A Comparative Study of Two Color Based Image Segmentation for Citrus Recognition

Thendral Amutha, Suhasini Ambalavanan and Anupriya

Department of Computer Science and Engineering, Annamalai University, Annamalai Nagar - 608002, India.

ABSTRACT

In this work we carry out a comparison study between the K-means clustering and HSI color space methods in color-based image segmentation. The image segmentation usually uses the region based, edge detection based, threshold based and feature based clustering methods. This research aims to recognize the fruit region from the background region for grading purposes of citrus fruit. In order to complete this image segmentation two color-based image segmentation methods are considered, and to identify the best representation method for background removal of input image.

INTRODUCTION

Segmentation is one of the most important tasks in image processing. The intention of image segmentation is the partition of an image into its component areas or regions. These regions could be associated with a set of objects. The regions must satisfy the following properties:
1. Similarity- Pixels belonging to the same region should have similar properties (intensity, texture, etc.).
2. Discontinuity- The objects stand out the environment and have clear contours or edges.
3. Connectivity- Pixels belonging the same object should be adjacent, i.e. should be grouped together.

Color image segmentation attracts more and more attention because it gives more details than gray level images. Generally, color segmentation methods are based on monochrome segmentation approaches operating in different color spaces. Color is viewed by humans as a combination of tristimuli red (R), green (G), and blue (B) which are usually called three primary colors. From R, G, B representation, we can get various kinds of color representations (spaces) by using either linear or nonlinear transformations. There exist several works trying to recognize, which is the best color space to represent the color information, but there is not a general opinion about which is the best choice. However, some papers identify the best color space for a particular task.

When inspected objects have different colors, sometimes a simple ratio can discriminate them, thus saving processing time. For instance, RGB ratios [Blasco, 2009] were used to discriminate four different kinds of pomegranate arils. They chose the average color coordinates of every aril to classify them in real-time. Five different color spaces are compared for the identification of external defects in citrus fruits and obtained the better results with HSI color space in [Blasco, 2007]. Both RGB and HSI were used to classify Fuji apples in four color categories in [Xiaobo, 2007]. Frequently, individual HSI coordinates provide simple means for color segmentation. In paper [Abdullah, 2006] RGB color space converted into HSI coordinates and used the H component to classify starfruits in four maturity categories. Simple algorithms based on a single L^*a^*b^* coordinate are also used for fruit classification. The strawberry automated grading system use the colour characteristic to grade the strawberry into three or four grades. In that the a* cannel [Liming, 2010] is used for color grading with 89% accuracy.

A comparison study of the 10 most common color spaces are used for skin color detection to build an efficient face detector in [Chaves, 2010]. It propose HSV is the best one to find skin color in an image. A similar study with five different color spaces is made in [Du, 2005] proving that the polynomial SVM classifier combined with HSV color space is the best approach for the classification of pizza toppings. For crop segmentation, in order to achieve real-time processing in real farm fields [Ruiz, 2009], they carry out a comparison study between RGB and HSV models, getting that the best accuracy is achieved with HSV.
representation. Our task is to segment the citrus fruit region from the background region for further processing such as feature extraction, defect identification and classification.

MATERIALS AND METHODS

To evaluate the proposed method, some citrus fruits were randomly selected from the Botanical garden of Annamalai University. To determine the capability of the algorithm, it was evaluated using two sets of images: a) near-view images, and b) far-view images. A digital color camera (Sony Cybershot, DSC-P8) was used to acquire the images. These images were then transferred to the computer and all proposed algorithms were developed in MATLAB environment using image processing toolbox version 7.0. Input image was initially applied to the pre-processing step of filtering [Yin, 2013]. The gaussian low pass filter was requested for averaging out the variations in lighting conditions.

1.1. Color Based Segmentation Using K-Means Clustering:

Clustering is a way to separate groups of objects [Jain, 1999]. K-means clustering treats each object as having a location in space. It finds separation of regions such that grouping a large set of data to desired number of groups depending on their similarity. The foreground and background separation process using K-means clustering is depicted in Figure 1.

![Flowchart of K-means clustering method](image)

**Fig. 1:** Flowchart of K-means clustering method.

The following steps show the K-means clustering algorithm to segment colors in an automated way.

**Step 1:** Choose K initial cluster centres D1 (1), D2 (1),..., DK (1).

**Step 2:** At the Kth iterative step, distribute the samples \{X\} among the K clusters using the relation, 

\[ X \in C_j(k) \text{ if } \|X - D_j(k)\| < \|X - D_i(k)\| \]

for all i = 1, 2, ..., K, i ≠ j, where the set of samples denoted by Cj(k) whose cluster is Dj(k).

**Step 3:** Calculate the new cluster centres Dj (K+1), j= 1, 2, ..., K, such that this cluster centre to the sum of the squared distances from all points in Cj (K) is minimized. Finally, the new cluster centre is given by

\[ D_j(k+1) = \frac{1}{N_j} \sum_{X \in C_j(k)} X \]

Where Nj is the number of samples in Cj (k).

**Step 4:** If Dj (k+1) = Dj (k) for j= 1, 2, ..., k, the algorithm has converged and the procedure is terminated otherwise go to step 2.

1.2. Color Based Segmentation Using HSI color space:

To be able to design a more accurate method to accomplish this separation, we select the HSI color space because it provides more efficient segmentation than various other color spaces, resulting in a clear difference.
between fruit and background colors. In the HSI color space saturation is the amount of gray (0 % to 100 %) in
the color. This means that by analyzing this region separation between fruit and background is straightforward.
The following functions permit the transformation of RGB to HSI space

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

\[
S = 1 - \frac{3}{R + G + B} \left[ \min(R, G, B) \right]
\]

\[
I = \frac{1}{3} (R + G + B)
\]

Input image transformed into the HSI color model and separate the ‘S’ plane to recognize the fruit region. The
recognized pixels were represented by the value of ‘1’ while the rest of the pixels were represented by the
value of ‘0’. This results in the binary representation of the ‘S’ plane in which the fruit areas are represented as
white and the background was represented by black color. In the binary image of ‘S’ channel the black dot
present in the white object represents the noise, which is happening due to illumination effect. Image morphing
is a technique used for the metamorphosis of one image to another [Mao, 2013]. Therefore, after binary
conversion a morphological closing operation was carried out, to close small gaps in the object on the image.

This binary mask image changed over to the same type of the input image. To remove the background, the
binary mask image was multiplied in red, green and blue channels separately. The color image was
reconstructed by composition of red, green and blue channels got from the past step. The resultant image shows
the recognized fruit regions only, in which points belonging to the background are zero (black), and those
corresponding to the fruit have their original color.

RESULTS AND DISCUSSION

2.1. K-means clustering results:

Fig. 2: Near-view input RGB image.

Fig. 3: Cluster 1 result of input image.

Fig. 4: Cluster 2 result of input image.
Figure 2 shows the near-view input RGB image. This image is given to the K-means clustering technique and the output has two clusters. Figure 3 shows the cluster 1 object which has the foreground pixels and Figure 4 shows the cluster 2 object which has the background pixels because in this input image the fruit region size (13339 pixels) is higher than the background region size (9161 pixels).

**Fig. 5:** Far-view input RGB image.

**Fig. 6:** Cluster 1 result of input image.

**Fig. 7:** Cluster 2 result of input image.

Figure 5 shows the far-view input RGB image. This image is given to the same K-means clustering technique and the output has two clusters. Figure 6 shows the cluster 1 object which has the background pixels and Figure 7 shows the cluster 2 object which has the foreground pixels because in this input image the fruit region size (6787 pixels) is lower than the background region size (15713 pixels). Compared to near view images, fruits in the far view images appear smaller in size. As the camera position varies, the area of the fruit region in the image also varies which affects the distribution of the fruit pixel regions and this affects segmentation.

This result reflects background pixels wrongly assigned to foreground and foreground pixels wrongly assigned to the background. For the citrus fruit grading purpose the features are extracted from the segmented foreground regions (fruit) only. So in k-means clustering for the selection of foreground region, we want to apply region of interest method and then extract the features. This ROI method is shown below if (now > nob)
k = ~ (k);
end

2.2. *HSI color space segmentation results:*

Figure 8 and 10 shows the ‘S’ component of near-view and far-view input RGB images. Among all the channels, except in the ‘S’ component, the fruit and background regions were highly presented in the images. So
from the HSI color space ‘S’ image plane was used for the segmentation of fruit regions. Figure 9 and 11 shows the segmented fruit region from the ‘S’ component. The results of the near-view and far-view tests showed that the HSI color space based detection was able to detect the fruits from the background at different camera positions. In both cases this algorithm correctly separates the foreground objects only. The processing time is lower than the k-means clustering method. It outperforms the result of k-means clustering method.

Conclusions:
The main idea was to develop a general algorithm to segment the fruit region from the background region for further processing such as feature extraction. In this study, two algorithms were developed and compared to detect the fruit region in each image. For different foreground and background region size ‘S’ channel image segmentation method correctly segment the foreground regions, but in K-means clustering method
misclassification of foreground and background regions occur. So ‘S’ channel image segmentation outperforms the results of K-means clustering method in all aspects. Accuracy of this segmentation method is suitable for automated machine vision applications in citrus grading.

REFERENCES


