Grading of Tomatoes into Different Classes Using Digital Image Processing

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Abstract:- Grading of fruits into different sizes is one of the important steps in transporting, marketing as well as reduction of losses. Sizes are the most preferable measure in the market while purchasing fruits and it helps consumers to get a right value for right fruits based on their acceptance. Tomatoes have been considered for this study and digital image processing technology is used to measure the external features of the tomatoes. Using Walter Shewhart control charts technique, the tomatoes are sorted out as small, medium and large based on warning, specification and control limits respectively. Results shows that grading of tomatoes meets market flexibility of the consumers, increase the economic value of producers and ultimately leads to wastage reduction. Further the feasibility of digital image process based grading system is also physically verified. The combination of digital image processing and Walter Shewhart control provides a rapid, consistent and objective inspection technique, which can be expanded into many diverse food processing industries.

***Keywords*: Tomato, image, surface area, control chart, sorting, food image processing.**

1. INTRODUCTION

The **tomato** is the edible, often red fruit/berry of the nightshade ***Solanum lycopersicum***, commonly known as a **tomato plant**. The species originated in the South American Andes and its use as a food originated in Mexico, and spread throughout the world following the Spanish colonization of the Americas. Its many varieties are now widely grown, sometimes in greenhouses in cooler climates.

The tomato is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, salads, and drinks. The fruit is rich in lycopene, which may

have beneficial health effects.The tomato belongs to the nightshade family, *Solanaceae*. The plants typically grow to 1–3 meters (3–10 ft) in height and have a weak stem that often sprawls over the ground and vines over other plants. It is a perennial in its native habitat, although often grown outdoors in temperate climates as an annual. An average common tomato weighs approximately 100 grams.

According to FAO, global tomato production amounted to 27.6 million tonnes in 1961.

The threshold of 50 million tonnes was reached in 1978, and 100 million tonnes in
1999. Considering an annual growth rhythm of 3.5 %, global tomato production –
which can be roughly assimilated to global consumption – amounted to 141 million
tonnes in 2009. Finally it can be considered that total tomato consumption increased from 109 million
tonnes in 1999 to 141 million tonnes in 2009.
Digital image processing analysis and computer visions have exhibited an impressive growth in the past decade in term of theoretical and applications. The most popular analysis techniques that have been used for both recognition and classifications of two dimensional (2D) fruit images are colour-based and shape-based analysis methods. However, different fruit images may have similar or identical colour and shape values. Hence, using colour, size and shape features analysis methods are still not robust and effective enough to identify and distinguish fruits images

II.MATERIALS AND METHODS:

Tomatoes are classified into wide range across the world.The classification is based on the characteristic feature of tomato.Bangalore tomato is one among the varieties and widely used.Thirty fruits/samples were selected carefully from Bangalore variety of tomato after washing and cleaning.Individual fruits were numerically marked from one to thirty. Individual fruits weight were measured using digital weighing machine and the diameter have been determined.Dimensions of the fruit were taken manually using vernier calipers.

III.CONTROL CHARTS FOR SORTING

Usually companies use control charts as successful devices to study the pattern of variation in the units inspected. Here the use of control chart aid in sorting sizes of Tomato based on process shifts. They depends on sub groups of a fixed numbers (n) of data points. The process shifts are considered 2σ and 3σ for the satisfactory choice of sorting sizes of Tomato.

For construction of control chart, 30samples of tomato have been taken.Control chart presents a graphic display of process stability or instability over time. As described by Chris Baumen et al., 2007, one more important reason for using control chart is to get the process stability, it is the state in which a process has displayed a certain degree of consistency in the past and is expected to continue to do so in the future. In quality control chart 2σ and 3σ limits were used to find the upper control limits (UCL) and lower control limits (LCL). They are

$$\mathbf{UCL/LCL = mean \pm 3(\sigma/\sqrt{n})}$$

2σ limits of the quality control chart are known as specification limits. They are upper specification limit (USL) and lower specification limit (LSL).

$$\mathbf{USL/LSL = mean \pm 2(\sigma/\sqrt{n})}$$

Where n is the sub group sample size.

The sorting of Tomato cultivars depends on the quality control chart performance measures. They are 3σ limits and 2σ limits and Tomato are sorted into three groups such as small, medium and large based on less than LSL, LSL to mean, mean to USL and more than USL respectively.

A.Features Extraction

MATLAB®7.7.0.47(R2008b) has been used as the platform for writing program in image processing, image analysis developing the algorithms and interfaces.Matlab® is a high –level technical computing language and interactive environment for algorithm development,data visualization, data analysis and numeric computation.

It provides Image processing tool box which extends the capability of MATLAB® environment for the solution of Image processing problems.

III. RESULTS AND DISCUSSION

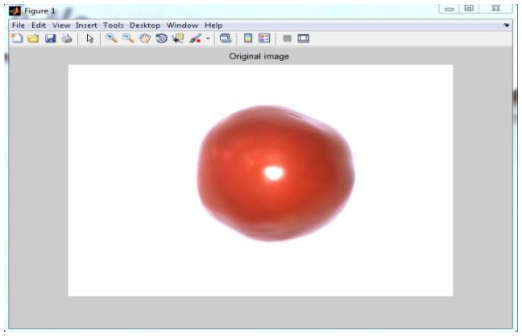
IBM software SPSS version 20.0 was used for statistical sorting of the fruits. The results obtained from the statistical analysis shows that the *tomato* variety contains the minimum fruit weight of 48g and the maximum fruit weight of 134.57 g and the mean weight of the fruits are 82.409g. In the commercial point of view, in the market big fruits fetch more money. Thus,the work was concentrated on cirumfernce sorting. The small circumference of tomato variety is 17.3432 cm and the largest circumference of the fruit is 23.5987 cm and the mean circcufernce of the fruit is 20.3213cm.

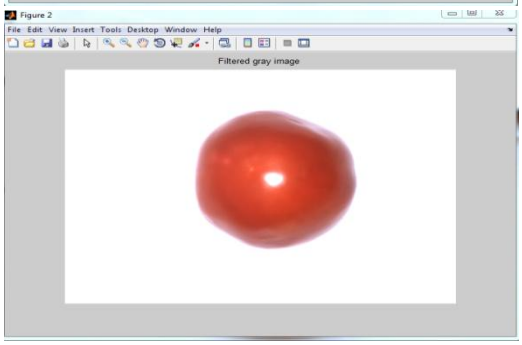
A. Program coding:

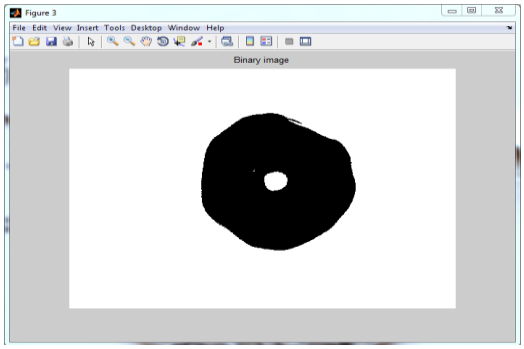
```
clc;
close all;
clear all;
% Read image
image =
imread('E:\matlab\18.02.15\1.jpg'
)
figure,
imshow(image);
title('Original image')
% guassian filter
filter=fspecial('gaussian');
gray=imfilter(image,filter);
figure,
imshow(gray);
title('Filtered gray image')
% binary image
T = graythresh(gray);
BW = im2bw(gray,T);
figure,
imshow(BW);
title('Binary image')
% edge detection
e=edge(BW,'sobel',[]);
figure,
imshow(e);
title('Edge detected image')
%  cleaning of noise regions
mylabel = bwlabel(BW);
tam = zeros(1,max(max(mylabel)));
for (i = 1:max(max(mylabel)))
tam(i) =
size(find(mylabel==i),1);
end
mayort = max(max(tam));
posic = find(tam==max(tam));
BW(find(mylabel~=posic)) = 0;
BW1 = BW;
figure,
imshow(BW1);
title('Denoised binary image');
% Edges detection for denoised
image
e1=edge(BW1,'sobel',[]);
figure,imshow(e1)
```

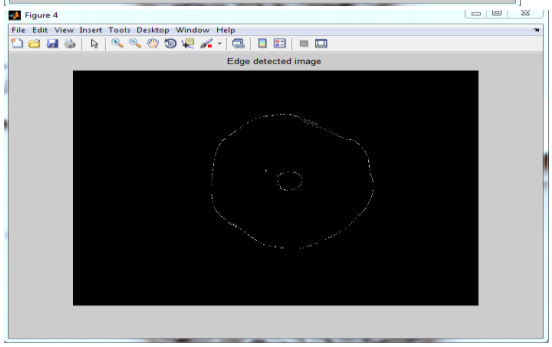
```
42 title('Denoised Edge detected
   image');
43 %size determination using
   circular method
44 figure,imshow(e1)
45
46 imtool(e1);
47 % circular method
48 px1=input('enter the value of x1
   pixel value=');
49 py1=input('enter the value of y1
   pixel value=');
50 px2=input('enter the value of x2
   pixel value=');
51 py2=input('enter the value of y2
   pixel value=');
52 px3=input('enter the value of x3
   pixel value=');
53 py3=input('enter the value of y3
   pixel value=');
54 a=[px1 py1 1;px2 py2 1;px3 py3 1
   ];
55 del=4*det(a);
56 x4=px1^2+ py1^2;
57 x5=px2^2+ py2^2;
58 x6=px3^2+ py3^2;
59 del1=-2*det([x4 py1 1;x5 py2 1;x6
   py3 1 ]);
60 del2=-2*det([px1 x4 1;px2 x5
   1;px3  x6 1 ]);
61 del3=-4*det([px1 py1 x4;px2 py2
   x5;px3 py3 x6 ]);
62 g=del1/del;
63 f=del2/del;
64 c=del3/del;
65 pc=[-g ,-f]
66 r=(sqrt(g^2+f^2-c))/100
67 CIRCUMFERENCE=2*3.14*r
```

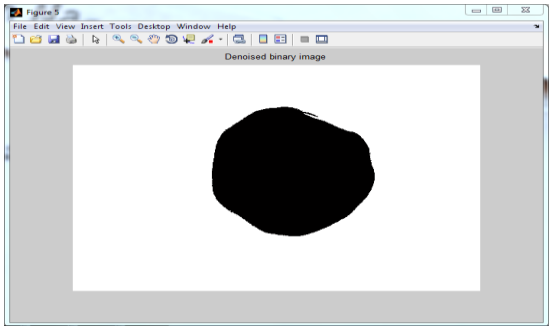
B. Output











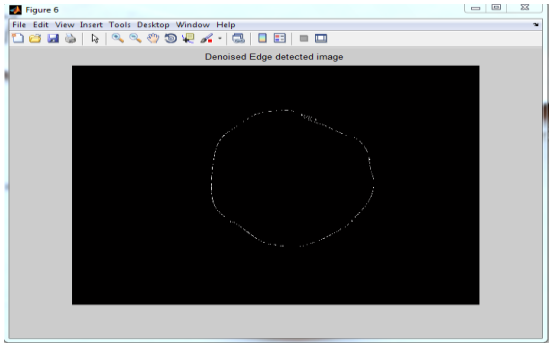


Fig1. Output screen

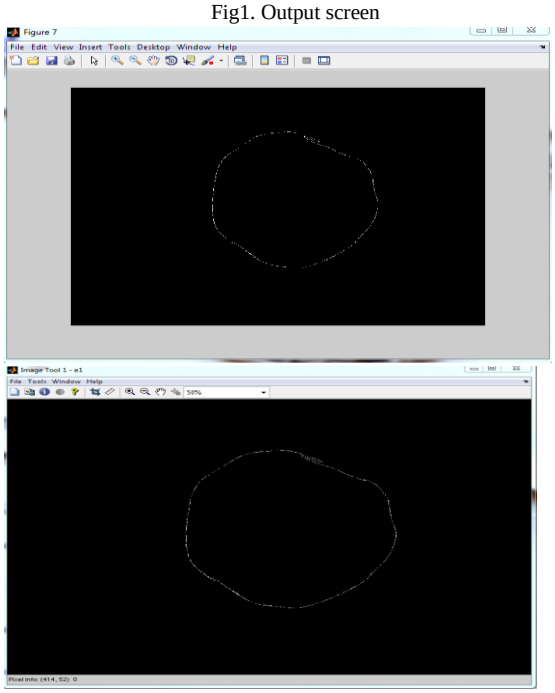


Fig 2. Output screen

enter the value of x1 pixel value=974
enter the value of y1 pixel value=292
enter the value of x2 pixel value=1112
enter the value of y2 pixel value=770
enter the value of x3 pixel value=562
enter the value of y3 pixel value=702

pc = 855.6585 585.0861
r = 3.1608
CIRCUMFERENCE = 19.8496

C. TABULATION

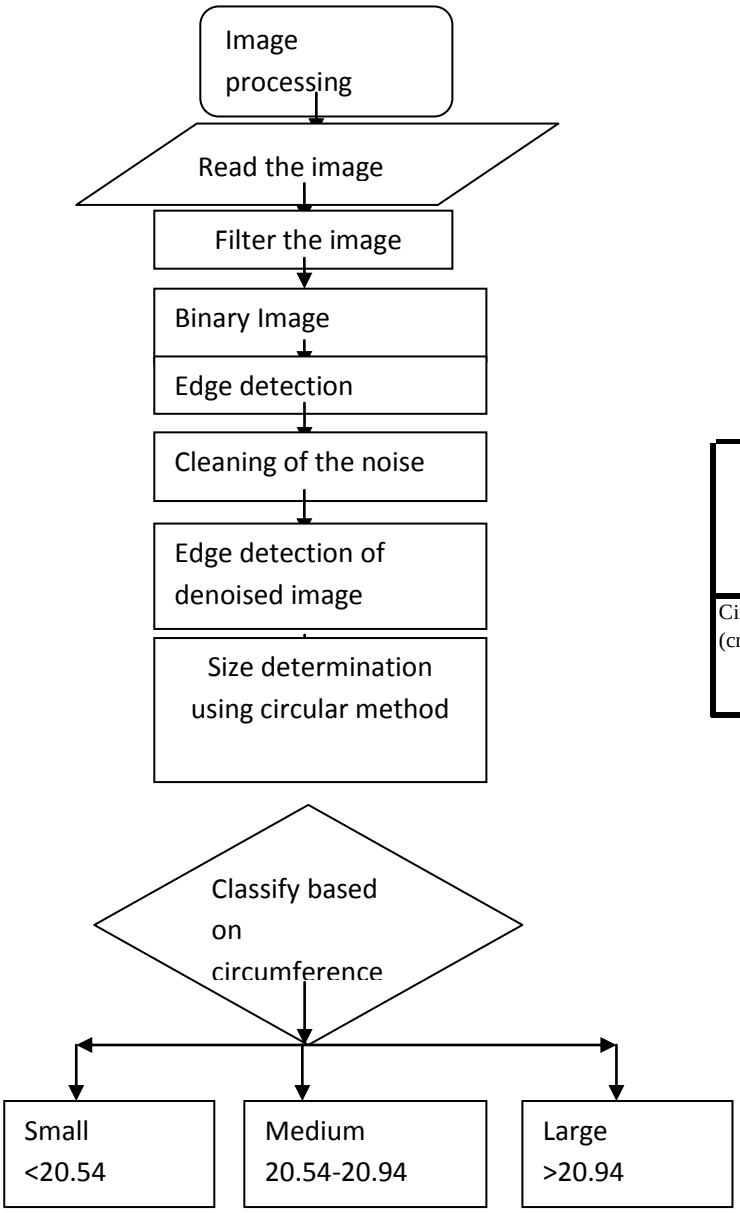
Manual classification is considered as a standard grade for the image processing of tomato fruits. Algorithm and the programme was developed using MATLAB and the captured images were run through the MATLAB software the circumference value obtained for different grades were mentioned.

TABLE 1 OITPUT VALUES

s.no	weight(g)	Circumference (cm)
1	93.61	19.8496
2	76.14	19.8671
3	81.47	20.6988
4	76.43	19.942
5	61.48	17.3432
6	78.21	19.905
7	66.58	18.6329
8	48	17.7197
9	55.37	17.915
10	81.18	20.4221
11	53.1	17.4577
12	95.77	20.7578
13	134.57	22.9736
14	84.66	22.106
15	78.81	19.6866
16	73.95	20.4412
17	123.85	22.3492
18	94.88	21.7022
19	71.88	19.133
20	71.95	20.7912
21	90.41	23.5987
22	111.84	22.548
23	98.05	22.0234
24	74.53	18.2588
25	95.69	21.5769
26	77.3	20.4857
27	94.92	21.7761
28	85.85	21.3817
29	52.14	18.1624
30	89.65	20.1331

D. Flowchart

The processing is shown in the following flow chart and the separation of tomato into different grades based on the circumference of the fruit was done through the MATLAB program.



IV.STATISTICAL ANALYSIS:

Using SPSS software the mean weight, maximum weight,minimum weight and standard deviation of the 30 tomatoes were tabulated in *Table 1*. Similarly the mean circumference,maximum circumference,minimum circumference and standard deviation of the 30 tomatoes were tabulated in *Table2*.

TABLE 1: PHYSICAL MEASURE FOR TOMATO BASED ON WEIGHT

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
weight(g)	30	48.00	134.57	82.4090	3.61059	19.77601

TABLE 2: PHYSICAL MEASURE FOR TOMATO BASED ON CIRCUMFERENCE

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Circumference (cm)	30	17.34	23.60	20.3213	.31119	1.70444

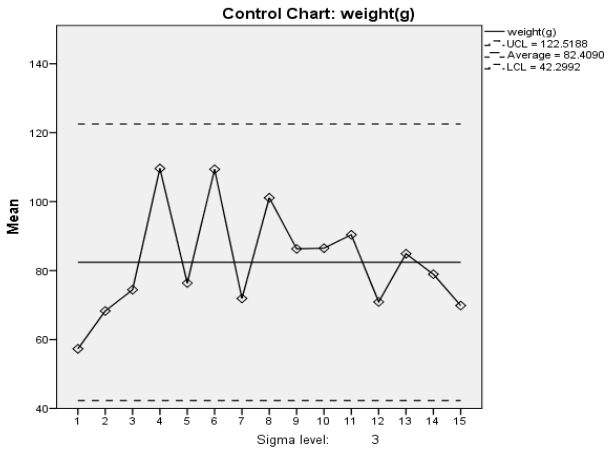


Fig.1: Control chart for Tomato variety based on weight

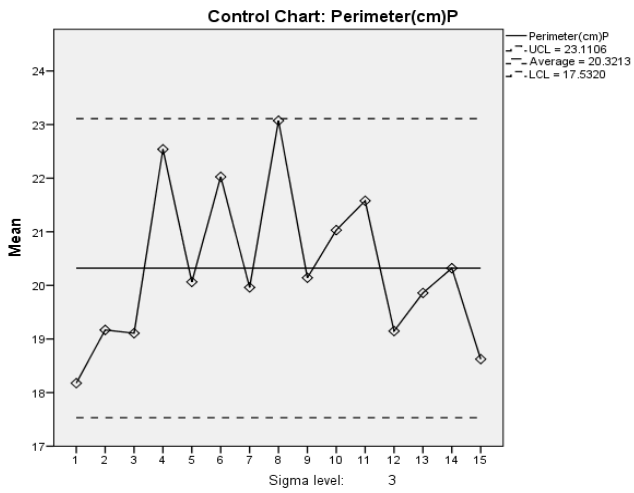


Fig.2: Control chart Tomato variety based on Cirumference

Control chart was used to classify the fruits with the help of 3σ level and obtained the upper control limit and lower control limit for Tomato variety for weight sorting that is 122.5 and 86.01 respectively. Similarly for cirumference of tomato variety also calculated the upper control and lower control limits are 23.11and 20.54 respectively.Based on the obtained results, fruits were classified into three categories namely small, medium and large. The results are given below.

TABLE 3: SORTING RESULTS OF TOMATO VARIETY

Parameter	Size	Range	Number of fruits
Weight (gm)	Small	82.4-86.01	19
	Medium	86.02-89.62	1
	Large	>89.63	10
Circum-ference (cm)	Small	20.32-20.54	17
	Medium	20.55-20.94	3
	Large	>20.95	10

V. CONCLUSION

The sorting of Tomato fruits based on weight and circumference into three groups were developed through statistical quality control chart. While getting the good results and to achieve the objective of sorting fruits, difference in various attributes of fruits has been found. Equivalence sorting of Tomato can be seen Table 3 using weight as well as circumference of the Tomato. This method of control charts can also apply for different fruits and can efficiently be used to develop sorting and grading machines.

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