A Comparative Analysis of Edge and Color Based Segmentation for Orange Fruit Recognition

R. Thendral, A. Suhasini, and N. Senthil

***Abstract*—In this paper, we presented two segmentation methods. Edge based and color based detection methods were used to segment images of orange fruits obtained under natural lighting conditions. Twenty digitized images of orange fruits were randomly selected from the Internet in order to find an orange in each image and to determine its location. We compared the results of both segmentation results and the color based segmentation outperforms the edge based segmentation in all aspects. The MATLAB image processing toolbox is used for the computation and comparison results are shown in the segmented image results.**

***Index Terms*— color based segmentation, edge based segmentation, machine vision, Orange harvesting.**

I. Introduction

Fresh fruit harvesting is a sensitive operation. According to the [1] cost of harvesting by labors is very expensive and time-consuming. In addition, picking of fruits by hand is very tedious. To solve these problems, human works can be replaced by automatic robots. Automatic harvesting operations reduce the harvesting costs. Therefore, automation and use of image processing methods in agriculture have become a major issue in recent years [2] – [4].

Jimenez et al. [5] presented a review of fruit recognition systems. Schertz and Brown [6] considered both individual-fruit harvest and mass harvest. The fruit surface was identified by photometric comparison. They reported that ten times more light reflected from a fruit than from a leaf. Parrish and Goksel [7] reported an experimental automated apple harvesting system in a laboratory. They used different green and red optical filters and a black-and-white TV camera to obtain images for apple orchard and developed an automated experimental system for harvesting apple. Problems accompanying with mechanical harvesting resulted in the development of robotic harvesting methods, thereby prototype machine vision based harvesters has been increasingly being developed. Several studies have been carried out to design a harvesting robot to pick up fruits from the trees or plants [8 – 12]. Bulanon and Kataoka [13] developed an algorithm for the automatic recognition of ripe Fuji apples from the tree; they enhanced the difference between fruit from other objects within the image, based on the difference between luminance and red color (R-Y). Hanan et al. [14] developed a vision system to pick orange using a harvesting robot. The R/(R+G+B) feature was used for recognition of orange fruits on the tree. The automated harvesting system [15] should perform the following operations: (1) recognize and locate the fruit; (2) reach for the fruit; (3) detach the fruit without causing damage both to the fruit and the tree; and (4) move easily in the orchard. There are an increasing number of robotics applications aimed at detecting fruits from images or videos [16 – 19].

The first major task of a harvesting robot is to recognize and localize the fruit on the tree. This paper focuses on recognition of orange fruits by using edge and color based segmentation methods and we compare the results of both segmentation results. In the next section the details of our proposed edge and color based segmentation methods are presented. The results and discussion is given in section III. Finally, in section IV, conclusions of the proposed approach were presented.

II. Materials and Methods

Twenty digitized images of orange fruits were randomly selected from the Internet and all the images are of different pixel size. These images were captured in different lighting conditions with different background and different camera distances.

A. Image Processing Algorithm

The input sectional tree images were having different lighting conditions. The fruit regions in many images were under the shadow of the leaves and branches. Recognition is the process of separating an object of interest from the background. This is an image processing procedure called segmentation [20]. In order to segment the acquired images, two algorithms were developed: edge based and color based segmentation.

B. Edge Detection Based Algorithm

The Canny edge detector [21] is a popular method for finding edges that begins by smoothing an image by convolving it with a Gaussian of a given sigma value. Based on the smoothed image, derivatives in both the x and y direction are computed; these in turn are used to compute the gradient magnitude of the image. Once the gradient magnitude

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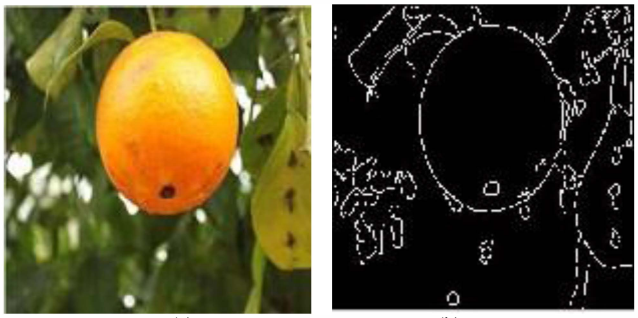


(a) (b)

Fig. 1. Edge detection based algorithm: a) Original image, b) Edge detected image.

of the image has been computed, a process called ‘non maximum suppression’ is performed; in which pixels are suppressed if they do not constitute a local maximum.

The final step in the canny edge detector is the hysteresis operator, in which pixels are marked as either edge, non edges and in-between, this is done based on threshold values. The next step is to consider each of the pixels that are in-between, if they are connected to edge pixels these are marked as edge pixels as well. The result of this edge detector is a binary image in which the white pixels closely approximate the true edges of the original image. The input image and edge detected images are shown in Fig. 1.

C. Color Based Algorithm

Figure 2 shows the complete block diagram of the proposed color based segmentation algorithm. The algorithm was implemented based on the following steps. The input image was first applied to the preprocessing step of filtering. The Gaussian Low Pass filter was applied for averaging out the variations in lighting conditions.

The preprocessed image, then converted from the RGB color space into the L*a*b space. Figure 3 shows the L*a*b color spaces independently. The “a” image plane was used for the coarse detection of fruit region. The pixel carries the values higher than the predefined threshold in the image of “a” plane was considered as pixels of fruits regions. So, this step was used for the coarse detection of probable fruit region within an input image.

The detected pixels were represented by the value of “1” while the remaining pixels were represented by the value of “0”. This resulted in the binary mask image (Fig. 4) where the fruit regions are represented as white and the background was represented by black color.

The orange fruit regions present in this binary image, but still some objects are available these are not fruits. These unwanted parts are eliminated by removing the very small objects in the binary image (Fig. 5). Finally the required fruit regions are obtained by fill binary image regions and holes. The resultant image shows the fruit regions only (Fig. 6).

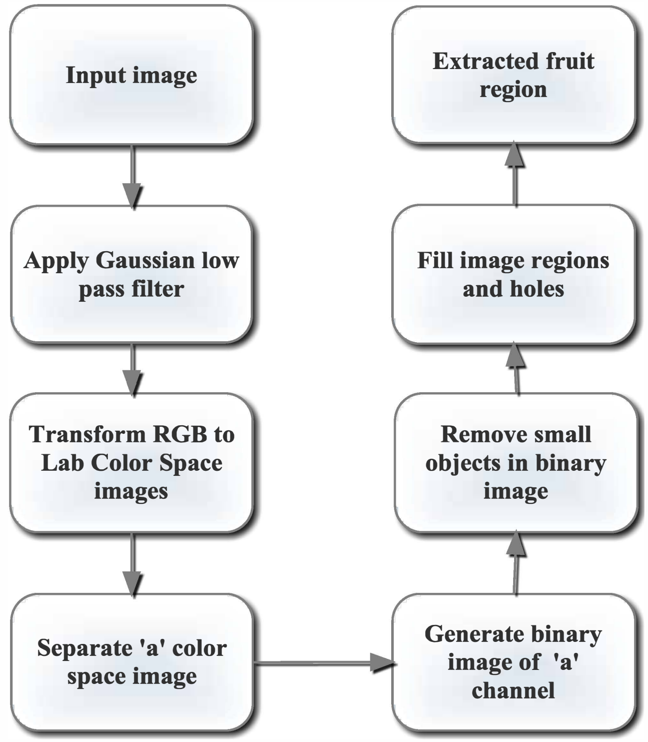
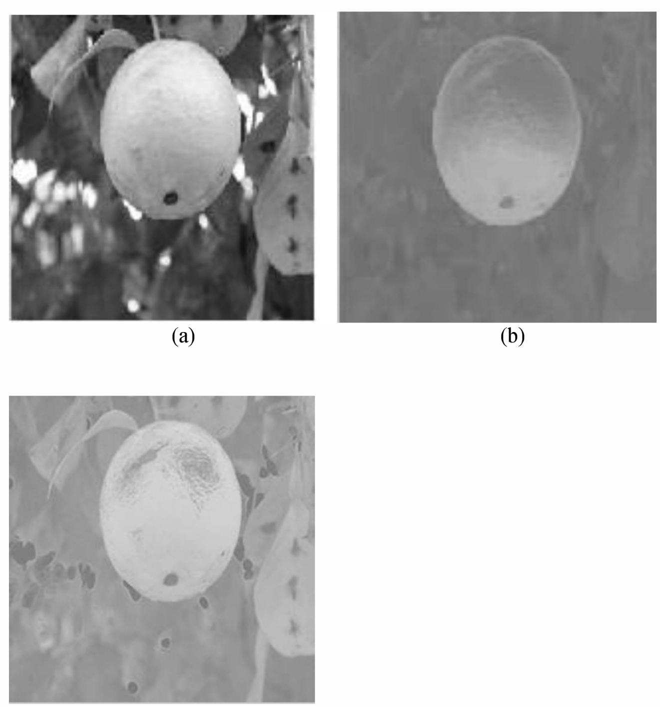


Fig. 2. Complete block diagram of the color based segmentation.



(a) (b)

(c)

Fig. 3. a) “L” color space image, b) “a” color space image, c) “b” color space image.

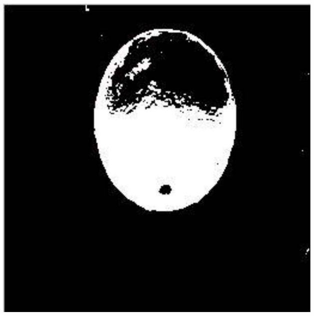


Fig. 4. Binarized image of “a” color space.

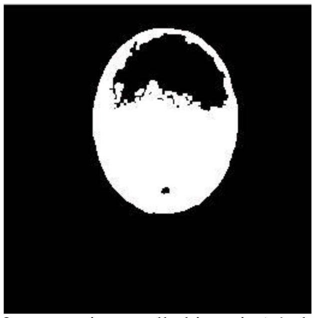


Fig. 5. After removing small objects in ‘a’ plane binary image.

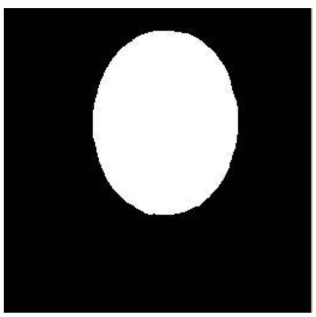


Fig. 6. After filling binary image regions and holes.

III. RESULTS AND DISCUSSION

The main idea was to develop a general algorithm under various natural lighting conditions. Thereby, no supplemental lighting source was used to control the luminance.

Since the images were acquired under uncontrolled natural daylight conditions, they included tree canopies including tree branches, leaves, fruits, sky, etc. Each object of the image has its own edges, making image sets of edges of which the orange is just a subset. So, an edge detection algorithm was not successful (Fig. 1).

Color based algorithm detect the fruit regions in the images better; however, it was more complicated than the edge detection. It can be safely concluded that this method can achieve closed and accurate results. Color based algorithm was able to detect the accurate oranges in 17 of 20 images. In other words, the accuracy of the algorithm was 85%. Figure 7 shows the comparative analysis of proposed edge and color based segmentation.

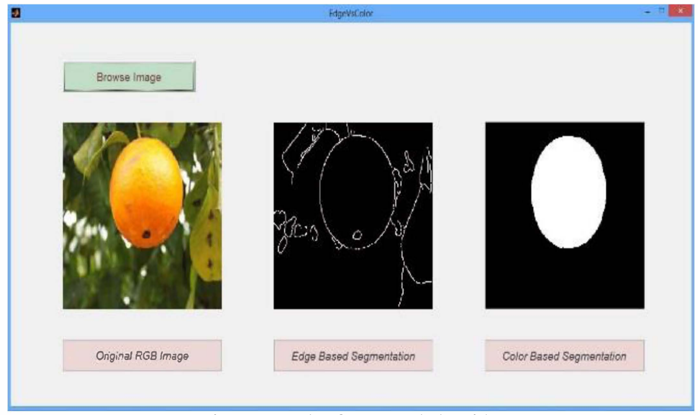


Fig. 7. Result of proposed algorithm.

IV. CONCLUSION

In this paper, the segmentation method based on color segmentation accurately detects the fruit regions in the image. It outperforms the results of edge based segmentation. So, edge detection based method was not successful; color based algorithm was able to detect oranges in 85% accuracy.

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