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An Efficient Retinex Image Enhancement based on 2D DTCWT

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Abstract-The task of image enhancement is focused on restoring and clarifying the corrupted images to improve their quality, and image enhancement methods has been widely applied to numerous image analysis techniques including pattern recognition, image fusion, image segmentation and so forth. Among the various methods used to enhance the image, algorithms created from retinex theory have received more and more attention and have been commonly used in many applications. This paper describes a retinex theory based method for contrast and illuminance enhancement in images of low light or unevenly illuminated scenes. This method firstly transformsimage from RGB color space to HSV colorspace, and decomposes the value channel using dual-tree complex wavelet transform. Then, to process the lesser frequency component of the image, an improved adaptive local tone mapping method is utilized and wavelet shrinkage method and fuzzy enhancement method are applied to denoise and enhance the reconstructed and a statistical histogram optimization method is used. After that, the enhanced value channel is the image is transformed back to RGB color space. Findings from experiments support the method suggested by this paper which performs very well with enhancement and de-noise of the corrupted images.

Keywords: Retinex, dual tree complex wavelet transform, adaptive local tone mapping, wavelet shrinkage, fuzzy, histogram optimization.

I. Introduction

Among the various factors involved in image processing, the foremost challenging factor is ‘Enhancement’. Enhancement aims to enhance the characteristics of an image in order to get a much clearer image [1]lacking the hassle of any degradation in the input image. It becomes much easier to identify the main features when noise and supplementary artifacts are removed from the image with the help of enhancement techniques.

A digital image is enhanced in regards to dynamic range compression, color/lightness rendition, and the color independence from the spectral distribution of the scene illuminant with the help of an automatic image enhancement method known as the retinex image enhancement algorithm. The Retinex Image Enhancement Algorithm helps to enhance the digital image in a manner that is similar to how a human visual system perceives a scene in regards to the different lightning variations as compared to any other method which enhances the digital image [2].Land [3][4] was the first to recommend the retinex theory so as to model the human visual system ’s imaging process. The basis of this particular theory is the assumption that when the human eye captures a scene, that particular scene is the result of the combination of reflectance and illumination [5][6]. A majority of enhancement algorithms based on retinex employ various methods in order to evaluate illumination and eliminate it in order to acquire the reflectance as the image that has been enhanced. Illumination removal aids in enhancing the details and textures. Due to the result not fulfilling the standards set by the human vision system, these enhanced results end up looking un-natural over-enhanced.
The most recent enhancement made to the DWT or the ‘Discrete Wavelet Transform’ is the DTCWT, also known as the ‘dual-tree complex wavelet transform’. The dual-tree complex wavelet was recommended by Nick Kingsbury [7] to be utilized in order to counter the difficulties of the traditionalwavelet transform. The standard DWT is further extended into the complex wavelet transform (CWT). A few of the advantages of the Dual-tree Complex Wavelet Transform (DTCWT) is the estimated shift invariance, flawless restoration above the traditional discrete water transform, and the good directional selectivity in two dimensions [8]. This is achieved with the aide of a redundancy factor that is marginally lesser than the un-decimated DWT. A variety of areas such as medical image processing, image sharpening, image inpainting, image topology, remote sensing, target recognition as well as Radar and Sonar imaging among others are provided supplementary scope by the DT-CWT.

A relatively new technique has been recommended in the research below for retinex enhancement using a hybrid approach comprising DT-CWT and decomposition followed by filtering where low illumination input image is first enhanced using dual-tree complex wavelet transform. Here, DTCWT is used to preserve the general properties for computational efficiency and flawless restoration with well-adjusted frequency responses [9]. The artifacts created by DTCWT are less than those produced due to DWT after the modification done in coefficients and hence provide better results[10].

Section II contain the related work of retinex based enhancement methods,Section III contain the methodology of proposed method, Section IV contain the results of present method,section V explain the conclusion.

II. RELATED WORK

In the past, various applications employed the use of a number of techniques to enhance images.Various methods have been recommended which would help in increasing the quality of the images in accordance to the enhancement by a majority of researchers.

Discrete and stationary wavelet decomposition technique centredaround the interpolation of subband images with relatively higher frequencies result due to DWT, according to Hasan and Gholamreza[11]. Stationary wavelet transform aide to enhance the high-frequencymodules of images. Compared to others, this method creates far better results.

According to Hasan Demirel and Gholamreza Anbarjafari [12],the images are interpolated by utilizing the DWT technique.However, as compared to the techniques used previously, the images that are obtained from the DWT and IDWT are not as sharp and also have a low PSNR.

The wavelet domain also contains a few issues such as introducing the artifacts as aliasing, and the occurrence a wavelet coefficient processing causes the balance amidst the forward and inverse transform to become unbalanced and thus produce artifacts in the images [13].

An Illuminance reflectance model considering noise for enhancement (IRMNE) has been recommended by *XinyanYu,XiaoyueLuo,GuohaoLyu*, *SiweiLuo*[14] that can aid in denoising the image which was clicked in the low light while enhancing it simultaneously. An advantage of this is that not only is the visual quality excellent but time is also saved when the image is denoised by the IRMNE during the process of image enhancement. The model's validity, as well as the benefits of the IRMNE, are demonstrated by the results from the experiment. The focus will be placed on improving the efficiency further with the help of comparison of the parameters (SNR,PSNR,MSE,SSIM) of our algorithm in order to comprehend the real-time image processing in the coming years.The flow of IRMNE as below:

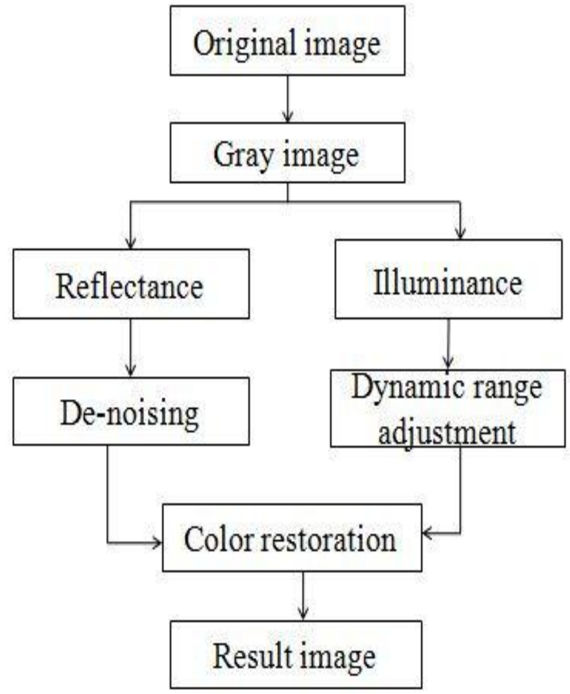

Fig1. Process of IRMNE

III. Methodology

The method recommended revolves around the shrinkage that is founded on data directionality, and the wavelet coefficients that are created by the DTCWT. The steps of the Retinex Improved image enhancement of the algorithm on which DTCWT is based upon are shown below:

1. For color images, the input image from RGB Color space conversion to HSV Color space, the hue (Hue) Channels and saturation (Saturation) Channels remain unchanged, only the luminance (Value) Channel and a next image enhancement decomposition denoising. For grayscale images, this step is skipped, directly for further processing.
2. Image luminance channel (or grayscale image) DTCWT, two low-frequency component to obtain high-frequency components in the complex domain and six-layer by decomposition of the complex domain.
3. Then, an improved adaptive local tone mapping method is utilized to process the low frequency component of the image, and wavelet shrinkage method and fuzzy enhancement method are applied to denoise and enhance the high frequency component of the image.
4. After that, the enhanced value channel is reconstructed and a statistical histogram optimization method is used.
5. Atlast, the enhanced image is altered back to RGB color space.

The block diagram of the recommended technique method is as follow:

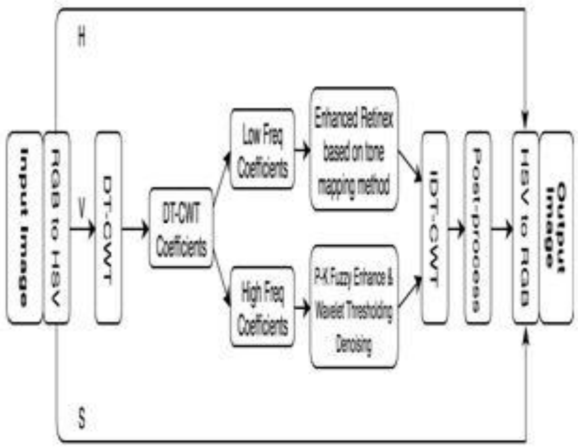

Figure 2**:** Proposed system Block diagram.

RGB to HSV color transformation

The color image is altered to HSV so as to lessen the color cast of the resut that was enhanced and to fasten the enhancement of the image by utilizing

$$V=\max(R_{channel}, G_{channel}, B_{channel}) \quad \text{--- (1)}$$

$$S = \begin{cases} 0 & if V = 0 \\ \frac{C}{V} & otherwise \end{cases} \quad \text{--- (2)}$$

$$H = \begin{cases} \frac{G-B}{S} & if R = V \\ 2+\frac{B-R}{S} & if\ G = V \\ 4+\frac{R-G}{S} & if\ B = V \end{cases} \quad \text{--- (3)}$$

Among them,R,G, B Image pixels are three color channels, and C It represents chroma (Chroma), Calculated by the following formula.

$$C = \begin{cases} 1 & if V = \min(R,G,B) \\ V-\min(R,G,B) & otherwise \end{cases} \quad \text{--- (4)}$$

Dual tree complex wavelet transform

There are two steps that are used in implementing of 2-D DT-CWT. In the first step, decomposition of an input image occurs up to a preferred level with the aid of two different 2D DWT branches, branch *a* and branch *b*, that have such filters which were specially designed to according to the Hilbert pair requirement.Generation of six high-pass sub-bands occurs next at every level; HL_a,LH_a,HH_a,HL_b,LH_b and HH_b.The second steps involves the linear combination (either by diferencing or by averaging) of every two corresponding sub bands that consist of identical pass-bands. Sub bands of of 2D DT-CWT are obtained at each level following this process and can be seen as

1.$(LH_a + LH_b)/\sqrt{2}$ 2.$(HL_a + HL_b)/\sqrt{2}$
3.$(HH_a + HH_b)/\sqrt{2}$ 4.$(LH_a - LH_b)/\sqrt{2}$
5.$(HL_a - HL_b)/\sqrt{2}$ 6.$(HH_a - HH_b)/\sqrt{2}$

The above shown oriented that defines the six wavelets having the sum/difference operation is orthonormal, that sets up a flaw less restoration wavelet transform. Both the real part and the imaginary part of 2D DT-CWT have the same basis function.There is an extension of conjugate filtering present inthe 2D DT-CWT structure in 2D case. Figure 3 displays the filter bank structure of 2D dual-tree.

Four trees are required for the analysis and the synthesis of the 2D structure. The two dimensions (x and y) directions have the pairs of conjugate Filters applied to them, in the following manner:

$$(h_x + jg_x)(h_y + jg_y) = (h_x h_y - g_x g_y) + j(h_x g_y + g_x h_y) \quad \text{--- (5)}$$

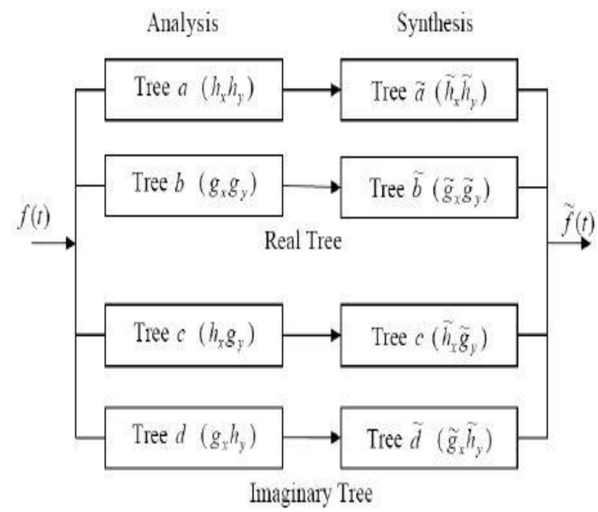

Fig 3. Filter bank structure for 2D DT-CWT

The above figure shows the he filter bank structure of tree a, almost identical to standard 2D DWT extended over over 4 level

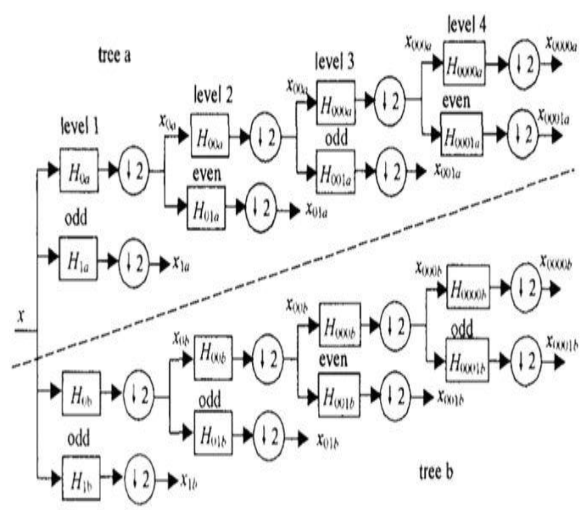

Fig 4.Levels in DTCWT

DTCWT transform each layer will have six (real and imaginary domains each of six fields) selective direction and two high-frequency components.

Enhancement processing and image denoisig

Two low-frequency component obtained by quantum 2D-DTCWT, since the low-frequency component mainly contains information about the overall image brightness and hue, and the like, so that part of the task is to enhance the overall image brightness and contrast.Improved adaptive local tone mapping method is utilized to process the frequency element of the image.Wavelet shrinkage and fuzzy enhancement method are applied to denoise and enhance high-frequency component of the image.

Inverse dual tree complex wavelet transform and adjust results

Once the procedure for reconstructed image luminance channel is completed, using Simplest Color Balance. The method of processing and optimizing be stretched histogram. The lack of an effective method that can exist in the corrected image exposure, and color cast uneven illumination problems, and can be a good stretch the histogram to adjust the dynamic range compressed image.

HSV color space to the RGB image conversion

Reconstruction of the luminance channel V Thereafter, the image is displayed for convenience and for other special applications, we need HSV

The image is converted back RGB Color space. Specific conversion follows.

$$(R,G,B) = (R' + m, G' + m, B' + m) \quad \text{--- (6)}$$

In which m = C – V and C is C = VS and (R’,G’,B’) is defined as follows

$$(R',G',B') = \begin{cases} (C,X,0) & if\, 0 \le H < 1, \\ (X,C,0) & if\, 1 \le H < 2, \\ (0,C,X) & if\, 2 \le H < 3, \\ (0,X,C) & if\, 3 \le H < 4, \\ (X,0,C) & if\, 4 \le H < 5, \\ (C,0,X) & if\, 5 \le H < 6, \\ (0,0,0) & otherwise \end{cases} \quad \text{--- (7)}$$

IV. RESULTS AND DISCUSSION

The following unit demonstrates the proposed system has been tested and verified on various standard data set of NASA image dataset(removing three fog images), Litao image dataset, BJTU image dataset(captured in BJTU) and HSRI (High Speed Railway Inspection)image dataset and real data images to show the superiority of the proposed system in terms of visual and numerical results over existing system. By considering the commonly used quantitative measures like, Mean-Squared Error (MSE), Structural similarity index (SSIM) and Peak Signal-to-Noise Ratio (PSNR) performance of proposed method can be evaluated.

(a)

(b)

(c)

Fig. 5 :Litao Standard image and respective processing on the same: (a) Original Image b) IRMNE Image (c) Proposed method output

(a)

(b)

(c)

Fig 6. Real data set image and respective processing on the same: (a) Original Image (b) IRMNE Image (c) Proposed method output

Figure 7 demonstrates the quantitative comparison results. The value of MSE that is lesser showcases the better denoising effect and the value of PSNR and SNR that is large showcases the better denoising effect.

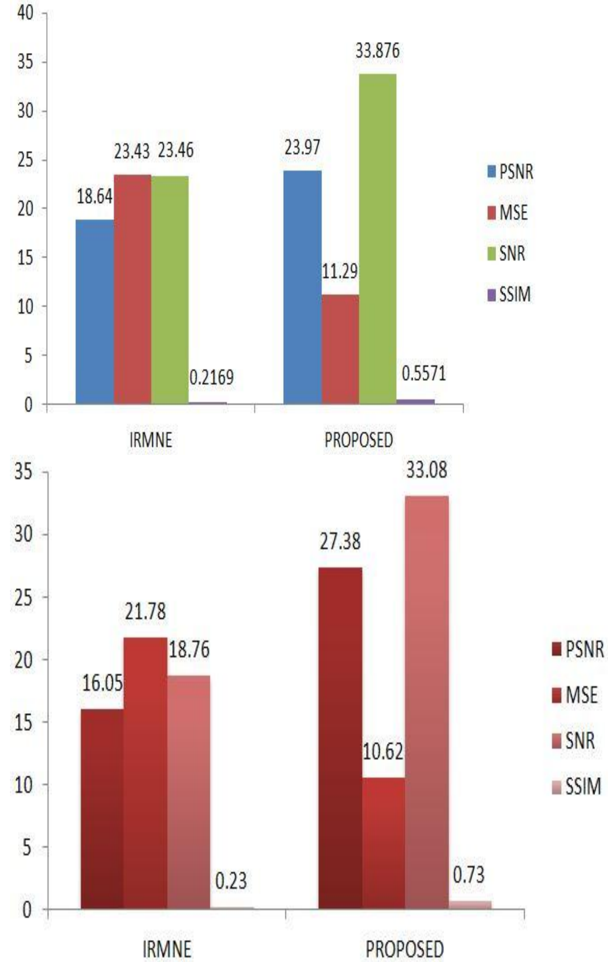

Fig 7. Quantitatively comparison between IRMNE and proposed method for standard and real data set images

V. CONCLUSION AND FUTURE SCOPE

The research presents a retinex enhancement built on 2D dual-tree complex wavelet transform.Noise is diminished with the aid of this method and the originality of the image can also be achieved along with an improved efficiency.Retinex is to be used as post-processing in this algorithm on the output of technique to enhance an image.Although the proposed method outperforms the existing techniques of super-resolution, butscope of improvement still exits. As this method involves multistage process, the number of computations is more therefore simulation time is increases. So as future work, modifications may be introduced to reduce the computation time.

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