Use of gamma encoder on HSL color model improves human visualization in the field of image processing

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***Abstract*— Human vision plays and important role in the areas of image processing. Without adequate and efficient human vision it is very hard to prove any computer vision related work successful. For better human vision, light and color plays most important roles. Gamma encoder is the one which is used to enhance the visualization property. However, depending on computer devices gamma encoder value varies. We proposed an approach which establishes an argument that gamma encoding application can be used efficiently on HSL color model which is important in the areas of image processing and will lead the image analysts to work more efficiently with minimal consideration of brightness issues.**

Keywords-Gamma, Human vision, RGB, HSL, Light, Color.

I. INTRODUCTION

A color space is a combination of three basic colors names RGB (red, green and blue). There are so many color models available named RGB, YUV, YIQ or YCbCr, CYMK, Munsell, HSI, HSV, HSL and few others. However, while considering hue, saturation and lightness RGB (works good for printing), YUV, YIQ, or YCbCr (used for video systems) and CMYK (used for color printing) are not popular whereas HSI, HSV and HSL are user oriented device dependent color model and are popular for image processing. Moreover, these three color models are suitable for their programming simplicity. In [7,8,24,25] HSI and HSB color model has been described already and hence our approach is to work on HSL color model, end user manipulation and processing purposes although all of these color models is derived from the RGB information supplied by devices such as cameras and scanners [1,2,3,4].

Color Model	Classifications
Munsell	Device dependent
RGB, CMY(K)	Device dependent
YIQ,YUV, YCbCr	Device dependent
HSI, HSV, HSL	User oriented-Device dependent
CIE XYZ, CIE L*U*V*,CIE L*a*b*	Device independent, color Metric

Table 1: Color models classifications [3]

Color Model	Application Area
Munsell	Human visual system
RGB	Computer graphics, Image processing, Analysis, Storage
CMY(K)	Printing
YIQ, YUV	TV broadcasting, Video system
YCbCr	Digital video
HSI, HSV, HSL	Human visual perception, Computer graphics, processing, Computer Vision, Image Analysis, Design image, Human vision, Image editing software, Video editor
CIE XYZ ,CIE L*U*V*, CIE L*a*b*	Evaluation of color difference, Color matching system, advertising, graphic arts, digitized or animated paintings, multimedia products

Table 2: Application Areas of Color Models [3]

In [8] it has been described clearly on RGB color model about cathode ray tube (CRT) where it has been mentioned that in most CRT displays have a power-law transfer characteristic with a gamma value of about 2.5. However, it has been observed that in most occasions' gamma remains out of consideration and thus an accurate reproduction of the original scene results in an image that human viewers judge as "flat" and lacking in contrast.

Image enhancement plays an important factor during the improvement of image quality. Image enhancement can be applied in photography, scanning, image analysis etc. There are two types of image enhancement approaches which includes spatial domain and frequency methods where spatial domain depends on image plane and is based on direct manipulation of pixels whereas frequency domain is depends on Fourier transform.

Adaptive neighborhood histogram equalization technique is considered to be the most popular color image enhancement approach for these days [14] whereas 3D histogram equalization has been proposed using RGB cube [15]. Moreover, there is a new approach considering enhancement problem [13, 20]. However, to enhance image edges there are some more available techniques these days which are called wavelength base image enhancement [19]. In paper [7, 8, 24] it has been described why histogram normalization approach is better than histogram equalization technique and hence we have applied histogram normalization technique for our proposed approach.

There can be two different types of images named gray-level images and color images. In compare to color images gray-level images have got only one value for each pixel. There are many existing algorithms named piecewise-linear transformation function which helps to enhance the image contrast while stretching with normalization and stretching with histogram techniques. However, most of these available algorithms results poor quality image with distorted effects [5]. In [7, 8, 24] is has been mentioned image enhancement using power law equation which is gamma and the equation is $S = C.r^{\gamma}$; where c and r are positive constants. Value of c= 1 and the value of gamma can vary to set the desired result and the process used to correct power-law transformation phenomena is called gamma correction or gamma encoding. To improve image quality for better visual perception it is needed to darken the bright images to obtain a better visualization [6]. However, gamma is one of the main factor which helps to brighten or darken an image.

All the above techniques are widely used in the areas of image enhancement without much considering the color shifting issues. It is to remember that color image enhancement technique should not change any pixel value from one color to another although in some cases color shifting may be necessary. For RGB color model it is almost an impossible task to control hue as hue is one of the main properties of a color and can not be changed at all. Gupta et al, Naik et al suggested that hue should be preserved while applying image enhancement method [16, 17, 18]. However, enhancement does not resolve human visualization perfectly.

This research indicates that gamma encoding application can be used efficiently on HSL color model which is important in the areas of image processing.

II. METHODOLOGY

Our proposed gamma encoding technique on HSL color model is based on spatial domain instead of frequency domain approach. In RGB color model, there are three primary colors considered named Red, Green and Blue where RGB is defined as additive or subtractive model and hence different colors can be preformed using the combination of these primary colors. But for HSL color model hue, saturation, and lightness have been taken into account. Hue is the main attribute of a color and thus hue should not be changed at any point. There are some limitations in CIE LUV and CIE Lab to control hue and color shifting. However, HIS, HSB and HSL are easy to control hue and color shifting. In this approach we have preserved hue but utilized saturation and lightness [21, 22, 23].

It is to mention that for traditional image processing such as histograms, equalization HSI color space is one of the best model [7], HSB color space is one of the best for manipulating hue and saturation (to shift colors or adjust the amount of color) and thus it capitulates a better active range of saturation [8]. However, handling intensity or brightness or lightness HSL could be one of the best practices.

III. COLOR MODEL CONVERSION

A. RGB to HSL conversion

RGB color model includes Red, Green and Blue color values which are divided by 255 to change the range from 0 → 255 to 0 → 1. The equations below describe the conversion from RGB to HSL color model. For easier definition Cmax and Cmin has been used.

The equation will look like as follows:

$R' = R / 255$ [equation 1]

$G' = G / 255$ [equation 2]

$B' = B / 255$ [equation 3]

$Cmax = \max(R', G', B')$ [equation 4]

$Cmin = \min(R', G', B')$ [equation 5]

$\Delta = Cmax - Cmin$ [equation 6]

Hue is the most important issues in color model for which the derivation is required. Mathematical equation of hue is as follows:

$$H = \begin{cases} 60^0\ x\ \left(\frac{G' - B'}{\Delta}\ mod\ 6\right), & Cmax = R' \\ 60^0\ x\ \left(\frac{B' - R'}{\Delta} + 2\right), & Cmax = G' \\ 60^0\ x\ \left(\frac{R' - G'}{\Delta} + 4\right), & Cmax = B' \end{cases}$$ [equation 7]

Saturation indicates the colorfulness of a stimulus relative to its own brightness and the mathematical equation of saturation is as follows:

$$S = \begin{cases} 0 & , \Delta = 0 \\ \frac{\Delta}{1-|2L-1|} & , \Delta <> 0 \end{cases}$$ [equation 8]

Similar to intensity for HSI, brightness for HSB, Lightness calculation is required for HSL.

The equation is:

$L = (Cmax + Cmin) / 2$ [equation 9]

B. HSL to RGB conversion

To convert HSL to RGB color model it is needed to use a specific range. For H (hue) the range is: $0 \le H < 360$, for S (saturation) the range is: $0 \le S \le 1$ and for L (lightness) the range is; $0 \le L \le 1$:

$C = (1 - |2L - 1|) \times S$ [equation 10]

$X = C \times (1 - |(H / 60^o) \bmod 2 - 1|)$ [equation 11]

m = L - C/2 [equation 12]

$$(R', G', B') = \begin{cases} (c, x, 0),\ 0^0 \le H < 60^0 \\ (x, c, 0),\ 60^0 \le H < 120^0 \\ (0, c, x),\ 120^0 \le H < 180^0 \\ (0, x, c),\ 180^0 \le H < 240^0 \\ (x, 0, c),\ 240^0 \le H < 300^0 \\ (c, 0, x),\ 300^0 \le H < 360^0 \end{cases} \quad \text{[equation 13]}$$

(R,G,B) = (R'+m, G'+m, B'+m) [equation 14]

C. *Gamma Encoder*

It is wise to use luma which represents the brightness in an image and can be denoted as Y. Luma is weighted average of gamma-encoding which can be denoted as Y' for R, G and B and hence denoted as R'G'B'.

The equation becomes,

Y=0.2126R+0.7152G+0.0722B for luminance [Equation 15]

Y'=0.2126R'+0.7152G'+0.0722B' for gamma encoding [Equation 16]

D. *Saturation*

To make the color image soft and better human acceptance it is necessary to use saturation adjustment. We have applied histogram normalization instead of histogram equalization because normalize models stretches image pixel values to cover the entire pixel value range from (0-255) whereas equalize module attempts to equalize the number of pixels in a given color thus uses a single row of pixels.

IV. PROCESSING STEPS

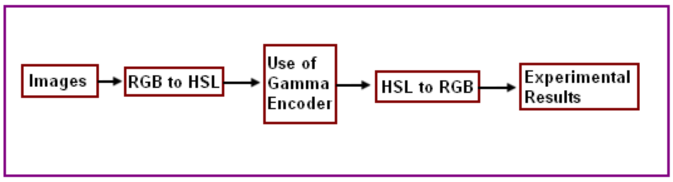

Fig 1: block diagram of proposed work

V. EXPERIMENTAL RESULTS

To test the performance of our proposed approach we have used three different contrast color images (low contrast or darker from the original outlook, medium contrast or similar to original outlook and high contrast or brighter than original outlook color images). To evaluate the contrast performance we have applied histogram normalization saturation value from 0.4 – 0.6 and gamma correction value ranges from 0.75 – 2.2 as different computers acts different according to gamma value. It is to mention that gamma value > 1 performs darkening and vice-versa [9, 10, 11, 12, 7, 8, 24, 25].

However, there is a fixed gamma value for device independent color and the value is 0.4545 but in reality it does not work or provide any better result at all.

Figure 2, 3 and 4 images with (a), (b), (c) illustrates that (a) is the original image, (b) is the experimental result using default gamma value and (c) is the experimental result obtained using HSL.

Fig: 2 (a) (b) (c)

Fig: 3 (a) (b) (c)

Fig: 4 (a) (b) (c)

VI. CONCLUSION

This paper has proposed gamma encoding application can be used efficiently on HSL color model which is important in the areas of image processing. It is to mention that it is difficult to judge an enhanced image result even with a subjective assessment. We claim that HSL color model is more useful and efficient from others because others have a chance to produce unrealistic colors and/or over enhanced resultant images. However, HSL color model is sensitive while working with single and combination of different colors. Moreover, there may be still some areas needs to be taken care of as the color enhancement needs to change or shift color using hue although these cases are exceptional and very rare.

VII. REFERENCES

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