International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Color Image Enhancement Using Histogram Equalization Method without Changing Hue

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Abstract: ***Digital Image Processing is an emerging field finding applications in several domains of science andengineering. Image processing forms the basis for the pattern recognition and machine learning technologies. Color Image Processing deals with different color spaces and models for performing operations on an image of one type and transform it to another model for efficient analysis and feature manipulation. In this paper, a new image enhancement method is established for better visual perception and improving image quality. Here a color image enhancement method ispresented by using color image histogram equalization HEapproach followed by adaptation of the image in H,S,V channels and Histogram equalization technique on the S channel , This hypothetical method should havebetter visual colorfulness than the conventional HE.***

Keywords: recognition , machine learning , histogram equalization, enhancement ,color spaces, color models ,image analysis, channels

1. Introduction

Human visual perception is met with several appropriate image enhancement techniques, which are in present days widely adopted for medical image processing, pattern recognition and texture synthesis [1]. The image enhancement tool works with the basic principle that subjects are clearly defined and are distinguishable from the background.

Histogram equalization (HE) has been one of the best used methods for luminosity conservation and contrast improvement of the image as it uses a probability distribution of each channel level of color images [2].

Histogram equalization (HE) is mostly used because of its simplicity and there are many modifications to this approach [3].

One of the well-known among the enhancement methods is the intensity histogram equalization (HE) method which stretches the concentrated histogram to the uniform histogram. Given an eight-bits gray level image with size M × N , the probability of occurrence of intensity level k I is approximated by

$$pI(I_k)=\frac{n_k}{MN} k=0,1,2.......,255 \quad (1)$$

where n_k is the number of pixels that have intensity I_k. The intensiy transformation is then computed by

$$c_k=T(I_k)= 255\sum_{j=0}^{k}(p_I I_k)$$

$$=\frac{255}{MN}\sum_{j=0}^{k} n_j \quad k=0,1,2,3.... \quad (2)$$

Therefore, an HE image is gotten by transforming each pixel in the input image with intensity k into a corresponding pixel with level k c in the output HE image. After reviewing the gray-level image HE method, let us describe the procedure of color image HE method below [4]. At First, three components in RGB space is converted to those in YCbCr space. Second, the gray-level image HE method is used to transform Y to Y'. Third, the Y', Cb, and Cr is inversely converted to the R', G' and B' of the resultant image.

Our method lastly decomposes the RGB model to HSV model of the three channels of hue, saturation and value before applying histogram equalization to only the saturation channel, keeping the mean brightness intact.

2. RGB Color Model

The additive color mixing of the primary colors - Red, Blue and Green - results in the generation of wide range of colors labeled as (RGB) model. In the RGB model, each color is represented in a Cartesiancoordinate system by a unique value of (R, G, B) as atriplet value. The RGB color format, also known otherwise as true color format, is widely used to display images in electronic devices like televisions, computer screens and mobile phones.[5]

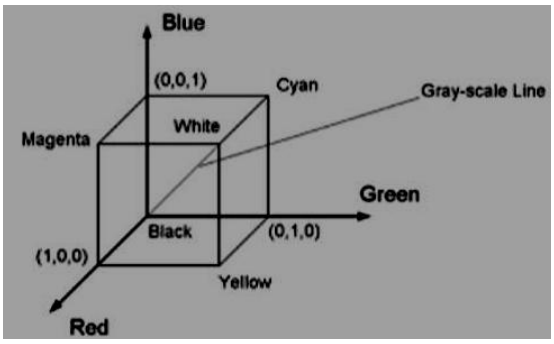


Figure 1: Color determination in RGB Color Space

3. HSV Color and HSL Representation

Coming to HSV color model, when humans view a color object, we describe it by its Hue, Saturation and Value. Hue is a color attribute that describes a pure color. Saturation is a measure of dilution of the pure color by the white light. Value is subjective descriptor that is practically impossible to measure. It embodies the achromatic notion of intensity and is one of the key features in describing color sensation. The HSV model can be understood as a cylindrical coordinate system as shown above and different values of (H, S, V) triplet values represent different colors.[5]

The RGB model is poorly aligned with the color-making attributes recognized by human vision, computer graphics researchers developed two alternate representations of RGB, HSV and HSL (hue, saturation, value and hue, saturation, lightness), in the late 1970s. HSV and HSL improve on the color cube representation of RGB by arranging colors of each hue in a radial slice, around a central axis of neutral colors which ranges from black at the bottom to white at the top. The fully saturated colors of each hue then lie in a circle, a color wheel.[7]

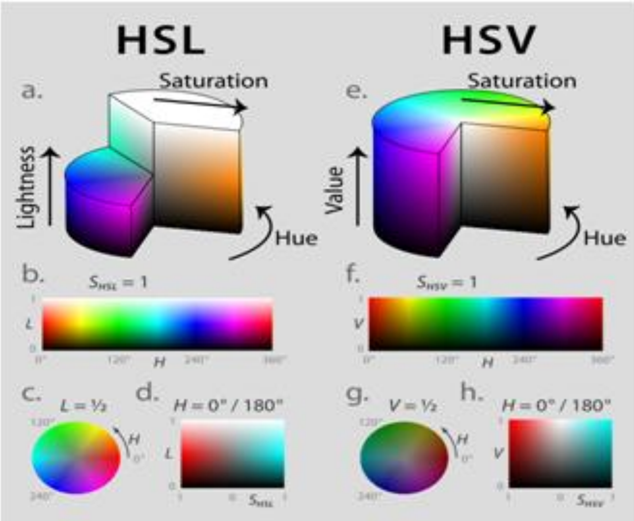


Figure 2: Color determination in HSL and HSV Color Space

4. CMYK Color Model

The CMYK color model (process color, four color) is a subtractivecolor model, used in color printing, and is also used to describe the printing process itself. CMYK refers to the four inks used in some color printing: cyan, magenta, yellow, and key (black). Although it varies by print house, press operator, press manufacturer, and press run, ink is typically applied in the order of the abbreviation.

The "K" in CMYK stands for key because in four-color printing, cyan, magenta, and yellow printing plates are carefully keyed, or aligned, with the key of the black key plate. Some sources suggest that the "K" in CMYK comes from the last letter in "black" and was chosen because B already means blue. However, some people disagree with this because C for Cyan is classed as the blue when printing in CMYK format. Some sources claim this explanation, although useful as a mnemonic, is incorrect, that K comes only from "Key" because black is often used as outline and printed first.

The CMYK model works by partially or entirely masking colors on a lighter, usually white, background. The ink reduces the light that would otherwise be reflected. Such a model is called subtractive because inks "subtract" brightness from white.

In additive color models, such as RGB, white is the "additive" combination of all primary colored lights, while black is the absence of light. In the CMYK model, it is the opposite: white is the natural color of the paper or other background, while black results from a full combination of colored inks. To save cost on ink, and to produce deeper black tones, unsaturated and dark colors are produced by using black ink instead of the combination of cyan, magenta, and yellow.

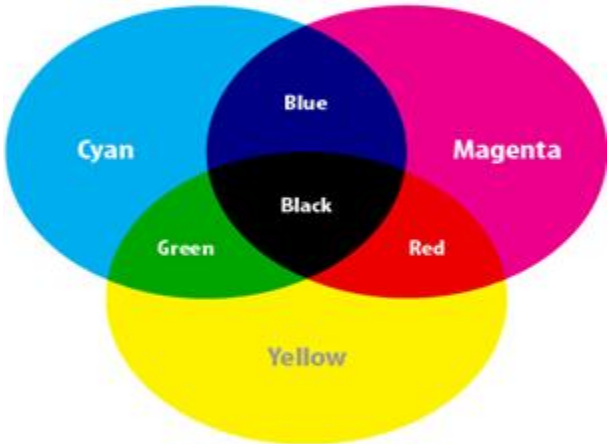


Figure 3: CMYK color model

5. Grey Scale Color Model

A grayscale or greyscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. Grayscale images are distinct from one-bit bi-tonal black-and-white images, which in the context of computer imaging are images with only two colors, black and white (also called bilevel or binary images). Grayscale images have many shades of gray in between.

Grayscale images are often the result of measuring the intensity of light at each pixel in a single band of the electromagnetic spectrum (e.g. infrared, visible light, ultraviolet, etc.), and in such cases they are monochromatic proper when only a given frequency is captured. But they can also be synthesized from a full color image.

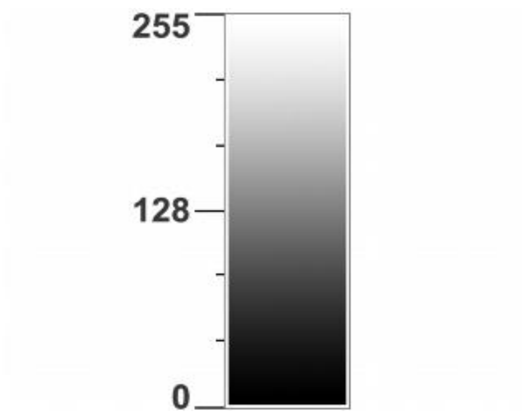


Figure 4: Grey scale model representation

6. Histogram Processing

Histograms are the basis for numerous spatial domain processing techniques. Histogram manipulations can be used for image enhancement. The inherent information contained in the histogram of an image can be used for image processing applications like image compression and segmentation. The histogram of a digital image with intensity values in the range [0, L-1] is a discrete function $h(r_k) = n_k$, where r_k is the kth intensity value and n k is the number of pixels in the image with intensity rk. The histogram of a digital image gives conclusive evidence about the quality of the image.

This transformation function uniformly spreads out the most frequent intensity values to improve the global contrast. The method is useful when both the background and foreground are either bright or dark.[5]

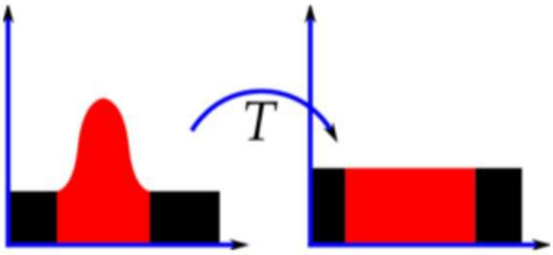


Figure 5: Equalization applied to Histogram of an image

7. Existing Methodology

In this section, a color image enhancement method in the HSI (hue, saturation, intensity) space is described. The HIS coordinate system has been studied in [2]. Given an imagewith RGB color format, the hue component of each RGB pixel is computed by

$$H = \begin{cases} \theta & If\ B \leq G \\ 360 - \theta & If\ B > G \end{cases} \tag{3}$$

With

$$\theta = cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}} \right\} \tag{4}$$

The saturation component is given by

$$S = \begin{cases} 0 & \text{If } R = G = B \\ 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] & \text{other} \end{cases} \tag{5}$$

And the intensity component is given by

$$I = \frac{R+G+B}{3} \tag{6}$$

In the above, it is assumed that the angleθ is measured with respect to the red axis. The inverse relationship from HIS to RGB can be found in[2]. Based on the above definitions of HSI color space, we have the following fact:

Fact: if α is a constant , the (huq, saturation, intensity) of color pixel (R,G,B) is denoted by (H,S,I) and the (hue, saturation, intensity) of the color pixel (αR,αG,αB) is denoted by (Hα,Sα, Iα), then we have that Hα=H, Sα=S, Iα= αI

This fact tells us that scaling a RGB color pixel by a constant α does not change the hue and saturation of the color pixel.

Given a color digital image with size
$M \cdot N$, four steps of the proposed method are listed below:
Step 1: Compute the intensity I of all pixels of given color image by equation (6).
Step 2: Use the intensity histogram equalization method in (2) to compute the intensity transformation formula $c = T(I)$ of the image.
Step 3: For each pixel, its scaling constant α is then computed as $\alpha = c / I = T(I) / I$.
Step 4: The color pixel R' , G' and B' of final enhanced image is computed as $R' = \alpha R$, $G' = \alpha G$ and $B' = \alpha B$.
Step 5: Convert from RGB model to HSV format and apply histogram equalization technique on the S channel .
Step 6: Merge to form adapted HSV image
Step 7: Convert from HSV format to RGB format

8. Proposed Method

Here the input image be in RGB format. This image will then be converted into YCbCrformat for contrast stretching. In digital image processing the YCbCrcolor space is often used inorder to take advantage of the lower resolution capability of the human visual system for color withrespect to luminosity. Histogram equalization will be applied to Y component of the converted imageand then the Cr, Cb and modified Y components will again be merged into RGB format.After this we convert the RGB format image into HSV(Hue, Saturation, Value) format, where weequalize the Saturation and Value components, but not the Hue. Thereafter, the image is againmerged back to RGB format and image quality is analysed.

Y: Luminance; Cb: Chrominance-Blue; and Cr: Chrominance-Red are the components.Luminance is very similar to the grayscale version of the original image. Cb is strong in case ofparts of the image containing the sky (blue), both Cb and Cr are weak in case of a colour likegreen, and Cr is strong in places of occurrence of reddish colours. Y component contains themost important (to the human eye) gray scale component and that is why we equalize the image in Y component alone and not the Cb and Cr components.[8]

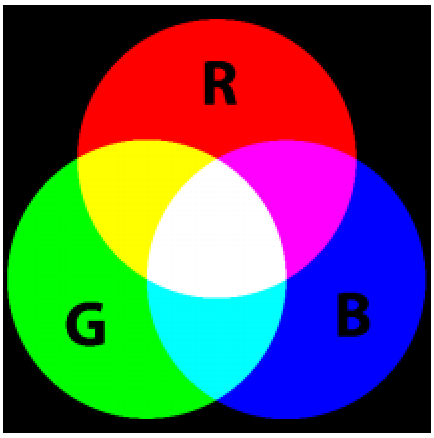


Figure 6: Image in RGB format

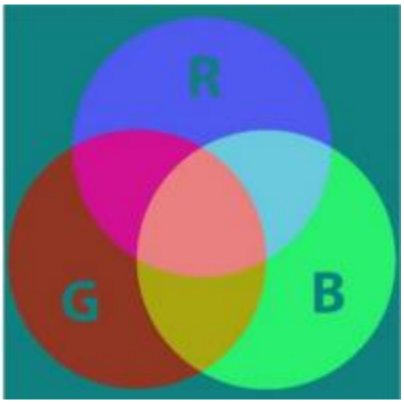


Figure 7: Image in YCbCr format

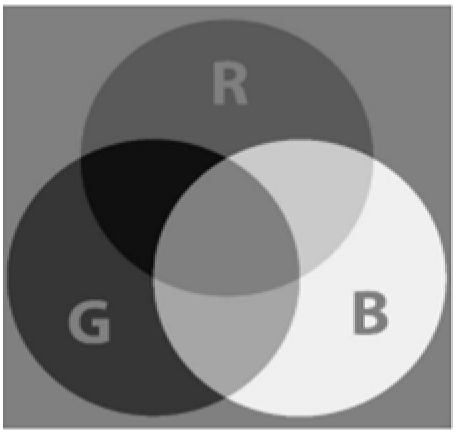


Figure 8: The Ycomponent

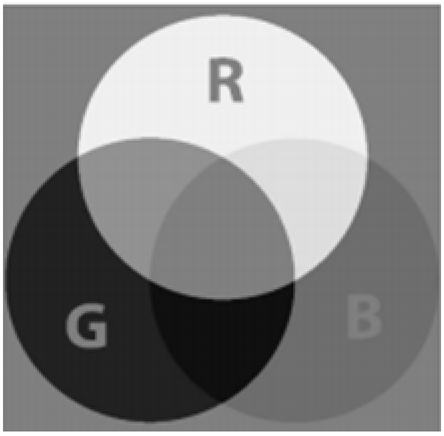


Figure 9: The Cb component

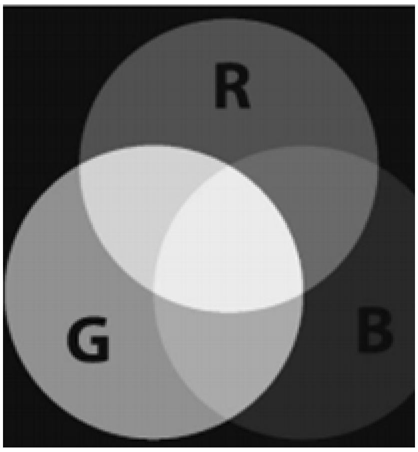
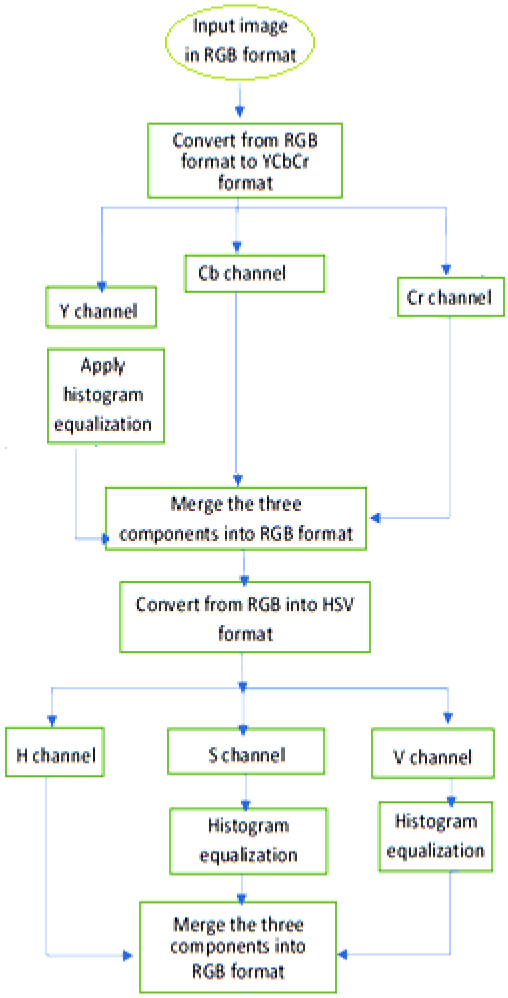


Figure 10: The Cr component

Process flow diagram



In this model our basic objective is to 4enhance the images which have dull and washed out look.For this we are first accepting an image in RGB format,there after we are converting the image into YCbCr format from where we histogram equalize the Y –component and then again we are converting the image the YCbCr to RGB format .Then we again convert from RGB format to HSV format from where we applyHistogram equalization of the saturation component and Value component and finally we get equalized image we convert it to (RGB) format .Therefore we get a final in RGB format.

Here are some of the dull look or washed out images to which we applied the above proposed conversions:-

Sample image (input image)

SAMPLE image 1

Output SAMPLE image1

Output Sample Image 3

Sample Image 2

Sample Image 4

Output Sample Image 4

Output Sample Image 2

Sample Image 5

Sample Image 3

Output Sample Image 5

Formulae used

- $MSE(x,y) = \frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)^2$ (7)

  x_i | i=1,2,3,4,.......... N

  y_i i=1,2,3,4,.......... N

- $PSNR = 10\, log_{10}\frac{L^2}{MSE}$ (8)

  Here L= 2^8 -1 =255 if 8 b/pixel

Here are the mse value and psnr value for the taken sample images

Sample Images	MSE Value	PSNR Value
SAMPLE IMAGE 1	MSE: 77.0056	PSNR:29.2996
SAMPLE IMAGE 2	MSE:126.0294	PSNR:27.1601
SAMPLE IMAGE 3	MSE:83.7561	PSNR:28.9346
SAMPLE IMAGE 4	MSE: 83.5899	PSNR: 28.9433
SAMPLE IMAGE 5	MSE: 40.3565	PSNR: 32.1057

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