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Image Analysis Technique for Automatic Characterization of Fruits and Measuring the Sweetness

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Abstract: ***Image analysis using computer vision has numerous potential capacities for automated food activities. Recently, unique components of segmentation level, flabbiness, size, color, and shape are considered as significant measurements in the food business. Flabbiness, size, color, and shape are important qualities of the normal image and it plays out the significant part in visual recognition. The main aim of this research is to understand the challenges that the Food and Agricultural Industries are facing for quality control and explore the existing Image Processing Analysis techniques for measuring the fruit sweetness. The present research proposed a design for Image Analysis technique for automatic characterization of fruit grading and measured sweetness and finally evaluated the performance of proposed application in terms of sweetness determination. The main objective of our research is to determine the sweetness level of apples and pears by using an image of the flesh of pears and apples. The overall work is done in MATLAB. This research used ANN (Artificial Neural Network) method to get the sweetness of the apples and pears.***

Keywords: Image processing, fruit grading, fruit characterization and ANN method (Artificial Neural Network)

I. INTRODUCTION

Image processing is a method which performs some operations on an image to get the enhanced image. In this way, beneficial information can be retrieved from it. It converts an image into digital or analog form. In image processing, processing is performed on the images using the mathematical operations with the help of the signal processing. Image processing is a type of signal processing in which image is the input such as a photograph and video frame and output may be the image or the characteristics related to that image. It is the core research area in the computer science and engineering [19].

Image processing analysis and computer visions have displayed a great development in the previous years in terms of hypothetical and applications. They establish a foremost technology in various important fields, for example, broadcasting medical imaging, telecommunication, smart sensing system, multimedia system, and remote sensing [1].

Mainly, two methods are used in the image processing, i.e. digital image processing and analog image processing. Digital image processing is used to manipulate the digital images with the help of computers that contains the general phases pre-processing, display, enhancement, and information extraction. Image processing is used in many applications such as remote sensing, medical imaging, military, material science, textiles, forensic studies, non-destructive evaluation, graphic arts, film industry, document processing, printing industries, etc.

The purpose of image processing is image retrieval, image sharpening and restoring, visualization, image recognition, and measurement of the pattern. Various techniques used in the image processing analysis are image processing, representation, enhancement, analysis, restoration, reconstruction and image data compression. There are three steps in the image processing that includes the following: Importing the image with the help of the image acquisition tool, analyze the image and then manipulating it and report on the analysis and output of the altered image.

A. Image Processing Analysis

The image processing is a technique to convert any image in the form of digital and it is a method in which there are some operations to be performed on the image. The image processing is a method used to get enhanced image or to get some useful data from the image. The image processing is basically a form of signal processing. In this method, the image is an input for e.g. photograph, video frame, etc. and the output could be an image or features or characteristics related to that image.

There are three basic steps in Image Processing [20]:

1) The first step of Image processing is to import the image with the help of an optical scanner or digital photography.

2) The second step of Image processing is to analyze the image and manipulate in which other processes also include, for example, compression of data, image enhancement, and pattern recognition, for e.g. satellite photography.
3) The last step of Image processing is output. In this step, the result could be an image or report based on image analysis.

B. Image Analysis

Image Analysis is a technique, which extracts data from an image by utilizing diverse techniques named as: Image description, Scene Analysis, Computer Vision, Image understanding, pattern recognition, etc. and so on. The Image processing analysis includes five basic steps in their algorithms. These steps are as follows: [12]

1)Image Acquisition: Image acquisition also known as Image formation is a process to create digital images of the items; [4]
2)Pre-Process: Pre-processing is a process to upgrade, clean, and enhance key parts of the input images; [4]
3)Segmentation: Segmentation process is used to identify important parts of an item, as disjoint and non-overlapping zones isolated from the background;
4)Image Recognition: Image recognition and estimation to measure key elements of the chosen objects;
5)Image Interpretation: Where the elements extracted from the items are interpreted utilizing application domain knowledge.

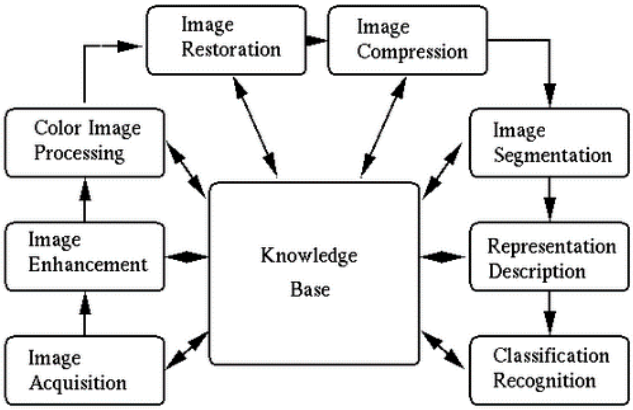

Fig. 1 Steps in Image processing analysis [4]

II. RELATED WORK

Ittatirut T, et al develops a system which is used for analyzing the sweetness of the apples using an image of the fresh part of the apple. This system was developed by using the MATLAB, and consists of four stages i.e. (1) Image acquisition to capture an image with the digital camera in the controlled light after the slice has been cut to prevent it from the oxidation. (2) Image processing consisting image resizing, edge detection, image segmentation, and image cropping. (3) Sweetness determination to measure the approximate sweetness value using Color Value Calculation and Neural Network Technique. Results were shown in the form of ranges. From the result, it was found that accuracy of ASMS is 84.34% for the training set and 73.72% for testing set [1].

Arakeri M & Lakshmana proposed an automatic and effective tomato fruit grading system which was based on computer vision techniques. In first phase hardware is created by capturing the images of tomato and in the second phase software is created using the image processing technique which is used to determine the defects and ripeness in fruit. The image processing module was implemented using MATLAB. The result shows that this method was 96.47%-100% accurate [2].

Banot, M S & Mahajan PM presented a study of fruit detecting and grading system which was based on the techniques of the image processing. Based on the study, they proposed techniques to develop an algorithm for detecting and sorting of fruit. Neural network algorithm was used to classify the fruits based on size, shape, color, and volume [3].

M Vyas, A Talati, Naik aimed to design an automated grading system algorithm which is used to determine the color and size feature of mangoes. The steps which are included in the processing are– Image acquisition, pre-processing and color feature extraction. The result shows that proposed algorithm has a tendency to classify mango with an accuracy of 94.97%. Average time taken for grading is less than one second [4].

Kumar & Rajpurohit V.S. throws light on the International status in the field of machine vision that is applied to various fruits grading. Xu Liming, Zhao Yanchao developed an automated strawberry grading system. A new algorithm is developed which calculates the shape of the strawberry and then grade the strawberry. The grading of the strawberry was based on the three types of

the features, i.e. color, shape and size. The result shows that there are less than 5% of the error size, 90% of the shape accuracy and 88.8% of color grading accuracy [5].

Gill J, Sandhu P S & Singh, emphasis on the developments in automatic fruit classification with the help of soft computing techniques for ten types of fruit. The result was like - (a) for Apple Fuzzy Logic grading system obtained 89% accuracy. (b) Results were evaluated from different classification models with accuracy between 85.7 to 99.6%. The model with the accuracy of 99.6 % employed a combination of physical and color features of the dates. (c) Blueberries were detected with the highest accuracy of 96%. (d) For peach, 96% accuracy is gained using HIS model and 99.3% accuracy using Neural Network model [6].

Gawande A. P. & Dhande S analyzed the implementation of fruit Grading System by using the Image Processing and Data Classifier. For this, various learning methods were examined for classifying infected and uninfected oranges from images of their outside region. Linear discriminant analysis was used to convert the feature space for better separability after feature fusion, while three classifiers, k-nearest neighbour, naive Bayes, and SVM were also investigated. The system discovered the infected and uninfected oranges and accomplished appropriate accuracy which ranged from 85% to 94% [7].

Mustafa N B gave the classification of banana using image processing tools in MATLAB. The system classified the bananas, according to their size, textures, shapes, color, and taste. Then pixels of the image determined the percentage of ripeness in the fruit. The research had stated the future improvements in the system by implementing artificial intelligence algorithms such as fuzzy logic and neural network [8].

Adelkhani A, et al characterized the orange taste with the help of the ANFIS application which was based on image processing. For this purpose, RGB components, texture features, HSV components, minor or major diameter ratio, R/B color component ratio and diameter ratio were extracted from the captured images of 300 orange samples. These features were used as the input by ANFIS and the value of taste was obtained as an output of ANFIS. The results found that three varieties of Bam, krooni and Thompson oranges showed the success rate for the taste classification [9].

Han Z, et al presented an automatic grading system which includes the hardware and software environment. These systems included the image processing and recognition module, control module, transportation module for grading the fruit. This grading includes the shape, color and defect detection as an input. The system detected the spots on pears surface for detection using spot removal method based on V component's dynamic threshold. The proposed grading model was constructed based on artificial neural network technique. The results of the research have shown the positive significance to on-line grading for pear's quality of appearance [10].

Khairunniza-Bejo, S & Kamarudin S analyzed the relation between the sweetness of mango and its pixel values in RBG and HSV color space. These features were used to determine the sweetness level of mango. The Keyence machine vision was implemented to capture the images in RGB and HSB. In this research, with the sweetness, the shade had a negative linear relationship, and the other color components had a positive relationship. The research has shown claimed that it is possible to determine the sweetness with 100% at Level 1 and Level 2 [11].

JA Kodagali and S Balaji presented an application and developments of the image analysis and the computer vision system in an automatic fruit recognition system. The computer vision systems are increasing for the purpose of evaluation and inspection which can provide an economical, rapid, consistent, hygienic and objective assessment. From the survey, it was concluded that much of the work was needed on the recognition of the fruits. This paper also describes the machine vision systems and its components on an automatic fruit characterization system [13].

S Teeracharichayut, et al compare the whole fruit sample with the reference plate which is used to determine the volume of fruit. With the help of the binary image analysis, the volume is predicted and the average density is calculated. From the result of the predictive evaluation, a low standard error of the estimate and a high correlation coefficient are obtained. From this paper, it was concluded that the image analysis procedure was efficient for use in the on-line sorting system for evaluating the quality of the fruit which was based on the technique of predicted density than the traditional floating [14].

T U Ganiron aimed to develop an efficient image analysis algorithm for the sorting and detecting mango. The features were extracted from the acquired image and it is used to identify the class of the mango. Percent defect and roundness are used to identify that whether the mangos quality was local, reject or export whereas area was used to identify the size of the mango. Boundary tracking is used to find the perimeter, and the optimal threshold was used in the segmentation. The quality of the mango is determined by using the Euclidean Distance [15].

H Wang, et al presented the applications of the visible and the infrared spectroscopy, hyperspectral imaging, multispectral imaging techniques which are used for the quality measurement attributes and the variety of the discrimination of fruit species such as orange, apple, peach, strawberry, mango, kiwifruit, grape, banana, jujube and others. The comprehensive review of the applications is

arranged according to the fruit species which focuses on the Vis/NIR spectroscopy. The applications mostly concentrate on the acidity, soluble solids contents (SSC), and the firmness and also measure the Vitamin C, dry matter, pigments, and polyphenols. For measuring the attributes of the various fruit species, optimal variable selection method and a calibration method are used [16].

AM Bermudez, et al described the image analysis for the automatic features estimation of the Mangifera Indica fruit. From the results, it is found that the proposed fruit classification methods are based on the digital image processing techniques which adequately classify the fruit. The coefficient of the weight-based classification proves that this technique has the highly accurate model used for weight estimation and the spot-based classification shows the lower accuracy due to the high dependency on the surface of fruit position during the image acquisition [17].

III. PROBLEM FORMULATION

Today, the emerging technology improvement and enhancement of modern world demand new quality and security standards to the food manufacturers. Consumers demand increasingly data about the products they purchase, exhibiting clear preferences for high-quality products. Specifically, on account of exports, the food industries in the importing nations apply the thorough test to ensure the safety and quality of the product. Essentially, today quality and safety are real drivers of the food chains.

To ensure the quality and security of food products, Image Processing analysis technique can play an essential role. Certainly, regarding quality, frequently the initial quality impression a buyer gets from a food product is its visual appearance and taste. Many of the previous researches concentrated on the use of computer vision for the inspections and grading of product quality. Usually, human graders perform this operation in food and agricultural industries. However, these manual investigations are labour-intensive and time-consuming.

Also, the precision of the investigations cannot be ensured. Here, Image Processing techniques may give objective methods of important visual attributes identified with food quality, for example, the shape, shading or sweetness of a product. The key challenge to creating an application is to have the capacity to derive the images usable and meaningful numerical information which can be utilized for quality control. In this research, we created Image analysis technique for the quality control of food product by measuring its sweetness.

IV. IMPLEMENTATION

The main objective of our work is to determine the sweetness level of apples and pears by using an image of the flesh part of pears and apples. The overall work is done in MATLAB. In the base paper they have considered only for the apple case, but in our work, we have taken for pears and apples. We have used ANN method (Artificial Neural Network) to get the sweetness of the apples and pears.

A. We have Divided Our Project into Two Parts

1) For Individual Fruit

2) Image Analysis

B. We have Taken the Slices of Apple and Pears to Determine its Sweetness

1) *For Individual Fruit:* When we run the main code file, Project.m then the new GUI (Graphical User Interface) will appear which looks like as shown below

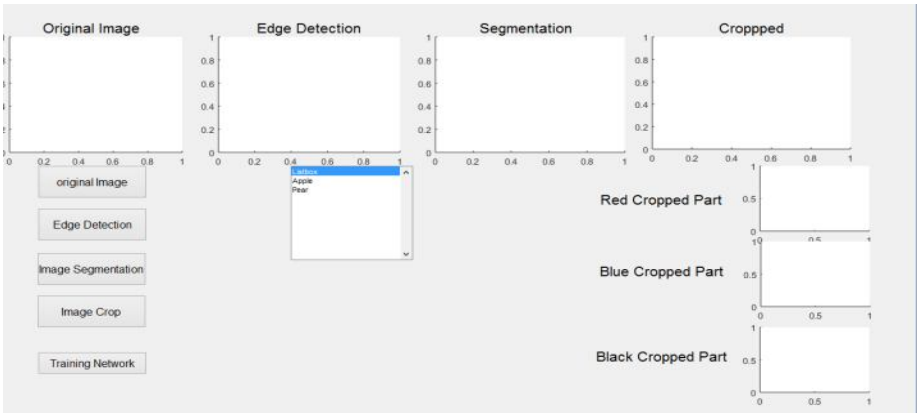

Fig. 2 GUI Main Window

There are seven axes which are for different visualization purpose, and we have Five Push Buttons which are of Original Image, Edge Detection, Image Segmentation, Image Crop, and Neural Network. There is one list box which will allow you to choose the Fruit on which you want to perform all the operations.

When the first Push Button of Original Image is clicked, then it will show the original image on which you want to perform various operations.

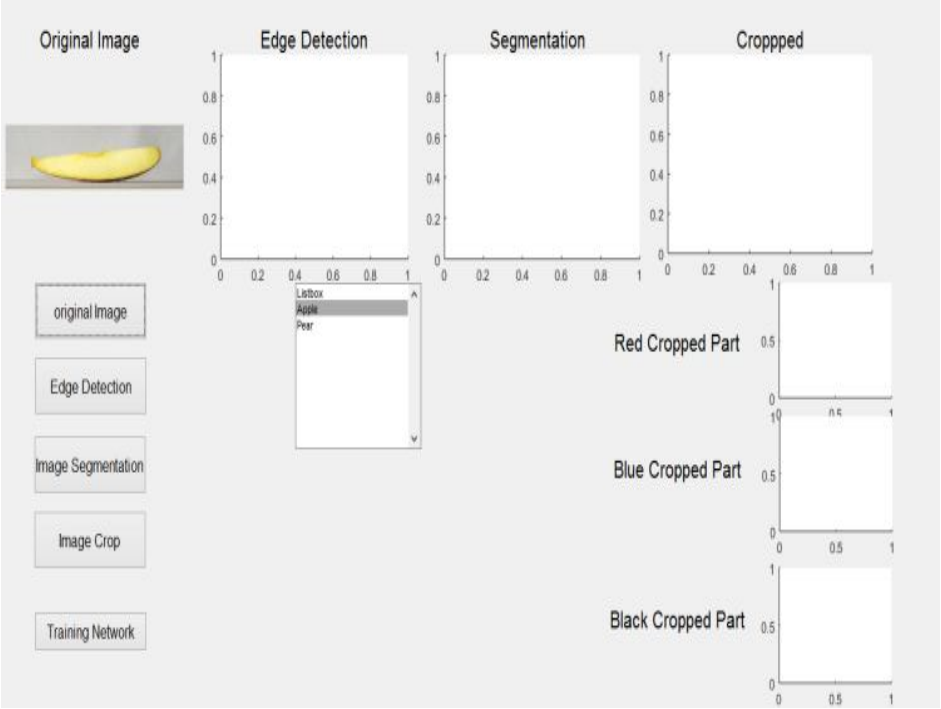

Fig. 3 Original Image

Next button is 'Edge Detection'. When the user clicks this button, it will distinguish the area of the object (apple) and the area of the background. The output is as shown below.

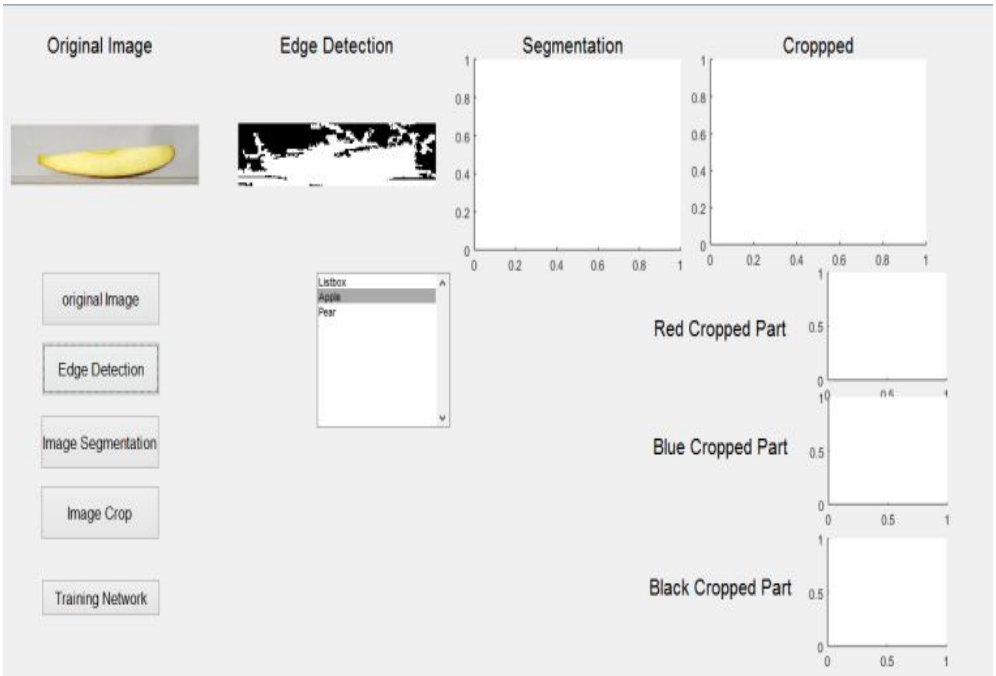

Fig. 4 Edge Detection

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After this, the user will press on the Image Segmentation button. The main objective of this process is to extract out the object (apple) from the Image and output will be as shown

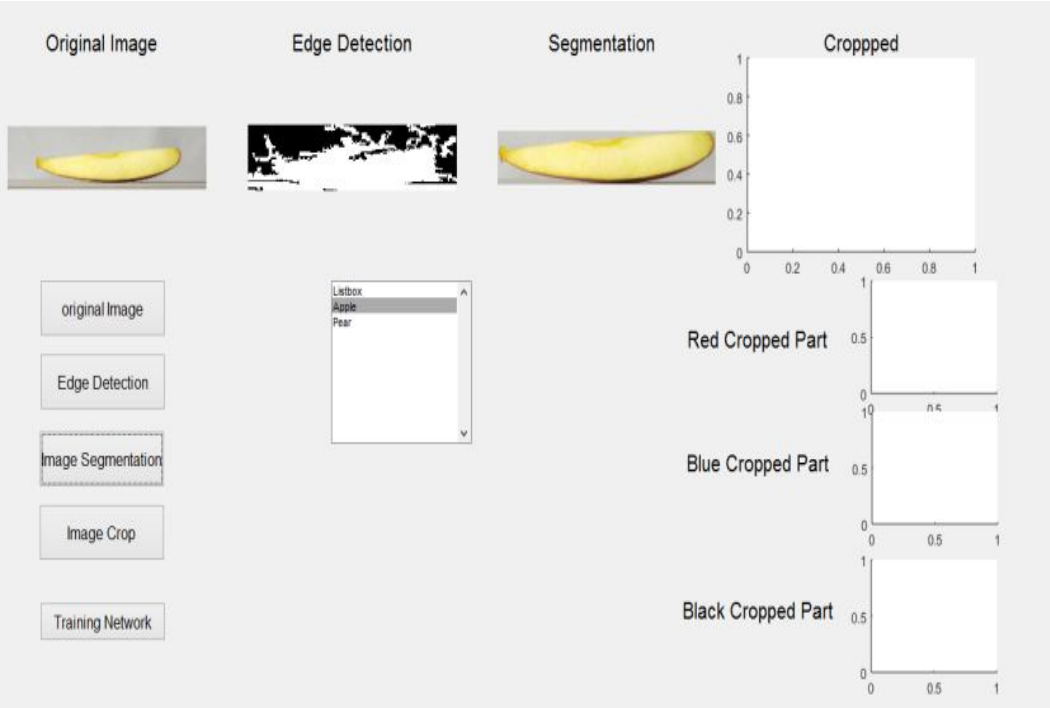

Fig. 5 Segmentation

Now, when the user clicks on the Image Crop button, then the output will be as shown below. To do this, we have marked 3 rectangles of different dimensions on the image then we cropped that particular area and used them further in our calculations.

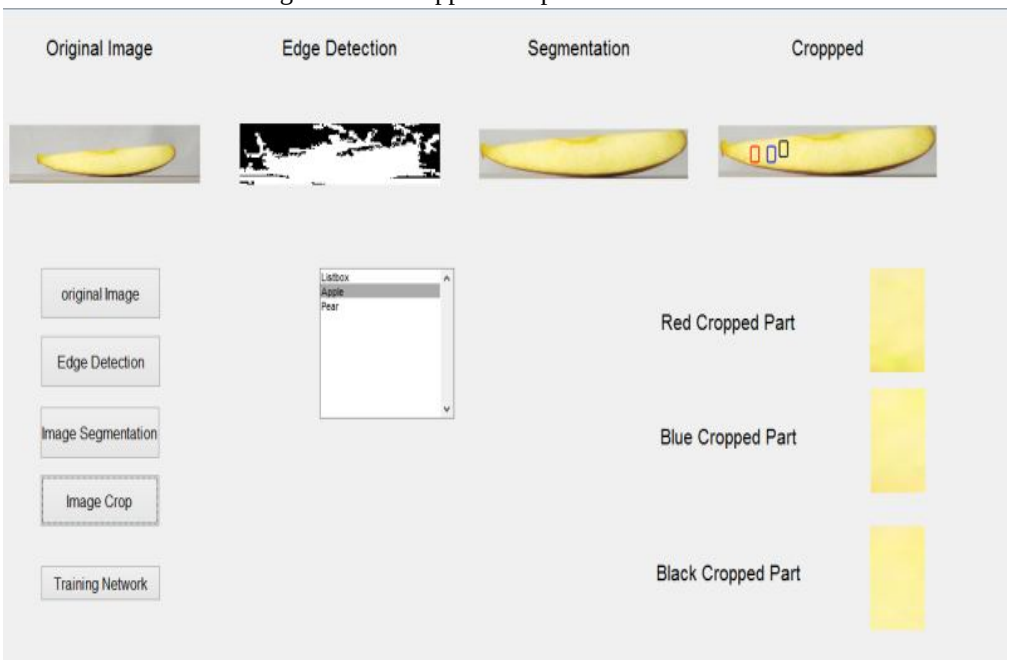

Fig. 6 Cropped Regions

The last button is for 'Training Network'. When the user clicks on this button the trained kit will open as shown in figure

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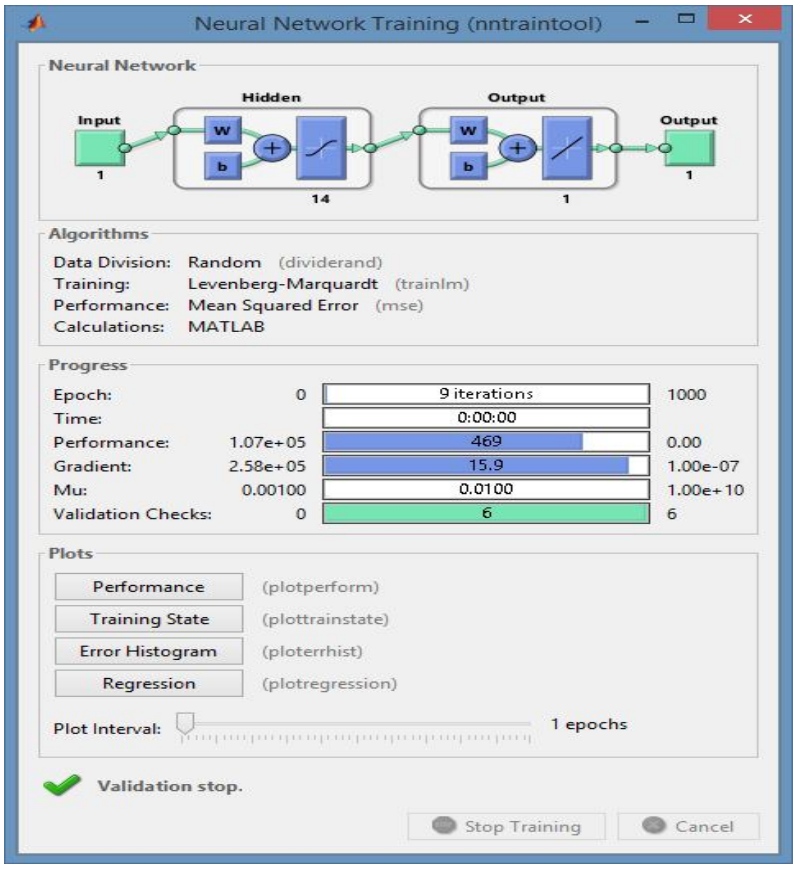

Fig. 7 Training Module

C. Results

In the training part, we can do an analysis of various graphs and plots by simply clicking on the four buttons as shown in figure (7). Performance plot is as shown in figure (8).

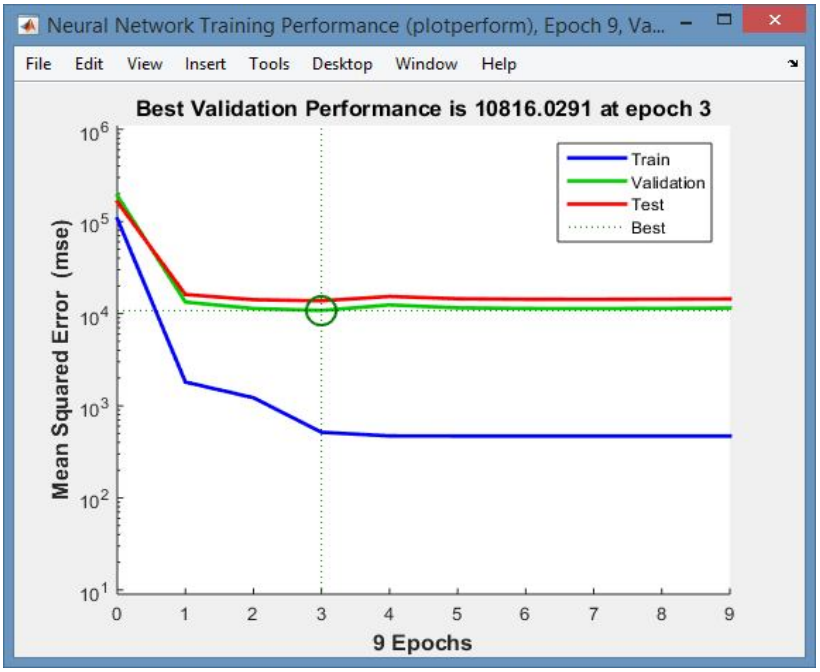

Fig. 8 Performance Plot

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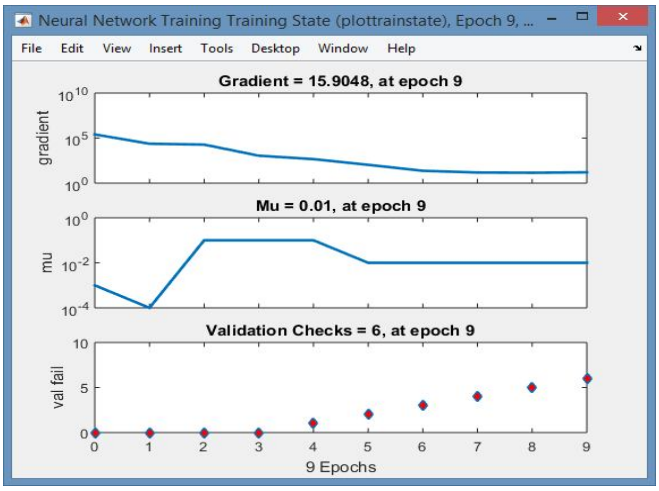

Fig. 9 Training State

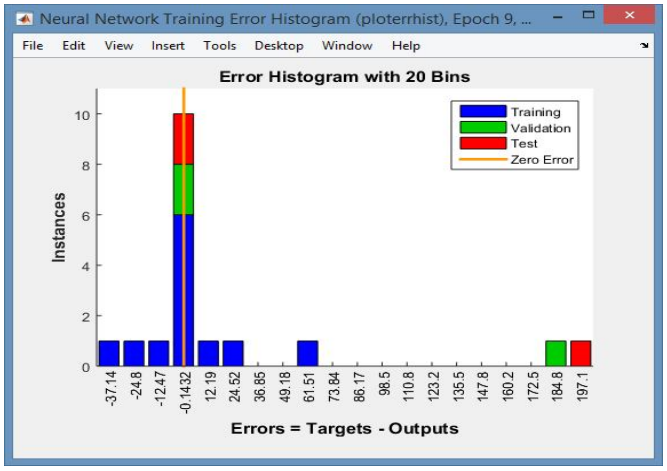

Fig. 10 Error Histogram

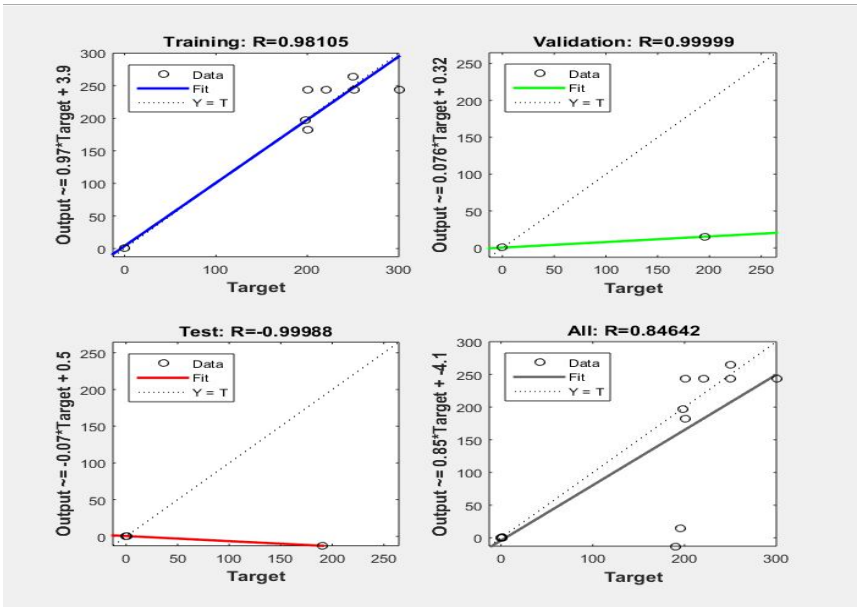

Fig. 11 Regression

In this, when you will run the main file named fruit grad.m then it will allow the user to choose the image on which the user wanted to perform the overall operation. When the code runs, it will perform the following operations.

1) Original Image:

Fig.12 Original Image

2) Edge Detection:

Fig. 13 Edge Detection

3) Cropping:

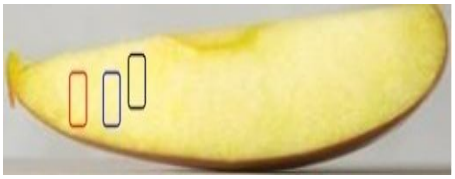

Fig.14 Cropping

4) Cropped Sub-Parts:

Fig. 15 Cropped Sub-Parts

V. FINAL RESULT

After this, there is one training apple.m file. Run that file, it will pick all the images from the directory and will evaluate the regression plots.

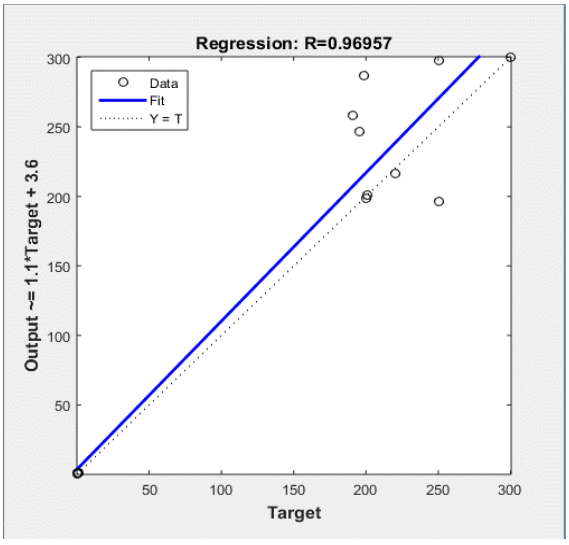

Fig. 16 Regression Plot of Apple

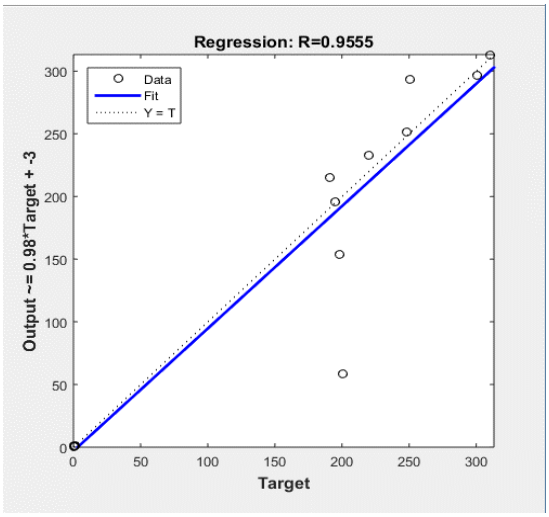

Fig. 17 Regression Plot of Pear

VI. COMPARISON OF PROPOSED AND EXISTING WORK

In the base paper, the authors have taken the database of 1000 images, but in our work, we have taken the database of 30 images. After evaluating this, we are getting better results as compared to the base paper. We have taken the two fruits that are apples and pears. But in the base paper, they have considered the results only for the single fruit.

In the base paper, they have taken only one fruit Apple, but in our case, we have shown for apples as well as for pear. The accuracy achieved by the base paper is about 73.72%. But in the case of apple accuracy achieved in our case is about 91.86% and for the pear case, the accuracy achieved is 90.90% which is far better from the base paper.

We have considered the 14 hidden layers for training set network and used TRAINLM algorithm (Levenberg-Marquardt back propagation). But in the base paper, they have considered the 12 hidden layers and used TRAINSCG algorithm (Scaled Conjugate Gradient back propagation).

TABLE I
Comparison of result

Results	Database	Average Value
Base Paperwork	1000 approx.	79.03%- Apples
Our work	30	91.86% Apples 90.90% Pears

VII. CONCLUSION

The proposed methodology selected the suitable Image processing technique for image analysis of fruit for the purpose of fruit grading and sweetness measurement. The research proposed a design of Image processing analysis technique was implemented using MATLAB. Simulation of the design was done by inputting the image of any fruit for sweetness measurement. The model was simulated and checked on entire database and results were obtained as compared with the previous researches. The performance of the proposed method was evaluated based on the results of the considered parameters, for example, sweetness value, color, shape etc. of fruit. In the case of apple, the accuracy achieved was 91.86% and for the pears case, the accuracy achieved was 90.90% which is far better that other techniques used in previous researches.

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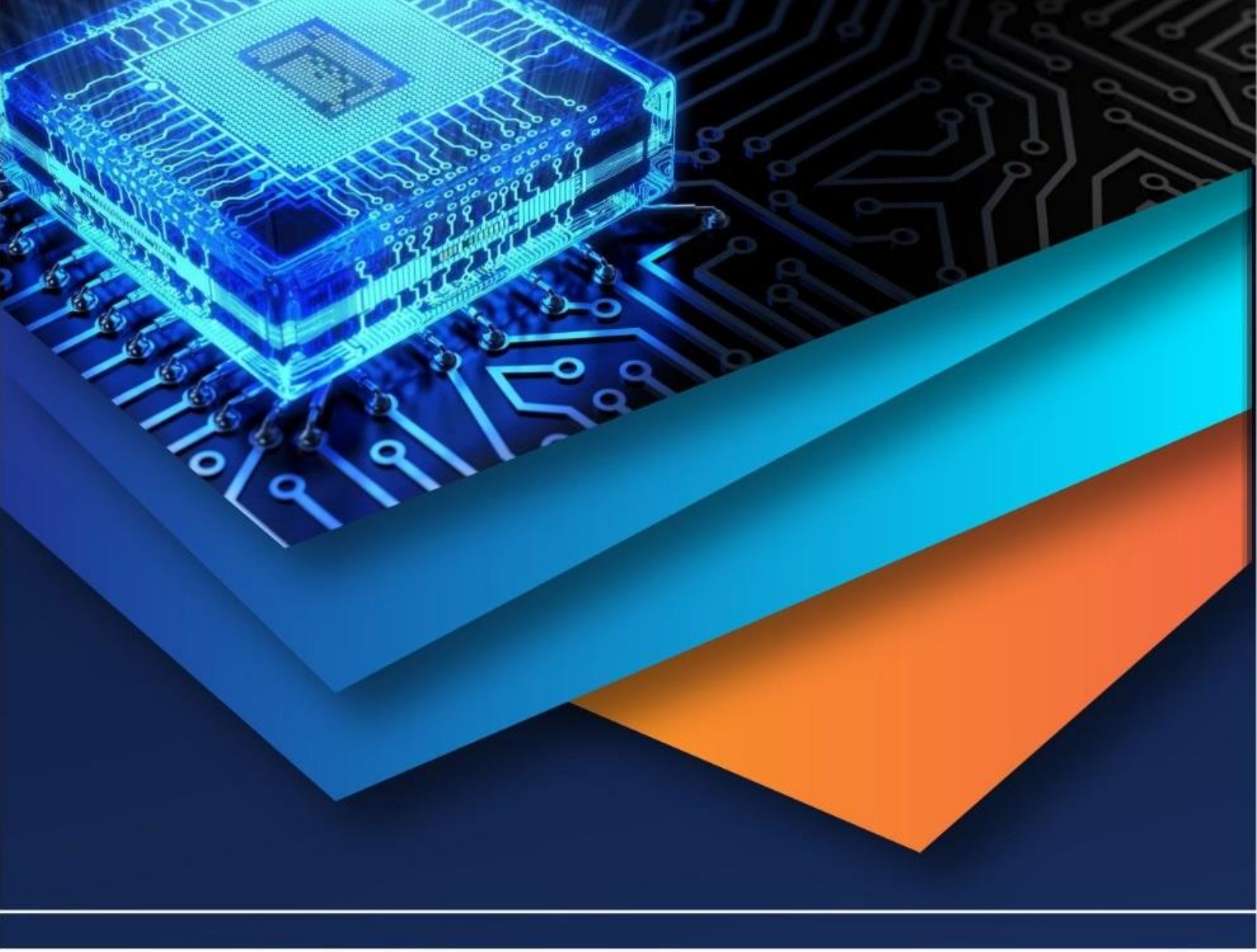

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