# Detection of red ripe tomatoes on stem using Image Processing Techniques

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**Abstract:** Image Processing Techniques are being used increasingly in the field of agricultural and food products for quality assurance purpose. The system offers the generation of precise descriptive data and reduction of tedious human involvement. Image segmentation based on color difference between mature fruits and backgrounds under natural illumination condition is a difficult task. By processing images in three color space of RGB, HSI and $YC_bC_r$ from CCD camera, tomato fruit, stems, leaves and a stem-supporting pole were recognized. Then the processed images were compared in three color spaces in order to identify ripe tomatoes with more than 50% redness. The average of error between actual number of red tomatoes and estimated number in 3 images of each 28 tomato trees was 3.85%.

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**Keywords:** Image processing; ripe tomato; natural illumination.

## 1. Introduction

Recently, there are a lot of researches work have been carried out by depending on the computer; in order to reduce the processing time and to provide accurate results. Digital image processing, as a computer based technique, has been extremely used by scientists to solve problems in agriculture (Chen, et al., 2002). Computer vision system has proven successful for the objective, online measurement of several agricultural and food products with application ranging from routine inspection to the computer vision system guided robotic control (Sun and Brosnan, 2003). Slamet, et al. (2007) classified papayas according to combinations of the three features to study the uniqueness of the extracted features. The proposed technique showed the ability to perform papaya size classification with more than 94% accuracy. Eggplant was graded by a mobile robot that was equipped with machine vision system (Chong et al. 2006). Ebrahimi, et al. (2011) used machine vision to analyze the greening area of potatoes based on RGB (Red-Green-Blue) and HIS (Hue-Saturation-Intensity) spaces. The difference between red and green components of RGB space for green parts of potatoes was lower than that of other parts. Mummert (2004) developed and investigated a machine vision system to measure the shape of sweet potato root. The results showed that the system could accurately measure the length and width for each sweet potato within several millimeters. Unay et al. (2011) introduced a fully automatic grading system for bi-colored apples by multispectral machine vision. They first segmented defective skin in a pixel-wise manner, then extracted several image features from the resulting segments, and assigned the fruits to the corresponding quality categories using statistical and syntactical classifiers. In the case of tomato product, Nielsen, et al. (1998) developed a technique to correlate the attributes of size, color, shape and abnormalities, obtained from tomato images, with the inner quality of the tomato samples. They applied fuzzy sets into their study. Recently, chaos theory was introduced into this area (Morimoto, et al., 2000). In their study tomato fruit shape was quantitatively evaluated using an attractor, fractal dimension and neural networks. The results showed that a combination of these three elements offers more reliable and more sophisticated classification.

Tomato fruit is one of major agricultural product in Iran. Currently around 18.5 million tons are harvested annually (Agricultural Ministry of Iran, 2010).

## 2. Materials and Methods

Greenhouse experiment was conducted in the greenhouse at Hashtgerd Greenhouse Center in Alborz province (Iran) during July 2010. To do experiments 28 tomato trees were selected in which there are at least 5 tomatoes with more than 50 percent redness.

### 2.1 Image Acquisition and Preprocessing

To carry out this work, a personal computer based on the microprocessor was used. At one expansion slot of the computer, an image digitizer board was placed with a random access memory of 1024 × 1024 × 8 bits, which allowed work with three images of 512×512 pixels. The acquisition of images in the greenhouse was made with a color CCD (Charged Coupled Device) camera with 1536 × 2048 pixels (CNB, 560 TV line, model GA4162PF, Korea), and automatic iris control. With the aim of creating uniform illumination conditions, all recording were done about 10 to 11 am. The images were taken from a distance of approximately 135 cm and three images were obtained from the same tomato tree. From each of them, all tomato fruits on the tree placed within the vision field of the camera were counted. Visible fruits were considered to be those which a human eye can distinguish on the monitor, using the red and green images, regardless of the size of the visible portion. A typical laboratory set for image processing is as shown in figure 1.

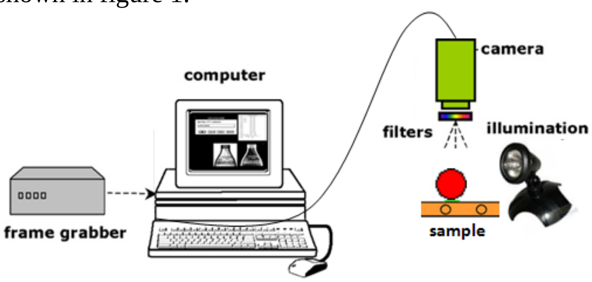


Figure 1. Components of a computer vision system

### 2.2 Color Spaces

The algorithm starts by converting a set of image from RGB to HSI and $YC_bC_r$ (Luma and Chroma signals) color spaces, where we limited the color segmentation step primarily to the hue plane. By setting the threshold values to include only the color shades that could represent regions of interest (ROI); we make a first approximation step towards the end result. RGB color image is converted to grey scale and HSI images, in two separate stages. Use of grey scale is for removing unvalued data of images, increasing speed and efficiency of sorting algorithms. The equations of converting colors from RGB to HSI are (Abbasgholipour, et al, 2011):

$$H = \begin{cases} \theta & B \le G \\ 360 - \theta & B \ge G \end{cases} \quad (1)$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \quad (2)$$

$$I = \frac{1}{3}(R+G+B) \quad (3)$$

where

$$\theta = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\}.$$

$YC_bC_r$ are also a practical approximation to color processing and perceptual uniformity, where the primary colors corresponding roughly to red, green and blue are processed into perceptually meaningful information. The $YC_bC_r$ color space is used for both digital television and image compression. The chroma components ($C_b$ and $C_r$) are difference values between the luminance and the blue and red components, respectively. The equations of converting colors from RGB to $YC_bC_r$ are:

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.169 & 0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} \quad (4)$$

### 2.3 Performance of proposed algorithm

In order to evaluate the performance of the proposed image segmentation methods, the red area of tomato images was computed using an own script in MATLAB. Performance of the algorithm was evaluated using two following formulas:
accuracy of positives prediction ($F_p$);

$$F_p = 100\frac{n_p}{N} \quad (5)$$

accuracy of negatives prediction ($F_n$);

$$F_n = 100\frac{n_n}{N} \quad (6)$$

where $N$ is the total number of tomatoes on each tree, $n_p$ is total number of correct predictions and $n_n$ is total number of false predictions (tomato with less than 50% redness that was recognized as red ripe fruit with more than 50% redness).

### 3. Result and Discussion

Figure 2 shows the result of the number red tomatoes of 28 tomato trees estimated by algorithm compared to the actual the number red tomatoes. The results showed that the average error is 3.85%. This shows this method has enough accuracy to be used in harvesting robots. Results of tomato fruit image segmentation methods such as RGB, HSI and $YC_bC_r$, are respectively given in (a) to (d) of figure 3. It is clear that RGB and HSI (when S> 0.50) color spaces can be more successful in identifying tomato fruits from background with at least noisy signal. The total visible tomato fruits express the percentage of the fruits that are visible by a static human observer with respect to all those actually existing on the tree. It appears that only about 60% of production could be seen by a person standing at the same place as the camera. The use of camera increased significantly the percentage of fruits detected, from 60% to 84%. With these data the efficiency of the algorithms to discriminate fruits from other objects is evaluated. The fruits detected refer to number of tomatoes detected with respect to the visible tomato fruits in the scene (Figure 3).

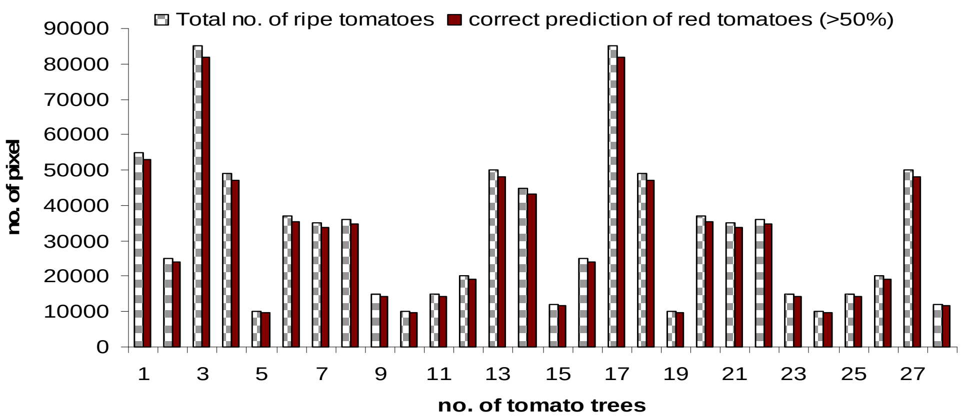


Figure 2. Comparison between estimated (by algorithm) and actual area of green parts

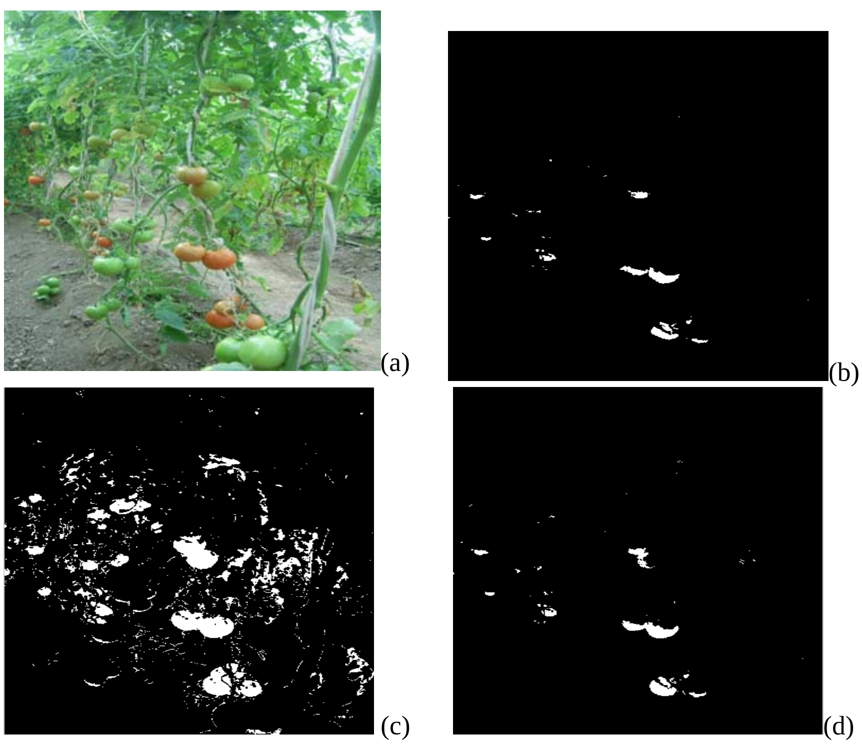

Figure 3. Detected tomato fruit: (a) raw image, (b) RGB gray level image, (c) $YC_bC_r$ thresholding and (d) HSI gray level image (S >50%).

**4. Conclusion**

In terms of color characteristic analysis of tomato images and test of image segmentation, RGB and HSI spaces may be implemented to realize dynamic threshold segmentation of color of fruit images in which color of objects and background show noticeable difference. It makes fruit image segmentation easy and change original 3D color image into 1D gray-level image segmentation. Future works in this direction will make vision systems accurate, robust, low cost and feasible for picking robot in greenhouse horticulture.

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