ANALYSIS OF COLOR IMAGE ENHANCEMENT IN MORPHOLOGICAL BASED WATERSHED SEGMENTATION

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ABSTRACT

*Color image segmentation is the area of color image analysis and pattern recognition. Many segmentation algorithms have been developed for this purpose. But, the segmentation results of these algorithms seem to be suffering from miss-classifications and over-segmentation. The reasons behind these are the degradation of image qualities during the acquisition, transmission and color space conversion. So, here arises the need of an efficient image enhancement technique which can remove the redundant pixels or noises from the color image before proceeding for final segmentation. In this paper, an effort has been made to study and analyze image enhancement techniques for morphological based watershed segmentation. Firstly, the input RGB images are converted to HSV, L*a*b and YCbCr color space models because these color spaces are more suitable for color image segmentation. In HSV, only V channel, in L*a*b, only L (luminance) channel and in YCbCr, all components(Y, Cb, Cr) are applied in histogram equalization for image enhancement, respectively. And then, replacing the original channels with the histogram equalized enhanced channel. Morphological based watershed segmentation technique is used to segment the enhanced images. Finally, their comparative study is done on three color spaces separately to find out which color space supports segmentation task more efficiently with respect to these enhancement techniques.*

Keywords: *Color Images, Color Spaces, Image Enhancement, morphological image processing, watershed segmentation.*

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1. INTRODUCTION

Color images carry a vast amount of information with them. But this information is somewhat hidden, so human eyes tend to fail in analyzing them. Most importantly, small changes in characteristics of information such as intensity, color and texture are really difficult to get realized. So, an efficient color image segmentation technique needs to analyze them. But the result of any color image segmentation technique totally depends on the quality of the image concerned. Especially, the quality of image is degraded because of noises that generally involved during capturing, transmission and acquisition process of the image. So, segmenting such noisy images does not produce an effective analysis result. Image enhancement is such a preprocessing technique to suppress the noise while preserving the integrity of edges and the other detailed information. In this paper, image enhancement with histogram equalization is applied on different color spaces to reduce noises and more contrast enhancement.

Color space always matters a lot when it comes to color image processing. RGB is the common one and that color space has three components red, green, and blue. HSV, L*a*b and YCbCr are the most popular color spaces satisfying this criterion. These color spaces are adopted for experimental study.

Morphology in context of image processing means description of shape and structure of the object in an image. Morphological operations work on the basis of set theory and rely more on relative ordering of the pixel instead on their numerical value. This characteristic makes them more useful for image processing. The input data for the mathematical morphological operations are two images: raw image and primitive image. Morphological operations are well defined for binary images but are equally valid and are found useful for gray scale images also.

The watershed transform is a broadly used technique for image segmentation. The watershed transform can be classified as a region-based segmentation approach. Watershed Transformation in mathematical morphology is a powerful tool for image segmentation. Watershed transformation based segmentation is generally marker controlled segmentation. Separating touching objects in an image is one of the more difficult image processing operations. The watershed transform is often applied to this problem. The watershed transform finds "catchment basins" and "watershed ridge lines" in an image by treating it as a surface where light pixels are high and dark pixels are low. Segmentation using the watershed transform works better if you can identify, or "mark," foreground objects and background locations.

2. CONTRAST ENHANCEMENT

Contrast enhancement is a process by which the pixel intensity of the image is changed to utilize the maximum possible bins. Generally, the “contrast” term refers to the separation of dark and bright areas present in an image. The advantage of contrast enhancement is that it removes the ambiguity that may otherwise arise between different regions in an image. Contrast enhancement can be categorized into two categories: (1) Local contrast enhancement; and (2) Global contrast enhancement. Global contrast enhancement techniques are histogram equalization and histogram specification.

2.1 Histogram Equalization

The histogram is a graph which shows the frequency of occurring of data in the whole data set. It plots the number of pixels for each tonal value. Consider an image with G total possible intensity levels. Then, the histogram of the image in [0, G-1] is defined as a discrete function:

$$P(r_k) = n_k/n,$$

Where, r_k is the k^{th} intensity level in the interval. n_k is the number of pixels in the image whose intensity level is r_k. n is the total number of pixels in the image.

Histogram equalization is an image enhancement technique which enhances the contrast of an image by spreading the intensity values over the entire available dynamic range. This is achieved through a transformation function T(r), which can be defined by the Cumulative Distribution Function (CDF) of a given Probability Density Function (PDF) of gray levels in an image.

3. COLOR SPACE MODEL

A color space is an abstract mathematical model for which represents colors in terms of intensity values. It specifies how color information can be represented in combination with physical device profiling, thereby allowing us to understand the color capabilities of a particular device or digital file. Color space is the most important factor that needs to be considered first while going for any color image analysis process. There exist different types color spaces with respect to different types of applications and devices. Maximum times RGB is taken as a default color space in common sense. RGB is a device dependent color space. So, it is recommended that the enhancement process should not be done in this color space. HSV, LAB and YCbCr are the mostly preferred device independent color spaces.

3.1 HSV Color Space

In HSV color space, we have three channels: Hue (H), Saturation(S) and Value (V).Here, Hue is an angle in the range $(0,2\pi)$ and is directly related to color. With respect to different hue angles, different colors will be presented. While saturation describes how pure the hue is with respect to a white reference and is measured as a radial distance from the central axis with values between 0 at the center to 1 at the outer surface. The V channel or value represents a percentage value goes from 0 to 100, expressing the amount of light illuminating a color

3.2 L*a*b **Color Space**

L*a*b is a device independent color space. Here, L channel is for luminance or light, and the other layers **a** and **b** are chromaticity layers. The **a*** layer shows where the color falls along the red-green axis, and **b*** layer will indicate where the color will fall along the blue-yellow axis.

3.3 YCbCr Color Space

YUV color space's offset and scaled version forms YCbCr color space. This color space splits RGB into luminance and chrominance information. YCbCr is a digital standard used for compression applications and each color is represented with three numbers. In this model, information regarding luminance is stored in Y component, and the Cb and Cr components hold the chrominance information. Cb indicates the intensity of blue component with respect to green and Cr indicates the intensity of red component relative to green component.

4. PROPOSED SYSTEM ARCHITECTURE

This image contrast**,** uses the image arithmetic functions, imadd and imsubtract to exaggerate the gaps between objects, uses the imcomplement function on the enhanced image to highlight the intensity valleys, uses the imextendedmin function and the imimposemin function to detect intensity valleys, and then finally uses the watershed function to accomplish watershed segmentation.

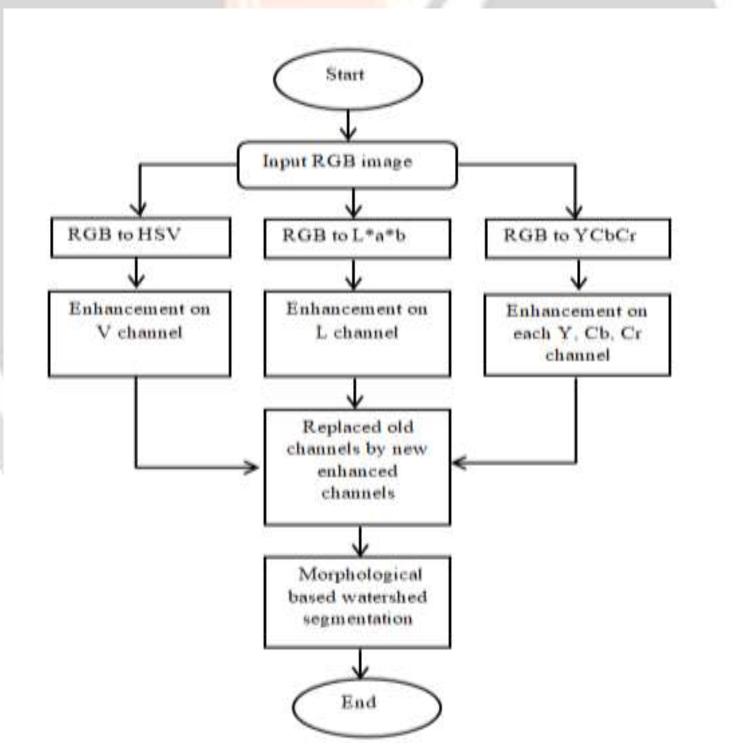


Figure -1: Flowchart of the proposed system

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

Step 1: Read in images
Step 2: Create the structuring element

Step 3: Enhance the image contrast
Step 4: Exaggerate the gaps between objects
Step 5: Convert objects of interest
Step 6: Detect intensity valleys
Step 7: Watershed segmentation

The image contains many objects of different sizes that are touching each other. To segment touching objects, the watershed transform is often used. If an image view as a surface, with mountains (high intensity) and valleys (low intensity), the watershed transform finds intensity valleys in an image. To get the best result, maximize the contrast of the objects of interest to minimize the number of valleys found by the watershed transform.

To enhance the image contrast, use the combination of the top-hat and bottom-hat transforms. The top-hat transform is defined as the difference between the original image and its opening. The opening of an image is the collection of foreground parts of an image that fit a particular structuring element. The bottom-hat transform is defined as the difference between the closing of the original image and the original image. The closing of an image is the collection of background parts of an image that fit a particular structuring element. The top-hat image contains the "peaks" of objects that fit the structuring element.

To maximize the contrast between the objects and the gaps that separate them from each other, that adds the top-hat image to the original image, and then subtracts the "bottom-hat" image from the result. Because the watershed transform detects intensity "valleys" in an image that uses the enhanced image to highlight the intensity valleys.Detection the intensity valleys are deeper 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 containing the imposed minima are detected by the watershed transform to accomplish watershed segmentation of the imposed minima image.

5. EXPERIMENTAL RESULTS AND COMPARISON

For the experimental analysis, I used the MatLab (R2014a) to implement the enhancement techniques and segmentation. Four different images: roses (normal), fruit (with high contrast), flowers (slightly blur) and satellite image are selected for analysis. These images are undergone enhancement with histogram equalization technique.

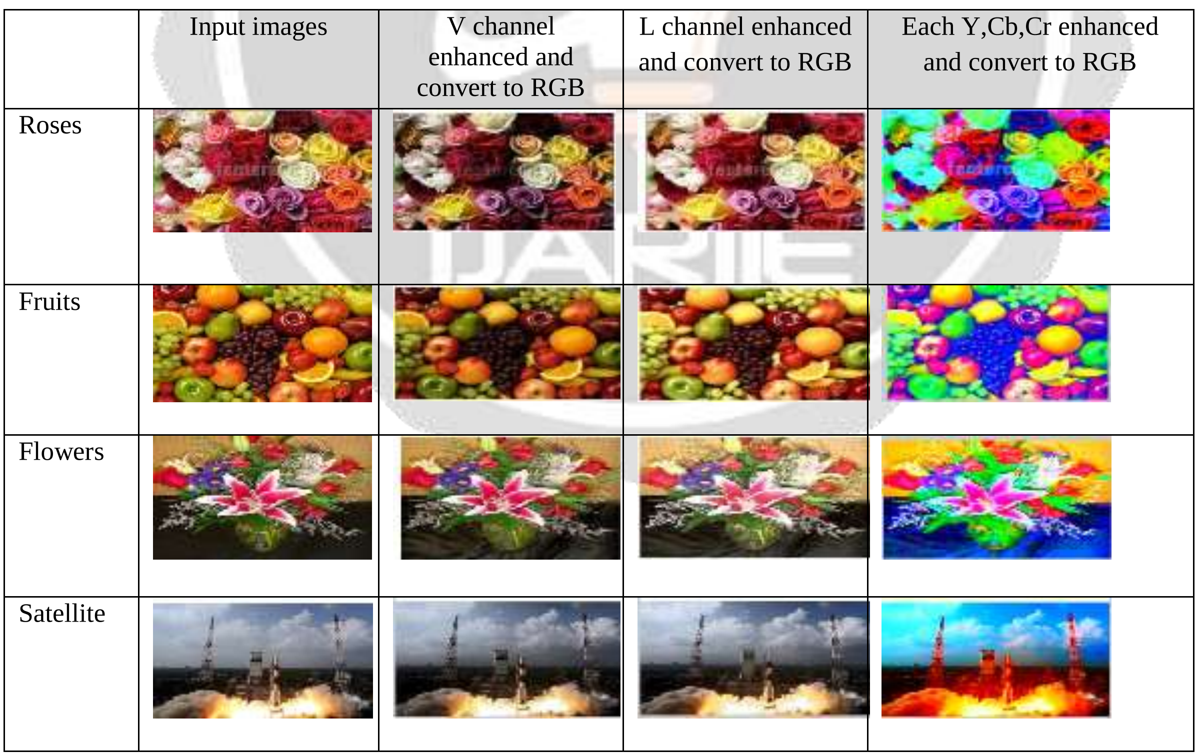


Figure -2: Comparison of enhanced images (a) Input images (b) V channel enhanced (c) L channel enhanced (d) each Y, Cb, Cr enhanced

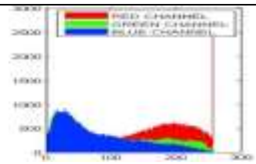
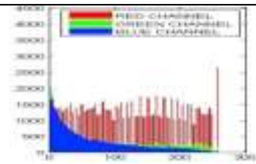
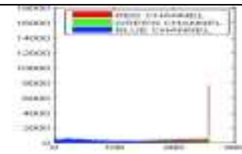
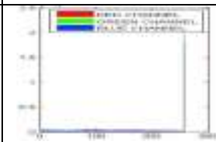
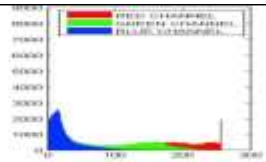
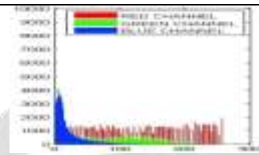
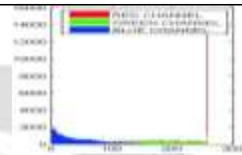
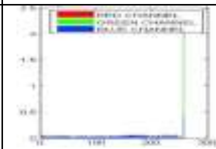
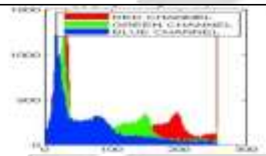
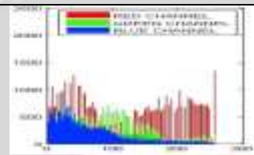
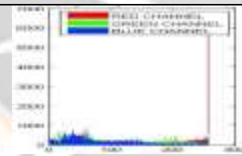
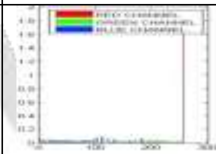
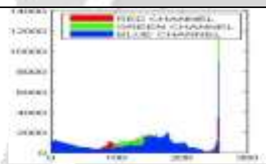
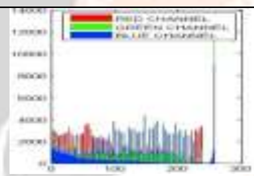
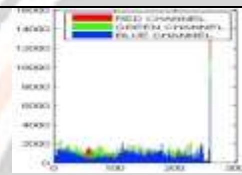
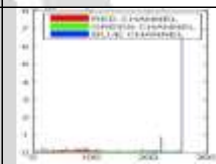
	Input images	V channel enhanced and convert to RGB	L channel enhanced and convert to RGB	Each Y,Cb,Cr enhanced and convert to RGB
Roses				
Fruits				
Flowers				
Satellite				

Figure-3: The equalized histogram of (a) Input images (b) V channel enhanced (c) L channel enhanced (d) each Y, Cb, Cr enhanced

Here, use entropy as the Shannon entropy which contains the maximum information. Images which have maximum entropy value have the better quality of the image. Entropy, **E** can be calculated by using the following equation:

$$E = -\text{sum}\ (p.\log_2(p)),$$

where, p is the histogram counts involved in the histogram of the concerned image.

Table -1: Entropy Values Comparison

	Origin input images	V channel enhanced and convert to RGB	L channel enhanced and convert to RGB	Each Y,Cb,Cr enhanced and convert to RGB
Roses	7.8831	7.8520	7.8945	7.6239
Fruits	7.7150	7.7269	7.9324	7.6385
Flowers	7.4776	7.8126	7.9208	7.6887
Satellite	7.6511	7.8185	7.8858	7.8207

Experimental results from table-(1), entropy values are compared with original images and enhanced images. From results, the entropy values of L channel for all images are greater than other channels. Thus, enhancement on L channel is better than the other two color spaces. Also, as per visual perspective is concerned, histogram equalization is showing good performance on L*a*b color spaces for all the images.

The resultant enhanced image will be undergone color image segmentation with morphological functions based watershed segmentation.

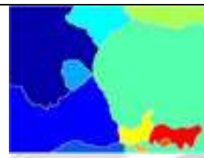
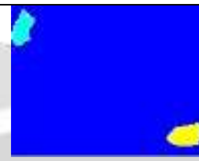
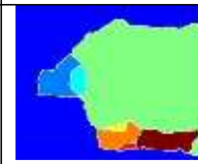
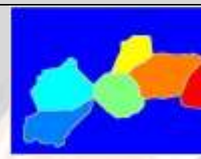
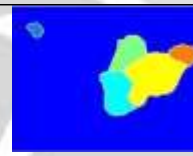
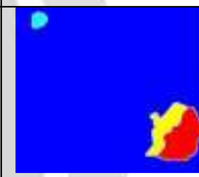
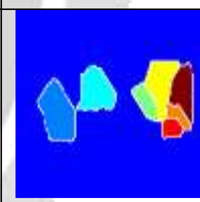
	Input image based segmentation	V channel enhanced based segmentation	L channel enhanced based segmentation	Each Y,Cb,Cr enhanced based segmentation
Roses				
Fruits				
Flowers				
Satellite				

Figure-4: Segmented images of (a) Input Images (b) V channel (c) L channel (d) YCbCr channel

Experimental results of the proposed technique shown in Figure 4 were tested on enhanced images. In the color version of the images, each labeled region displayed in a different color and the pixels that separate the regions displayed white. The disk sizes and threshold values for original image and enhanced images were used (100, 180) to detect minima watershed region. From experimented figures, input fruits image was detected 15 regions, V channel enhanced based segmentation was detected 7 regions, L channel enhanced based segmentation was detected 6 regions and each Y,Cb,Cr channel enhanced based segmentation was detected 8 regions. And also, input satellite image was detected 21 regions, V channel enhanced based segmentation was detected 5 regions, L channel enhanced based segmentation was detected 5 regions and each Y, Cb, Cr channel enhanced based segmentation was detected 8 regions. Similarly, other two images were detected same results on each color channel. Thus, segmented on L channel is better than the V channel color space to detect minima watershed region.

Finally, after the analysis with respect to visual perspective, I task for quantitative evaluation of the results for mathematical proof of quality. For that task, I used mean SSIM (MSSIM) index to estimate the overall image quality. I will compare the results with MSSIM value for quality of image segmentation.

Table-2: MSSIM Values Comparison

	V channel enhanced based segmentation	L channel enhanced based segmentation	Each Y,Cb,Cr enhanced based segmentation
Roses	0.5901	0.5784	0.5694
Fruits	0.5319	0.5496	0.5318
Flowers	0.5229	0.5237	0.5249
Satellite	0.4265	0.4296	0.4256

From the above table -2, it is seen that L channel enhanced based segmentation results in higher MSSIM values than other two channels. A higher value of MSSIM implies a better quality of segmentation. From this analysis, the segmentation based on image enhancement is better in L*a*b color space than other two color spaces.

6. CONCLUSION

In the color image processing, color image enhancement is the mostly concerned topic as distortion in the color image will impact the later analysis process like segmentation. In this paper, a comparative study is done on histogram equalization technique and this impact on color image segmentation. All the experiments are done HSV, L*a*b and YCbCr color space separately. After analyzing all the experimental results, conclusion that histogram equalization as a preprocessing technique will bring better color image segmentation if the task is performed in L*a*b color space.

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