International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 15, Issue 01) and (Publishing Month: July 2014)
(An Indexed, Referred and Impact Factor Journal)
ISSN (Online): 2319-6564
www.ijesonline.com

HSV Space based Color Enhancement

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Abstract

In this paper, the image enhancement using HSV color space is done. In the existing work only V component is changed while the H and S component of the HSV format remains the same. In the proposed work the S component remains the same as any change in the s component changes the image color. The h component of the image is changed in the proposed system. The DWT of the h and v component is taken that divide these components in approximation and the detailed part. The approximation and detailed are enhanced separately for the both components. Then inverse DWT is used to combine these parts. Finally we get enhanced image by converting the image in to RGB format. The change in the H component enhances the color the image.

Keywords *Image Enhancement, DWT, RGB, HSV, PSNR.*

1. Introduction

Image Enhancement is very important topic in the researches. The principle of image enhancement is to process an image so that the result is more suitable than the original image in many applications. A typical image enhancement is achieved through the high-pass filter followed by the post-processing in order to make the image suitable. In other words, this method uses a typical principle behind un-sharp masking and high-boost filtering [1]. Image enhancement is a commonly used method for the improvement of the quality of a blurred image. Among many image enhancement approaches, the nonlinear image enhancement (NIE) method has a simple structure and can obtain a good processing effect [2]. The conventional NIE method in which uses a low-pass filter and non-linear operator to predict a high-frequency component, can be used to enhance the visual quality of a blurred image[3].

Image Enhancement (IE) transforms images to provide better representation of the subtle details. This is an indispensable tool for researchers in a wide variety of fields including (but not limited to) medical imaging, forensics, atmospheric sciences and art studies. It is application specific: an IE technique suitable for one problem might be inadequate for another. Eg: Forensic images/videos employ techniques that resolve the problem of low resolution and motion blur while medical imaging benefits more from increased contrast and sharpness. For such an ever increasing demand of digital imaging software companies have released commercial software's for users who want to edit and visually enhance the images [4].

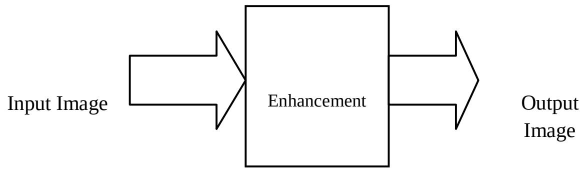


Fig 1: Process of Image Enhancement [5]

2. Contrast Enhancement

Contrast is an important factor in any subjective evaluation of image quality. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in medical imaging. Among them, histogram modification and edge enhancement techniques have been most commonly used along with traditional methods of image processing [6].

The contrast is created by the difference in luminance reflected from two adjacent surfaces. Local contrast stretching (LCS) is an enhancement method performed on an image for locally adjusting each picture element value to improve the visualization of structures in both darkest and lightest portions of the image at the same time[6]. Some of the improved techniques of histogram equalization with brightness preserving include the bi-histogram equalization (BHE) .Histogram equalization is the most popular algorithm for contrast enhancement due to its effectiveness and simplicity [7].

3. Color Enhancement

Color images provide more and richer information for visual perception than that of the gray images. Color image enhancement plays an important role in Digital Image Processing. The purpose of image enhancement is to get finer details of an image and highlight the useful information [8]. During poor illumination conditions, the images appear darker or with low contrast.

4. Non-Linear Image Enhancement Algorithm

Nonlinear image enhancement based on partial differential equations enhances the image contrast also changes the image gradient distribution. First of all, transform the image to the gradient domain. Because high contrast of the image means gradient strength large and texture clear. So they can enhance image gradient intensity to achieve image contrast enhancement.

There are three methods of nonlinear contrast enhancement:

- **Histogram Equalizations**

When an image's histogram is equalized all pixel values of the image are redistributed so there are approximately an equal number of pixels to each of the user-specified output gray-scale classes (e.g., 32, 64, and 256)

- **Adaptive Histogram Equalization**

The adaptive histogram equalization where you can divide the image into several rectangular domains; compute an equalizing histogram and modify levels so that they match across boundaries.

- **Homomorphic Filter**

Homomorphic filter is the filter which controls both high frequency and low-frequency components. Homomorphic filtering aims at handling large of image intensity; it has a multiplicative model [7].

5. Discrete Wavelet Transformation (DWT)

The basic idea in this is to multi-frequency decompose the image into 4 various sub-bands at different frequency. DWT decomposes the image into four frequency bands: LL, HL, LH, and HH band. LL band represents low frequency, HL and LH represent middle frequency and HH represents high frequency band, respectively. LL band represents approximate details, HL band gives horizontal details, LH provides vertical details and HH band highlights diagonal details of the image [9] The basic idea in the DWT for a one dimensional signal is the following. A signal is split into two parts, usually high frequencies and low frequencies. The edge components of the signal are largely to the high frequency part. The low frequency part is split again into two parts of high and low frequencies. This process is continued an arbitrary number of times, which is usually determined by the application at hand.

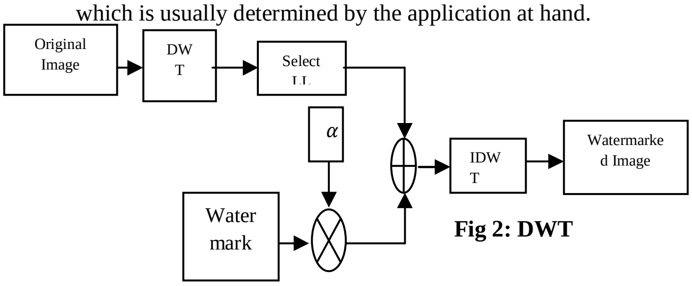


Fig 2: DWT

6. Proposed Work

In the existing work only V component is changed while the H and S component of the HSV format remains the same. In the proposed work the S component remains the same as any change in the s component changes the image color. The h component of the image is changed in the proposed system. The DWT of the h and v component is taken that divide these components in approximation and the detailed part. The approximation and detailed are enhanced separately for the both components. Then inverse DWT is used to combine these parts. Finally we get enhanced image by converting the image in to RGB format. The change in the H component enhances the color the image. The process can be easily explained by the flowchart explained below: The proposed work can be implemented using the MATLAB.

6.1 Image Enhancement In HSV Color Space

HSV color model is similar to color palette from which colors are selected and is based on how human perceive colors. Hue is a color attribute, saturation gives the purity of color and Luminance value indicates the brightness of the color. The change in the saturation and value component of the image can change the overall quality of the image. The relationship between RGB and HSV color space is defined using (1)-(4).

$$H = \begin{cases} H_1 & if\ B \le G \\ 360 - H_1 & if\ B > G \end{cases} \quad (1)$$

$$H_1 = cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right. \quad (2)$$

$$S = 1 - \frac{3}{R+G+B}[\min(R, G, B)] \quad (3)$$

$$V = \frac{1}{3}(R + G + B) \quad (4)$$

In the existing method, the input RGB color image is converted into HSV color image.

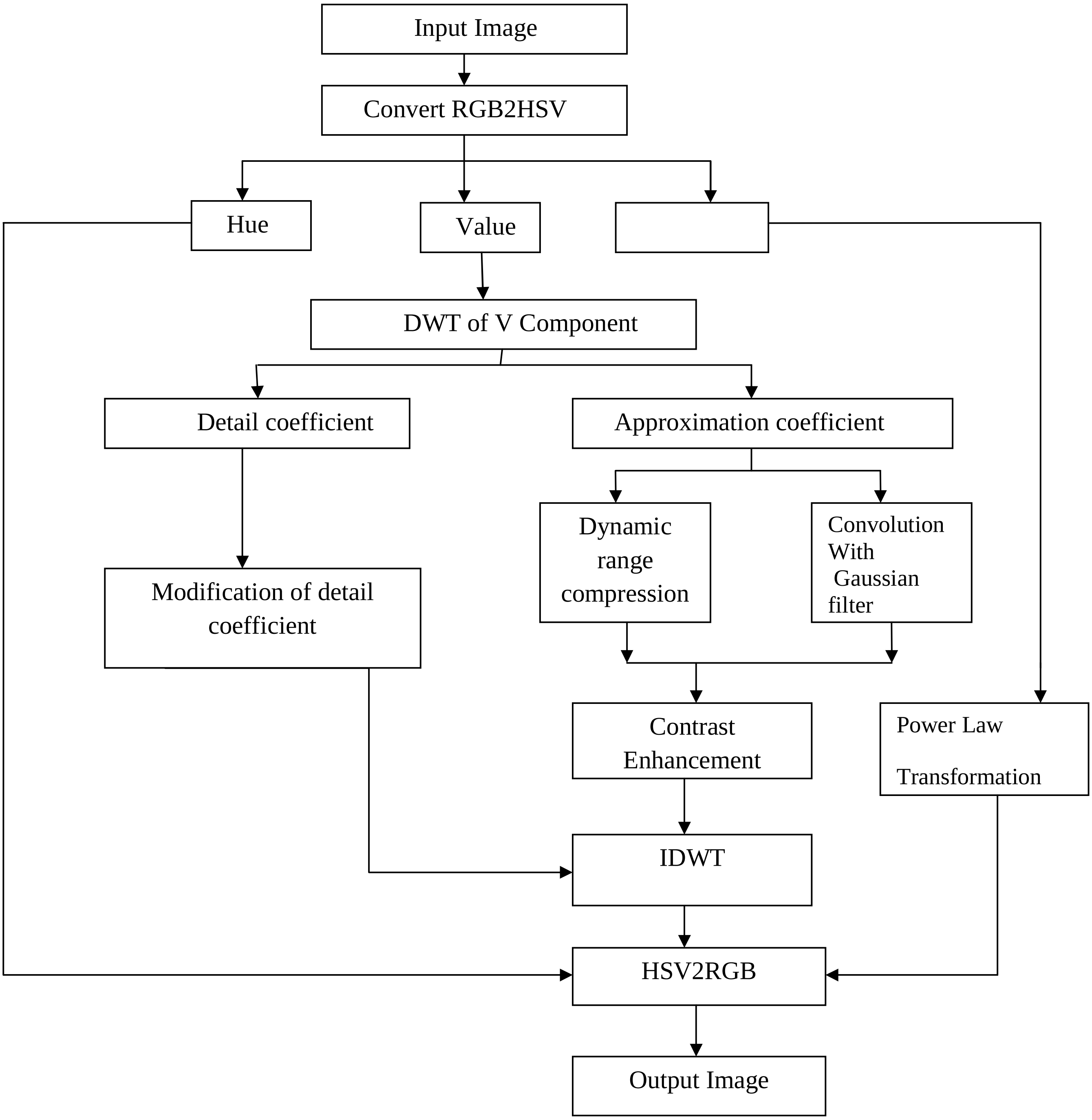
6.2 Discrete Wavelet Transform (DWT)

The DWT has been widely used in image processing for wide variety of applications. The DWT is used to decompose the luminance component of the image into approximation and detail coefficients using the haar wavelet transform.

$$V(x,y) = \sum A_{jkl}\varphi_{jkl}(m,n) + \sum_{j\ge jkl\epsilon Z}\sum d^h_{j,k,l}\psi^h_{j,k,l}(m,n) + \sum_{j\ge jkl\epsilon Z}\sum d^v_{j,k,l}\psi^v_{j,k,l}(m,n) + \sum_{j\ge jkl\epsilon Z}\sum d^d_{j,k,l}\psi^d_{j,k,l}(m,n) \quad (5)$$

Where 4567 represents approximation coefficient at scale J with corresponding scaling functions8967,and<967are the detail coefficients at each scale with corresponding wavelet functions>567. While the first term on the righthand side of (4) represents the approximation to *V (x, y)*, the second, the third, and the fourth terms represent the detail components in horizontal, vertical and diagonal directions, respectively.

Fig 3: Proposed Flow Chart



6.3 Luminance Enhancement

Based on image formation and human vision behavior, the image intensity I(x, y) can be simplified as product of the reflectance R(x, y) and the illuminance L(x, y) at each point (x, y). The illuminance L is assumed to be containing the low frequency component of the image while the reflectance R mainly includes the high frequency component, since R generally varies much faster than L in most parts of an image with a few exceptions, like shadow boundaries. In most cases the illuminance has several orders of larger dynamic range when compared to reflectance. By compressing only the dynamic range of the illuminance and preserving the reflectance, dynamic range compression can be achieved. In the exitsing method, the dynamic range compression is achieved by applying non-linear transfer function(6), to the approximation co-efficient of the value component of the HSV image (Step 3).

$$A_{enh}^{drc} = \frac{A1^{0.75z+0.25} + 0.4(1-z) + A1^{(2-z)}}{2} \quad (6)$$

Where z is the image dependent parameter given by

$$z = \begin{cases} 0 & for\ L \leq 5 \\ \frac{L-50}{100} & for\ 50 < L \leq 150 \\ 1 & for\ L > 150 \end{cases} \quad (7)$$

Where L is the approximation coefficient of the value level V corresponding to cumulative distributive function of 0.1 which is calculated from the histogram of the image.

In most of the images the illumination all over the image is not same so applying the transfer function by estimating the parameter z all over the image will not preserve the local details. In order to preserve the local details of the image the image is divided into equal sized blocks and find the parameter z for each block And again to solve the problem of blocking artifacts and region transition we further sub divide the blocks into sub blocks and find the parameter z for each sub block by interpolating the previously calculated z for each block. Simple bilinear interpolation is used for interpolating the parameter z from blocks to sub blocks.

7. Contrast Enhancement

The center surround ratio proposed by Hulbert is used for contrast enhancement in which the Gaussian filter is used. It is the optimal surround for the approximation coefficient obtained by using a 2D discrete convolution with Gaussian kernel G (m, n) given by

$$G(x,y) = Ke^{\left(-\frac{x^2+y^2}{2\sigma^2}\right)} \quad (8)$$

where *x* and *y* are spatial coordinates, r standard deviation of the Gaussian distribution function or Gaussian surround space constant and K is selected such that

$$K = \frac{1}{\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} F(x,y)} \quad (9)$$

Where mxn represents the size of the image.

$$A_{enh}(m,n) = 255 * A_{enh}^{drc^{E(m,n)}} \quad (10)$$

Where E(m, n) is obtained by

$$E(m,n) = \left[\frac{A_{fil}(m,n)}{A(m,n)}\right]^g \quad (11)$$

Where A_{filt} (m,n) =A(m,n)*G(m,n)

Where g is the parameter determined from the original approximation coefficient of the value component of the image in HSV space for tuning the contrast enhancement process.

The parameter g is determined using the following equation

$$z = \begin{cases} 0.45 & for\ \sigma \leq 2 \\ \frac{27-2\sigma}{13} & for\ 2 < \sigma < 10 \\ 0.25 & for\ \sigma \geq 10 \end{cases} \quad (12)$$

Where σ denotes the, standard deviation of the individual blocks of the original approximation coefficient of the value component of the image.

8. Detail Coefficient Modification

Contrast enhancement through detail coefficient modification is a well-established technique and relevant to large variety of applications [10]. In this contrast enhancement technique generally small valued coefficients, which also represent the noise content are weakened or left unmodified while large valued ones are strengthened by linear or non-linear curve mapping operators. Determining the threshold that separates the small and large coefficients is still merit of interest. Modifying these coefficients is very susceptible and may lead to undesired noise magnification or unpredictable edge deterioration such as jaggy edges. Thus, the inverse wavelet transform with the modified approximation coefficients will suffer from edge deterioration, if the detail coefficient is not modified in an appropriate way.

To meet this requirement, the detail coefficients are modified using the ratio between the enhanced and original approximation coefficients. This ratio is applied as an adaptive gain mask such as:

$$d^h new = \frac{A^{enh}}{A} d^h$$

$$d^v new = \frac{A^{enh}}{A} d^v$$

$$d^d new = \frac{A^{enh}}{A} d^d \quad (13)$$

9. Saturation Enhancement

The purpose of the saturation adjustment is to make the color image soft and vivid. In the proposed method, the

saturation component is enhanced by stretching its dynamic range to get rich color display [40]. The mathematical model to describe the saturation enhancement is given by
$S_{enh} = S^{\gamma}$ (14)

Where S is the original saturation component of the image, S_{enh} is the enhanced saturation component and γ is the stretch coefficient which determines the degree of saturation enhancement. The higher the . γ value the less saturated the image looks. The lower . is, the more the saturated image looks. In this work, the γ value is taken as 0.8 to get the satisfactory results.

10. Results

The table 1 shows the comparison the PSNR values of the existing and the proposed algorithm

Table 1 : Analysis Parameters of Existing and Proposed Algorithm

Image Name	Existing PSNR	Proposed PSNR
3.jpg	21.1018	36.4416
5.jpg	25.5872	44.1891
Lenna.png	20.6718	35.6991

The results of the above table can be shown graphically . The fig 4 shows the comparison of PSNR value of existing and proposed algorithm.

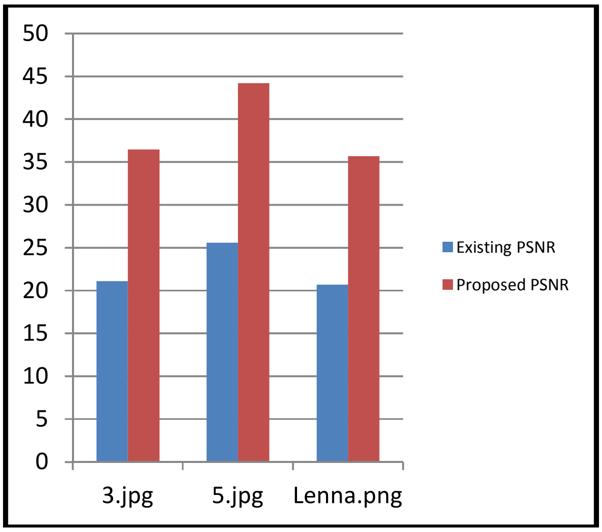


Fig 4: Comparison of PNSR Of Existing And Proposed Algorithm

11. Conclusion

The paper proposes a modified approach to image enhancement. The result shows that the performance of the proposed protocol is better than the existing protocol. The PSNR value of the proposed algorithm is better than the existing algorithm. The snapshot of the histogram of resultant image produced using the existing and proposed algorithm are different. The histogram of the resultant image of the proposed algorithm is more uniform as compare the resultant image of the existing algorithm. The histogram and the PSNR value confirm the better performance of the proposed algorithm as compared to the existing algorithm. In future, algorithm can be compared with other existing algorithms. The algorithm can be extended to use the neuro-fuzzy to enhance the performance. The algorithm can be extended to use the Bio-inspired techniques.

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