

# Color Image Segmentation using Thresholding and K-Means Technique

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**Abstract** - The technology of image segmentation is widely used in medical image processing, face recognition, Pedestrian detection, etc. The current image segmentation techniques include region-based segmentation, edge detection segmentation, segmentation based on clustering, segmentation based on weakly-supervised learning in CNN, etc. Image can be represented using different color models like RGB, HSV, Lab, and CMYR while segmentation process. In this paper we have segmented a color image using two different image segmentation techniques called *Thresholding* and K-means using HSV color model. We have also analyzed two techniques with different performance metrics like Sensitivity, Specificity and Accuracy of segmentation.

**Keywords:** Image segmentation, Clustering techniques, K-means, *Thresholding*, RGB, HSV.

## 1. INTRODUCTION

An image is a way of transferring information, and the image contains lots of useful information. Understanding the image and extracting information from the image to accomplish some work is an important area of application in digital image technology, and the first step in understanding the image is the image segmentation [1].

Image segmentation is a process of partitioning an image into a multiple number segments, so it is a method to classify the pixels of an image correctly in a decision oriented application. Therefore, we can state that the objective of image segmentation is to simplify or change the representation of an image or convert the information of an image into a more meaningful form so that it make it easier for further analysis. It divides an image into a number of specific regions such that the pixels exhibits high similarity in each region and between the regions they have high contrast. The basic applications of image segmentation are Content-based image retrieval, Medical imaging, Object Detection and Recognition Tasks, Automatic traffic control systems and Video surveillance, etc. There are different techniques and approaches for image segmentation like threshold based, graph based, and morphological base, edged based, clustering based, neural network based etc [2]. All these methods have their own advantages and disadvantages and therefore, one have to choose the algorithm based on the needs from their own perspective. The image segmentation approaches can be categorized into two types based on properties of image.

### *A. Discontinuity detection based approach.*

This is the approach in which an image is segmented into regions based on discontinuity. The edge detection based segmentation falls in this category in which edges formed due to intensity discontinuity are detected and linked to form boundaries of regions.

### *B. Similarity detection based approach*

This is the approach in which an image is segmented into regions based on similarity. The techniques that fall under this approach are Thresholding techniques, Region growing techniques and region splitting and merging. These all divide the image into regions having similar set of pixels. The clustering techniques also use this methodology. These divide the image into set of clusters having similar features based on some predefined criteria.

## 1.1 Image segmentation techniques

There are many methods for segmenting an image that have been recognized by scientists and researchers. Therefore, there are several such techniques that are quite popular, important and are regularly used for image segmentation. These are classified as follows [2].

1. Thresholding based segmentation
2. Region based segmentation
  - a. Region growing
  - b. Region merging and splitting
3. Edge based segmentation
4. Clustering based segmentation
5. Bayesian based segmentation
6. Classification based segmentation

### 1. Thresholding Method

Thresholding methods are the simplest methods for image segmentation. These methods divide the image pixels with respect to their intensity level. These methods are used over images having lighter objects than background. The selection of these methods can be manual or automatic i.e. can be based on prior knowledge or information of image features. There are basically three types of Thresholding.

*A. Global Thresholding:* This is done by using any appropriate threshold value  $T$ . This value of  $T$  will be constant for whole image. On the basis of  $T$  the output image can be obtained from original image as:

$$g(x,y) = 0 \text{ if } f(x,y) < T \text{ and } g(x,y) = 1 \text{ if } f(x,y) \geq T. \quad (1)$$

*B. Variable Thresholding:* In this type of Thresholding, the value of  $T$  can vary over the image. This can further be of two types:

- Local Threshold: In this the value of  $T$  depends upon the neighborhood of  $x$  and  $y$ .
- Adaptive Threshold: The value of  $T$  is a function of  $x$  and  $y$ .

*C. Multiple Thresholding:* In this type of Thresholding, there are multiple threshold values like  $T_1$  and  $T_2$ . By using these output image can be computed as:

$$g(x,y) = 0 \text{ if } f(x,y) < T_1 \text{ OR } f(x,y) > T_2 \text{ and } g(x,y) = 1 \text{ if } T_1 \leq f(x,y) \leq T_2. \quad (2)$$

### 2. Region based segmentation

*Region Growing:* Region growing is a method for extracting connected regions of the image which consists of group of pixels with similar intensities. In this method, a point is initially defined which is known as seed point. Then all the points which are connected to seed point having same intensity as that of seed point are selected and are added to the growing regions. This procedure is repeated until no more pixel can be added to the region.

*Region Splitting:* Rather than choosing initial seed as in case of region growing, image can be divided into unconnected regions and then merge again based on some condition. That means it consists of two steps- splitting and merging step. Quad tree method is generally used in splitting [2].

### 3. Edge based segmentation

The edge of the object is in the form of discontinuous local features of the image, that is, the most significant part of the image changes in local brightness, such as gray value of the mutation, color mutation, texture changes and so on. The use of discontinuities to detect the edge, so as to achieve the purpose of image segmentation. There is always a gray edge between two adjacent regions with different gray values in the image, and there is a case where the gray value is not continuous. This discontinuity can often be detected using derivative operations, and derivatives can be calculated using differential operators. Parallel edge detection is often done by means of a spatial domain differential operator to perform image segmentation by convoluting its template and image. Parallel edge detection is generally used as a method of image preprocessing. The widely first-order differential operators are Prewitt operator, Roberts's operator and Sobel operator. The second-order differential operator has nonlinear operators such as Laplacian, Kirsch operator and Wallis operator [1].

4. Clustering based segmentation

Clustering method is an unsupervised image segmentation method. It classifies the image into a finite number of clusters, where the number of cluster can be user defined or can be find using an algorithm. So in this process there are no training stages, but train themselves using the available data. Based on some criteria, the pixels are grouped together and form the cluster. Initialization of values is required and these initializations play an important role in determining the performance of the segmentation. So initialization should be done very carefully [2]. K-means is one of the most commonly used clustering algorithms. The basic idea of K-means is to gather the samples into different clusters according to the distance. The closer the two points are, the closer they are to get the compact and independent clusters as clustering targets. The implementation process of K-means is expressed as follows:

- (1) Randomly select K initial clustering centers;
- (2) Calculate the distance from each sample to each cluster center, and return each sample to the nearest clustering center;
- (3) For each cluster, with the mean of all samples as the cluster of new clustering centers;
- (4) Repeat steps (2) to (3) until the cluster center no longer changes or reaches the set number of iterations.

The advantage of K-Means clustering algorithm is that the algorithm is fast and simple, and it is highly efficient and scalable for large data sets. And its time complexity is close to linear, and suitable for mining large-scale data sets. The disadvantage of K-means is that its clustering number K has no explicit selection criteria and is difficult to estimate. Secondly, it can be seen from the K-means algorithm framework that every iteration of the algorithm traverses all the samples, so the time of the algorithm is very expensive. Finally, the K-means algorithm is a distance-based partitioning method. It is only applicable to the data set which is convex and not suitable for clustering on convex clusters [1].

5. Bayesian based segmentation

Bayesian method is used for the classification purpose and it works by considering probability in the image to construct models based on the probability that is further utilized for the class assignment of pixels in the image. There are different approaches in Bayesian method like Markov Random Field (MRF), Expectation Maximization (EM).

6. Classification based segmentation

Classification method use data with known labels to partition the image feature space. In other word, classification of image done by deriving a feature space from the image. Then this feature space is further divided into different regions depending upon the function being defined in the feature space. This classification method can be both supervised and unsupervised. In supervised, the image is trained and it is manually segmented and it is used further for the automatic segmentation of new images.

**Table-1:** Comparison of various segmentation techniques

Segmentation Technique	Description	Advantages	Disadvantages
<b>Thresholding Method</b>	Based on the histogram peaks of the image to find particular threshold values	No need of previous information, simplest method	Highly dependent on peaks, spatial details are not considered
<b>Edge Based Method</b>	Based on discontinuity detection	Good for images having better contrast between objects	Not suitable for wrong detected or too many edges
<b>Region Based Method</b>	Based on partitioning image into homogeneous regions	More immune to noise, useful when it is easy to define similarity criteria	Expensive method in terms of time and memory
<b>Clustering Method</b>	Based on division into homogeneous clusters	Fuzzy uses partial membership therefore more useful for real problems	Determining membership function is not easy
<b>Watershed Method</b>	Based on topological interpretation	Results are more stable, detected boundaries are continuous	Complex calculation of gradients
<b>Partial Differential Equation Based</b>	Based on the working of differential equations	Fastest method, best for time critical	More computational complexity

Segmentation Method		applications	
<b>Artificial Neural Network Based Segmentation Method</b>	Based on the simulation of learning process for decision making	No need to write complex programs	More wastage of time in training

## 1.2 Color space conversion

### 1. RGB Color Space

A color image is made of three independent images, one for each channel red, green and blue which is called RGB color space. Here Size  $N = n \times n$  of the image; where  $n = 256$ ;  $N = n \times n$ . RGB is the most widely used color space, that each color image is combination of three different images, those are Red image, Blue image and black image.

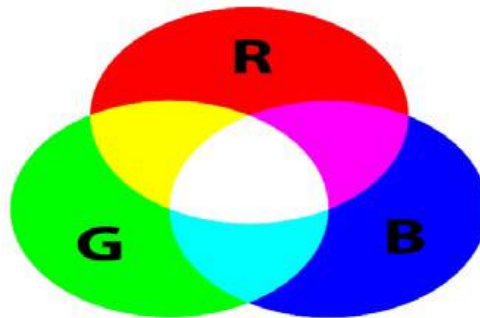


Figure-1: RGB Color Space

RGB color space is also called additive color space, which can be described well based on the RGB color model. Three chromaticity's is represented by a particular RGB color space which includes the red, green, and blue additive primaries, and also generate any chromaticity with a triangle which represented by those fundamental colors. A gamma correction curve and a white point chromaticity also requires for the total specification of an RGB color space Typical RGB input devices are color TV and video cameras, image scanners, video games, and digital cameras[3].

### 2. HSV Color Space

HSV color space will be more compatible for conduct with segmentation of rough color images. We can describe HSV color space with the help of a hex cone with three extensions where the middle vertical axis describes the intensity [level 18]. Here H represents Hue. Basically Hue is an angle, which range is  $[0, 2\pi]$  comparative to angle 0 at red axis,  $2\pi/3$  at green axis,  $4\pi/3$  at blue axis and red a gain a  $t 2\pi$ . S represents Saturation, which represents how authentic the hue is with respect to a white section. This can be concern of as the depth or integrity of color and is measured as a long range distance from the middle axis with properties between 0 at the center to 1 at the outer surface. While, for a given intensity and hue, if the saturation is qualified from 0 to 1, the comprehend color switch from shade of gray to the most authentic form of the color represented by its hue. Diagrammatic view is given below.

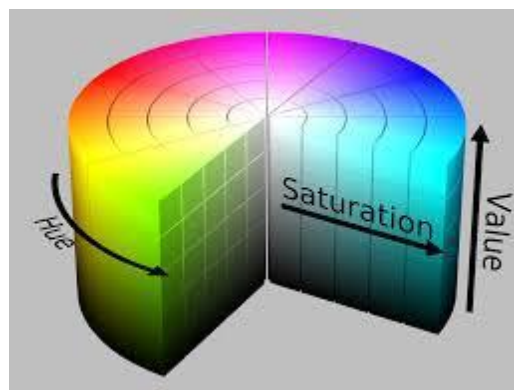


Figure-2: HSV Color Space

V represents Value which is between 0 to 100 percentages. This percentage range can be concern as the amount of light expressing a color. For example, the value is high and when the hue is red, the color seems bright. On the other hand, it looks dark when the value is low [3].

## 2. LITERATURE REVIEW

In [5], Danesh R and Shrinivasa Naika C. L. proposed a method to segment the areca nut bunches using HSV color model , Experiments were conducted on two hundred Areca nut bunch images, which incorporate different maturity levels. Experimental results show that, the projected methodology segments Areca nut bunches from an associate input image with the accuracy of 85% to 90%. The segmentation performance metrics VOE and DSC are used to measure accuracy of obtained results.

In [6], Junying Chen et al, studied combined image segmentation algorithms and image preprocessing methods to automatically segment the whole thyroid area out from thyroid ultrasound images. The experiment results were analyzed and compared against each other. From the experimental results, authors concluded that segmenting the thyroid area is easier by using the studied combined methods

In [7], Pengfei Shan, uses gray-gradient maximum entropy method to extract features from the image, uses K-mean method to classify the images, and uses average precision (AP) and intersection over union (IU) evaluation methods to evaluate the results. The results show that the method of K-mean can achieve image segmentation very well.

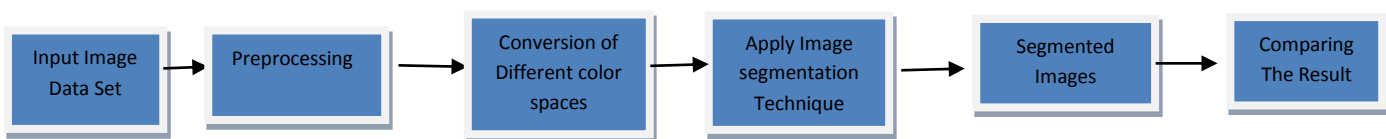
In [8], Rafael Divino Ferreira Feitosa et al, present the results of a study that investigated the reduction of the color spectrum in the HSV system for sample-based skin detection of individuals of different ages and ethnicities. The proposed HSV filter reduced the color spectrum by 97.4648% so as to select candidates for human skin tones. It achieved low sensitivity (54.6333%) and high specificity (92.6390%) in human skin detection in color digital images when compared to the performance of other algorithms proposed in the literature. this model presents and discusses 13 intervals in the possible spectrum which present a well-defined variation in terms of tone.

In [9], Eel Susilowati et al This research aims to extract color features to get the minimum and maximum values of each component R, G, B, H, S, V, H, C and L from an image using the RGB, HSV and HCL methods, and see the differences of the three. Then these results used as a basis to see the characteristics / classification of the level of maturity of oranges/citrus fruits: pass ripe, ripe and raw like as experts (farmers oranges) doing.

In [10], Vinicius R. P. Borges et al, describes a methodology for the segmentation of blood vessels in digital images of human eye retina. The proposed method is based on the background subtraction between a filtered retinal image by anisotropic diffusion and an approximation of the retinal background, obtained by a median filtering. The subtraction operation results in an image of differences, which is enhanced by a local histogram stretching and threshold to detect the blood vessels. Finally, the obtained binary image is filtered aiming to remove small signals and false responses which are related to retina pathologies. We evaluated the proposed method using STARE and DRIVE image sets, in which the results have shown higher accuracy rates when compared with similar approaches.

## 3. PROPOSED METHOD

The proposed methodology segments the images by using 3 simple segmentation techniques Thresholding, Edge detection and K-means Clustering algorithm. The different stages in the process are as follows:



*Figure-4: Steps in Proposed Image Segmentation*

**Preprocessing:**

Digital Images are often corrupted by impulse noises. It is caused by sharp and sudden disturbances in the image signal. So the image processing scheme should be one of the important part in any vision application permitting to suppress noise and improve the image performances. This demand to have several filtering schemes such as fuzzy & non-fuzzy is used. So in proposed method we have used fuzzy and non-fuzzy filters to remove unwanted noise in the input images.

**Color Space Conversion:**

Many color spaces are in use today. For pictures acquired by digital cameras the most popular is RGB model. RGB is an additive color system based on tri-chromatic theory and nonlinear with visual perception. The space color seems to be the more optimal one for tracking applications. This color space based segmentation is not accurate for computer vision applications. For segmentation HSV and Lab color space have given satisfactory results [paper-12]. In our proposed method we have converted preprocessed RGB images to HSV color spaces and compared the segmented images

**Apply Image segmentation Technique:**

In this proposed methods is to demonstrate the two different segmentation technique, Thresholding and K-means clustering algorithm, these methods are applied on Images with HSV color spaces and compared the result.

**4. RESULT AND DISCUSSION**

Normally ground truth images are used to verify the results of segmentation process. Parameters used for statistical analysis of segmented image and ground truth image are

TP: True Positive, means region segmented as mass that proved to be mass.

FP: False Positive, means region segmented as mass that proved to be not mass.

FN: False Negative, means region segmented as not mass that proved to be mass.

TN: True Negative, means region segmented as not mass that proved to be not mass.

Different metrics are used to measure the accuracy of segmentation using above parameters. The most commonly used statistical measures used in this paper are explained below.

The quantitative evaluation based on Sensitivity (SEN) and Specificity (SPE) as given by the equation (3) and (4) were performed between the ground truth and the segmented image by the proposed method. The Sensitivity was the percentage of Region of Interest (ROI) recognized by the segmentation method. The Specificity was the percentage of non ROI recognized by the segmentation method.

$$SEN = \frac{TP}{TP + FN} \quad (3)$$

$$SPE = \frac{TN}{TN + FP} \quad (4)$$

The segmentation errors False Positive Rate (FPR) and False Negative Rate (FNR) were used to measure the errors done by the segmentation method. FPR was the number of items incorrectly labeled as belonging to the positive class and FNR was the items which were not labeled as belonging to the positive class but should have been by the segmentation method which is given by equation (5) and (6).

$$FPR = \frac{|FP|}{|TN| + |FP|} \quad (5)$$

$$FNR = \frac{|FN|}{|TP| + |FN|} \quad (6)$$

As an evaluation metric, Dice's coefficient (Dice, 1945) was used, which was an overlap between the ground truth (GT) and the calculated segmentation mask (S). The Dice (Dsc) similarity is given by equation (7).

$$Dsc = \frac{2|S \cap GT|}{|S| + |GT|} = \frac{2TP}{2TP + FP + FN} \quad (7)$$

Accuracy of the system was defined as the ratio of the correctly segmented area over the ground truth which is given by equation (8).

$$Accuracy = \frac{(TP + TN)}{(TP + FP + FN + TN)} \quad (8)$$

The original color image used for segmentation and ground truth image used for analysis are shown in figure 5 and figure 6 respectively. The Result of the segmentation using Thresholding and K-means are shown in figure 7 and figure 8 respectively. The Evaluation of segmentation using metrics is displayed in Table -II. Results shown that Sensitivity, specificity and accuracy of Thresholding is more than the K-means method for this input.



Figure-5: Original Color Image

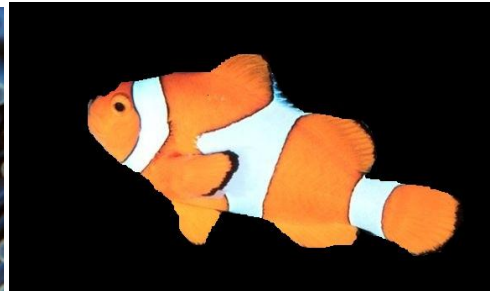


Figure-6: Ground Truth Image

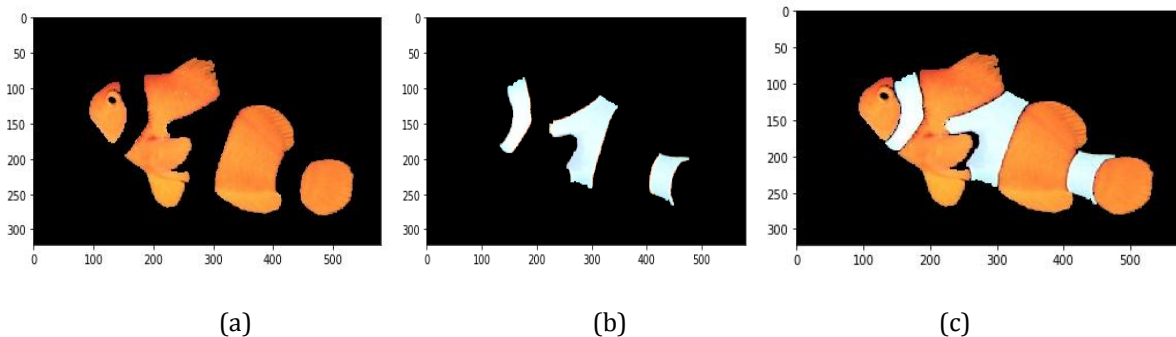
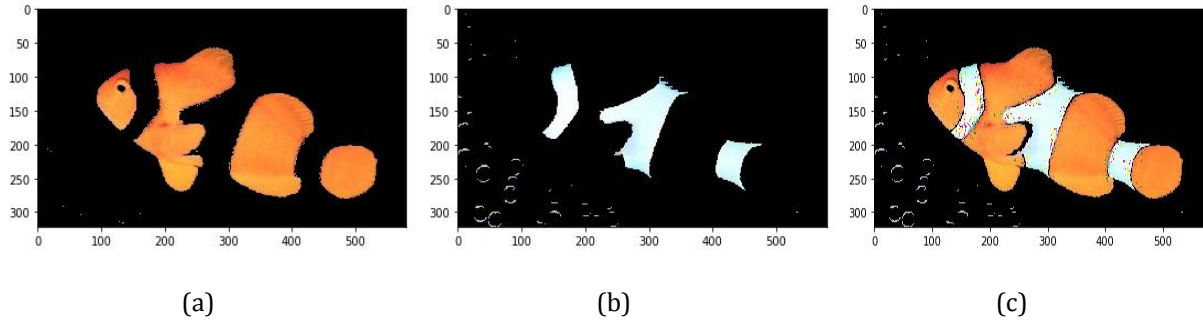


Figure-7: Segmentation Process Using Thresholding. (a) Segmented part with Orange color (b) Segmented part with White color (c) Final Segmented Image



**Figure-8:** Segmentation Process Using K-Means. (a) Segmented part with Orange color (b) Segmented part with White color (c) Final Segmented Image

**Table-2:** Evaluation of segmentation using performance metrics

Segmentation Metrics	K-Means Clustering Technique	Thresholding Technique
TPR(Sensitivity)	0.9881	0.9938
TNR(Specificity )	0.9709	0.9849
FPR	0.1264	0.0965
FNR	0.0120	0.0063
F-score (Dice Similarity Coefficient)	0.9662	0.9755
Accuracy	0.9524	0.9656

## 5. CONCLUSION

In today's image processing research, color image segmentation becomes a leading topic for the researchers as because color images allow for more reliable image segmentation than for gray scale images. Today we have different segmentation technique and also different color spaces u for Image segmentation. Choosing proper segmentation technique and color space is application dependent. So, we should go for using such color space which has the ability of dealing with noises. Means to say, color spaces should carry as low noise as possible. L\*A\*B\* and HSV are the two frequently chosen color spaces for color image segmentation research. Both are good at dealing with noises and at the top among other color spaces available.

In this paper, we have performed a comparative analysis between Thresholding and K-means segmentation techniques. The experimental results shows that The Sensitivity(99.37%), Specificity(98.48%) and Accuracy(96.55%) of Thresholding technique is better than K-means technique which is having Sensitivity(99.37%), Specificity(98.48%) and Accuracy(96.55%). With the above results we can conclude that Thresholding technique with HSV color model is better than K-means technique for the segmentation of color images with non overlapping colors in it.

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