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RetinexBased Image Enhancement for Better Visual Effects

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Abstract: Process of improving quality of image to give better visual appearance is called Image enhancement. Modified L_o Norm Based Algorithm which preserves sharp edges better than existing L_o Norm Algorithms . But the proposed algorithm gives better visual results than the modified lo norm. Human visual perception method is used in this enhancement technique. The input color image is transformed into HVS component. And from that only V component is enhanced. Robust envelope is introduced to reduce halo artifacts. This paper includes comparative study of modified lo norm and proposed Retinex with Robust Recursive Envelope algorithm. Existing image enhancement techniques have some drawbacks. Experimental result show that proposed algorithm reduces distortion and improves the visual quality of image.

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I. INTRODUCTION

The main aim of image enhancement is the improving visual quality of image. Image enhancement plays important role in the field of image processing[11].Lo norm based algorithm[2] has various applications in the field of image enhancement. It provides smoothing as well as sharpening of image .But for further improvement in visual appearance new algorithm is proposed. Modified Lo norm algorithm results in the improvement of quality of image.And quality is judge by using quality parameters namely, PSNR, MSE, AMBE. Retinex theory was developed in 1971 as a model of human perception. It is observed that degree of reflectance is related to color sensation. The intensity I(x, y) is the product of reflectance R(x, y) and the illumination L(x, y) [3].

Single scale retinex (SSR) model [4] &multiscaleretinexmodel[5]was proposed by Job Son at (1996, 1997). SSR & MSR are applied independently on approximate R.G.B channel so the gray world violation occurs in resultant image. To overcome this problem MSRCR [MultiscaleRetinex With Color Restoration) was proposed .But still color shifting problem occurs.Then this color shifting problem is solved by mapping RGB domain into HSV color space & only V channel is enhanced .For smoothness requirement & simultaneously avoid hallow artifacts , new robust envelope is proposed. Kimmel et al. (2001) solved the color-shifting problem by mapping the colors from the RGB domain into the HSV color space and only enhancing the input image on the V channel. They also constructed a stronger theoretical concept for retinex based on the envelope requirement and spatially smooth illumination assumption [6]. Shaked et al. (2003) developed a robust recursive envelope and proposed a generalization of recursive filters for retinex [7]. Elad (2005) employed bilateral filters to prevent hallow artifacts [10]. More recently, Choi et al. used a Gaussian pyramid to estimate the global illumination and JND-based nonlinear low pass filter to estimate local illumination in an image[8].

In this paper we modified the traditional approach of envelope requirement. To spatially piecewise smooth the illumination traditional envelope requirement combined with a new robust envelope with a gradient dependent weighting function. Remaining paper organized as follows- in next section related work is summarized. In section III proposed work is introduced as well as compared with modified lo norm method to judge the visual results. Experimental results are illustrated in section IV to verify performance of proposed algorithm Retinex with Robust Recursive Envelope. Finally paper is concluded in last section.

II. RELATED WORK

A. Modified lo norm

To reduce effects like gradient reversal artifacts and halo artifacts, only all the gradients except those of pixels at sharp edges are enlarged. Such an idea is formulated as lo norm based global optimization problem[1].

$$min_E\{\sum_p(Ep - Ip^2) + \lambda\,.\,\mathrm{C}(\mathrm{E} - \mathrm{K} \circ \mathrm{I})\} \qquad (1)$$

Where, E is detail enhanced image, I is input image, λ is lagrangian factor, P is pixel index of image, o denotes element-wise product operator, $\mathrm{C}(\mathrm{E} - \mathrm{K} \circ \mathrm{I})$is*lo norm* of gradient field.

B. Retinex based models SSR, MSR, MSRCR

SSR is given by,

$$\log R_i(x,y) = \log I_i(x,y) - \log[F(x,y) * RI_i(x,y)] \quad (2)$$

Where, $\log R_i(x,y)$ is SSR output, $I_i(x,y)$ is color component, *is 2D convolution operation, $F(x,y)$ is surrounding function.

MSR is weighted sum of output of different SSR,

$$\log R_{MSRi}(x,y) = \sum_{n=1}^{N} \omega_n \log R_{ni}(x,y) \quad (3)$$

Where, $\log R_{MSRi}(x,y)$ is MSR output, N is no. of scale, $\log R_{ni}(x,y)\, isn^{th}$ scale o/p, ω_n weight corresponding to n^{th} scale

MSRCR (MSR with color restoration)is given by,

$$\log R_{MSRCRi}(x,y) = C_i(x,y) \cdot \log R_{MSRi}(x,y) \quad (4)$$

Where, $C_i(x,y)$ is weighted function for color restoration represented as,

$$C_i(x,y) = a \log[b \frac{\log R_{MSRi}(x,y)}{\sum_{i\in\{R,G,B\}} \log R_{MSRi}(x,y)}] \quad (5)$$

Where a, b are constants.

C. Quality parameters

To compute the performance of algorithms three quality parameters are used namely PSNR(Peak Signal to Noise Ratio), MSE (Mean Square Error), AMBE(Average Mean Brightness Error).

PSNR(Peak Signal to Noise Ratio)

A higher PSNR is normally indicated that the resultant image is of higher quality. The PSNR is calculated by using following formula

$$PSNR = 10log \frac{(maximumpixelvalue\quad)^2}{MSE} \quad (6)$$

MSE(Mean Square Error)

The MSE between two images f & g is given by

$$MSE = \frac{1}{N} \sum_{j,k} (f(j,k) - g(j,k))^2 \quad (7)$$

Where the sum over j, k denotes sum over all pixels in the images, and N is number of pixels in each image.

AMBE(Average Mean Brightness Error)

It is defined as

$$AMBEE(x,y) = |X_m - Y_m| \quad (8)$$

Where X_m is mean intensity of input image $x = \{x(i,j)\}$ and Y_m is mean intensity of output image $y = \{y(i,j)\}$. For better brightness preservation, AMBE should be small.

III. PROPOSED WORK

Retinex based Robust Recursive Envelope used to get better visual results. For smoothness requirement and to reduce thehallow artifacts, we propose a new combined retinex with a robust envelope with a gradient dependentweighting function. To avoid the gray-world violation problem, we transfer ourimages to the HSV color space, but only apply the proposedalgorithm on the V channel.

Illumination estimation

Instead of processing an image in logarithmic scale, process the original pixel value. Moreover, required spatial piecewise smoothness, and a weighting function combined with the envelope requirement to limit the behavior of the illumination around the edges and corners.

Since estimating the illuminationfrom an image is an ill-posed problem, we use a costfunction to derive a better output image.

$$\mathrm{F}(\mathrm{L}(\mathrm{x},\mathrm{y})) = \int_\Omega \|\nabla L(x,y)\|^2 + \propto \|L(x,y) - I(x,y)\|^2 \, dx\, dy \quad (9)$$

Where$\Omega$is the support of the image, ∇ is the first-order differential operator, and$\|\cdot\|$denotes the absolute value. Next apply a gradient-descent algorithm to minimize this cost function F(L(x, y)). An iteration of the algorithm can be formulated as follows:

$$L_j(x,y) = L_j - 1(x,y) - \beta.G \quad (10)$$

WhereLj(x, y) and Lj−1(x, y) are the illumination images at step j and j-1, respectively; β is the line-search step size; and G is the gradient of F(L(x, y)). Similar to
the gradient G:

$$G = -\Delta L + \propto \cdot (L - I) \quad (11)$$

$$\approx -L(x, y) * K_{lap}(x, y) + \propto \cdot L(x, y) - I(x, y) \quad (12)$$

whereΔ is a second-order Laplacian differential operator that can be approximated by a linear convolution with the spatial filter K_{lap}.

$$K_{lap} = \begin{pmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

The illumination to become spatially piecewise smooth and simultaneously eliminate the hallow artifact. The illumination is expected to change rapidly with the intensity around the edges. By combining the weighting function with the envelope requirement, we obtain:

$$L_j(x, y) = max\{\omega(\nabla I) \cdot I(x, y) + (1 - \omega(\nabla I)) \cdot L_j(x, y), I(x, y)\} \quad (13)$$

where$\omega(\nabla I)$is the gradient-dependent weighting function associated with the gradient of the intensity. The profile of the weighting function is described by the following expressions:

$$\omega(\nabla I) = \begin{cases} \omega_0, & if \nabla I \geq Th \\ \omega_0 \cdot (\frac{\nabla I}{Th})^2 & Otherwise \end{cases} \quad (14)$$

$$\nabla I \approx \|I(x, y) * H(x, y)\| + \|I(x, y) * H^T(x, y)\| \quad (15)$$

where$Th$is the threshold of the gradient, H(x, y) is the truncated pyramid operator [9]and$H^T(x, y)$the transpose of H(x, y). H(x, y) is adopted to detect strong edges.

$$H = \frac{1}{34}\begin{bmatrix} 1 & 1 & 1 & 0 & -1 & -1 & -1 \\ 1 & 2 & 2 & 0 & -2 & -2 & -1 \\ 1 & 2 & 3 & 0 & -3 & -2 & -1 \\ 1 & 2 & 3 & 0 & -3 & -2 & -1 \\ 1 & 2 & 3 & 0 & -3 & -2 & -1 \\ 1 & 2 & 2 & 0 & -2 & -2 & -1 \\ 1 & 1 & 1 & 0 & -1 & -1 & -1 \end{bmatrix}$$

Illumination correction

The reflectance image R(x, y) can be deduced as follows:

$$R(x, y) = \frac{I(x,y)}{L_f(x,y)} \quad (16)$$

Furthermore, tune up *L(x, y)* by a gamma correction operation with a free parameter ϒand obtain a new illumination$L_{\Upsilon}(x, y)$:

$$L_{\Upsilon}(x, y) = W \cdot \left(\frac{L_{\Upsilon}(x,y)}{W}\right)^{1/\Upsilon} \quad (17)$$

WhereW is the white value (equal to 255 in 8-bit images or 1in normalized images).
The new intensity$I_{EN}(x, y)$, i.e., the new V component in the HSV color system, is obtained by:

$$I_{EN}(x, y) = R(x, y) \cdot L_{\Upsilon}(x, y) \quad (18)$$

IV. EXPERIMENTAL RESULTS

Retinex with Robust Recursive Envelope method is implemented to get better visual results.Human visual perception is used to judge the results .To analyze the result of modified lo norm algorithms values of PSNR, MSE, AMBE are observed.For large value of PSNR, we get better results.As the value of MSE and AMBE decreases, quality of image improves.

Qualitative analysis plays vital role to analyze performance of only modified lo norm algorithm. We compare the experimental results for lo norm, modified lo norm and RRRE algorithm by PSNR, MSE, AMBE. We apply lo norm,modified lo norm and RRRE algorithm to different images to get the values of quality parameters. Table no. 1 shows the values of PSNR, MSE, AMBE for different values of λ for lo norm , modified lo norm and RRRE algorithm . We have select the values of λ between 0.01 to 0.2.If value of λ taken beyond the limit then algorithm does not modify the image further.

Table no. 1. Values of quality parameters for modified lo norm and RRRE method

Input	Parameters	Method	Value of λ		
			0.01	0.16	0.2
Image 	PSNR	Lo norm	64.9201	66.2061	66.5178
		Modified lo norm	67.1766	69.126	69.7425
		RRRE	66.83	66.83	66.83
	MSE	Lo norm	0.021466	0.0155996	0.014527
		Modified lo norm	0.013100	0.007969	0.006920
		RRRE	0.01371	0.01371	0.01371
	AMBE	Lo norm	36.1252	31.4029	30.1654
		Modified lo norm	27.0645	22.0843	20.7612
		RRRE	181.057	181.057	181.057

Figure 1 shows the graphical representation of quality parameters for first input image, In all the graphs X-axis represents the value of λ while Y-axis represents value of quality parameter. From the all graphs we can observe that beyond the range 0.01 to 0.2, results are not modified. Figure 1(a) is graph of λ V_s PSNR. It shows values of PSNR are better for modified lo norm than lo norm and RRRE. Figure 1(b) & (c) are graph for λ V_s MSE and λ V_sAMBE respectively. The values of MSE & AMBE should be smaller for better quality of image. The graphs shows that values of MSE & AMBE are smaller for lo norm and modified lo norm than RRRE.

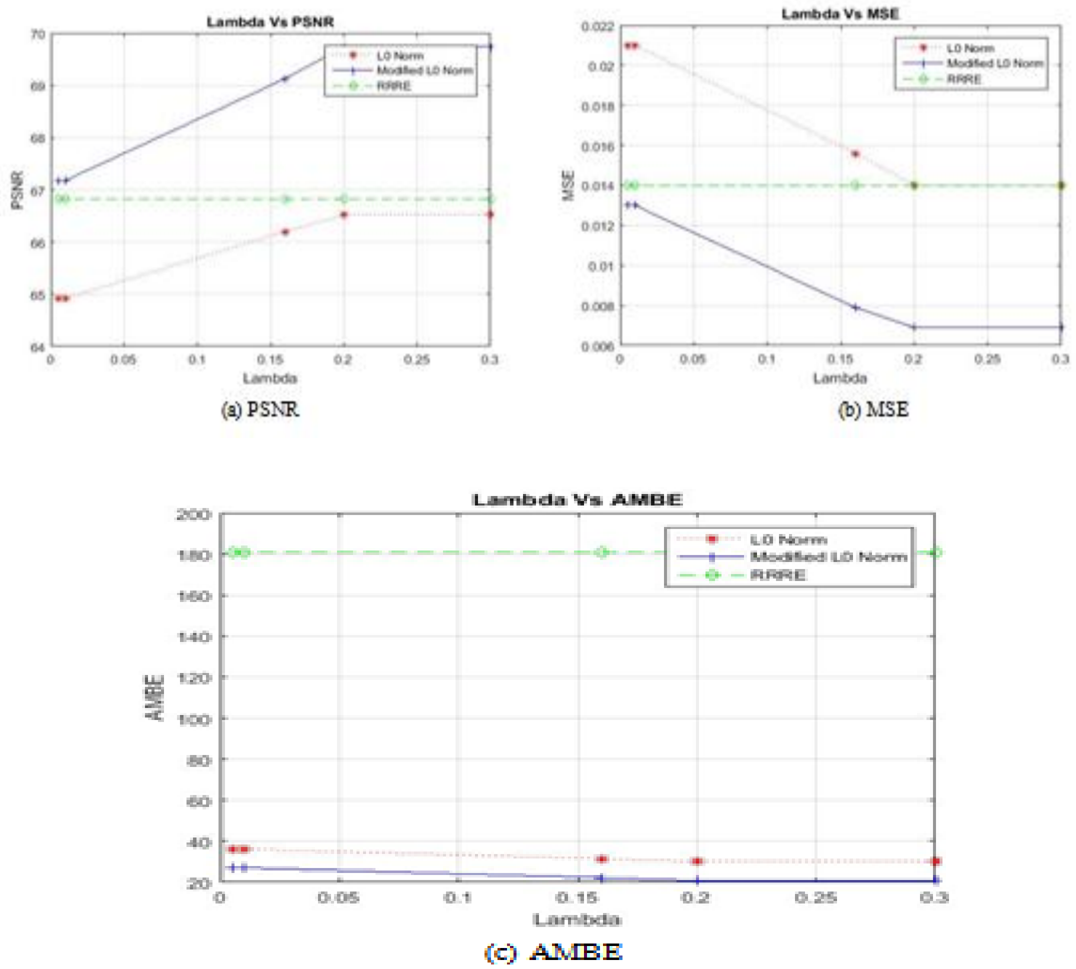

Figure 1. Graphical representation of quality parameters for first input image

From all the graphs we observed thatquality parameters cannot be used to analyze performance of RRRE algorithm. Because it does not give satisfactory values of quality parameters as compare to other algorithms. It analyzed only using human visual perception concept.

To analyze performance of RRRE algorithm only visual results are taking into consideration.It improves visual appearance of images better than modified lo norm algorithm. In this algorithm, the input image is converted to HSV component. Among these components we enhance only V component to give better visual results.

We apply the algorithms to different color images. In Figure 2, 3 and 4, (a) is the original input image. (b) is the image after applying modified lo norm algorithm. (d) is the enhanced image after applying Retinex with Robust Recursive Envelop method. The output image is visually better than modified lo norm.

Figure 2. Result for first input image after applying enhancement algorithm

Figure 3. Result for second input image after applying enhancement algorithm

Figure 4. Result for third input image after applying enhancement algorithm

V. CONCLUSION

It is concluded that RRRE algorithm plays vital role to improve the visual appearance of image. Existing image enhancement methods produces some drawbacks like gradient reversal artifacts, over sharpening, ringing blurring etc. The gradient reversal artifacts and halo artifacts are significantly reduced by RRRE method. Quality parameters PSNR, MSE and AMBE values shows that for modified lo norm values are good but not for RRRE algorithm. So only human visual perception is used to observe the performance of RRRE method not the quality parameters. From the experimental results we conclude that Retinex with Robust recursive envelope method improves visual appearance of image effectively than other methods. It yields nearly hallow-free and non-color-shifting results.

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