would be turned to grey scale. This grey-scaled image is then enhanced and its histogram values adjusted to yield a better toned histogram. The threshold and the mean pixel intensity of the image is calculated.

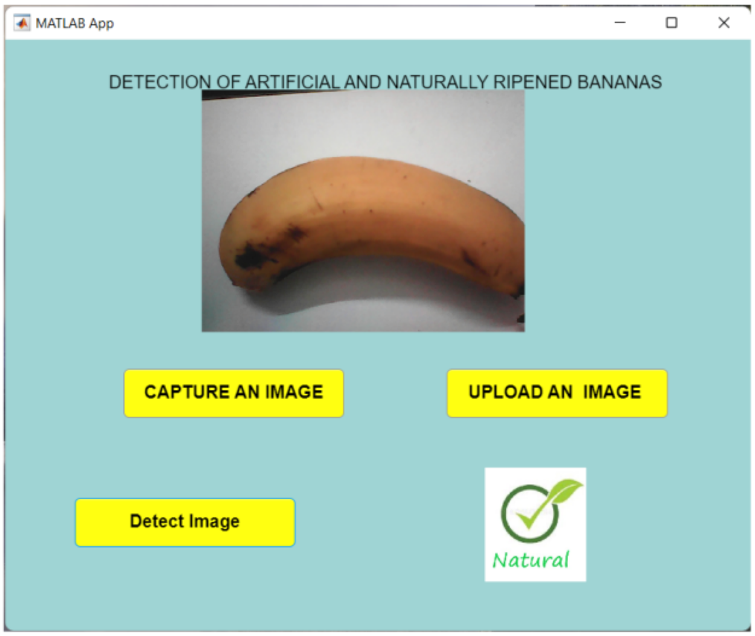

Figure 7.3: Detecting of the natural sample captured through camera

The captured image gets displayed on the window and as we can see in the figure 7.2 given, Clicking on the 'detect' button will first run the code for image processing and then run the values in our Machine learning model which will find out with our preferred algorithm whether the values is naturally ripened or artificially ripened. This we can show by giving a final output of the image.

Now depicting the procedure for acquiring image through user device. In this depiction we have used a laptop so an ideal scenario should be that the appliction would open a directory after clicking on upload image option and then the directory files should list all the different image files we have in the given format. Then if we upload the image from the directory, we shall be displayed with our selected image in the window.

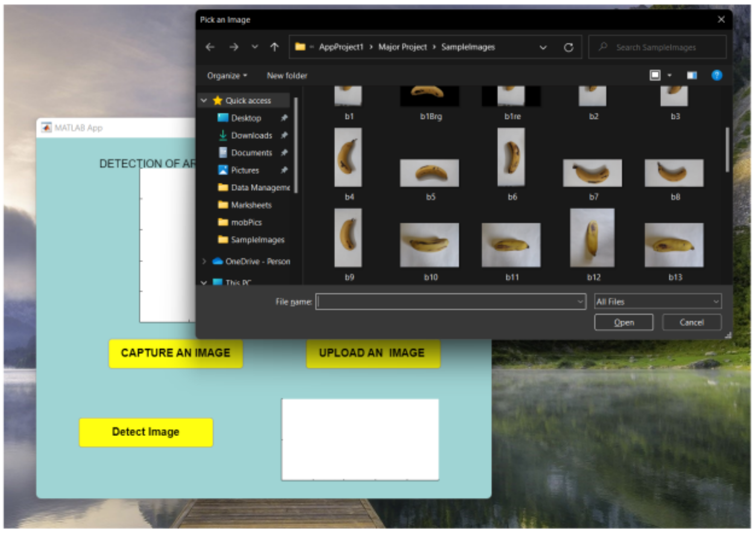

Figure 7.4: Caption

Again we follow the same procedure for determining the ripening stage, by clicking the detect image button and then the image processing code will gather the threshold and mean pixel intensity values and then pass unto the Machine learning model that will then detect whether the sample is naturally ripened or artificially ripened.

Figure 7.5: Caption

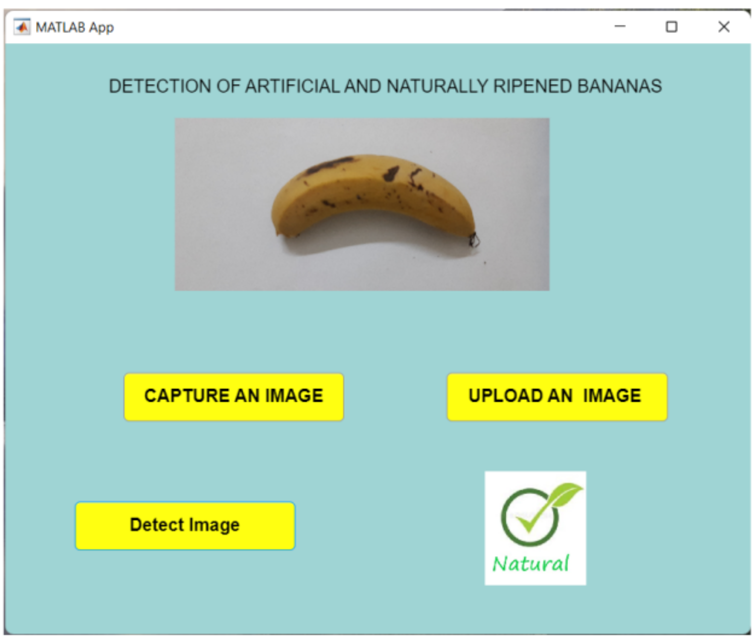

Figure 7.6: Caption

Now we can observe the results of artificially ripened samples by using these two methods i.e., capturing an image and uploading an image. The functionality remains the same while the results may vary. The same procedures are pretty much observed. Now let us begin by considering a given sample which is artificially ripened.

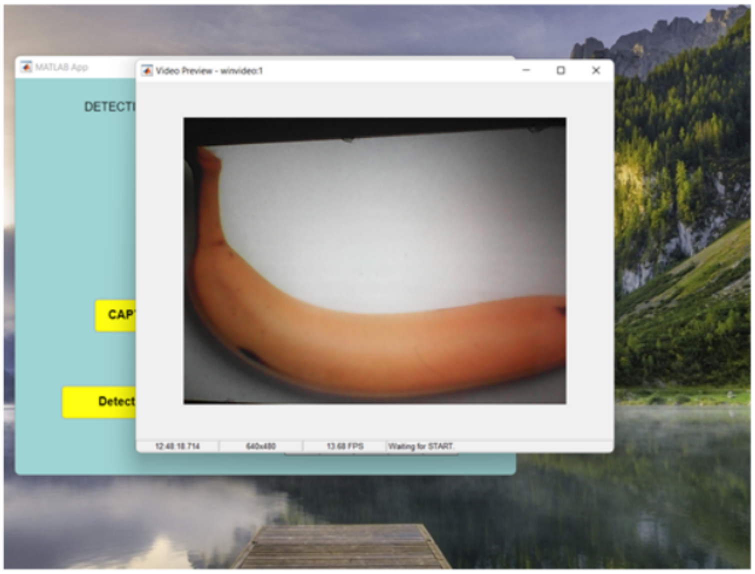

Figure 7.7: Caption

The image is then displayed in the window and we can see if we need to take another snapshot in case the image is not proper or proceed with the detection process. Then we can click on the detect image button to see whether the image is artificially ripened or naturally ripened.

Now similar examples can be seen for uploading the images from the directory. We will take an artificial image in question and check its ripening using our application by uploading it from the user directory.

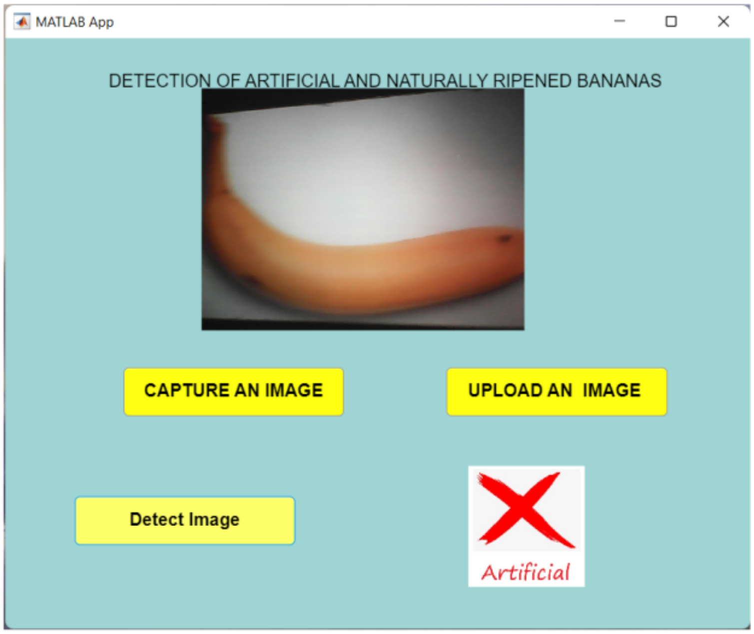

Figure 7.8: Caption

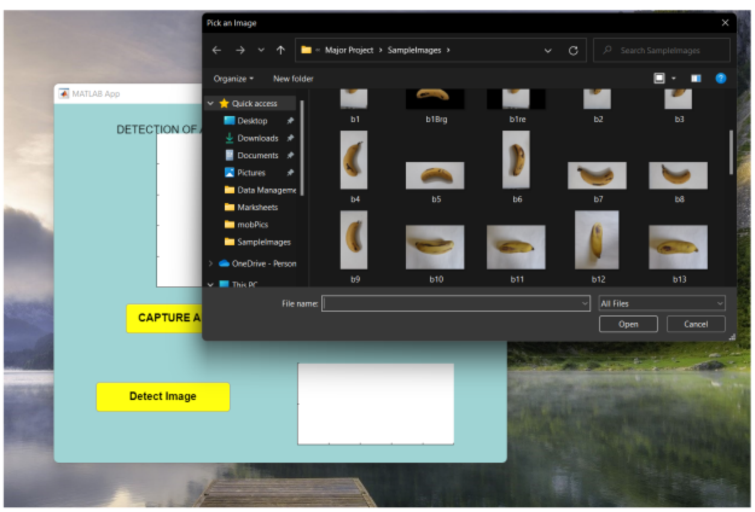

Figure 7.9: Caption

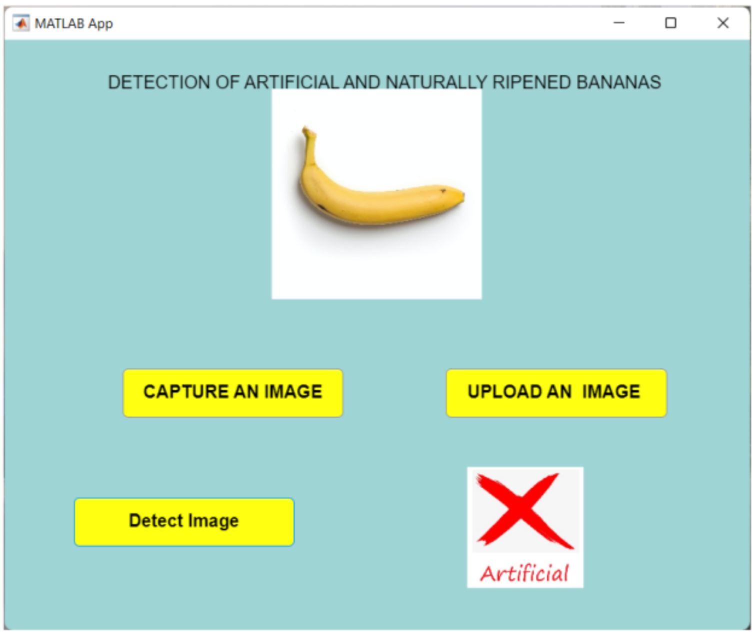

Figure 7.10: Caption

Table 7.1: Threshold and MPI values

Sample No.	Threshold (By Otsu's method)	Mean Pixel Intensity
1	0.3745	30.3509
2	0.402	29.8888
3	0.3588	36.3193
4	0.3588	30.258
5	0.3431	26.3431
6	0.3725	25.099
7	0.3627	33.6194
8	0.3745	25.9833
9	0.3863	30.6708
10	0.3588	31.8026
11	0.402	26.4069
12	0.3706	22.1764
13	0.3824	29.9373
14	0.3784	37.3513
15	0.3686	31.277
16	0.3765	32.6262

Chapter 8

Conclusion

8.1 Conclusion

Initial testing under as low as 16 samples, we use the MATLAB processing and computation to form a set of greyscale threshold and mean intensity values and tabulate it to perform further statistical operations that establish a limit to compare with a random sample under testing. With the given data, we can perform statistical operation that will help in finding the standard limits and range for the mean pixel intensity and threshold values. The drawback of the given dataset is that it holds only 16 samples which is far less for computation of accurate and reliable standard values. The proposed project aims to provide an easy to access, portable system for the detection of artificial or naturally ripened bananas. The further aim is to increase the light calibration of the device and produce minimum error in various conditions. The accuracy of the system will be improved by calculating multiple samples and heat spots with smaller radii as well. A mobile application will provide multiple features as well as detection of other fruits in addition to banana detection. It will be configured to suit mobile camera's various capacities.

8.2 Future Scope

Resizing, reshaping and filtering operations can be done as the initial step when taking the fruit under testing which would ensure uniformity between the samples taken as standard values and also for the samples under testing. Multiple object detection should be added for identifying multiple samples in the bunch of banana samples. This offers efficiency for the users and also does not interfere with segmentation and processing of a single sample. The most effective method would be to introduce machine learning and feature detection. One of the methods would be to take a large number of naturally ripened and artificially ripened bananas and plot them on the scale which has image processing intensity parameters. With this data we can use KNN classification to differentiate naturally ripened and artificially ripened bananas. CNN and SVM methods offer a reliable and low error detection and determination of extracted features from the given samples. Hence the accuracy of prediction increases and the system is less prone to false triggering and failed detection.

Appendices

Appendix A

Design Code devlopment

we have appended various codes along with their coding environment software which show us the back-end of the functioning of our proposed system. We began by the initial MATLAB codes we have programmed which were meant to predict the procedure of ripening through variance and standard deviation operation we had performed from a limited dataset. This method would formuate the limits and that can be taken as standard for further checking. Then moving further, we formulated the data points in a data-set and used them to predict the ripening using Machine learning Algorithms. Appended are the code and snapshots of the fore-mentioned.

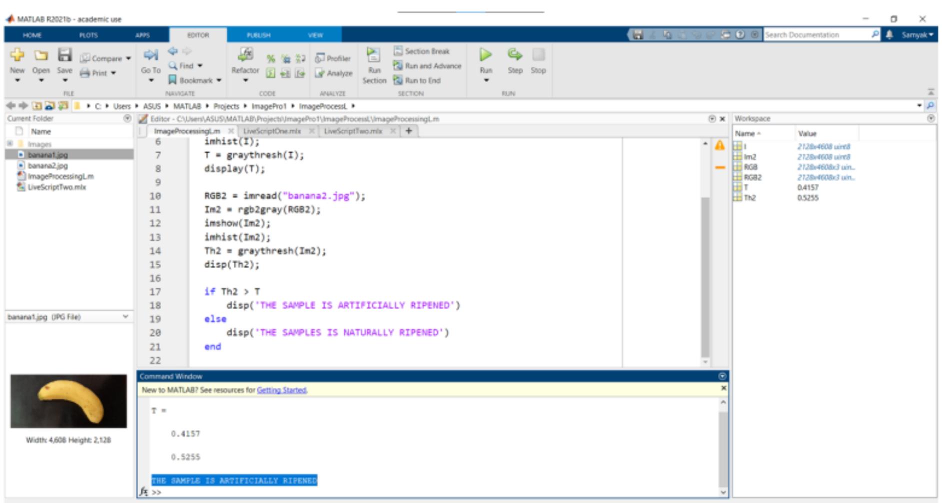

Figure A.1: Code Environment

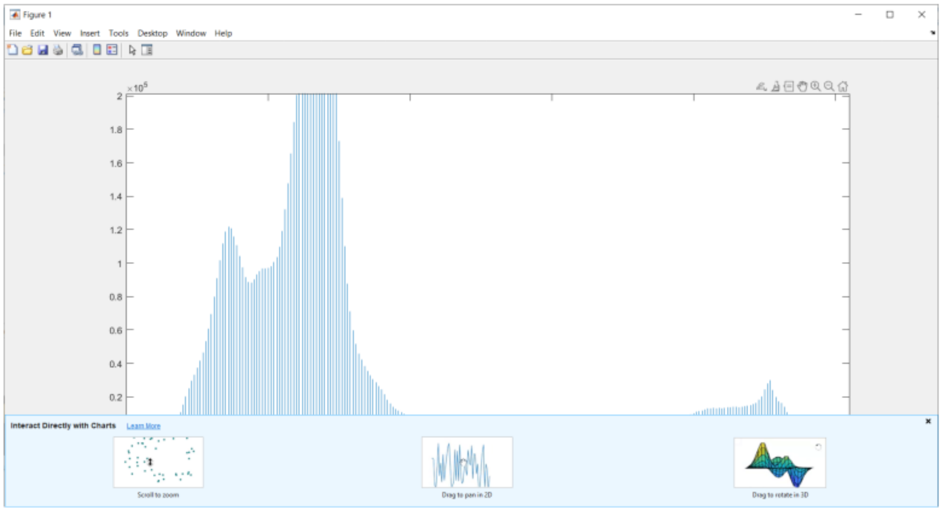

Figure A.2: Code Environment for ML algorithm

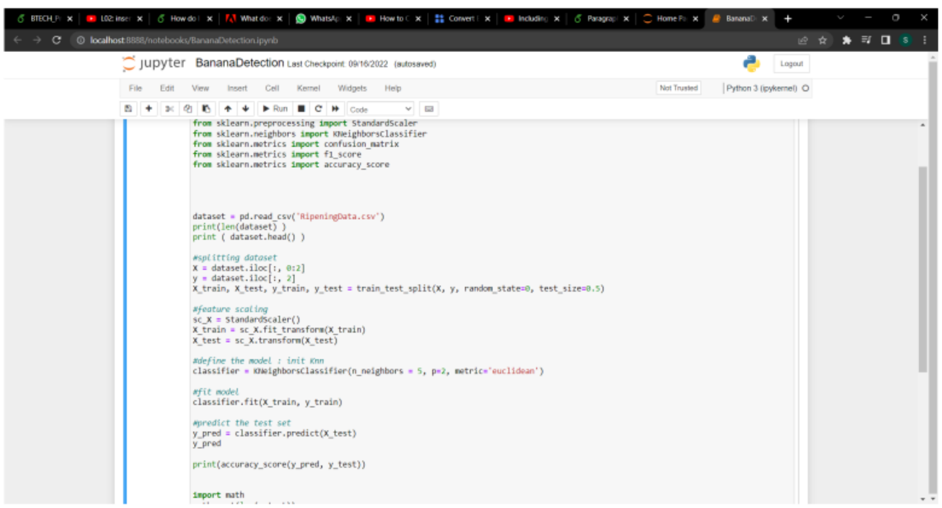

Figure A.3: Code Environment for ML algorithm

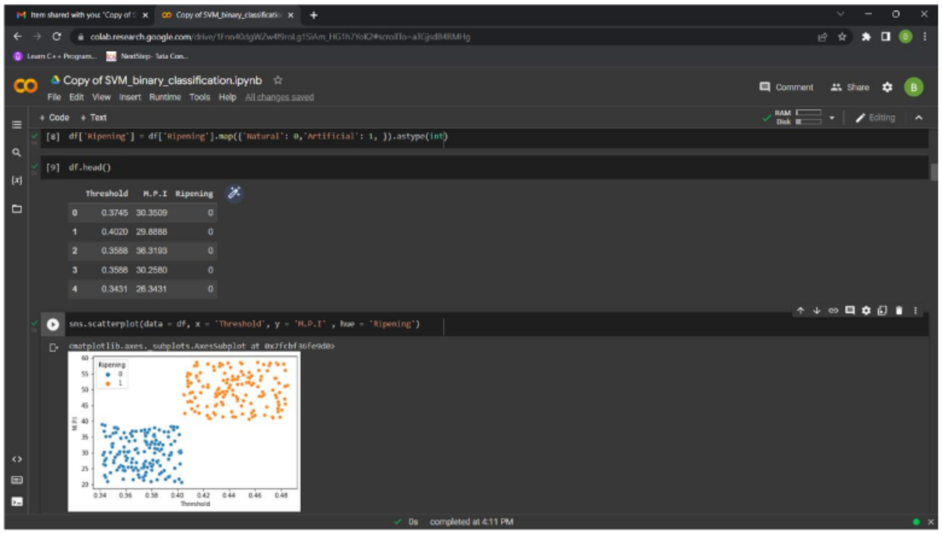

Figure A.4: Code Environment for ML algorithm

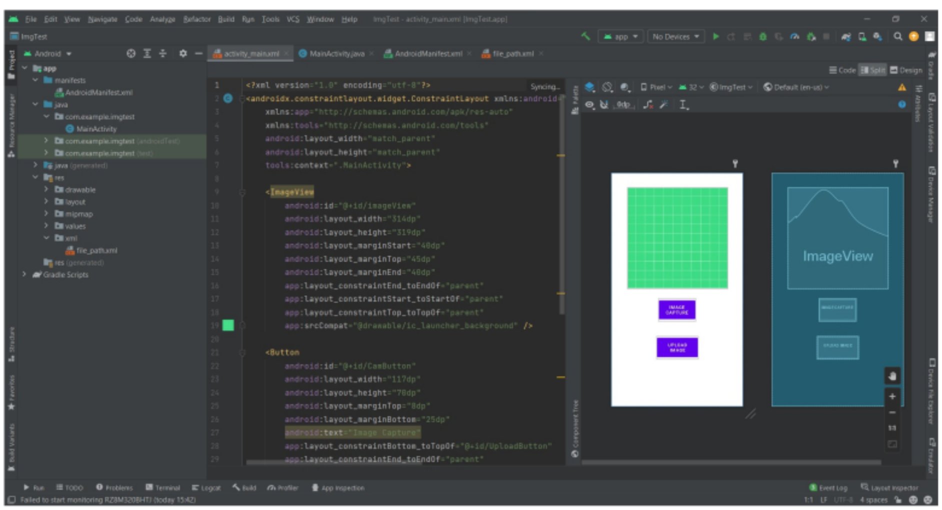

Figure A.5: Code Environment for ML algorithm

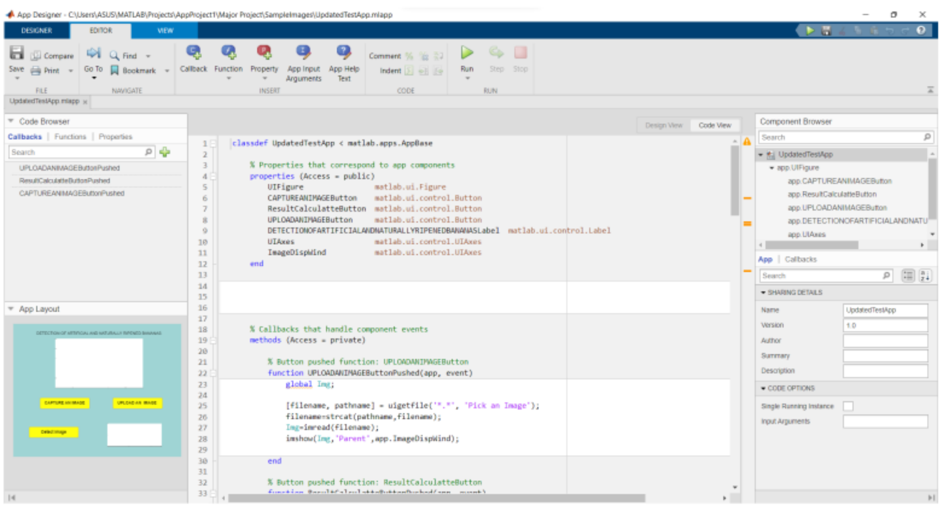

Figure A.6: Code Environment for MATLAB app (code view)

Appendix B

Sponsorship Certificate

Appendix C

Publications/ Achievement Certificate / Patent

Appendix D

Plagiarism Report of Text

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Detection of Artificially and Naturally Ripened Bananas

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