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HUE PRESERVING ENHANCEMENT ALGORITHM BASED ON WAVELET TRANSFORM AND HUMAN VISUAL SYSTEM

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This paper proposes a new method for enhancing the contrast as well as brightness of color images, based on orthogonal D4 Wavelet transform human visual system and also considers distinction between the background and foreground of the images. The RGB (Red, Green, and Blue) values of each pixel in a color image are converted to HSI (Hue, Saturation, and Intensity) value. On the S components of the color image, the orthogonal D4 Wavelet transform is applied in the appropriate blocks. It can be detected by suitable edge detector. The orthogonal D4 Wavelet transform decomposes the S component into detail and approximate components. Then the contrast as well as brightness enhancement on the approximate component based on the human visual system is applied. For I component histogram equalization is applied. IWT is applied on the detail and modified approximate component for the selected block. The old H, modified S and modified I, are then converted into the RGB color space. The effectiveness of the proposed method is demonstrated experimentally.

Keywords: Human Visual System; RGB & HSI Color Space; D4 Wavelet Transform; Histogram Equalization and Canny Edge Detector.

1. Introduction

The objective of the image enhancement is to improve the interpretability of information present in an image. An enhancement algorithm is one that yields a better-quality image for the purpose of some particular application which can be done by either suppressing the noise or increasing the image contrast and brightness. Image enhancement algorithms are employed to emphasized, sharpen or smoothen image's features for display and analysis. Enhancement methods are application specific and are often developed empirically.

The enhancement process does not increase the inherent information content in the data but it does increase the dynamic range of chosen features so that they can be detected easily. As there are many image acquisition techniques, so for many applications image enhancement techniques are needed. The greatest difficulty in image enhancement is quantifying the criteria for enhancement. Therefore, a large number of techniques are empirical and require interactive procedures to obtain satisfactory result. Images are classified into grey level and color images. Each pixel of the gray level image has only one grey level value. There are many algorithms for image enhancement in the gray level images such as contrast stretching, slicing and histogram equalization. Such algorithms are discussed in many articles and books. On the other hand, each pixel in the color images consists of color information. So these typical techniques are not applicable for color image enhancement. Therefore the color image enhancement is more difficult compared to gray level image and there is more points to be researched. Based on histogram equalization techniques some color image enhancement methods are proposed by Buzuloiu, et al [1]; but Trahanias, et al [2] proposed 3D histogram equalization on RGB cube. Thomas, et al [3, 8] proposed an enhancement method considering the correlation between luminance and saturation components of the image locally. The above mentioned method is very useful for color image enhancement. However they are not considering the color shifting property. A color enhancement method should not convert a red color to yellow color (for example). So we have introduced the color shifting property. Therefore, it is very important to consider the hue in the color enhancement method. Some researchers are also considering the color shifting problem. For example, Chanda et al [4] proposed a hue preserving enhancement scheme for class of color images. Murthy et al [5] proposed a hue preserving color image enhancement without gamut problem.

In the above mention methods the hue is preserved, but there is also color shifting problem and they have not considered the human visual system in all the cases. But Ding et al [6, 7] introduce the human visual system for enhancing the image. But they are not able to distinguish between the foreground and background images.

To solve the above mention problem, we propose a hue preserving algorithm with the human visual system and also consider the distinction between background and foreground for color image enhancement. We transform the

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RGB color space into corresponding HSI color space. The components are not changed, because changes in the H components could change the color balance between HSI components. The orthogonal wavelet transform [14] is applied on the illumination component to decompose it into approximate and detail components for the selected blocks. This is selected by appropriate edge detector. Then the contrast as well as brightness enhancement method on the approximate components based on human visual system to enhance the approximate components is applied. For the I components, a histogram equalization is applied for contrast enhancement. Then IWT is applied on the detail components and modified approximate components for selected blocks. Now convert the old H, modified S and modified I components to RGB color space.

2. Color Space Conversion

RGB to HIS

The conversion algorithm is shown in Equation(1) mentioned in [10, 11]. Max is the maximal value in R, G and B of all the pixels in the image and Min is the minimal value.

$$H = \cos^{-1}\left[\frac{(R-G)+(R-B)}{\sqrt[2]{(R-R)^2+(R-B)^2}}\right]$$

$$S = 1-\left[\frac{3\times \mathrm{Min}\{R,G,B\}}{R+G+B}\right]$$

$$I = \left[\frac{R+G+B}{3}\right] \quad (1)$$

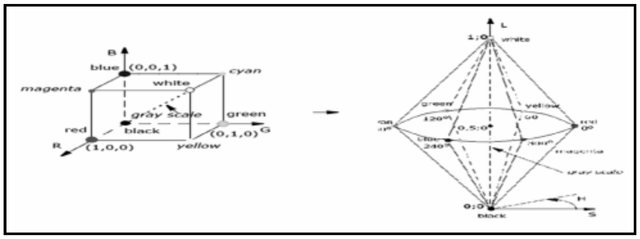

Fig. 1: RGB Color Space to HSI Color Space

HSI to RGB

After performing the enhancement in HSI color space we need to convert back from HIS to RGB color space to exhibit the result of the enhancement. The inverse conversion algorithm can be given as follows which is mentioned in [10, 11]

If($0 \le H \le 120$) Then

$$R = I\left[1+\frac{S\times \cos(H)}{\cos(60-H)}\right]$$

$$G = 3\times 1-(R+B)$$

$$B = I(1-S) \quad (2)$$

If ($120 \le H \le 240$) Then

$$H = H-120$$

$$R = I(1-S)$$

$$G = I\left[1+\frac{S\times \cos(H)}{\cos(60-H)}\right]$$

$$B = 3\times I-(R+G) \quad (3)$$

If ($240 \le H \le 360$) Then

$$H = H-240$$

$$R = 3\times I-(G+B)$$

$$G = I(1-S)$$

$$B = I\left[1+\frac{S\times \cos(H)}{\cos(60-H)}\right] \quad (4)$$

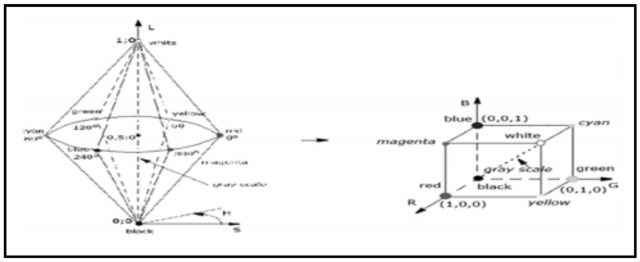

Fig.2: HSI Color Space to RGB Color Space

3. Wavelets Transform

Wavelets transform is an efficient tool to represent an image. It allows multi resolution analysis of an image. The aim of this transform is to extract relevant information from an image [9]. Wavelet transform has received considerable attention in the field of image processing due to its ability in adapting to human visual characteristics mentioned in [14]. It is most powerful and widely used tool in the field of image processing. It divides the signal into number of segments; each corresponds to a different frequency band. The continuous wavelet transform of a one dimension signal x(t) is given by

$$W_f(a,b) = \frac{1}{\sqrt{|a|}}\int_{-\alpha}^{\alpha} x(t)\psi^*\left(\frac{t-b}{a}\right)dt \quad (5)$$

The continuous wavelet transform is a function of two variables a and b. Here a is scaling parameter and b is a shift parameter. $\Psi(x)$ is the mother wavelet or the basis function and it is used as a prototype for generating all the basis functions. The transformation parameter or the shift parameter b gives the time information in the wavelet transformation. It indicates the location of the window as it is shifted through the signal. The scale parameter a gives the frequency information in the wavelet transforms. A low scale corresponds to wavelets of smaller width, which gives the detail information in the signal. A high scale corresponds to the wavelets of larger width which gives the global view of the signal. The IWT is given by

$$X(t) = \frac{1}{c_\psi} \int \int_{-\alpha}^{\alpha} W_f(a,b)\, \psi_{a,b}(t) ab \frac{da}{a^2} \quad (6)$$

and $$c_\psi = \int_{-\alpha}^{\alpha} |\psi(w)|^2 \frac{dw}{w} \langle \propto$$

The wavelet transform of a signal using the CWT is obtained by changing the scale of the analysis of the window, shifting the window in time, multiplying the signal & integrating the result over all time. According to the orthogonal wavelet transform, the S values are decomposed by the following equation

$$F(x,y) = \sum_{j=0}^{n-1} A_j \phi_{jn}(x,y) + \sum_{j=0}^{n-1} \sum_{k=0}^{n} D_{jk} \psi_{jk}(x,y) \quad (7)$$

Here ϕ is the scale function and Ψ is the wavelet transform. The former component of the decomposition is the approximate components and the latter one is the detail components. A_j are the approximate and D_{jk} are the detail components. As the transformation is an orthogonal transformation, each A_j is in the range [0, 255].

In our method, we assign two thresholds m and M ($0 < m < M < 255$) and divide the range of A_j into three parts: [0, m]; [m, M]; [M, 255]. If $A_j < m$ or $A_j > M$ we do not convert and simply set $A'_j = A_j$ otherwise we transform the following transformation

$$R(I) = \log\left(\frac{I - k1}{k2 - I}\right) \quad (8)$$

In the above equation I is the input and R is the output result. Parameter K1 should be less than the minimum of input I and the parameter k2 should be larger than maximum of input I. As the input $I \in [m, M]$ we can simply assume that the validity of the equitation by setting k1<m<M<K2.

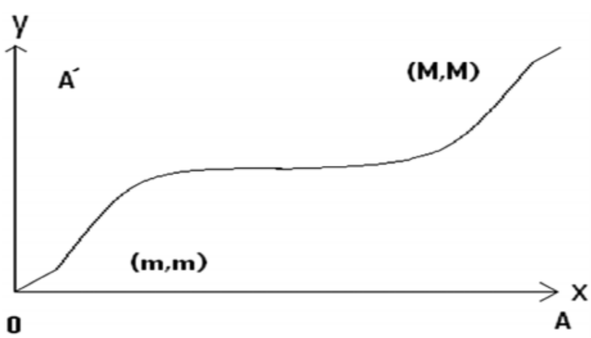

Fig.3: Coefficient Conversion Mapping Diagram

The following steps are the contrast enhancement for the approximate component:

Step 1: Compute R for each approximate coefficient A in the range by the above equation (8) for each block.

Step 2: Normalized R by the following equation:

$$R' = \left(\frac{R - R_{min}}{R_{max} - R_{min}}\right) \quad (9)$$

Where R_{min}, R_{max} are the minimum and maximum values of all the R obtained by the equation (8) for each block in the step 1.

Step 3: Convert them to the approximate range and get the new approximate coefficient A' by the following equation $A' = R' * (M - m) + m$

The image is reconstructed by using the inverse Wavelet transformation as indicated by the equation:

$$F(x,y) = \sum_{j=0}^{n-1} A'_j\, \phi_{jn}(x,y) + \sum_{j=0}^{n-1} \sum_{k=0}^{n} D_{jk}\, \psi_{jk}(x,y) \quad (10)$$

The purpose of I adjustment is to make the color image soft and vivid. The different researchers can do it in different way mentioned in [12, 13]. In our research we consider the histogram equalization method.

4. Proposed Method And Its Process Flow

Step 1: Read the color image.

Step 2: Convert RGB color space to HSI color space and find out the each component like H, S and I.

Step 3: Divide S component into appropriate blocks.

Step 4: Select the proper blocks for processing using suitable edge detection method.

Step 5: If the block satisfies the threshold value then apply suitable transformation (D4 wavelet) on that block. Selected blocks will decompose into detail and approximate components. Apply enhancement method on approximate components. For this apply the reverse S shape transform to approximate components. Apply inverse D4 wavelets transform on modified approximate components and detail components for reconstructing the S component.

Step 6: If the block does not satisfy the threshold value then copy that blocks directly.

Step 7: Apply histogram equalization on I component.

Step 8: Now H component, modified S and modified I components are converted to RGB color space.

5. EXPERIMENTAL RESULT

We present a novel algorithm for color image enhancement, which consists of orthogonal wavelet transform on S component of HSI color space. This paper has proposed a color contrast and brightness enhancement method based on wavelet transform on certain blocks, which is obtain by certain rules. More specifically, reverse S shape enhancement based on human visual system for the approximate component coefficient obtain by the orthogonal D4 Wavelet transform on S components of the selected blocks. The I components are enhance by histogram equalization. This method gives the successful result for low contrast images, i.e., why we give the few examples, which shows the effectiveness of our proposed method. To test the performance of our algorithm, we apply it to a low contrast color images and a dark color images and compare the results with original images.

Fig. 4

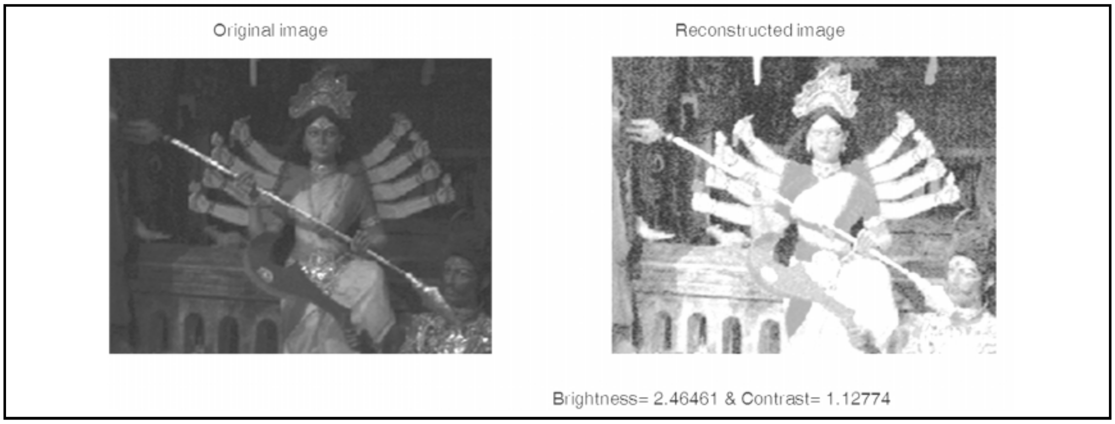

Fig. 5

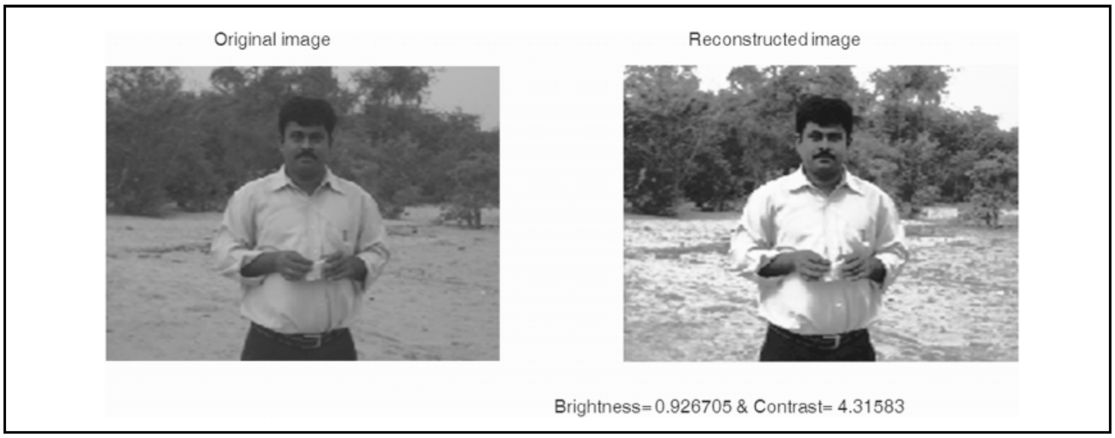

Fig. 6

Fig. 7

To evaluate the contrast as well as brightness enhancement performance of our method, we evaluate the following two evaluation parameters [7] mentioned below:

$$C = \frac{Var_{out} - Var_{in}}{Var_{in}} \quad (11)$$

$$L = \frac{I_{out} - I_{in}}{I_{in}} \quad (12)$$

where Var_{out} , I_{out} are the variance and average of the luminance values of the output image and Var_{in}, I_{in} are the variance and average of the luminance values of the input image respectively.

Table 1
Experimental Result

Si. no	Fig. Name	Contrast (%)	Brightness (%)
1	Fig.3	104.39	91.35
2	Fig.4	112.77	246.46
3	Fig.5	431.58	92.67
4	Fig.6	215.29	66.19

6. CONCLUSION

This paper presented a novel algorithm for color image enhancement by enhancing the contrast and luminance based on human visual system using the orthogonal (D4) wavelet transform. The Intensity of the image is also increased by histogram equalization. We also extract the picture from the background so that special attention can be given to the pictures only. The experimental result proves the efficiency of the proposed algorithm to enhance the image with low contrast to a better one. But, still are some issues. The performance might be better if we use Histogram Modification. Another topic is that some time color contrast enhancement requires changing color, so the Hue should also be used in some cases.

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