

APPLE GRADING USING IMAGE-PROCESSING

Project report submitted for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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DECLARATION BY THE SCHOLAR

We hereby declare that work reported in the B-Tech project report entitled “**Apple Grading Using Image Processing**” submitted at **Jaypee University of Information Technology, Waknaghat India**, is an authentic record of our work carried out under the supervision of **Dr. Sunil Datt Sharma**. We have not submitted this work elsewhere for any other degree or diploma.

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CERTIFICATE

This is to certify that the work which is being presented in this project report titled “**Apple Grading Using Image Processing**” for partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Electronics and Communication Engineering and submitted to the Department of Electronics and Communication Engineering , Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Aditya Thakur(151002) , Mahesh Kumar(151022) And Nikhil Thakur (151023)** during a period of July 2018 to May 2019 under the supervision of **Dr. Sunil Datt Sharma** (Assistant Professor (Senior Grade), Department of Electronics and Communication Engineering), Jaypee University of Information Technology, Waknaghat.

The above statement is made correct to the best of our knowledge.

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ABSTRACT

Here in this project report we have presented a method to grade the apples using Image processing techniques. We have graded apples on the basis of parameters like colour, size, disease and maturity level of the apple. We have used colour ratio method to segregate apples on the basis of their colour. In this technique we have segregated RGB image of the apple into R plane, G plane and B plane. After this we have taken mean value of each plane and hence calculated the ratio of R plane to G plane .On the basis of this ratio we have classified apples into four categories i.e. Green , Yellow, Light red and Bright red. To segregate apples on basis of their size we have found the area by converting image into black and white and then calculating no. of white pixels. On the basis of area we have classified the apples into three sizes i.e. Small, Medium and Big. To find the percentage of diseased area of apple we have used thresholding technique like Otsu's and sauvola thresholding technique. The Fuzzy logic has been implanted to find the maturity level of apple.

CHAPTER-1

1. INTRODUCTION:

Besides the natural beauty of Himachal Pradesh, it is also famous for its world-class apples. The orchardists and farmers invest their lot of money, hard work and time for the growth of best quality apples. But this is not sufficient since for the sake of best revenues out of fruit crops we need to sort the good fruits from the diseased fruits. We need to grade them on the basis of different colours, textures, and sizes.

Apple can be separated using various techniques. There are many techniques available for the segregation of apples, some of which are traditional techniques such as Diverging belt, traditional roller, etc. These techniques have their own limitations like MSD. To overcome the limitations of the traditional methods we have some of the new techniques available which are described below :-

1.1. *Computerized weight grader* – It is a technique which works on the basis of tipping buckets that drops to release the pre-weighed item at a particular position. [1]

1.2. *NIR Spectrometers* – In this technique we use infrared red waves to determine the internal quality of the fruit in a non-destructive way. In this method we irradiate the fruit with infrared light and measure the reflected light by a spectrometer. The reflectance or transmittance spectra contain the characteristics of both absorption and scattering properties of the internal tissue. Absorption property is affected by the chemical composition of the fruit and scattering property is related to the texture of the fruit. Therefore, NIR spectroscopy can be used to measure both absorption-related attributes such as soluble solids content (SSC) of fruits and texture-related attributes such as firmness. Sang Ryong Suh, Kyeong-Hwan Lee investigated the effect of configuration parameters in interactance mode on the estimation of SSC and firmness of muskmelon using NIR spectroscopy[2].

1.3. *X-ray imaging and Computer-aided tomography* - Similar to NIR spectroscopy, X-ray imaging and Computer –aided tomography can also be used to determine the internal quality of fruit which can't be detected just by looking at the fruit. X-ray computed tomography (X-ray CT) is a proven method for evaluating a cross-section of an object

using a movable X-ray source and detector assembly to accumulate data from a thin projected slice of a sample. The basic principle behind the CT is that the internal structure of an object can be reconstructed from multiple projections of the object. Eufemio G Barcelon presented a paper where X-ray computed tomographic (CT) scanner was used to monitor the internal quality changes in peaches during ripening. The physicochemical constituents were monitored and the X-ray absorption expressed in CT number was used as an index. Relationships between the CT number and the physicochemical contents were determined. Results showed that CT number, moisture content and titratable acidity decreased significantly with postharvest ripening time, while pH and soluble solids increased with postharvest ripening time. The X-ray CT number is directly related with density, moisture content and titratable acidity.[3]

1.4. *Volatile emission analysis* - It's basically based on the analysis of volatile components and fragrance of the fruit to determine its internal qualities. The volatile emissions of the fruit vary when fruit is subjected to temperature, pressure and other physical conditions. Freezing also has been found to have a pronounced effect on volatile emanation. For example, volatile hydrocarbons, including both acetaldehyde and ethanol, increased following freezing of the leaves of a number of plant species. The volatile emissions can also be used to detect the maturity level of fruit. David M. Obenland and Louis H. Aung evaluated volatile emissions of naval oranges. as a means for predicting and gauging freeze damage. The fruits were subjected to -5 or -7 °C treatments in a laboratory freezer for various time periods of 2-9.5 h and stored at 23 °C for 1, 2, or 7 days, after which time the emission of volatiles from the fruit was measured. Peel injury in the form of brown lesions, drying of the juice vesicles, a decline in acidity, and a loss of flavour were observed to occur as a result of freezing. Corresponding to the loss in fruit quality were large increases in the emissions of ethanol, ethyl butanoate, methyl hexanoate, and ethyl octanoate. [4]

1.5. *Acoustic methods* – This method is used to determine the firmness of the fruit. When an acoustic wave reaches a food product, the reflected or transmitted acoustic wave depends on the characteristics of the product. Acoustic technology is often used to estimate product firmness along with other quality parameters. Acoustic firmness index is based on the relationship between modulus of elasticity and the resonant frequencies of vibration of the fruit. T. Tiplica, P. Vandewalle worked on Identification of apple varieties using acoustic measurements where they have shown that acoustic measurement can be a

useful tool to discriminate different apple batches with a low error rate. Starting from the spectrum of the signal recorded by a microphone after the impact of a small hammer on the fruit, 18 key features were identified and used for the classification of apples belonging to 10 different varieties. [5]

1.6. *Image capture and analysis* – It's used for size, colour and external defect grading in fruits. Image processing in sorting apple consist of mainly four steps:-

- Image acquisition
- Image segmentation
- Feature extraction and processing
- Classification

1.6.1. *Images acquisition*:- The first step consists of acquiring images of the surface of the fruit, while it goes through the grading machine. In order to grade apples, two requirements have to be met:

- a. The images should cover the whole surface of the fruit;
- b. High contrast has to be created between the defects and the healthy tissue.

1.6.2. *Image segmentation*:- Here we need to separate the main object from its background. For this, we can use different thresholding techniques like global thresholding , local thresholding , adaptive thresholding , etc.

1.6.3. *Features extraction and processing*:- After apple segmentation from background we need to extract various features from the image like mean values of each colour plane , total area of apple , area of diseased part if any etc.

1.6.4. *Classification*:- We have classified apple into various categories on the basis of features extracted from the image. On the basis of colour we have categorized apple into four classes i.e. green, yellow, light red and bright red. On the basis of size we have classified apple into small size, medium size and big size. On the basis of diseased area we have classified apple into four categories i.e. heavily damaged, medium level damage, least damage and no damage. At last on the basis of maturity we have classified apple into four categories i.e. least mature, less mature, more mature and fully mature.

Here in this project we are using one of the above novel technique for sorting i.e. image processing. Image processing is among the latest available technique to sort out apples on the basis of color, size, and disease. The reason for choosing image processing is that among the latest available techniques this is less expensive and easily implementable technology as compared to other new techniques which have been discussed above.

CHAPTER-2

2. LITERATURE REVIEW:

- Guo Feng and Cao Qixin developed a method to segregate the fruit on the basis of . A typical color-image-processing based fruit sorting system is introduced in this paper. Two different color spaces (Ohta color space for image segmentation, HSI for color ratio calculation) are utilized in color image process to get distinct and smooth contour of fruit , so the correct quality feature (color ratio) extraction is guaranteed. With the parameters acquired from study module, classic Bayes classifier is adopted to realize sorting. Experimental result shows the performance of this system is stable and satisfying. This system was tested with Crystal Fuji apples, and an average sorting accuracy of 90% was achieved. [6]
- Chandan Kumar, Siddharth Chauhan developed a method for sorting and colour grading of defected fruits using GLCM parameters such as Contrast , Energy, Correlation and Homogeneity . Algorithms were developed to classify the selected citrus fruits like orange, sweet-lime and lemon, into different classes based on grey level co-occurrence matrix parameters like contrast, energy, correlation, homogeneity. The test image sample was compared with the standard image sample and the dissimilarity value was obtained. The sum variance of the parameter value was calculated and it was compared with the set threshold value. If the dissimilarity value is greater than the set threshold value, the fruit is bad. On the contrary if the dissimilarity value is less than the set threshold value, the fruit is good. [7]
- Manali R. Satpute used two methods to detect disease in the fruit. The image taken of fruit is RGB image. Firstly this image is converted to gray scale and the edge detection is performed and the blob detection is performed and defected region is marked with red circle. Another method used for defected fruit detection is that RGB image is converted to YCR color space. Then lower and upper ranges are defined. Then ranges of binary image are defined. Then convert single channel mask back into 3 channels. The accuracy of defect fruit detection is up to 90%. This system is much closer to manual expert judge. [8]

- Dah-Jye Lee *et al.*(2011) designed a Direct color mapping technique for obtaining the color of fruit. Advantage of this system is that it have arrangement of adjusting color preferences or grading parameters as per application. it is user friendly technique.[9]
- Sherlin Varughese, Nayana Shinde presented a paper where they calculated the amount of disease in the fruit using k-means technique. K-means clustering is performed on the image and it is segmented to obtain the region of interest and determine the extent of disease infection. Further, feed forward back-propagation algorithm is used to train the system for learning.[10]

CHAPTER-3

3. MATERIAL AND METHOD:

3.1. Database

To create the database for the project we have borrowed some of the images from internet and other we have clicked ourselves.

Database for colour detection



Fig-1

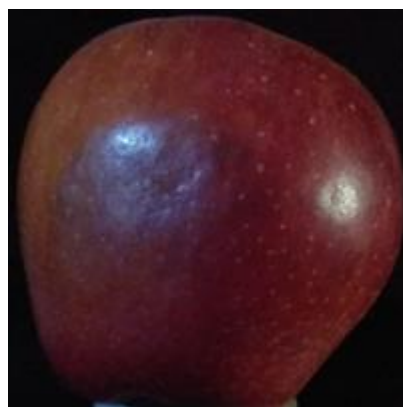


Fig-2



Fig-3



Fig-4



Fig-5



Fig-6



Fig-7



Fig-8



Fig-9

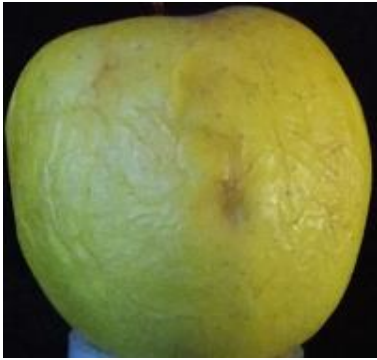


Fig-10



Fig-11



Fig-12



Fig-13



Fig-14



Fig-15



Fig-16



Fig-17



Fig-18



Fig-19

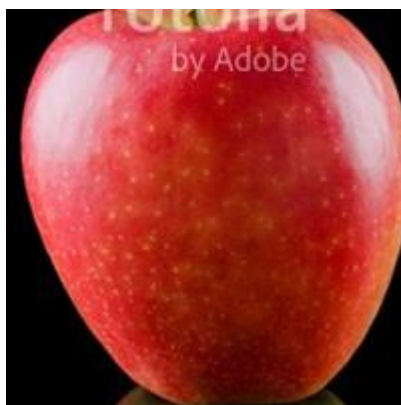


Fig-20



Fig-21



Fig-22



Fig-23



Fig-24

Database for size detection



Fig-25



Fig-26



Fig-27



Fig-28



Fig-29



Fig-30



Fig-31



Fig-32



Fig-33

Database for disease



Fig-34



Fig-35



Fig-36



Fig-37



Fig-38



Fig-39

3.2. Separation of apple from the background

We need to remove the apple from its background for better processing. For this we do thresholding. There are various types of thresholding techniques present like Global

thresholding, Local thresholding, Adaptive thresholding, Optimal thresholding , Iterative thresholding etc.

3.2.1. *Global thresholding*:- This technique is applicable when the intensity distribution of objects and background pixels are sufficiently distinct. In the global threshold, a single threshold value is used in the whole image.

3.2.2. *Iterative thresholding* :- Iterative methods give a better result when the histogram doesn't clearly define valley point. In this methodology we don't require any specific knowledge about the image. The iterative method has the ability to improve the anti-noise capability.

3.2.3. *Local thresholding*:- A single threshold will not work well when we have uneven illumination due to shadows or due to the direction of illumination. In this method we partition the image into sub-images and then choose a threshold for each sub-image. Local thresholding is used where the gradient effect is small with respect to the chosen sub-image size. In local thresholding technique, the value $T(\text{threshold})$ depends on gray levels of $f(x, y)$ and some local image properties of neighboring pixels such as mean or variance.

3.2.4. *Adaptive thresholding*:- The global thresholding method is not preferable whenever the background illumination is not uniform. In this thresholding technique we calculate a threshold for each pixel. If the pixel value is less than the threshold it is assumed to be background value, otherwise, it is set to the foreground value. There are two main approaches to finding the threshold: -

- (i) Chow and Kaneko approach
- (ii) Local thresholding.

3.3 *Algorithm used for thresholding*:- Here we use the local thresholding techniques to remove the background from the main object. . We need to divide the image into smaller sub-images because when we try to separate the apple from it's background just by using global thresholding on entire image then sometimes due to non-uniform illumination on whole apple we may not be able to separate whole apple from it's background. So to avoid this problem of

non-uniform illumination we divide the image into sub-images and separate apple part from its background using respective threshold value of each sub-image.

Step1 : Convert rgb image to gray scale and divide into four parts. To convert rgb image into grayscale we use function graythresh present in MATLAB library. The MATLAB code for local thresholding is present in appendix.

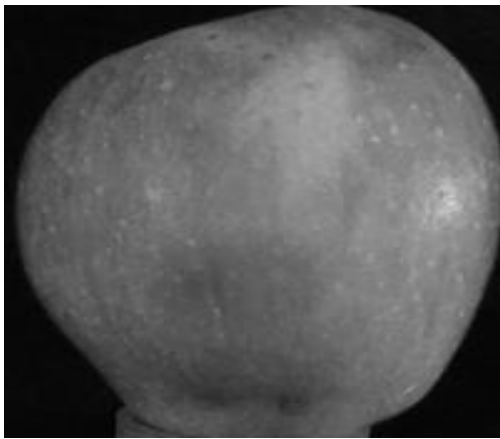


Fig-40. Image of apple

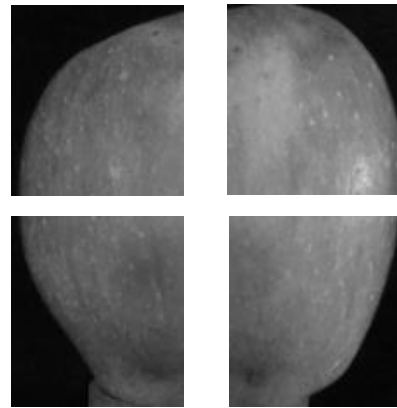


Fig-41(a ,b ,c ,d). Image divided four parts into

Step2: Draw histograms of each sub image

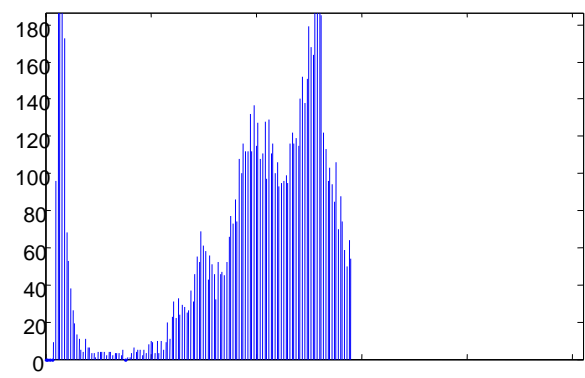
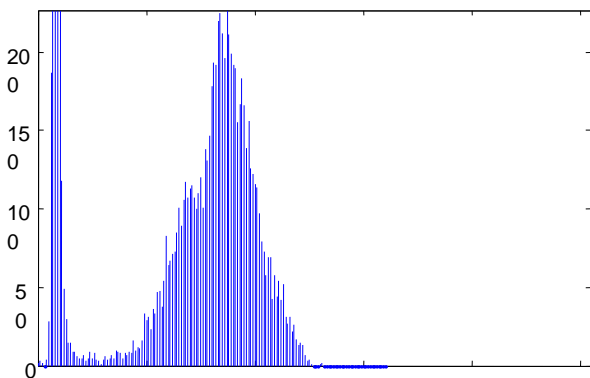
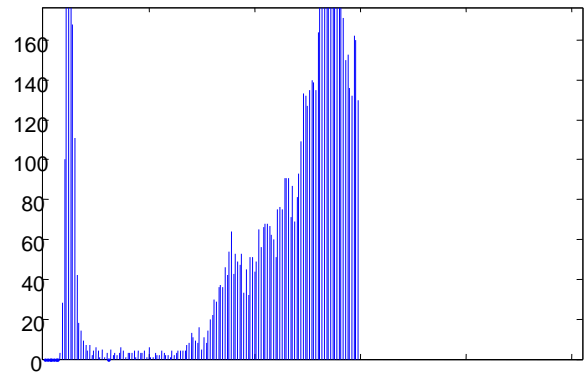
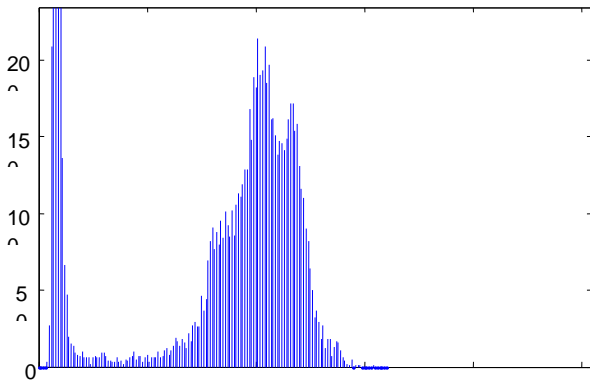


Fig-42 (a ,b ,c ,d). Histogram of each part of image

Step3: Find threshold value for each sub image using otsu's method

Threshold for sub image-a 56	Threshold for sub image-b 75
Threshold for sub image-c 47	Threshold for sub image-d 63

Step 4: Extract the apple from the background on the basis of this threshold value

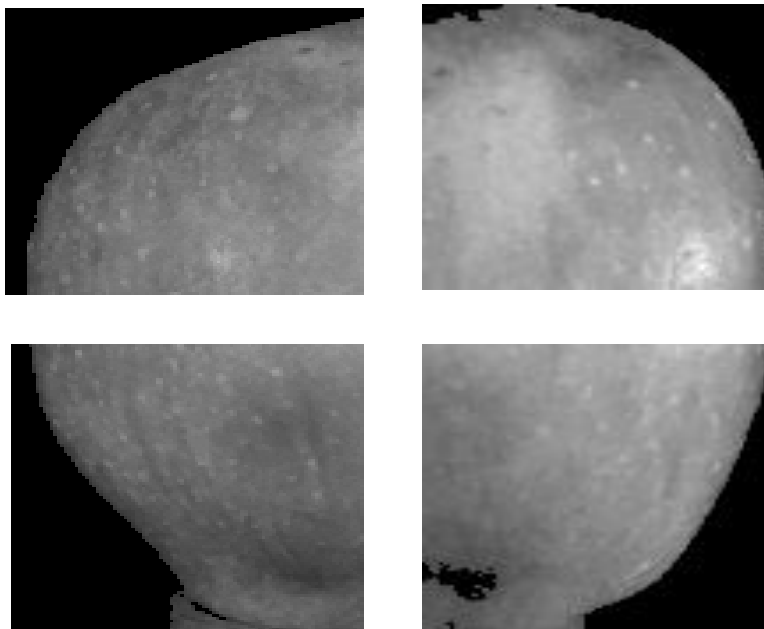


Fig-43 (a ,b ,c ,d). Four parts of image with background removed

3.4. Algorithms used for colour detection

We take images of two sides of apple in the same environment and add these images to generate a net image. Now for colour detection, we convert this added RGB image into the red plane, green plane, and blue plane. The mean value of the colour for each plane is found separately. After this we find ratio of mean of red plane to green plane of apple's image.

Now using ratio as a criterion we classify apple's into four categories :

- Green
- Yellow
- Light red
- Bright red

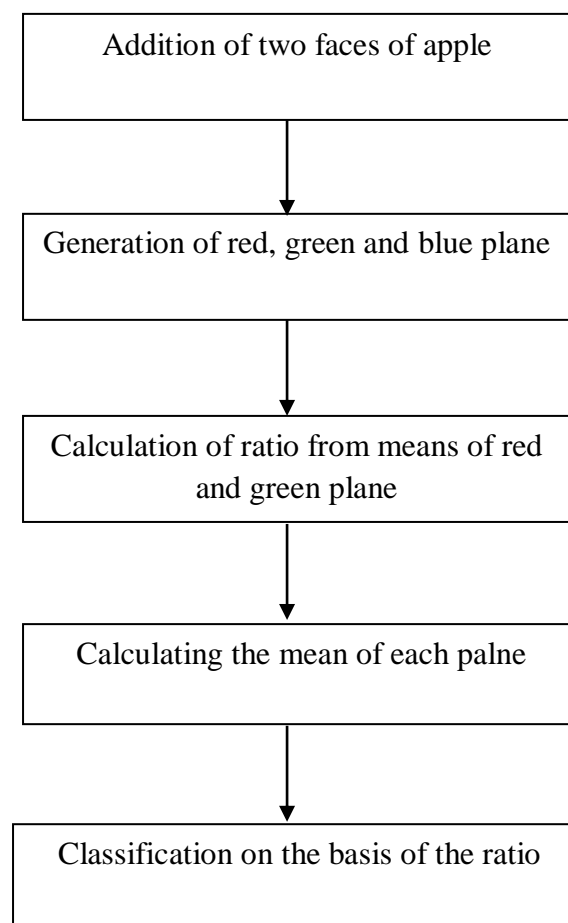


Fig-44. Flow graph for colour detection

- a. Addition of two faces of apple:- We can directly add the two faces of apple in RGB form required both images are taken in same environment and both are of the same size. The MATLAB code for the same has been added in the appendix.



Fig-45. 1st face of apple

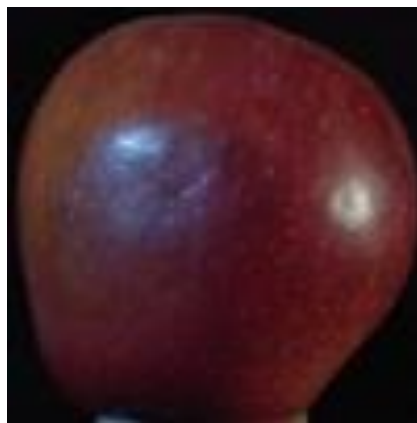


Fig-46. 2nd face of apple



Fig-47. Added image

- b. Segregate added image into red, blue and green plane

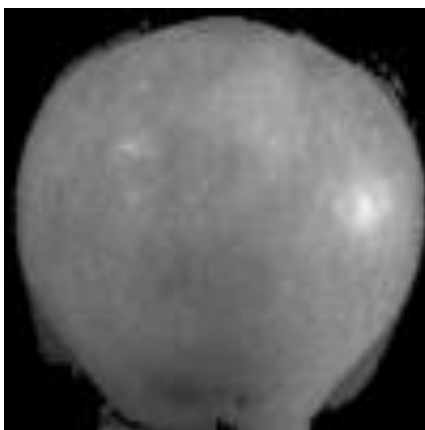


Fig-48. Red plane

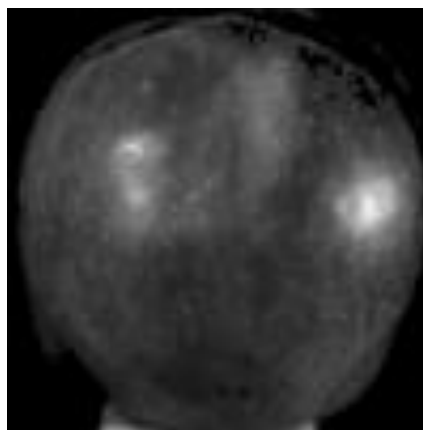


Fig-49. Green plane

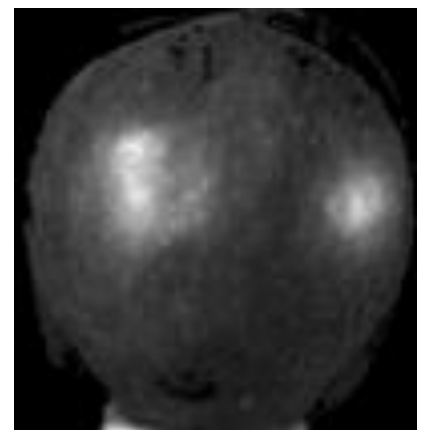


Fig-50. Blue plane

c. Take the mean value for each plane using mean function of matlab

mean_red =mean of red plane

mean_green=mean of green plane

mean_blue=mean of blue plane

The mean of each plane can be taken using ' mean' function of MATLAB.

d. Now take out ratio of mean of red plane to green plane

Ratio=mean_red / mean_green.

e. Now classify the fruit on the basis of ratio into any one out of four categories i.e. green, yellow, light red or bright red.

3.5. Algorithm for size detection

To detect the size of the apple we have to first segregate the apple from the background. After this convert the grayscale image into black and white with white portion as apple. Now to segregate apples on the basis of their sizes we use AREA as one of the parameters.

Algorithm to find area of object in black and white image:-

1. Run two nested for loops equal to the size of the image so that the loop crosses each and every pixel.
2. Take a counter initialized to zero.
3. If the value of pixel =255 (white)
Then increment the counter
4. Else if pixel value=0(black)
Then don't change the value of the counter
5. At last, after all pixels are processed we get total no. of white pixels.

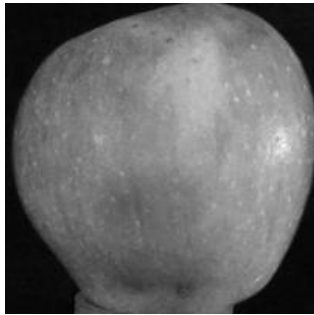


Fig-51. Original image
=Apple +Background

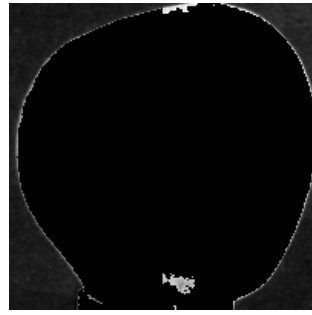


Fig-52. Background image

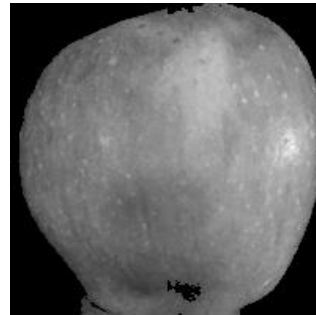


Fig.53. Apple image
without background =
(original image)-
(background image)



Fig-54. Black and white
image of apple to calculate
it's area

3.6. Algorithm for disease detection

3.6.1 *Disease detection methods*:- Though there are many types of diseases in apple here our main focus is on apple scab which are clearly visible on the surface of the apple. To identify whether an apple has a scab or not, we perform local thresholding on apple, image using threshold generated by Otsu's method. After performing local thresholding and separating diseased part from apple, we convert the image into black and white form and after doing morphological operations we calculate the area of diseased part. We repeat the same process by using Sauvola thresholding technique and compare the results of disease detection by otsu and sauvola technique.

- Sauvola :- In Sauvola's technique, the threshold $T(x, y)$ is computed using the mean $m(x, y)$ and standard deviation (x, y) of the pixel intensities in a $w \times w$ window centered around the pixel at (x, y) .

$$T = m * (1 - k * (1 - (s/R)));$$

$$R = 128;$$

k is generally taken as 0.5.

- Otsu

In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes.

3.6.2 *Problem Of Apple Boundary:* - Due to thresholding we get boundary of apple which gives error in calculating the diseased area of apple.

So to remove it we have used the following procedure:

- Start traversing each pixel row wise from left side of image from left to right..
- As soon as we encounter a white pixel make all white pixels adjacent to it in same row as black until we encounter a black pixel in the same row.
- As soon as we encounter black pixel move to next row and repeat the procedure.
- Once the procedure is completed from left side of main object repeat it from right side with each pixel being traversed from right to left.



Fig-55. Before boundary removal

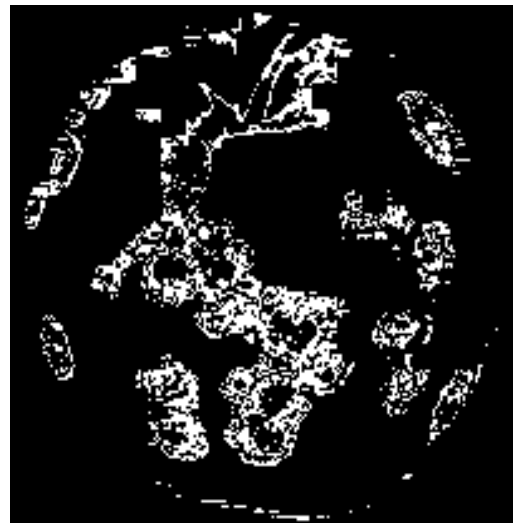


Fig-56. After boundary removal

- After boundary removal we perform morphological operations



Fig-57. After morphological operations

3.7. Maturity detection

Here we try to detect the maturity level of the apple on the basis of its color.

Note: - The below-mentioned maturity detection method is applicable only for royal red apples. To detect the maturity level of the apple we use FUZZY LOGIC. Here the ratio of the mean of red and green planes is taken as i/p and % of maturity as o/p.

3.7.1 *Fuzzy Logic*:- The term “fuzzy logic” means a logic of approximation. Boolean logic assumes that every fact is either entirely true or false. Fuzzy logic allows for varying degrees of truth. For fuzzy systems, truth values (fuzzy logic) or membership values (fuzzy sets) are in the range $[0, 1]$, where 0 representing absolute falseness and 1 representing absolute truth.

We have membership functions of many types like:

1. triangular
2. sigmoidal
3. gaussian
4. trapezoidal

But in most of the cases and here also we use triangular and trapezoidal membership function, since the data varies linearly.

3.7.2 *Fuzzy operations*:- The crisp set operators are very well defined and understood, however when fuzzy sets are considered this definition is fuzzy and many other operations can be considered. Fuzzy set operators must obey a set of rules that generalize the operations.

$$A \sqcup B = \text{MAX}(A, B)$$

$$A \sqcap B = \text{MIN}(A, B)$$

$$A' = 1 - A$$

3.7.3 *Input membership functions*:-

At input we take the ratio of the mean of red to green

We take membership functions for color as triangular:

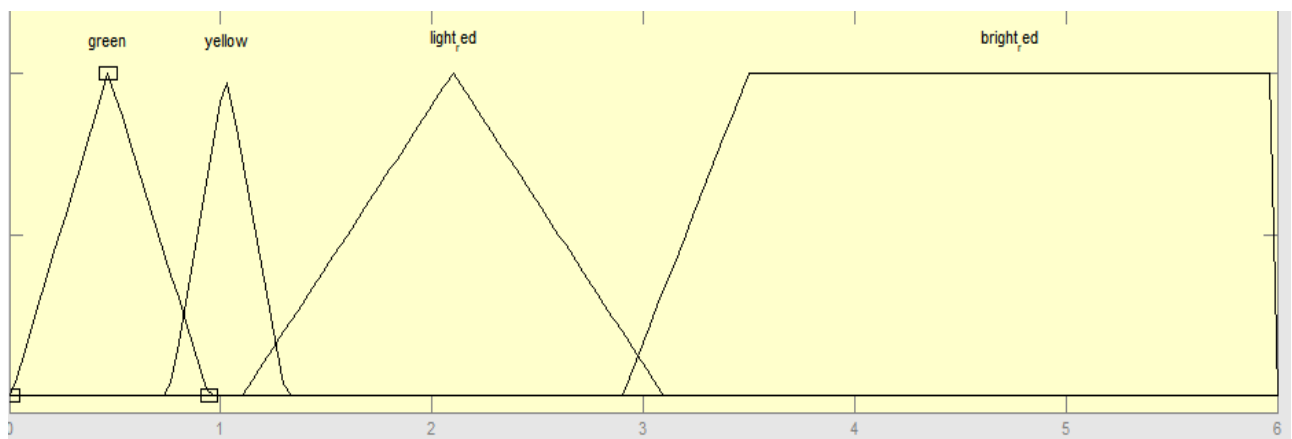


Fig-58. Input membership function

3.7.4 *Membership function for output*:

We plot the membership functions for output also i.e. different classes of maturity of apple:

- 1.) Least mature
- 2.) Less mature
- 3.) More mature
- 4.) Most mature

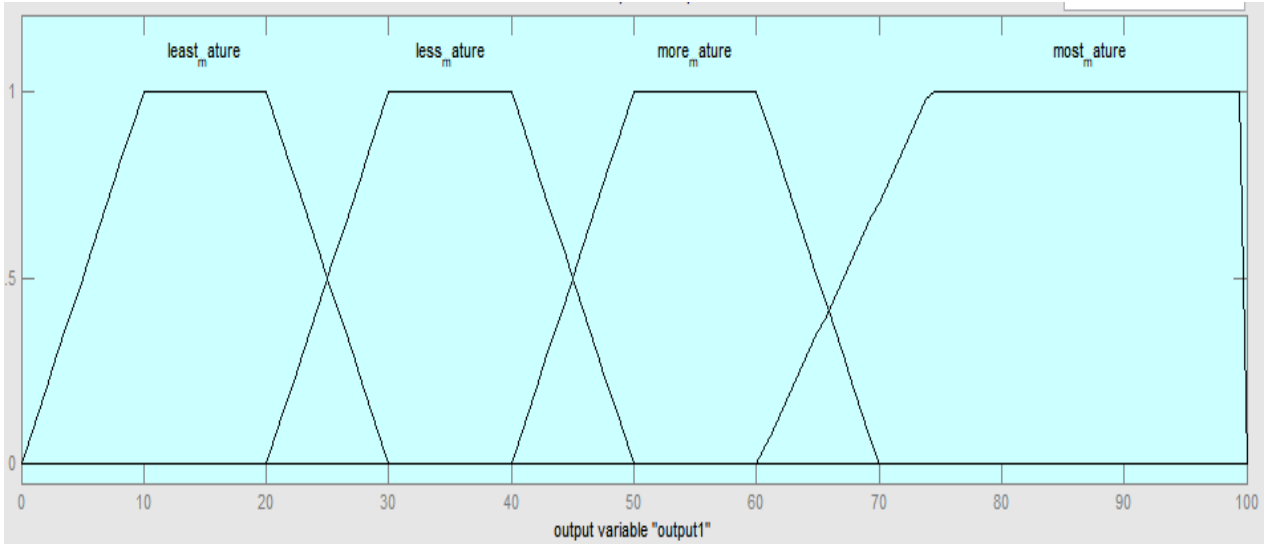


Fig-59. Output membership function

3.7.5 *Rules:-* To connect i/p to o/p we need if then else rule

1. if the input is green then output is least mature
- 2.if the input is yellow then output is least mature.
- 3.if the input is light red then output is more mature.
- 4.if the input is bright red then output is most mature.

3.7.6 *Defuzzification:-* we defuzzify using the center of mass technique. The crisp value can be found using the following equation for centre of mass.

$$z = \frac{\sum_{j=1}^q z_j u_c(z_j)}{\sum_{j=1}^q u_c(z_j)}$$






CHAPTER-4



4. RESULT AND DISCUSSION

4.1. Colour detection results

Using the algorithm for colour detection as discussed in chapter-3, section-3.4 on our own database, we have got the following results

Result table-1. Colour detection

Apples/means	Red (m1)	Green(m2)	Ratio(m1/m2)
a. 	71	15	4.4
b. 	83	46	1.8
c. 	99	57	1.7
d. 	126	131	0.96
e. 	86	110	0.77

f.		115	126	0.96
g.		101	57	1.7



From above results we can classify apple into four categories on the basis of it's colour ratio:




- If $(m1/m2) \leq 0.85$ then apple is GREEN.
- If $0.85 < (m1/m2) \leq 1.2$ then apple is YELLOW.
- If $1.2 < (m1/m2) \leq 3$ then apple is LIGHT RED
- If $(m1/m2) > 3$ then apple is BRIGHT RED

4.2. Size detection results

Using the algorithm for size detection as discussed in chapter-3, section-3.5 on our own database, we have got the following results .

Result Table 2. Size detection

Apple	Area(px.)
a. 	1985199
b. 	1981109

c.		1681361
d.		1471328
e.		1387295



From above results we can classify our apples into three categories on the basis of their size:








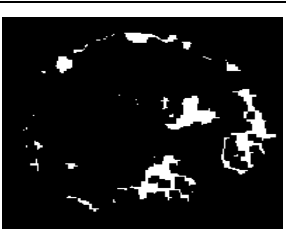

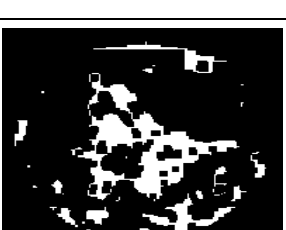
- Size is small if $\text{area} \leq 1400000$
- Size is medium if $1400000 < \text{area} < 1700000$
- Size is big if $\text{area} \geq 1700000$

4.3. Disease detection results

Using the algorithm for disease detection as discussed in chapter-3, section-3.6.2 on our own database, we have got the following result

Result Table 3. Diseased area

Original apple	Otsu	%Disease
		27

		13
		39
		23
		10
		20












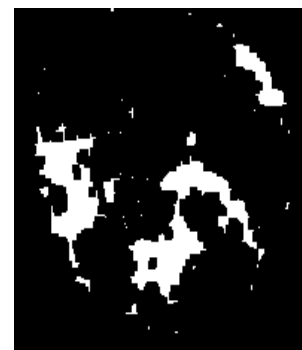
On the basis of above results we can classify our apple's into four categories:





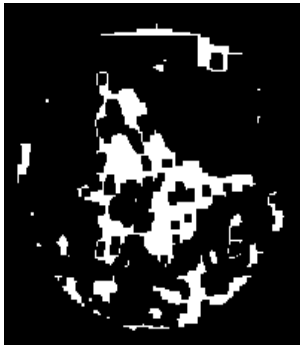

- If diseased area = $>25\%$ then apple is heavily damaged.
- If $15\% \leq \text{diseased area} < 25\%$ then apple is medially damaged.
- If $5\% < \text{diseased area} \leq 15\%$ then apple is least damaged.
- If diseased area $\leq 5\%$ then apple is not damaged.

4.4. Otsu's and Sauvola's comparison

Using the algorithm for size detection as discussed in chapter-3, section-3.5 on our own database, we have got the following results

Result Table 4. Comparison of diseased area by otsu and sauvola

Original apple	Otsu	%dise ase	saovala	%dise ase
		27		22
		13		11
		39		13
		23		15

		10		11
		20		15

So, from above results we can easily conclude that we get better results of disease detection by Otsu's method compared to Sauvola's thresholding technique.

4.5. Maturity detection results

- a. For $i/p = 0.621$ we get the maturity of apple as 15%

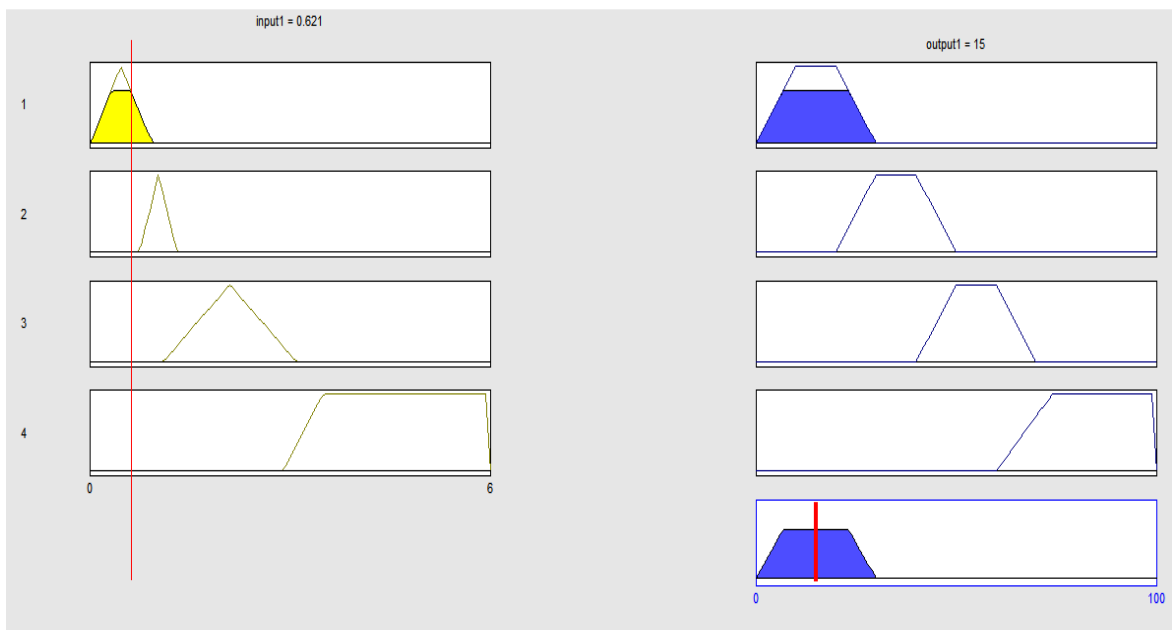


Fig-60. Output for input as 0.621

b. For $i/p = 0.862$ we get maturity as 29%

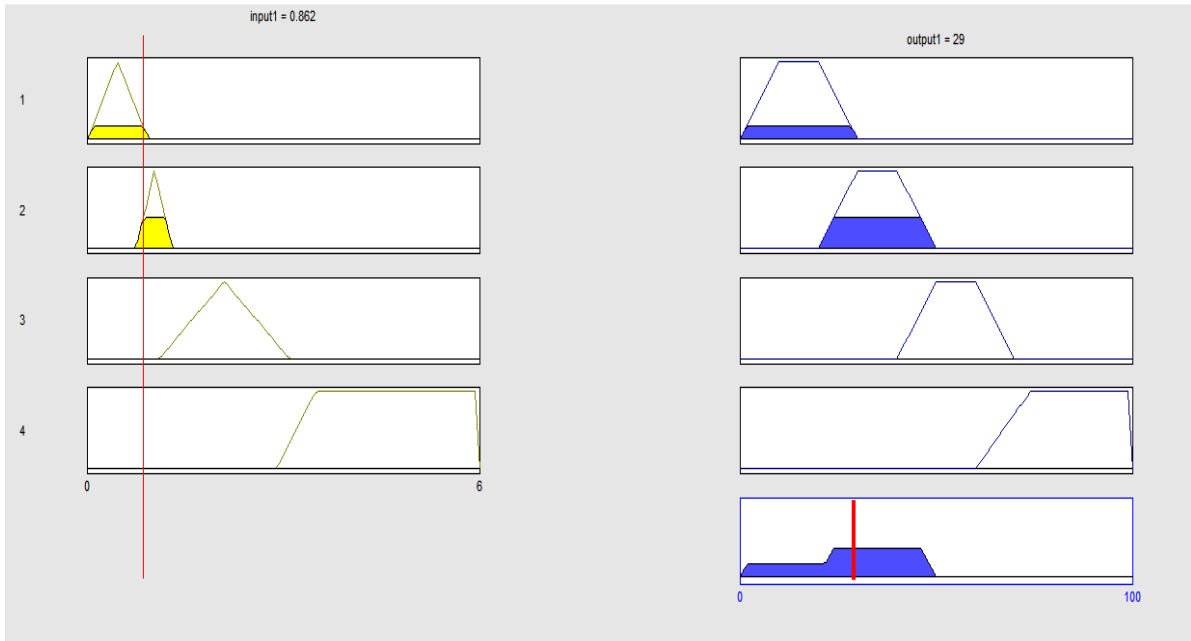


Fig-61. Output for input=0.862

c. For $i/p = 3.94$ we get maturity as 83%

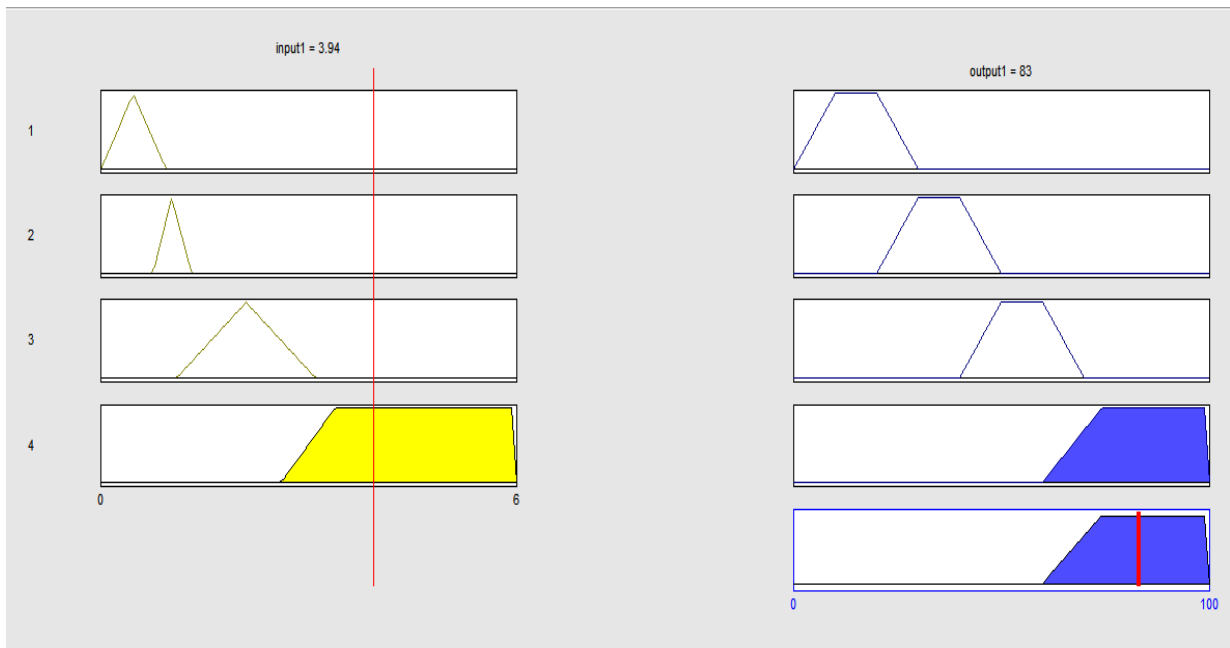


Fig-62. Output for input=3.94

CHAPTER -5

CONCLUSION AND FUTURE WORK

In this project report we classified apples on the basis of their colour, size, disease extent and maturity level. In this paper we have found a new way to classify apple's into different colours on the basis of ratio of mean values of red plane to green plane. We found a new way to remove the boundary of apple where we had to find it's diseased area since boundary of apple adds to the increase in the error. At last we have performed maturity detection using fuzzy logic where ratio of mean of red to green plane has been taken as the input parameter. The above mentioned algorithms for colour ,size ,disease and maturity detection have been well tested on our own database. These algorithms can be used in future for other datasets for the grading of fruits similar to apple in shape and colour like tomatoes , oranges etc.

CHAPTER-6

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APPENDIX

1. Addition of two faces of apple (to get the whole color of apple)

```
img=appleclradd(imga,imgb);  
  
//function for adding rotating versions  
function [img] = appleclradd( img1,img2 )  
  
//img1 and img2 are the two images to be added.  
  
img1=imresize(img1,[1600 1600]);  
img2=imresize(img2,[1600 1600]);  
img3=(double(img1)+double(img2))/2;  
img=uint8((img3));
```

2. Local thresholding

```
x=200;//used to divide main image into 4 parts  
  
//we do local thresholding for each plane of image i.e. RGB  
  
img001=locthreshing(img1,200,x);  
img002=locthreshing(img2,200,x);  
img003=locthreshing(img3,200,x);  
  
//function for background removal  
  
function [ img1bw ] = remblack(img1)  
  
//this function is used to do thresholding  
  
// we segregate red plane from image  
  
img1=img1(:,:,1);  
g1=graythresh(img1)*255;  
img1=double(img1);  
[r,c]=size(img1); for i=1:r  
    for j=1:c  
if (img1(i,j)>=g1) img1bw(i,j)=0;  
else
```



```

img1bw(i,j)=img1(i,j);
end
end
end

function [ img001 ] = loctreshing( img,rsz,z )
img=imresize(img,[rsz,rsz]);
img1=img;
[r,c]=size(img1); d=1;
for i=1:(r/z) e=1;
    for j=1:(c/z)
        img01((d:d+z-1),(e:e+z-1))=remblack(img1((d:d+z-1),(e:e+z-1))); e=e+z;
    end
    d=d+z;
end
img001=double(img1)-double(img01);
img001=nrm(img001);
end

//used for normalization

function [ y ] = nrm(a)
a=double(a);
mn=min(a(:)); a=a-mn; mx=max(a(:));
a=a./mx;
a=a*255;
y=uint8(a);
end

```

3. Colour detection

```
// take mean value for each plane i.e. red , green and blue
m1=mean(mean(img001))
m2=mean(mean(img002))
m3=mean(mean(img003))

//if else condition has been decided on the basis of experimental value

function [ apple ] = appleIrdetect( m1,m2,m3 )
if(m1/m2>=1.2)
    if(m1/m2>=3.0)
        apple='bright red';
    else
        apple='light red';
    end
else
    if(((m1/m2)<=1.2)&&((m1/m2)>=0.85))

        apple='golden';
    else
apple='green';

end
end

end
```

4. Size detection

```
function [ asize,p ] = applesizedetect(img)
img1=rgb2gray(img);
img1=imresize(img1,[2000,2000]);
[r,c]=size(img1);
g=graythresh(img1)*255;
for i=1:r
    for j=1:c
        if(img1(i,j)>=(g))
```

```

        imgh(i,j)=1;
    else
        imgh(i,j)=0;
    end
end
end
end
fill=imfill(imgh,'holes');
clearl=imclearborder(fill);
se=strel('disk',7);
//performing morphological operations
open1=imopen(fill,se);
d=regionprops(open1,'majoraxis');
a=regionprops(open1,'area');
c=regionprops(open1,'minoraxis');
p=a.Area;
if(a.Area>1700000)
    asize='big';
elseif(a.Area<1700000&& a.Area>1200000)
    asize='medium';
else asize='small'
end
end
end

```

5. Removing boundary of apple

```

[r c]=size(img01);
img0=img01;
l=1;
for i=1:r
    d=1;

```

```

for j=1:c-1
if(img0(i,j)==255)
img0(i,j)=0;

if(img0(i,j+1)==255)
d=d+1;
else
d=0;
end end
if(d==0)
break;
else l=j;
end end end
for i=1:r
d=1;
for j=c:-1:2
if(img0(i,j)==255)
img0(i,j)=0;
if(img0(i,j-1)==255)
d=d+1;
else
d=0;
end end
if(d==0)
break;
else l=j;
end end

```

6. Disease detection

```

imgs=imread('C:\Users\aditya\Desktop\scab2.png');
figure(1)
imshow(imgs)
img1=imgs(:,:,1);
img4=img1;
img1=imresize(img1,[200,200]);
[r,c]=size(img1);
% remove background otsu
d=1;
img11=remlack1(img1);
figure(2)
imshow(uint8(img11))
% find area of apple
for i=1:r
for j=1:c
if (img11(i,j)==0)
img110(i,j)=0;
else
img110(i,j)=1;
end end end
figure(3)
imshow((img110))
fill=imfill((img110),'holes');
figure(4)
imshow((fill))
a01=regionprops(fill,'area');
% finding diseased grayscale
z=10;
for i=1:(r/z)

```

```

    e=1;
for j=1:(c/z)
    img01((d:d+z-1),(e:e+z-1))=remblack2(img11((d:d+z-1),(e:e+z-1)));
    e=e+z;
end
    d=d+z;
end
figure(5)
imshow(uint8(img01))
%finding the diseased area

for i=1:r
for j=1:c
if (img01(i, j)==0)
    img01(i, j)=0;
else
    img01(i, j)=255;
end end end
figure (6)
imshow ((img01))
7. Area of object
k=0;
for i=1:r
for j=1:c
if (open1(i,j)==255)
    k=k+1;
else
    k=k;
end end end
area= k;

```

[17]