Impact of Image Enhancement Parameters on Variations in GM & CM

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Abstract— In this paper, impact of color image enhancement parameters on variations in global mean and contrast enhancement index is studied. For color image enhancement human visual system based adaptive filter is used. This algorithm considers color information for enhancing image. For this parameters are used for enhancement process. This paper reveals how these parameters affect enhancement results. Experimental results show that these parameters affect mean and contrast enhancement index.

Keywords- *Color image enhancement, Global mean, Contrast enhancement index, Human visual system*

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I. INTRODUCTION

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce great deal of subjectivity into the choice of image enhancement methods. There exist many techniques that can enhance a digital image without spoiling it. The enhancement methods can broadly be divided in to the following two categories:

1. Spatial Domain Methods
2. Frequency Domain Methods

In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values[1].

In early researches there were several attempts on color image enhancement. Meylan and Susstrunk had proposed algorithm based on retinex technique[3]. This is effective technique for color image enhancement. This system is to mimic the processing of the human visual system on a scene to render high dynamic range images. Retinex theory intends to explain how the visual system extracts reliable information from the world despite changes of illumination. But the enhanced image has color distortion and calculation is complex.

Ghimire and Lee, proposed a method for enhancing the color images based on nonlinear transfer function and pixel neighborhood by preserving details[4]. In this method, the image enhancement is applied only on the V (luminance value) component of the HSV color image and H and S component are kept unchanged. ZhengyaXu, et all introduced a new hybrid image enhancement approach driven by both global and local processes on luminance and chrominance components of the image[5]. This approach, based on the parameter-controlled virtual histogram distribution method, can enhance simultaneously the overall contrast and the sharpness of an image. The approach also increases the visibility of specified portions or aspects of the image whilst better maintaining image colour. Wang Shou-jue, et all had proposed new algorithm[6]. The algorithm is based on bilateral filter and has much better effect than the above mentioned two algorithms. However, the image still exhibits halo phenomenon at the edges in spite of the algorithm improving it. In , distance and luminance information of pixels are considered in the bilateral filter instead of only considering distance information in Gaussian filter. But the color information is still not taken into consideration.

II. TECHNIQUE IMPLEMENTED

There are many methods available for gray image enhancement but it is not suitable to directly use gray image enhancement technologies for color images. Xinghao Ding et all proposed algorithm based on adaptive filter[2]. The algorithm consists of three major parts: (1) obtain luminance image and background image, (2)adaptive adjustment, (3)color restoration.

First part of implementing this algorithm is to obtain luminance image. The color images we usually see are mostly in RGB color space, which employ red, green, and blue three primary colors to produce other colors. In RGB color space, other colors are synthesized by three primary colors, which is not effective in some cases. Consequently, we use another color space YCbCr. If we remove color components from image then original image will become gray image. Therefore intensity of pixel at (x,y) is luminance value at point. The luminance image of the original color image is $I_L(x,y)$. Subjective luminance is the logarithmic function of the light intensity into human eyes. Logarithmic function of the original luminance image is obtained and then normalized it to get the subjective luminance

$$I_L(x,y) = \log(Y(x,y)) / \log(255) \quad (1)$$

where, $Y(x, y)$ is the Y value of the pixel (x, y).

The background image is obtained through adaptive filtering. Background image is denoted by $I_B(x,y)$.

$$I_B(x,y) = \frac{\sum G_R G_N\, N(x,y)}{\sum G_R G_N} \quad (2)$$

The $N(x, y)$ represents the pixel of (x, y), G_N is the scale parameter of pixel filtering, and G_R is the distance parameter. In classical filter, $N(x, y)$ is the intensity of the pixel (x, y). But the pixel (x, y) of color image has three values in fact, which are Y, U and V values. We usually overlook the color information of color images in filtering.

where, $I(x, y)$ is the intensity at (x, y) ;

$U(x, y)$,$V(x, y)$ are the color values of the pixel (x, y) ;

σ_R, σ_I and σ_C are the corresponding scale parameters.

The image is enhanced by making use of the relationship between the image and its background image. Adaptive adjustment is done by using formula

$$\beta(x,y) = (a\alpha + b).\omega(x,y)$$

where, α is intensity coefficient according to the cumulative distribution function (CDF) of the lumin ance image. $\omega(x,y)$ is the ratio value between the background image and the intensity image. a and b are constants. Now α is selected from

$$\alpha = \begin{cases} 0, & g \le 60 \\ (g-60)/130, & 60 < g \le 190 \\ 1, & g > 190 \end{cases}$$

g is the greyscale level when the cumulative distribution function(CDF) of the intensity image is 0.1. If more than 90% of all pixels have intensity higher than 190, α is 1; when 10% of all pixels have intensity lower that 60, α is 0; other times a linear changes between 0 and 1.

In the paper, when we get the background image, we take all this three values into consideration. It means that $N(x, y)$ has three components, Y is luminance value, and U, V are color values.

$$I_B(x,y) = \frac{\sum_{i,j=-W}^{W} G_R G_I G_C I(x_i,y_j)}{\sum_{i,j=-W}^{W} G_R G_I G_C} \quad (3)$$

$$G_R(x,y,x_i,y_j) = \exp\left\{-\frac{(x-x_i)^2+(y-y_j)^2}{2\sigma^2_R}\right\} \quad (4)$$

$$G_I(x,y,x_i,y_j) = \exp\left\{-\frac{I(x,y)-I(x_i,y_j)}{2\sigma^2_I}\right\} \quad (5)$$

$$G_C(x,y,x_i,y_j) = \exp\left\{\frac{\left(U(x,y)-U(x_i,y_j)\right)^2+\left(V(x,y)-V(x_i,y_j)\right)^2}{2\sigma^2_C}\right\} \quad (6)$$

$$\omega(x,y) = I_B(x,y)/I(x,y)$$

Through index transformation of $I_E(x, y)$ the image $I'(x, y)$ is obtained . Subsequently, the color restoration is used to obtain the enhanced color image, which is based on a linear process of the original color image.

$$R'(x,y) = R(x,y)\frac{I'(x,y)}{I(x,y)}$$
$$G'(x,y) = G(x,y)\frac{I'(x,y)}{I(x,y)}$$
$$B'(x,y) = B(x,y)\frac{I'(x,y)}{I(x,y)}$$

$R(x, y)$,$G(x, y)$, $B(x, y)$ represent the R, G, B values of the original color image, $R'(x, y)$, $G'(x, y)$, $B'(x, y)$ are the R, G, B values of enhanced color image.

III. EXPERIMENTS TO STUDY ENHANCEMENT PARAMETERS

Using the algorithm proposed in the paper, color image is enhanced. In this algorithm two parameters are used a and b for adaptive adjustment. These parameters can be changed for

Table1.Values of GM and CM for various combinations of ‘a’ and ’b’

a / b	a1=0.1		a2=0.15		a3=0.2		a4=0.25		a5=0.3	
	GM	CM	GM	CM	GM	CM	GM	CM	GM	CM
b1=0.3	248.36	0.5557	247.52	0.5884	246.32	0.6286	244.46	0.6801	241.04	0.7416
b2=0.4	235.32	0.8446	232.20	0.8810	227.66	0.9143	221.72	0.9337	213.11	0.9382
b3=0.5	216.85	0.9569	210.43	0.9700	201.75	0.9750	192.38	0.9717	183.36	0.9633
b4=0.6	192.31	0.9858	183.39	0.9847	174.92	0.9814	167.27	0.9771	160.33	0.9715
b5=0.7	167.74	0.9873	160.55	0.9857	153.98	0.9833	148.00	0.9801	142.49	0.9761

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better results. For studying impact of these parameters, algorithm is applied on image shown in fig1. Experiments are done by varying values of a and b and results are compared by observing two parameters global mean and CM.

Fig.1 Input image

For the objective estimation, global mean and contrast enhancement index are used to assess enhanced images. The contrast enhancement index is defined as follows:

$$CM = {C_{enhanced}}\Big/{C_{original}}$$

where *CM* is the average local variance comparison between the enhanced image and the original image, and *C* is the local variance comparison. Dividing the image into non-overlapped regular small blocks, and then calculating the mean value of variance for every block, the local variance can be obtained. Furthermore, calculating the average value of all local variance, we can get the *CM* value. In the table shown in table 1, values of GM and CM are given. Two parameters ‘a’ and ‘b’ are varied as a1,a2,a3,a4,a5 and b1,b2,b3,b4,b5. Eg. When a1 is 0.1 and b1 is 0.3 then GM comes as 248.36.

III. RESULTS AND DISCUSSION

It is observed from graph in fig2 that for all values of ‘a’, nature of graph remains same i.e. value of CM increases initially up to b=0.5 and then it moves towards constant value.

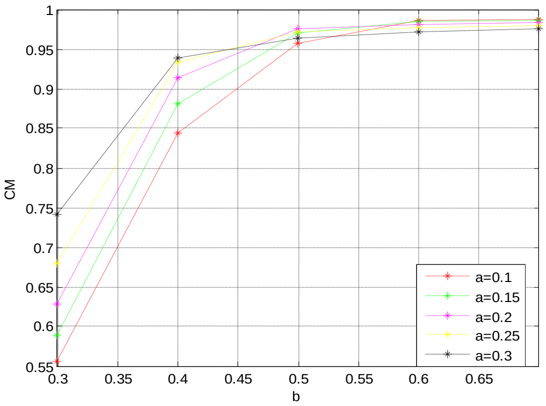

Fig.2 Variation in CM for change in ‘b’ at selected values of ’a’

In fig.3 ,from subplot 1 it is seen that values of CM increases over variations of ‘a’ when ‘b’<0.5. Nature of CM is decreasing for ’b’>0.5 as in subplot2.At b=0.5, CM increase for variations in ‘a’ and it gives maximum value for a=0.2 and then starts decreasing as shown in subplot 2.

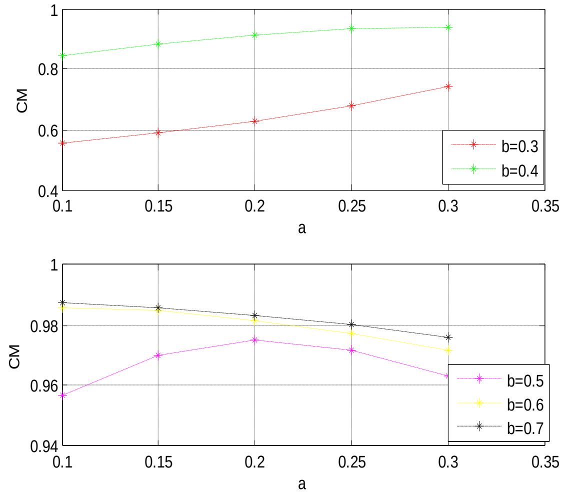

Fig.3 Variations in CM over range of ‘a’ when ‘b’ is varied

For variations in both parameters ‘a’ and ‘b’ the global mean decreases. It can be observed from first graph in fig.4, slope of graph is almost same for all values of ‘b’ but value of GM drops from approximately 250 to 170. In second graph of fig.3, it is observed that that difference between GM at ‘a’=0.1to ‘a’=0.3remains almost same for all values of ‘b’.

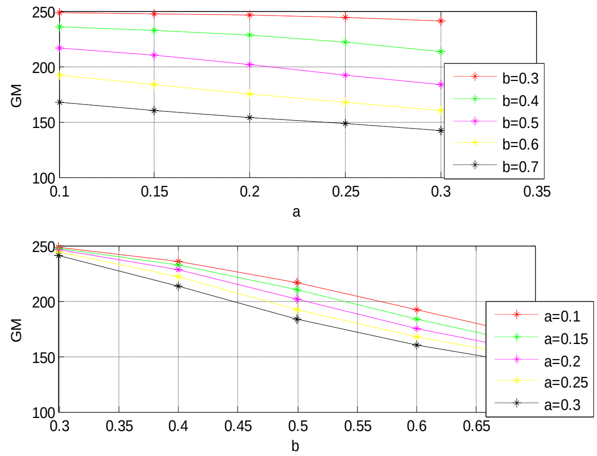

Fig.4 Variation in GM for selected values of ‘b’ and ‘a’

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