Comparative Study the Effect of Color Image Enhancement in Image Segmentation

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***Abstract*: Segmentation the image is a very important area of study in color image processing. Many algorithms have been developed for this purpose. However, the segmentation algorithms results suffer from miss-classification and over-segmentation. This is due to the degradation of image quality, during transmission, acquisition and color space conversion. That is why the need of an efficient image enhancement technique that removes the noises or redundant pixels from the color image prior to process of final segmentation arises. In this paper, an effort has been made to analyze and study image enhancement techniques by histogram equalization and adaptive histogram equalization on HSV and L*a*b color spaces separately to search for the better way for color image segmentation. Then, morphological based marker-controlled watershed segmentation technique is used to segment the enhanced images. Lastly, the comparative study is done with the entropy values to measure the performance of image enhancing. Also, compare the minima watershed region for quality of image segmentation with respect to visual perspective. Then, determine the most suitable color space that provides segmentation results more powerfully with respect to those enhancement techniques.**

***Keywords*: color image enhancement, morphological image processing, marker- controlled watershed segmentation, entropy values**

I. INTRODUCTION

Color images contain much amount of information. But this is hidden to some extent, so human eyes fail to analyze them. Mainly, minor changes in characteristics of information such as texture, intensity, color, etc., are in fact difficult to notice. So, an efficient color image segmentation technique is needed to inspect them. But the results depend on the quality of the image concerned. Particularly, the quality of the satellite image is degraded due to the noises that involved during capturing, transmission and acquirement process of the image.

A color space is an abstract mathematical model which represents specific composition of colors in terms of intensity values. It determined how color information can be showed in combination with physical device profiling, and allowing us to see the color capabilities of a certain device or digital file. Color space is also like a digital palette because it links numbers to actual colors in three-dimensional coordinate system which contains all visible color combinations. It is the major factor that needs to be considered first while doing color image analysis process. Different types color spaces present with respect to different types of applications and devices.

Image enhancement is the process that improves the visual quality of an image. Then, the results are better than the original. In frequency domain, frequency transform of the image is operated, whereas in spatial domain, techniques operate directly on the pixels of the image. Image Enhancement is used to improve the contrast of the image which has low luminance and to remove the distortion from the image thus improves the quality of the image.

Image segmentation is an important and, likely to be the most difficult task in image processing. Segmentation is the process that involves grouping of image elements that contains “similar” characteristics. All successive clarification tasks, such as object recognition and classification, depend mainly on the quality of the segmentation process.

Morphological operations based segmentation [5] that binary images may consist of countless defects. In some cases, binary regions constructed by simple thresholding are distorted by noise and textures. Morphology is a vast extensive of image processing operations which modifies the images based on shapes. It is one of the useful data processing methods in image processing.

One of the most difficult operations in image processing is marker-controlled watershed segmentation [2] which extracts the touching objects in the image. The watershed transform is often handled to solve this difficult problem. It detects "catchment basins" and "watershed ridge lines" in an image by making it as a surface where light pixels are high and dark pixels are low. Segmentation using the watershed produces work better if we can recognize, or "mark" foreground objects and background locations.

II. PROPOSED SYSTEM

This system is to study the performance of the enhancement techniques with respect to color image segmentation. Fig 1 display the steps involved in the whole process:

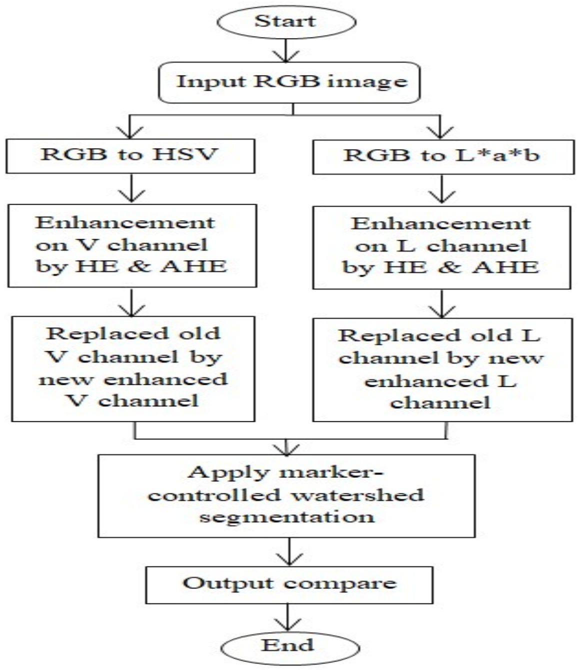


Fig. 1 Flowchart of the proposed system

A. Color Space

Maximum times RGB is taken as a default color space practically. RGB represents a color in which different percentage of red, green and blue hues mixed together. A color space has two types. It can be either device dependent or device independent. Device dependent color space is confined to the parameters and limitations of device used for display. It may deliver a different display of colors in different devices. Device independent color spaces produce the same color regardless of the device used. RGB is a device dependent color space. So, the enhancement process is recommended not be done in RGB color space. Two mostly preferred device independent color spaces are HSV and L*a*b [3]. These two color spaces have a strong and useful characteristic that is used in image enhancement process .This characteristic is important in separating image intensity and color information.

1) HSV Color Space

In HSV color space, three channels are present: Hue (H), Saturation(S) and Value (V).In these three channels, Hue is an angle in the range [0,2π] and is directly associated with color. Different colors will be presented according to different hue angles. Whereas saturation describes how to pure the hue is with relation to a white reference. It is measured as radial distances from the central axis with the values vary between 0 at the center to 1 at the outer surface. The V channel or value expresses a percentage value from 0 to 100, showing the amount of light illuminating a color.

2) LAB Color Space

LAB color space (L*a*b) is a device independent that this provides us the opportunity to communicate different colors across different devices. This color space is originally specified by the International Commission on Illumination. Here, *L* channel is indicated for luminance or lightness, and the other layers ***a*** and ***b*** are chromaticity layers. The $a*$ layer displays where the color drops along the red-green axis, and $b*$ layer point to where the color will fall along the blue-yellow axis.

B. Contrast Enhancement

In this process, the pixel intensity of the image is transformed to utilize the maximum possible bins. Generally, the "contrast" term refers to the division of dark and bright areas present in an image. The benefit of contrast enhancement is that it eliminates the obscurity which may arise between different regions in the image. Contrast enhancement can be characterized into two categories: (1) Local contrast enhancement; and (2) Global contrast enhancement [6].

Histogram equalization [5] is the enhancement technique is used to improve the color image intensity and straightforward method for enhancing image quality. This process allocates the pixels of the image on the dynamic range to improve the visual appearance of an image.

Adaptive histogram equalization [6] is the better enhancement technique where the information of all intensity ranges of an image can be viewed simultaneously. This method solves the problem of many ordinary devices. Firstly, for every pixel in the image a contextual region is defined. It is the region which focuses on that particular pixel. Then, the histogram equalization mapping function is found by the intensity values for this region. The mapping function obtained is then applied to the pixel being processed in the region .After each pixel in the image mapped differently, the resultant image is produced. The main advantage of AHE is that the local spreading of intensities and final enhancing are mostly based on local area than the entire global area of the image.

C. Morphological Based Marker-Controlled Watershed Segmentation

In the image segmentation, the objects in an image that are touching each other are divided into separate objects. In this paper, many different functions are used in combination to accomplish the image segmentation. The all segmentation steps are as follows:

Step 1: Read input color Image and convert to gray scale.

Step 2: Compute the surface area of the image. (Function :strel ('disk', 20))

Step 3: Enhance the image contrast. (functions: Imtophat, imbothat, imsubtract, imadd)

Step 4: Estimate foreground markers that are connected spots of pixels within each of the objects. (functions: graythresh, imextendedmin)

Step 5: Compute background markers that pixels are not part of any object. (functions: Watershed, bwdist)

Step 6: Modify the image by imposing regional minima so that it only has minima at the foreground and background marker locations. (Imimposemin.m)

Step 7: Estimate the watershed transform of the marker-modified image. (watershed.m)

Step 8: Convert to true color images for visualization purposes. (label2rgb.m)

In order to enhance the image contrast, the combination of the top-hat and bottom-hat transforms are applied. The top-hat transform is stated as the difference between the original image and its opening. The opening of an image is the gathering of foreground parts of an image that fit a particular structuring element. The bottom-hat transform is simplified as the difference between the original and the neighbor region of the original image.

Because in an image that uses the enhanced image to highlight the intensity valleys, the watershed transform detects intensity "valleys" of that image. Detection the intensity valleys are profounder than a particular threshold. Here, modifies the image to contain only those valleys and then changes a valley's pixel values to zero. All regions comprising the imposed minima are detected by the watershed transform to complete watershed segmentation of the imposed minima image. The watershed lines always resemble to the most significant edges between the markers. The watershed transform always finds a contour in the area even if there are no robust edges between the markers. This contour will be situated on the pixels with higher contrast.

III. EXPERIMENTAL RESULTS AND COMPARISON

For the experimental analysis, MatLab (R2014a) is used to implement the enhancement techniques and segmentation. Three different input images: pagoda, flower and fruit images are selected for analysis. For this comparative study, firstly, enhance the images with histogram equalization (HE) and adaptive histogram equalization (AHE) techniques by replacing old channel with new enhanced channel to enhance the quality of images. These experimental results are shown in Fig 2 and 3.

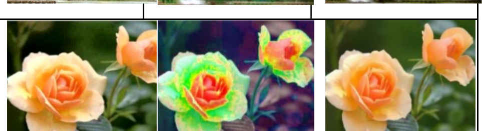
	Input Image	V channel enhanced and convert to RGB	L channel enhanced and convert to RGB
Pagoda			
Flower			
Fruit			

Fig.2 Image Enhancement by Histogram Equalization (HE) in Two Color Spaces

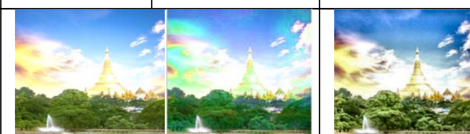
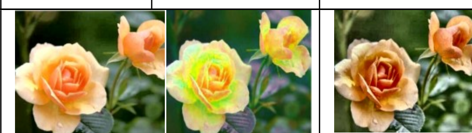
	Input Image	V channel enhanced and convert to RGB	L channel enhanced and convert to RGB
Pagoda			
Flower			
Fruit			

Fig.3 Image Enhancement by Adaptive Histogram Equalization (AHE) in Two Color Spaces

Visual perspective should be given first preference, according to which the enhancement is concerned. Thus, from the entropy value calculation, the minute differences are brought into light. A high value of entropy implies a large amount of information collected in the image. So, a higher value of entropy means a better enhancement is brought out. Entropy, E can be calculated by using:

$E = -\text{sum}\ (p.\log_2(p))$, where, p is the histogram counts involved in the histogram of the concerned image. For entropy computation of a color image, it is taken as a multidimensional gray image.

Table I: Entropy Values Comparison

	Input Image	Histogram Equalization		Adaptive Histogram Equalization	
		HSV	L*a*b	HSV	L*a*b
Pagoda	7.4020	7.5230	7.4898	7.6033	7.5268
Flower	7.4890	7.6169	7.4966	7.6974	7.5400
Fruit	7.6004	7.7908	7.6965	7.8299	7.6522

Experimental results from TABLE I, entropy values are compared with original images and enhanced images. From results, the entropy values of HSV color space for all images are greater than L*a*b color spaces. Thus, enhancement on HSV color space is better for every enhancement techniques than the same in L*a*b color space. As per visual perspective, AHE is showing better performance than histogram equalization, but sometimes it fails to produce desired output. Histogram equalization is often suffered from over enhancement that producing unwanted dark regions or artifacts. So, it is not suggested to use histogram equalization as a preprocessing step in any image analysis process. But, if we express about computational complexity, the histogram equalization is less complicate, while AHE is highly complex.

Then the resultant enhanced image will be undergone color image segmentation with segmentation steps.

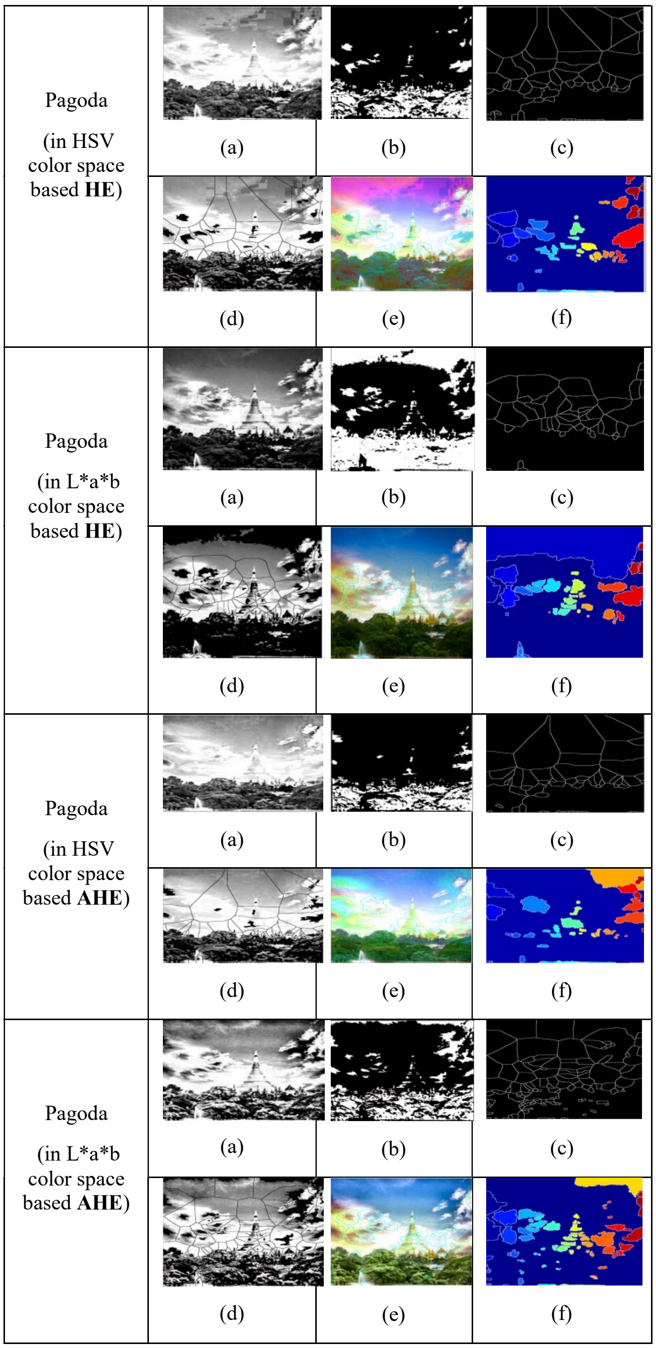


Figure 4: Results of Pagoda Image Obtained by using Segmentation Steps (a) Contract Enhancement with Morphological Functions (b) Foreground Markers (c) Background Markers (d) Watershed Segmentation of Imposed Minima Image(e) Marker-Modified Image (f)True Color Images of Segmented Regions

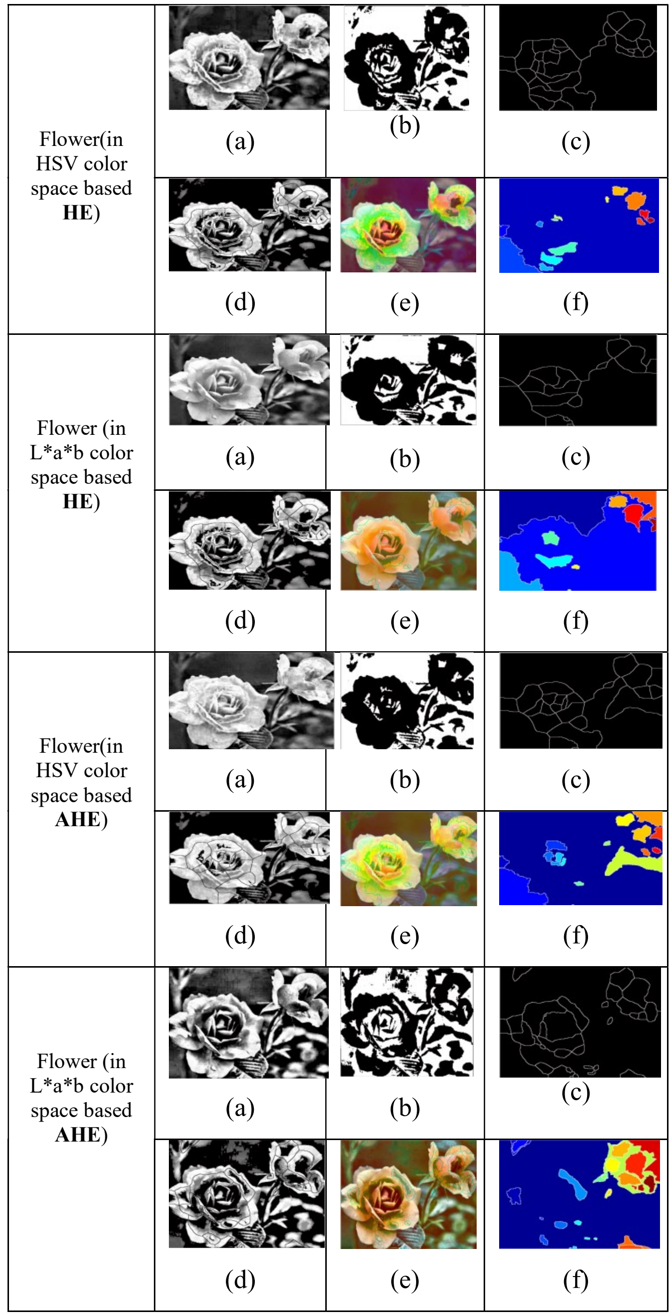


Figure 5: Results of Flower image Obtained by using Segmentation Steps (a) Contract Enhancement with Morphological Functions (b) Foreground Markers (c) Background Markers (d) Watershed Segmentation of Imposed Minima Image(e) Marker-Modified Image (f)True Color Images of Segmented Regions

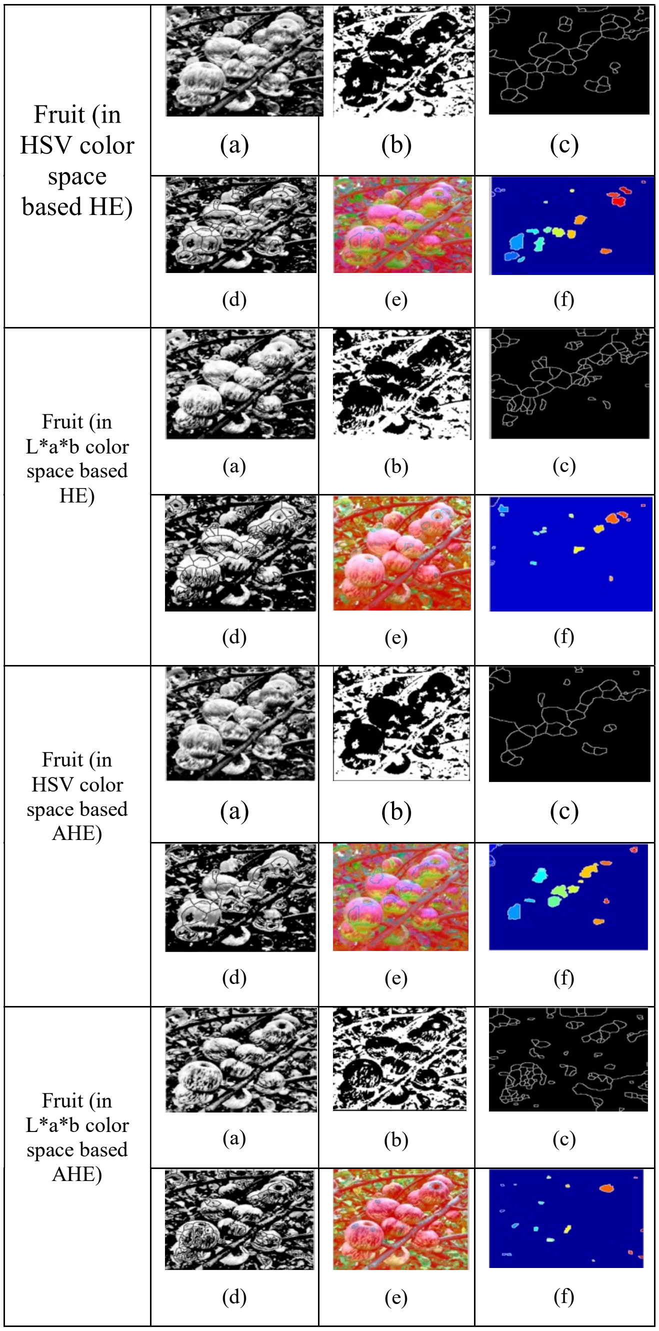


Figure 6: Results of Fruit image Obtained by using Segmentation Steps (a) Contract Enhancement with Morphological Functions (b) Foreground Markers (c) Background Markers (d) Watershed Segmentation of Imposed Minima Image(e) Marker-Modified Image (f)True Color Images of Segmented Regions

The proposed algorithm was tested on enhanced images**.** All the test images were used of size (445×435). The disk sizes and high threshold values were used (20, 80) for three images to detect minima watershed region. From experimented figures, it is accomplished that HSV color space is better performance than L*a*b color space for color image enhancement as well as image segmentation by considering the visual perspective point of view.

Finally, compare the number of minima watershed region to analyze the quality of image segmentation with respect to visual perspective. These results are shown in TABLE II.

Table II: Comparison of Minima Watershed Region

Test image	HE based Segmentation		AHE based Segmentation	
	HSV	L*a*b	HSV	L*a*b
Pagoda	48	36	45	78
Flower	15	12	18	28
Fruit	19	20	19	21

Experimental results from TABLE II, it is clear that segmentation after preprocessing with AHE based color image segmentation results in minima watershed region than the HE based segmentation. Also, the analytical results are better in HSV color space than the L*a*b color space to detect minima watershed region.

IV. CONCLUSIONS

In the case of color image processing, image preprocessing is utmost required for a better image analysis. Color image enhancement is the mostly concerned topic. Because the distortion in the color image, that will impact the later analysis process like segmentation very negatively. That is why this distortion should be removed through enhancement techniques as much as possible. One of such preprocessing techniques is contrast enhancement that is frequently adopted. After studying in this paper, we come to the conclusion that AHE as a preprocessing technique will bring better color image segmentation if the task is performed in HSV color space. So, any AHE based local contrast enhancement technique on HSV color space should be preferred than other global enhancement techniques like histogram equalization if we want to achieve an optimal color image segmentation result.

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