Gamma encoding on image processing considering human visualization, analysis and comparison

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***Abstract*— When a physical process converts image signal to a physical image is called image processing. To process images it is important to consider human vision. There are two important points to be considered to improve human vision which includes light and color. Gamma encoding helps to reimburse the properties of human vision. This is why images needs to be gamma encoded to maintain visual quality. There is a misconception that gamma encoding has been established to reimburse for the I/O characteristics of cathode ray tube (CRT) displays. However, gamma encoding is needed to maximize the visual quality of the signal, apart from the gamma characteristics of the display devices. Hence, gamma characteristics of the display device do not play a factor in the gamma encoding of images and videos.**

Most images including medical images are RGB images. When images are captured using cameras using different magnifications, the images appear either dark or bright in contrast with original outlook. Human vision affects and thus poor quality image analysis may occur. Consequently this poor manual image analysis may have huge difference from the computational image analysis outcome. Question may arise here why we will use gamma encoding when histogram equalization or histogram normalization can enhance images. Enhancing images does not improve human visualization quality all the time because sometimes it brightens the image quality when it is needed to darken and vice-versa. Human vision reflects under universal illumination environment (not pitch black or blindingly bright) thus follows an approximate gamma or power function. Hence, this is not a good idea to brighten images all the time when better human visualization can be obtained while darkening the images. Better human visualization is important for manual image processing which leads to compare the outcome with the semi-automated or automated one. Considering the importance of gamma encoding in image processing we propose a new method of image analysis approach which will improve visual quality for manual processing as well as will lead analyzers to analyze images automatically for comparison and testing purpose.

Keywords-Gamma; human vision; color; HSB; light; comparison.

I. INTRODUCTION

Color model system is used to represent color. Moreover, it is a mathematical model which is used to describe how colors can be represented. Color space is used to describe how the components are to be interpreted. Colors can be seen as variable combinations of primary colors. Primary colors of light are additive and hence additive primary colors are red, green and blue. Combinations of R+G+B creates white. Moreover, primary colors of pigment are subtractive and hence subtractive primary colors are cyan, magenta and yellow. Combinations of C+M+Y creates black.

Various types of color model have been established already. One main color model is RGB color model where 3 different colors are added together in different ways to produce a wide range of colors. As for example for a 24 bit RGB color image, a total number of colors can be $(2^8)^3 = 16,777,216$.

RGB color model is used to represent and display images in electronic systems. It is to mention that RGB color model is device dependent as Red, Green and Blue levels are different from manufacturers to manufacturers. Sometimes these colors vary even in same devices over a period of time and hence without a color management RGB color value does not acts as same in devices.

To display RGB colors in hardware a display card named cathode ray tube (CRT) is used to handle the numeric RGB color values and in most CRT displays do have a power-law transfer characteristic with a gamma of about 2.5. In most occasions it has been observed that gamma remains out of consideration. Under these circumstances, an accurate reproduction of the original scene results in an image that human viewers judge as "flat" and lacking in contrast.

To improve the quality of visual perception for color images, the term image enhancement is an important factor. Image enhancement is needed in many areas such as photography, scanning, image analysis etc. Image enhancement approaches fall into two broad categories such as spatial domain and frequency domain methods. The term spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image whereas frequency domain processing techniques are based on modifying the Fourier transform of an image.

Color image enhancement is considered the most frequently used method these days by Buzuloiu et al using adaptive neighborhood histogram equalization technique. 3D histogram equalization has been proposed using RGB cube by Trahanias et al. Shue et al has established a new approach considering enhancement problem.

There are some more techniques available for wavelength based image enhancement proposed by Brown, this technique enhances the image edges. It is generally unwise to histogram equalize the components of a color image independently because it causes erroneous color. A more logical approach is histogram normalization while spreading the color intensities uniformly, leaving the color themselves (eg. Hue) enhanced.

Images can be gray-level images or color images. Comparing with color images gray-level images have got only one value for each pixel as images are made with pixel representation. There are many existing algorithm available which helps to enhance the image contrast for gray-level images considering piecewise-linear transformation function named contrast stretching with normalization, stretching with histogram techniques. Most of these available algorithm are not suitable for color images although they are used widely having poor quality and distorted effects.

Gray level transformation is proved to be better approach than any other transformation and hence most proposed methods are based on spatial domain approach. Image enhancement using spatial domain works with gray-level transformation or power law transformation. Power law equation is referred to as gamma.

$s = cr^{\gamma}$; 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.

However, it is to mention that, only enhancing the image does not improve the image quality for better visual perception. Sometimes it is needed to darken the bright images to obtain a better visualization. Gamma is one of the main factor which helps to brighten or darken an image.

The above mentioned techniques are widely used in the areas of image enhancement without much considering the color shifting issues. A color image enhancement technique should not change a pixel value from red to yellow as an example although in some cases color shifting may be necessary while controlling them before it can be applied. Hue is one of the main properties of a color and hence it is not easy to control hue in color enhancement especially in RGB color model. The color shifting issue has been considered in some research by Gupta et al, Naik et al where it has been suggested that hue should be preserved while applying image enhancement method. These methods keeps hue preserved and avoids color shifting but still there are problems. However, enhancement does not resolve human visualization perfectly because sometimes images need to make dark instead of enhancement. In that case enhancement does not help at all.

To resolve the above mentioned for human visualization considering two issues 1) color shifting and 2) human visualization we have come up with an idea that gamma encoding is necessary while decomposing the luminance (is an objective term and it is a measure of the amount of light coming off from a source, or reflected from an object) or brightness (perception of how much light is coming from a source or an object, and depends upon the context as well as the luminance) and for saturation instead of histogram equalization, histogram normalization can be applied.

II. METHODOLOGY

We have already mentioned that there are various types of color model available and most popular is RGB. Most images including medical images are RGB images. When images are captured using cameras using different magnifications, the images appear either dark or bright in contrast with original outlook. Human vision affects and thus poor quality image analysis may occur.

Human vision affects and thus poor quality image analysis may occur. Consequently this poor manual image analysis may have huge difference from the computational image analysis outcome. Question may arises here why we will use gamma encoding when histogram equalization or histogram, normalization can enhance images. Enhancing images does not improve human visualization quality all the time. Human vision reflects under universal illumination environment (not pitch black or blindingly bright) thus follows an approximate gamma or power function. Hence, this is not a good idea to brighten images all the time when better human visualization can be obtained while darkening the images. Better human visualization is important for manual image processing which leads to compare the outcome with the semi-automated or automated one. Considering the importance of gamma encoding in image processing we propose a new method of image analysis approach which will improve visual quality for manual processing as well as will lead analyzers to analyze images automatically for comparison and testing purpose.

We have proposed gamma encoding technique using spatial domain instead of frequency domain approach. Again, as mentioned earlier in RGB, 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 HSB color model, color in decomposed in hue, saturation and brightness value and thus easy for human visualization.

Hue is the main attribute of a color and thus decides which color the pixel has obtained. However, hue should not be changed at any point because changing the hue changes the color as well as distortion occurs in the image. Moreover, comparing with color space like CIE LUV and CIE Lab, in HSB it is easy to control hue and color shifting. Our main approach is to preserve the hue and apply better human visualization using saturation and brightness and hence we have chosen HSB color space instead of other color space.

As mentioned earlier that image are prepared in the medical laboratory are RGB images. It is important to convert the RGB images into HSB images so that we can have hue, saturation and brightness in differently.

III. COLOR MODEL CONVERSION

A. RGB to HSB

Below equations describes the conversion from RGB to HSB color space. For easier definition we have used maximum and minimum component values as M and m respectively and R for Red, G for Green and B for Blue and C is the difference between maximum and minimum.

$$M = \max (R , G , B) \quad (1)$$

$$M = \min (R , G , B) \quad (2)$$

$$C = M - n \quad (3)$$

Hue is the proportion of the distance around the edge of the hexagon which passes through the projected point, measured on the range [0,1] or in degree [0,360]. Mathematical expression for hue is

$$H' = \begin{cases} Undefined, & if \quad C = 0 \\ \frac{G-B}{C} \bmod 6, & if \quad M = R \\ \frac{B-R}{C} + 2, & if \quad M = G \\ \frac{R-G}{C} + 4, & if \quad M = B \end{cases} \quad (4)$$

$$H = 60^o \; x \; H' \quad (5)$$

B. HSB to RGB

Below equations describes the conversions from HSB to RGB.

$$H' = \frac{H}{60^o} \quad (6)$$

$$X = C\left(1 - \left|H' \bmod 2 - 1\right|\right) \quad (7)$$

$$(R_1, G_1, B_1) = \begin{cases} (0,0,0) & if\ H\ is\ Undefined \\ (C, X, 0) & if \quad 0 \le H' < 2 \\ (X, C, 0) & if \quad 1 \le H' < 2 \\ (0, C, X) & if \quad 2 \le H' < 3 \\ (0, X, C) & if \quad 3 \le H' < 4 \\ (X, 0, C) & if \quad 4 \le H' < 5 \\ (C, 0, X) & if \quad 5 \le H' < 3 \end{cases} \quad (8)$$

m= Y' – (0.30R1 + 0.59 G1 + 0.11 B1) (9)

(R,G,B)=(R1+m,G1+m,B1+m) (10)

This is a geometric warping of hexagons into circles where each side of the hexagon is mapped onto a 60 degree arc of thecircle.

S=0, if C=0 (11)

S=1- min / max, otherwise (12)

S is denoted for saturation

$$I = \frac{1}{3}(R + G + B) \quad (13)$$

where I is denoted as intensity

B = max (14)

where B is denoted in HSB as brightness.

IV. 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

Y'=0.2126R'+0.7152G'+0.0722B' for gamma encoding

V. 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.

VI. PROCESSING STEPS

This Following steps are used for our research approach.

1) Selection of a color image in RGB format.
2) Get the values (R,G,B) for each pixel for that specific image.
3) Conversion of RGB color image to HSB color image.
4) Gamma encoding applied for brightness or darkness for better visualization.
5) Saturation value applied using histogram normalization.
6) Conversion of HSB color image to RGB color image.
7) Save and use the resultant image for other image analysis.

VII. 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 in different computers as different computers acts different according to gamma value. It is to mention that gamma value > 1 performs darkening and vice-versa.

Figure 1 image with (a),(b),(c) illustrates that (a) is the original image, (b) is the existing image and (c) is our proposed approach image. Figure 1 (b) has color shifting which is remarkable where as figure 1(c) seems more perfect in compare to the original image. For figure 2(b) color has been faded rather although light has been passed to gain bright color however 1(c) seems more perfect and thus same is true for 3(b) and 3(c).

Table 1: Detailed comparison between existing approach without gamma and our proposed approach with accuracy. Sample results were collected considering human visual perception.

Method applied	**Images used**	**Error**	**Accuracy**
Existing approach without Gamma	Bright Images (Total 25 images)	27.3%	73.7%
	Dark Images (Total 34 Images)	21.67%	78.33%
Proposed method	Bright Images (Total 25 images)	11.25%	88.75%
	Dark Images (Total 34 Images)	8.7%	91.3%

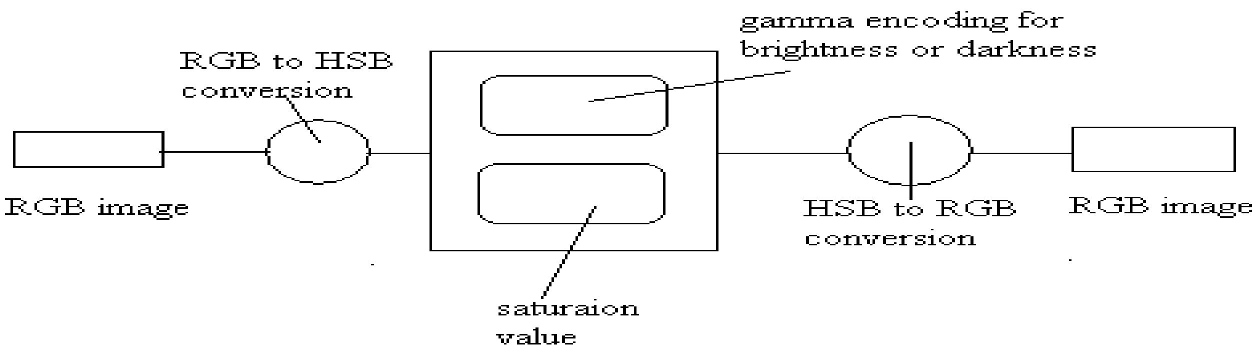

Fig 1: System Block Diagram

Fig 1(a): Original Image

1(b): Existing Approach

1(c): Proposed Approach

Fig 2(a): Original Image

2(b): Existing Approach

2(c): Proposed Approach

Fig 3(a): Original Image 3(b): Existing Approach 3(c): Proposed Approach

VIII. CONCLUSION

This paper has proposed a color enhancement approach using luminance component on gamma correction based on human visualization as well as saturation component using histogram normalization. However, 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.

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