Color Image Enhancement Based on Contourlet Transform Coefficients

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Abstract: In this study, new method for enhancing color image based on contourlet transform and human visual system proposes. The color image is converted to HSV (Hue, Saturation, Value) values. The V, which represents the luminance value of color image, decomposed to its coefficients by nonsubsample contourlet transform, then applying grey-level contrast enhancement technique on some of the coefficients. Then, inverse contourlet transform is performed to reconstruct the enhanced V values. The S component is treated by histogram equalization while the H component does not change to avoid degradation color balance between the HSV components. Finally, the enhanced S and V together with H are converted back to its original color system. The new approach gives color enhancement more than 50% in the Contrast and more than 25% in the Luminance.

Key words: Image Processing, Image Enhancement, Color Enhancement, Contourlet Transform, HSV Color Space.

INTRODUCTION

Images are classified into grey level and color images (Kartik et al, 2010). Each pixel of the gray level image has only one grey level value (Ding and Jun, 2007). There are many algorithms for image enhancement in the gray level images such as contrast stretching, slicing and histogram equalization (Kartik et al, 2010). Such algorithms are discussed in many articles and books (Kartik et al, 2010). 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 (Kartik et al, 2010). Color images provide more and richer information for visual perception than that of the gray images (Ding and Jun, 2007). 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 (Anish, 2012). Image enhancement is a technology to improve the quality of an image in terms of visual perception of human beings (Ding and Jun, 2007). 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 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 (Kartik et al, 2010).

Related Work:

In 2007, Ding Xiao and Jun Ohya presented in their research "Contrast Enhancement Of Color Images Based On Wavelet Transform And Human Visual System", a method to improve the contrast of color image, wavelet transform applied on value component, the approximate components enhancing by using contrast enhancement technique based on human visual system (Ding and Jun, 2007).

In 2008, Li He and You Yang presented in their research "An Improved Color Image Enhancement Algorithm Based on MSR". The appropriate wavelet bases were selected to decompose the input image into three levels. Then different enhancement algorithms were employed to process the decomposed wavelet coefficients and scale coefficients. For the scale coefficients, the MSR algorithm was used (Li and you, 2008).

Kartik Sau, Amitabha Chanda and Milan Pal, In 2010, presented in their research "color image enhancement based on wavelet transform and human visual system". A schema to enhancing the color image, contrast enhancement technique applied on approximate component of wavelet transform after applied on intensity component (Kartik et al, 2010).

In 2010, K. Punnam Chandar, Dr. T. Satyasavithri, B. Narasimha and E. Hari Krishna presented in their research "Enhancement of Color Images by Scaling Hirschman Optimal Transform Coefficients". A method to...
Deepak Ghimire and Joonwhoan Lee, in 2010, presented in their research "Color Image Enhancement in HSV Space Using Nonlinear Transfer Function and Neighborhood Dependent Approach with Preserving Details", a method for enhancing the color images. The image enhancement is applied only on the V (luminance value) component of the color image. The V component is enhanced in two steps. At first the V channel is divided into smaller blocks and in each block dynamic range compression is carried out using nonlinear transfer function. In the second step each pixels in each block are further enhanced for the adjustment of the image contrast depending upon the centre pixel and its neighborhood (Deepak and Joonwhoan, 2010).

In 2012, Murtaza Saadique Basha presented in their research "Color image enhancement based on Daubechies wavelet and HIS analysis", A new image enhancement algorithm, in I component applied wavelet decomposition and histogram equalization in order to reduce noise and improve contrast. In the S component, we adopt saturation enhancement by exponent stretching (Ramakrishnan and Murtaza, 2012).

Elsa Alias and Jilu George, 2012, presented in their research "Enhancement of Color Images by Scaling the DCT Coefficients and Interpolation", a method to enhance the color images in the block DCT domain and after enhancement the image is interpolated with bicubic interpolation (Elsa and Jilu, 2012).

Color Space:

If the visible portion of the light spectrum is divided into three components, the predominant colors are red, green and blue. These three colors are considered the primary colors of the visible light spectrum. The RGB color space, in which color is specified by the amount of Red, Green and Blue present in the color, is known as the most popular color space (Ding and Jun, 2007). RGB is an additive and subtractive model, respectively, defining color in terms of the combination of primaries, whereas HSV color space encapsulates information about a color in terms that are more familiar to humans. In HSV color space, the color is decomposed into hue, saturation and luminance value similar to the way humans tend to perceive color. Ledley’s research shows that the performance of HSV color space is good in color improving[9]. Among the three components of HSV color space, hue is the attribute of a color, which decides which color it is. For the purpose of enhancing a color image, it is to be seen that hue should not change for any pixel. If hue is changed then the color gets changed, thereby distorting the image. Compared with other perceptually uniform such as CIE LUV color space and CIE Lab color space, it is easier to control the Hue component of color and avoid color shifting in the HSV color space. In our method, we keep hue preserved and apply the enhancement only to luminance and saturation. In Yang’s research, they have paid attention to the effect of luminance and saturation to color image enhancement. Therefore, we chose HSV color space for our enhancement method (Ding and Jun, 2007).

3.1 Color Space Conversion:

we apply our enhancement method in HSV color space. In general, color images are represented by RGB color space. Therefore the first step is to convert RGB color space to HSV color space. The conversion algorithm is shown in Fig.(1), Fig(2) which show a complete relation between the two color model (Ding and Jun, 2007).

\[
H = \begin{cases} 
\text{undefined}, & \text{if } MAX - MIN = 0 \\
60 \times \frac{G - B}{MAX - MIN} + 360, & \text{if } MAX = R \\
60 \times \frac{B - R}{MAX - MIN} + 120, & \text{if } MAX = G \\
60 \times \frac{R - G}{MAX - MIN} + 240, & \text{if } MAX = B 
\end{cases}
\]

\[
S = \begin{cases} 
0, & \text{if } MAX = 0 \\
\frac{MAX - MIN}{MAX}, & \text{otherwise} 
\end{cases}
\]

\[
V = MAX
\]

Fig. 1: relation between RGB and HSV

And the reverse wise conversion (HSV color space to RGB color space) given below:
4. Contourlet Transform:

The Contourlet transform was proposed by M. N. Do and M. Vetterli. The contourlet transform provides a multi-scale and multi-directional representation of an image. It consists of a double filter bank structure for obtaining sparse expansions for typical images having smooth contours. In this double filter bank, the Laplacian pyramid (LP) is first used to capture the point discontinuities, and then followed by a directional filter bank (DFB) to link point discontinuities into linear structures. The required number of directions can be specified by the user (Malini and Anurenjan, 2011).

4.1 NonSubSampled Contourlet Transform (NSCT):

The nonsubsampled contourlet transform is a new image decomposition scheme introduced by Arthur L. Cunha, Jianping Zhou and Minh N. Do. NSCT is more effective in representing smooth contours in different directions of an image than contourlet transform and discrete wavelet transform. The NSCT is fully shift invariant, multi-scale and multi-direction expansion that has a fast implementation. The NSCT exhibits similar subband decomposition as that of contourlets, but without down samplers and up samplers in it. Because of its redundancy, the filter design problem of nonsubsampled contourlet is much less constrained than that of contourlet. The NSCT is constructed by combining nonsubsampled pyramids and nonsubsampled directional filter bank as shown in fig(3). The nonsubsampled pyramid structure results the multi scale property and nonsubsampled directional filter bank results the directional property (Jianping, 2005).

4.1.1 Nonsubsampled pyramids:

The nonsubsampled pyramid is a two channel nonsubsampled filter bank as shown in Fig(5)(a). The $H_0(z)$ is the low pass filter and one then sets $H_1(z)=1-H_0(z)$ and corresponding synthesis filters $G_0(z)=G_1(z)=1$. The perfect reconstruction condition is given by Bezout identity (Cunha et al., 2005)

$$H_0(z)G_0(z)+H_1(z)G_1(z)=1 \ldots \ldots \ldots 1$$

**Fig. 2:** conversion from HSV to RGB.

**Fig. 3:** The nonsubsampled contourlet Transform (a) nonsubsampled filter bank structure that implements the NSCT. (b) Idealized frequency partitioning obtained with NSCT

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Multi scale decomposition is achieved from nonsubsampled pyramids by iterating the nonsubsampled filter banks. The next level decomposition is achieved by up sampling all filters by 2 in both dimensions. The complexity of filtering is constant whether the filtering is with $H(z)$ or an up sampled filter $H(z_m)$ computed using ” a trous “ algorithm. The cascading of three stage analysis part is shown in Fig(3) b.

### 4.1.2 Nonsubsample Directional Filter Banks:

The directional filter bank (DFB) is constructed from the combination of critically-sampled two-channel fan filter banks and resampling operations. The outcome of this DFB is a tree structured filter bank splitting the 2-D frequency plane into wedges. The nonsubsampled directional filter bank which is shift invariant is constructed by eliminating the down and up samplers in the DFB. The ideal frequency response of nonsubsampled filter banks is shown in Fig(6) a.

To obtain multi directional decomposition, the nonsubsampled DFBs are iterated. To obtain the next level decomposition, all filters are up sampled by a quincuncx matrix given by (Jianping et al., 2005).
The analysis part of an iterated nonsampled filter bank is shown in Figure 6(b).

5. proposed Algorithm:
Fig(7) show the block diagram of proposed algorithm.

![Diagram](image)

5.1: Color Enhancement Phases:
Step 1: read the color image (RGB color space).
Step 2: convert (RGB) color space to (HSV) color space and focus on components like H, S and V.
Step 3: apply nonsampling contourlet transform on V complement.
Step 4: apply enhancement techniques (contrast stretch) to coefficients.
Step 5: Reconstruct V by inverse nonsampling transform.
Step 6: Apply the Histogram Equalization on S complement.
Step 7: Now H component, modified S and modified V components converted to RGB color space.

5.2 Applied Example:
Testing the performance of proposed algorithm, by applying it on a low contrast color images and a dark color images and compare the results with original image. Fig(8) show the experimental result on different images:
RESULT AND DISCUSSION

To evaluate the performance of the proposed color image enhancement algorithm experiment was conducted using color images with different size. Simulations were done using Matlab Software. After converting the image to the color system (HSV). The (V) components is composed to level two using NSCT. The result contains a low pass band and many high pass sub bands, then apply the algorithm on the coefficients, the algorithm applied on different size of image.

The following two Enhancement measurements mentioned below where applied (Ding and Jun,2007) (Kartik et al,2010).

\[
C = \frac{\text{var}(I_{\text{out}}(x,y)) - \text{var}(I_{\text{in}}(x,y))}{\text{var}(I_{\text{in}}(x,y))}
\]

\[
L = \frac{\text{mean}(I_{\text{out}}(x,y)) - \text{mean}(I_{\text{in}}(x,y))}{\text{mean}(I_{\text{in}}(x,y))}
\]

\(I_{\text{in}}(x,y)\) is the original image before Processed, \(I_{\text{out}}(x,y)\) is the enhance image. \(\text{var}\) and \(\text{mean}\) represent the mean of local variance and the mean of the whole image. C is the contrast change rate , and L is the luminance change rate.

**Table 1:** show the result of algorithm on images

<table>
<thead>
<tr>
<th>S1. no</th>
<th>Image name</th>
<th>Contrast enhancement %</th>
<th>Luminance enhancement %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>32.760</td>
<td>16.168</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>53.423</td>
<td>24.5</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>14.191</td>
<td>7.284</td>
</tr>
</tbody>
</table>

**Conclusion:**

This paper has proposed a color image enhancement method that uses a luminance component enhancement based on contourlet transform. The Saturation components are enhanced by histogram equalization. It turns out
that the proposed contourlet based color enhancement method can achieve a successful enhancement of color images which are dark or with low contrast.

The algorithm can effectively enhance the color images especially the fuzzy ones with low brightness. At the same time, this method is easy one and a new approach to achieve the later transformation on color enhancement.

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