Detection of Fruits Defects Using Colour Segmentation Technique

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***Abstract*—In image processing colour segmentation is used to extract features of an object in both special and frequency domains. The objective of this paper is to use colour segmentation technique to identify the defected region of fruits and corresponding percentage of frequency components from its Spectrogram. Here we separate the defective portion of fruit using colour segmentation technique taking four images from four directions to get the appropriate result of 3D images. The percentage of the defective portion is determined using scatterplot of the colours of the image. Next, we apply the similar concept to spectrogram of an image (even applicable in speech signal) to extract the percentages of frequency components of the signal.**

Keywords-Scatter plot, mean Euclidian distance, L*a*b image, Spectrogram of image and spectral components of speech signal.

I. INTRODUCTION

The value of fruits depends on its quality hence retailers categorize various fruits according to their quality. For example in the European Community, apples have three categories in fresh apple market. Fruits with no defects are in a class called 'extra'. Fruits with little defects are placed in class I. If the defects are too large, these fruits are considered as a Class II category and these types of fruits are rejected as given in [1]. To meet the increasing demand of high-quality products, fruits are graded before being sent to market or for further processing analyzed in [2]. However, manually identification of fruit's defects requires more time as well as cost. This type of process could be done automatically with the help of computer vision systems. To identify the defected region, the first step is to segment the defect.

Image segmentation means separation of an image in different region based on its properties. The goal of segmentation is to simplify and change the description of an image into something that is more suggestive and easier to analyze as explained in [3-4]. The colour is one of the properties which bears information of the image and colour based image segmentation has wide applications. It is convenient to identify different colours in an image on $L*a*b$ colour space instead of conventional RGB component.

For automating detecting of fruits defects, many types of research have been done using the computer vision system, but it is still challenging task due to various types of defects, shape, the presence of stem and so on described in [5].

In this paper, we proposed a very efficient and quick segmentation technique based on colour segmentation. Our work carried out several stages; the steps of algorithm is show in next section. In the frequency domain, each colour indicates the different frequency components. Therefore, getting the spectrogram of an image we can separate the sequences of colour components which resembles to different frequency components. That's why it is easy to identify the defected part at a glance as given in [6].

Histogram based image segmentation technique is computationally very efficient when compared to other image segmentation techniques because they usually require only a single pass through the image pixels inspected in [1]. Many colour models are used to represent the colour like RGB, CMY, HSV, HSL; an effort is made to defeat the problems encountered while segmenting an onset by using the colour properties of the image explored in [3]. A region growing algorithm typically starts with some seed pixels in an image and from these, it grows regions by iteratively adding unassigned neighboring pixels that satisfy some homogeneity criterion with the existing region of the seed pixel found in[7]. In paper [8] the authors proposed a new quantization method for HSV colour space to create a colour histogram and a gray histogram for K-means clustering which operates across different dimension in HSV colour space. Image acquisition is the process of acquiring an image from some hardware-based sauces in which the output image can be used for further processing that is analyzed in[9]. The choice of colour space representation could be taken to enhance the performance of processes such as segmentation because of the increment in demand for the colour-driven images as compared to grayscale images inspected in [10-11]. A hybrid method for colour segmentation based on seeded region growing in which the initial seeds are provided by a conservative threshold colour segmentation found in [12]. Creating code elements on the description hexagonal hierarchical structure each island has one or more so-called code elements as explored in[13]. Identifying of fruit defects based on the selection of image region and object offering has been proposed in [14]. A technique has been proposed which can isolate the healthy parts of olive fruits as well as the actual defected region analyzed in[15]. A computer vision method has been used to identify the grade quality of agricultural products described in [16].

The entire paper is organized as: section II deals with theoretical analysis and algorithm of colour segmentation of fruits, section III provides result based on analysis of section II and chapter IV concludes entire analysis with some future work plan.

II. BASIC THEORY OF L*A*B COLOUR SPACE

It is three axis colour system; where the first axis is L channel or lightness, goes up and down the three-dimensional model and consists of white and black. When $L^* = 0$, it indicates the darkest black and $L^* = 100$ indicates the brightest white found in [10]. The axis a^* indicates where the colour falls along the red to green axis, the negative value of a^* indicates green, and the positive value of a^* indicates magenta. Along b^* axis the colour runs between the blue to yellow. Positive values of b^* represents Yellow and the negative values of b^* indicate Blue. When the channels a^*=0 and b^* = 0, these represent the true neutral gray. As L^*a^*b model is a three-dimensional model, so it can only be represented accurately in a three-dimensional space. The formula for converting digital images from RGB space to the $L^*a^*b$are given below.

$$\begin{bmatrix} L* = 116f\left(\frac{Y}{Y_n}\right) - 16 \\ a* = 500[f\left(\frac{X}{X_n}\right) - f(\frac{Y}{Y_n}) \\ b* = 200[f\left(\frac{Y}{Y_n}\right) - f(\frac{Z}{Z_n}) \end{bmatrix} \tag{1}$$

$$f(x) = \begin{cases} x^{\frac{1}{3}};\ \text{if } x > 0.620 \\ 7.787x + \frac{16}{116}; \text{Others} \end{cases}$$

;Where X, X_n, Y, Y_n, Z, Z_n are the coordinates of CIEXYZ colour space.

For many digital image manipulation, L^*a^*bcolour space is more suitable than the RGB colour space since it is device independent.

A. Colour segmentation of image

Generally colour is the most important and influential attribute of fruits quality. Numerous defects of fruits appear as discolouration on surface as mentioned in [2]. Colour based image segmentation means the image will be separated according to colour. The primary aim is to identify different colours in an image by analyzing the L^*a^*b colour space. Segmentation of an image is referred to separate the image into a non-overlapping region based on some feature as given in[17]. Colour image segmentation simplifies the vision problem by assuming that objects are coloured distinctively; where the gross colour differences matters. In our paper, we concentrated on the colour since it is easy to find out defected region according to colour variation.

B. Algorithm

Algorithm for the proposed work is given below.

Step 1. Read the RGB image.
Step 2. Convert the image into L^*a^*b.
Step 3. Select a region of a particular colour of L^*a^*b image.
Step4.Take the average value of the pixels excluding luminance component. Let the average value is $(u_a, v_a) = z_a$.
Step 5. If the magnitude of i^{th} pixel of the image is $(u_i, v_i) = z_i$. Evaluate the Euclidian distance,$\|z_a - z_i\| = D_i$
Step 6. If $D_i \le \tau$; (τ is a threshold value of D_i), Then select the pixel, otherwise, ignore it.
Step 7. Repeat step 5 and 6 for all pixels of the image.
Step 8. Now show the image for pixels satisfies steps 5 to 7.
Step 9. Repeat steps 3 to 8 for all the required colours.
Step 10. Draw the scatter plot of all colours on $a - b$ axis.
Step 11. Repeat steps 1 to 10 for another image of same class.
Step 12. Determine to mean Euclidian distance between the pixels of a particular colour (for example purple) on scatter plot. If it is less than the threshold, then the 2nd image is identical with the 1st one.

C. Scatter plot of segmented image

Sometimes instead of x-y, two orthogonal basis functions: $\varphi_1(x)$ and $\varphi_2(x)$ are used along x and y direction; where the cross-correlation between them are zero i.e. $< \varphi_1(x), \varphi_2(x) > = 0$. The signal component correlated with $\varphi_1(x)$ gives abscissa and that of with $\varphi_2(x)$ gives ordinate. In colour segmentation, we separate the 'a^*' and 'b^*' components of each pixel then plot a^* level values along horizontal axis and b^* level along the vertical axis as found in [18-19]. By counting different colour points from the scatter plot, defected portion is detected.

D. Spectrogram of a signal

The spectrogram is usually represented on a two dimensional plane where the horizontal and vertical axis represents time and frequency; a third dimension indicating the value of a particular frequency at a given time is depicted by the intensity or colour of each point in the image [20-21]. The defected region is usually darker than the original colour of fruits hence the spectrogram will provide distinct region.

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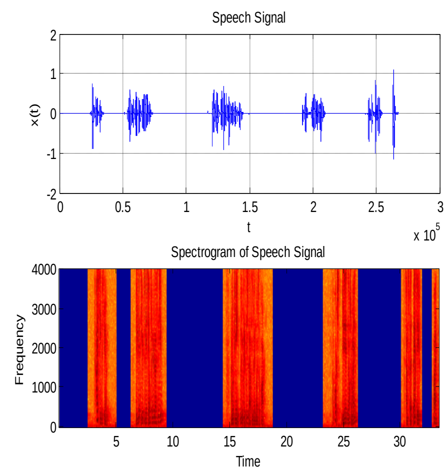

Figure 1. Spectrogram of audio signal

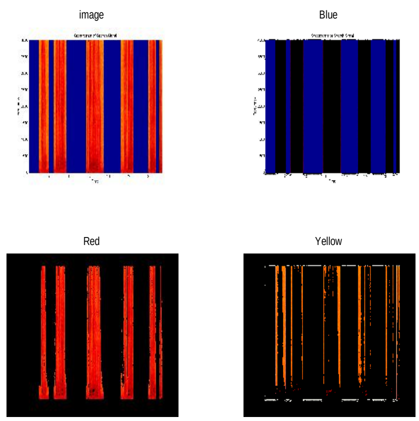

Figure 2. Segmented image of different frequency

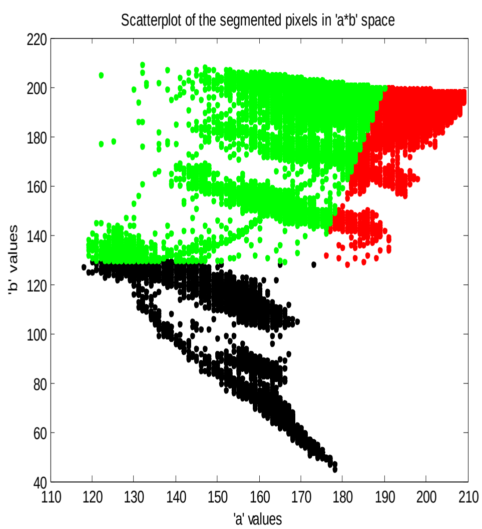

Figure 3. Scatter plot of speech signal

For example a sound wave in time domain varies with amplitude and each segment of the wave possesses different frequency components. Applying simple Fourier transform will provide frequency components but time information will be lost. Applying short time Fourier transform on each segment will preserve both time and frequency components. The graphical presentation of such phenomenon is actually the spectrogram as shown in fig.1. The colour segmentation and scatter plot of the spectrogram are shown in fig. 2 and 3.

III. RESULT AND DISCUSSION

In this section, we detect the faulty portion of a fruit using colour segmentation technique along with the scatter plot of the different portion of a fruit. In the second technique, we did the similar job using spectrogram of the image. In Fig.4 four images are shown for a particular region of a defective banana. The first image of the figure shows the original image, the second image provides a healthy portion of the image, the third image shows the partially defected portion and the fourth image reveals the fully rotten portion of the image. The Fig.5 shows the scatter plot of the corresponding region of the image. Here we show three colours (green colour represents the faultless portion, the colour of partially defected portion is represented by yellow and red colour represents the fully rotten portion) to acquire the percentage of partially or fully defected portion of the defective fruits.

Next, we take a similar image from four sides of 3-D fruits then measure the percentage of the defective portion from individual scatter plot. Then four scatter plots are summed up to get the illusion of scatter plot of the 3-D image of a defected fruit. The percentage of individual colour are measured from the combined data of four scatter plot. The corresponding figures are shown in Fig. 6-11. Next, we apply similar operation on oranges and apples shown in Fig. 12-27. The entire result of above analysis is shown in table 1.

Next part of the result section, we consider different colours of an image using its spectrogram. In this paper we only provide the guideline of colour segmentation of a spectrogram but detail analysis will be done in future. For simplicity of analysis we show the spectrogram of grayscale image of defective fruit in fig. 28 (a) and (b). In real life situation, we have to separate *a* and *b* components of the image first then spectrogram of both component will be taken. The scatter plot of each spectrogram will be count to get the real scenario of the rotten fruit. However, in spectrogram different colour or frequency of an image are separated along frequency axes, hence separation of colour is a little bit easier to compare to the original image. Therefore, we expected to get more accurate result from the spectrogram of an image. This analysis will be performed in details in future and expect to make compares in future. The concept is applicable in biometric identification.

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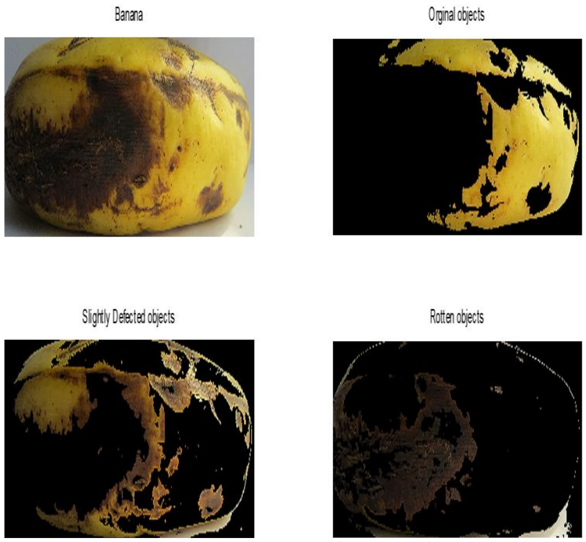

Figure 4. Segmented image of banana of side 1

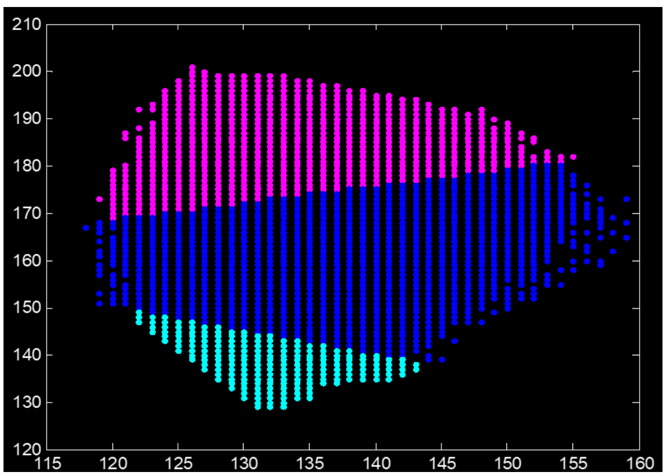

Figure 5: Scatter plot diagram of banana of side 1

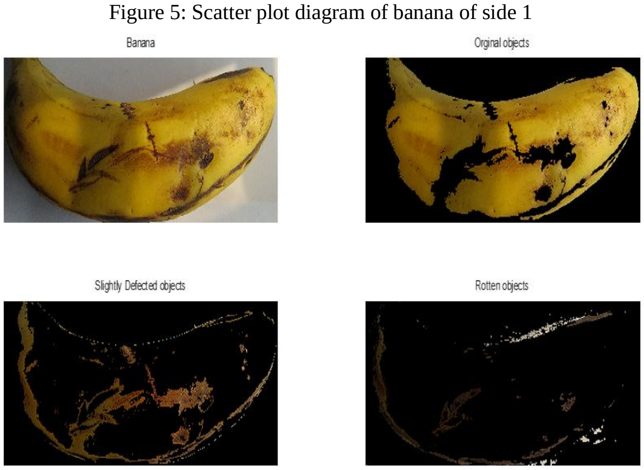

Figure 6. Segmented image of banana of side 2

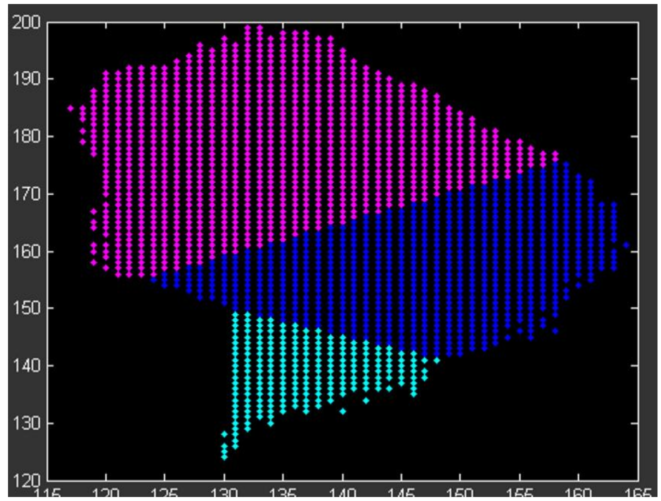

Figure 7. Scatter plot diagram of banana of side 2

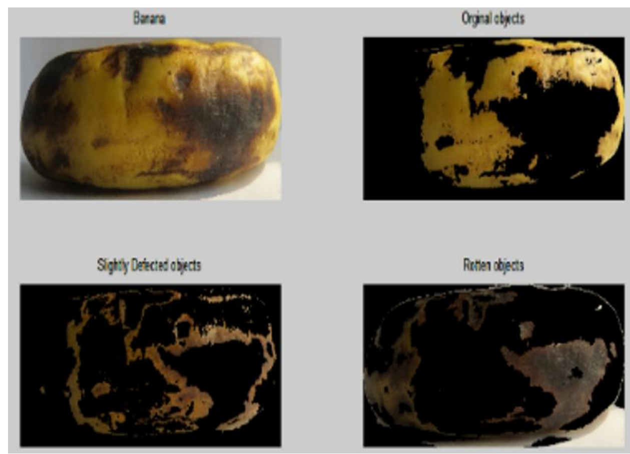

Figure 8. Segmented image of banana of side 3

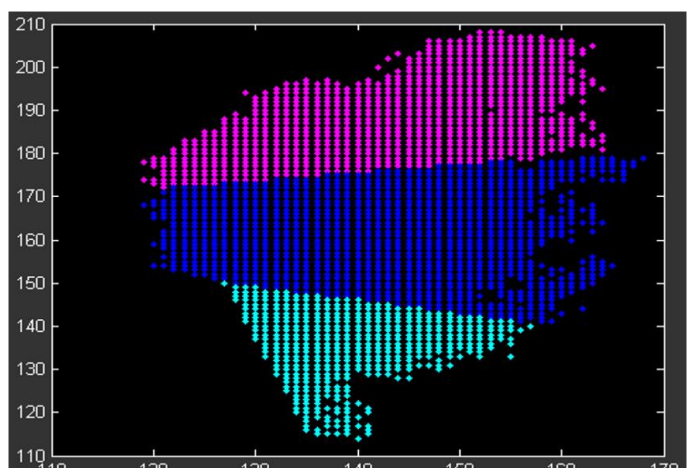

Figure 9. Scatter plot diagram of banana of side 3

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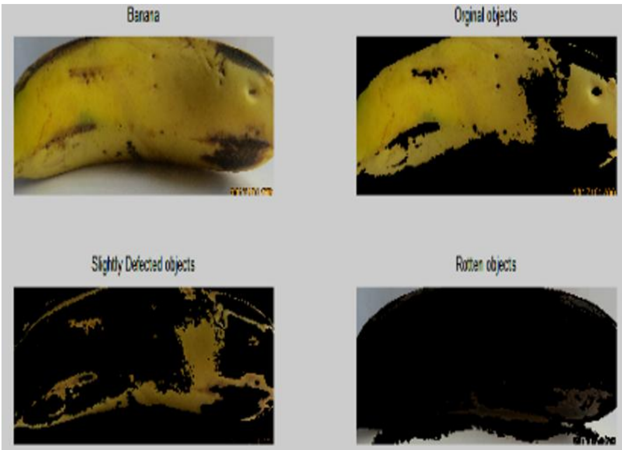

Figure 10. Segmented image of banana of side 4

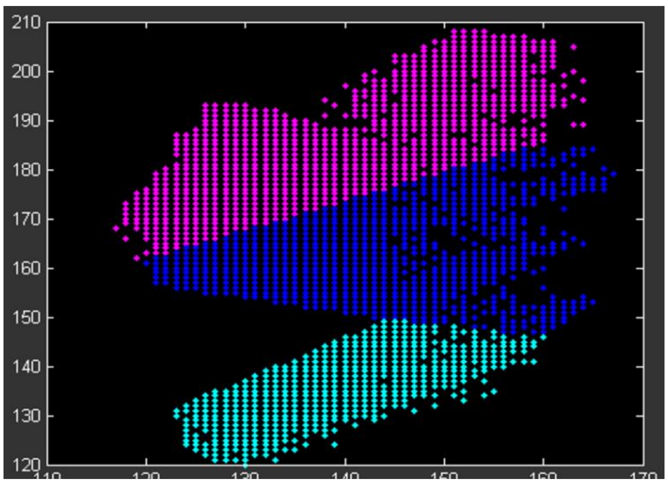

Figure 11. Scatter plot diagram of banana of side 4

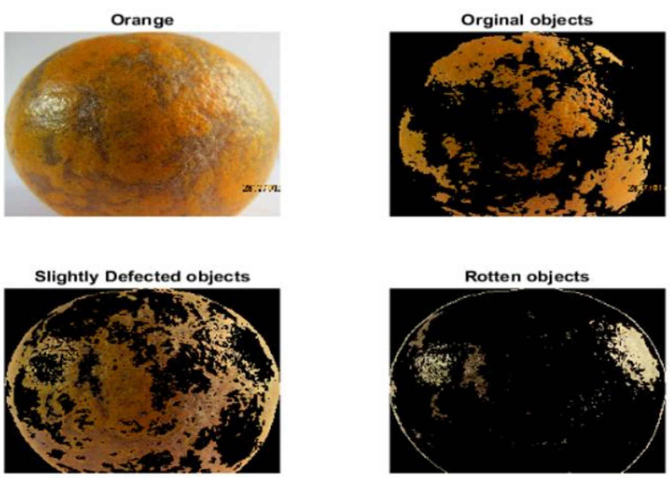

Figure 12. Segmented image of orange of side 1

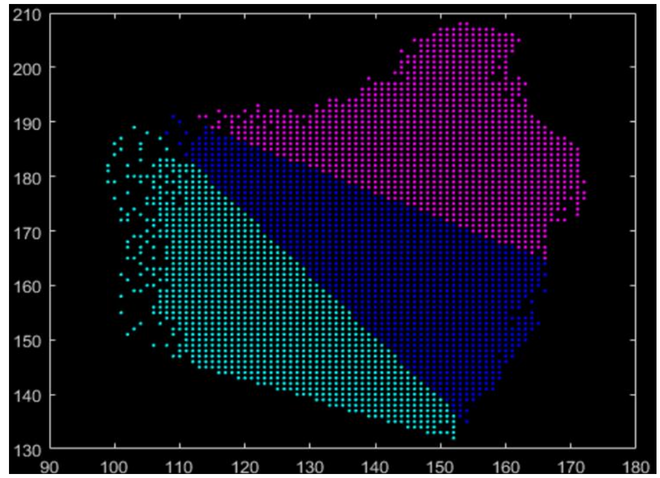

Figure 13. Scatter plot diagram of orange of side 1

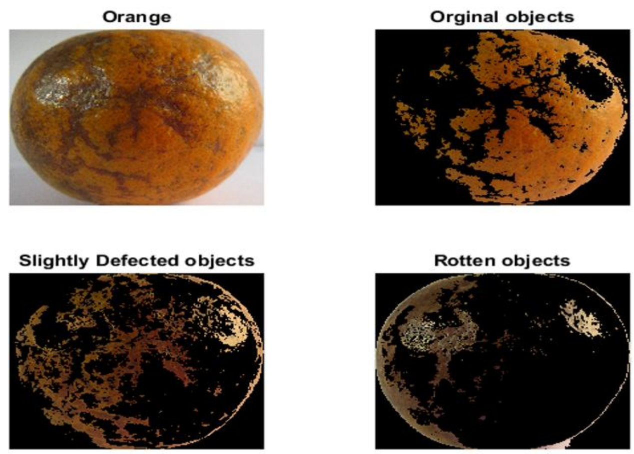

Figure 14. Segmented image of orange of side 2

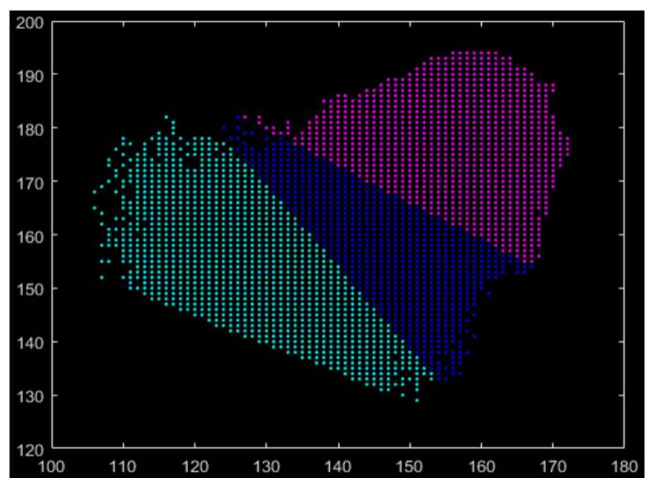

Figure 15. Scatter plot diagram of orange of side 2

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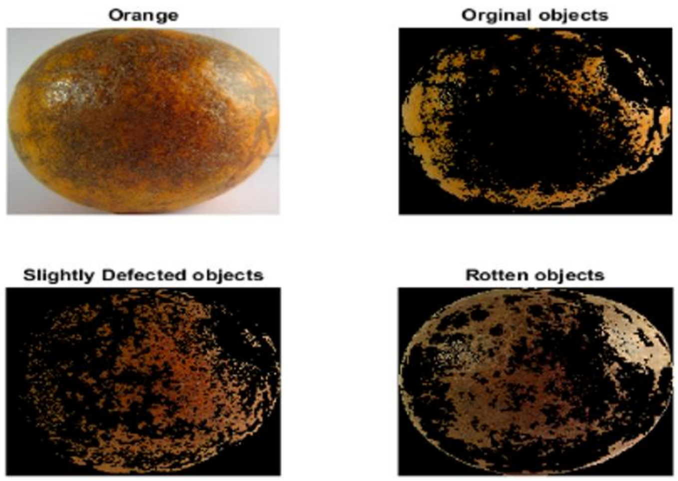

Figure 16. Segmented image of orange of side 3

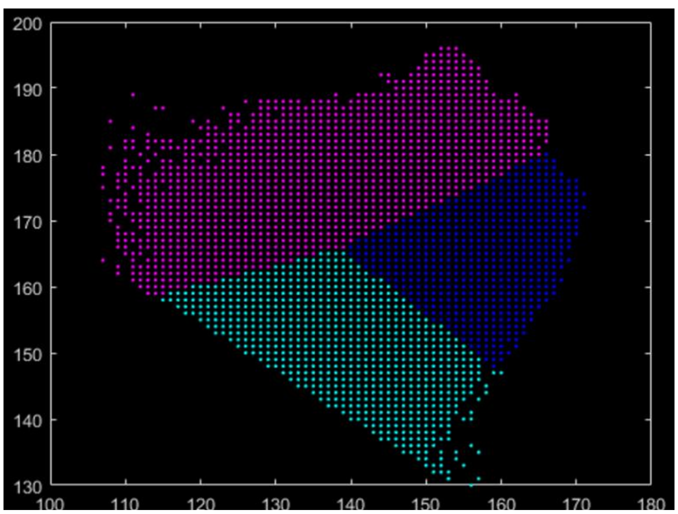

Figure 17. Scatter plot diagram of orange of side 3

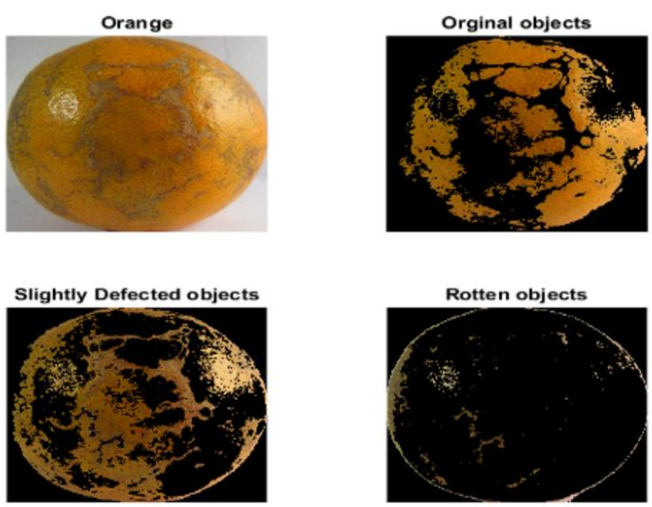

Figure 18. Segmented image of orange of side 4

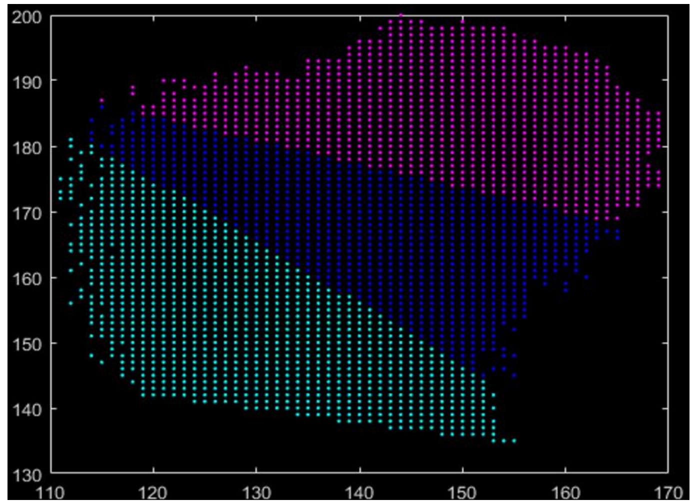

Figure 19. Scatter plot diagram of orange of side 4

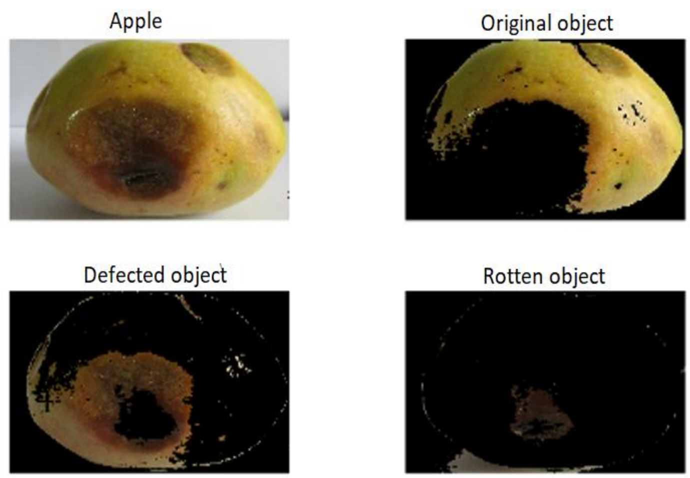

Figure 20. Segmented image of apple of side 1

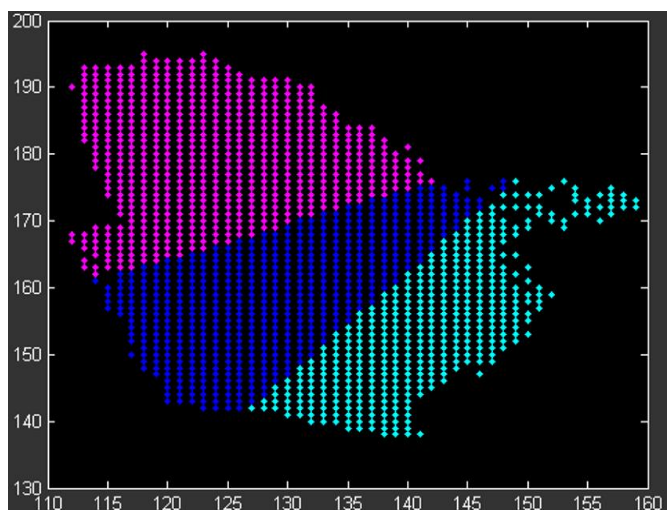

Figure 21. Scatter plot diagram of apple of side 1

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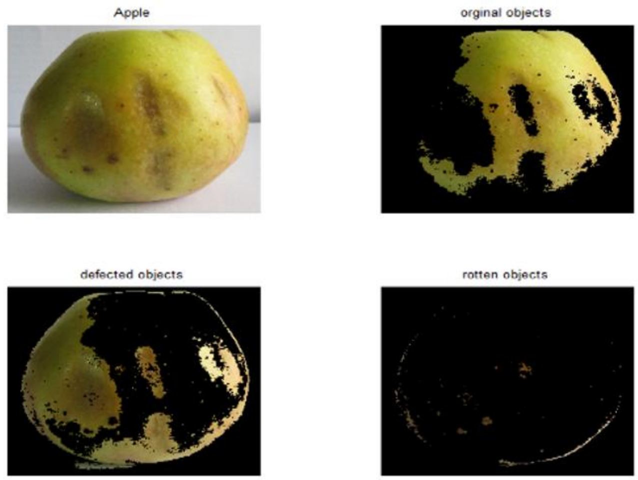

Figure 22. Segmented image of apple of side 2

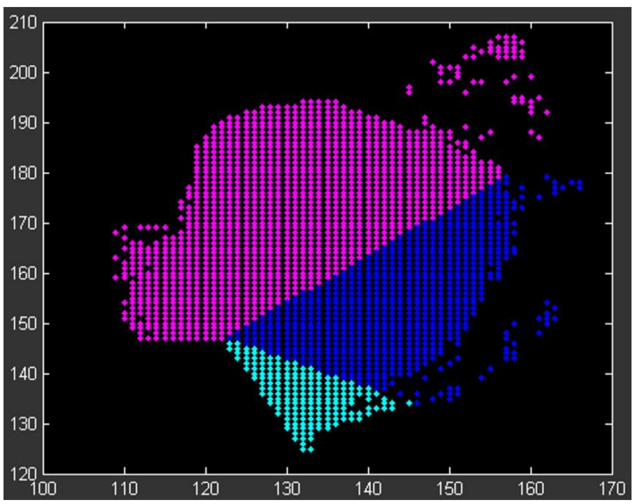

Figure 23. Scatter plot diagram of apple of side 2

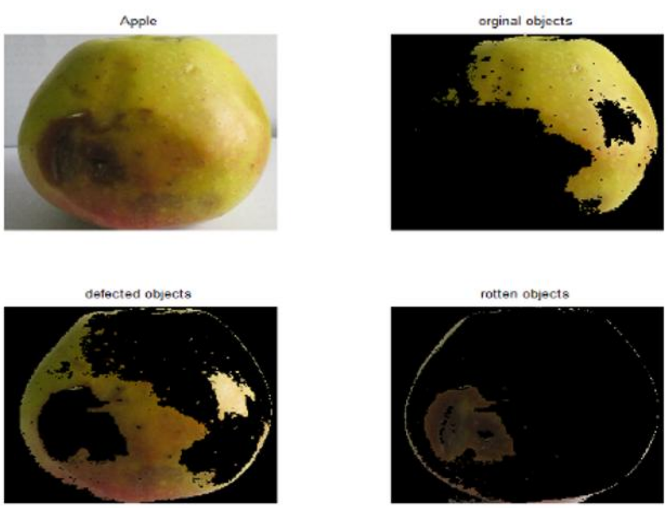

Figure 24. Segmented image of apple of side 3

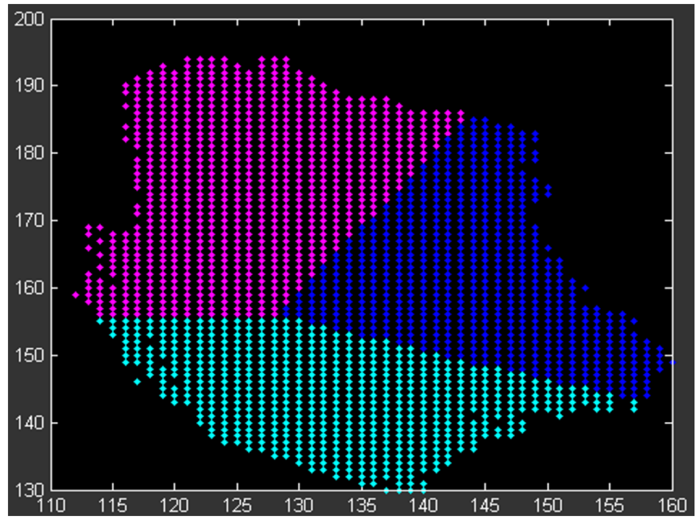

Figure 25. Scatter plot diagram of apple of side 3

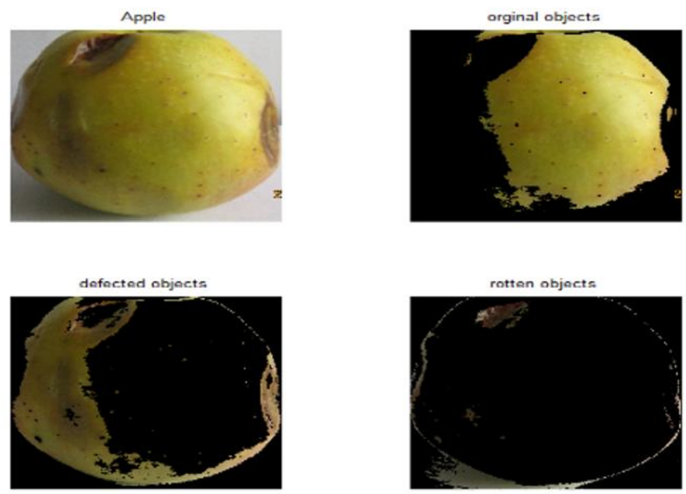

Figure 26. Segmented image of apple of side 4

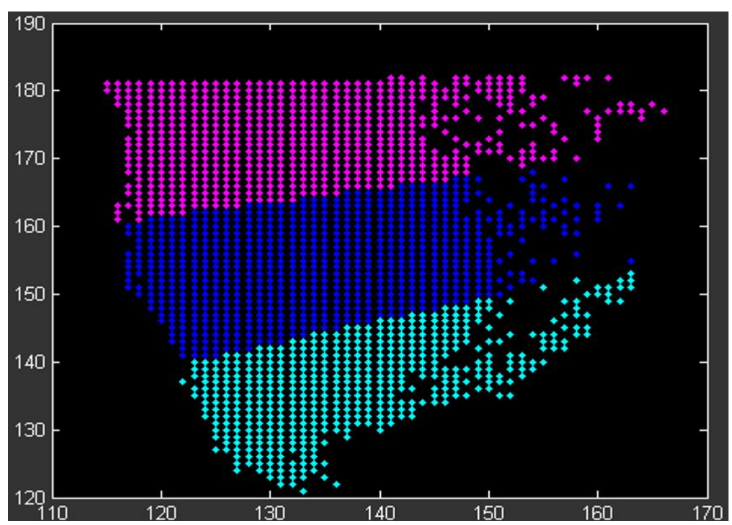

Figure 27. Scatter plot diagram of apple of side 4

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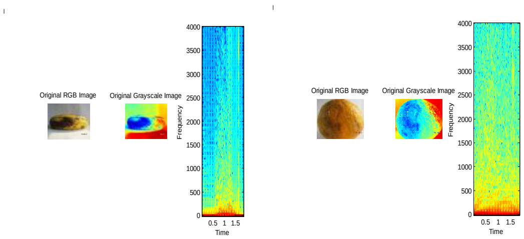
Table 1
Percentage of slightly defected and rotten portion of fruits

Fruits Name	Slightly Defected Portion	Rotten Portion
Banana	22%	14%
Orange	42%	20%
Apple	13%	45%



(a) Banana (b) Orange

Figure 28. Spectrogram of fruit

IV. CONCLUSION

We took four images from four directions to get the illusion of 3-D image but due to few overlapping region, there is some error in the numerical result. To overcome the situation 3-D image can be used directly but the system model will be very complicated. The concept of the paper can be applied to identify the disease of crop fields and percentage of contamination of field, the condition of the flower of mango, percentage of damage of an object, the condition of soil from satellite map etc. Another application of the paper will be separation of background from the foreground of video frames. Several consecutive frames of a video file can be analyzed, based on the concept of the paper to model the background of the video in identification of a moving object from the foreground.

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