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Low Contrast Image Enhancement Based On Undecimated Wavelet Transform with SSR

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***Abstract*—** Image Enhancement refers to accentuation or sharpening of image features such as edges, boundaries or contrast so as to get finer details of an image. In this paper a low contrast image enhancement algorithm using Single Scale Retinex (SSR) with undecimated wavelet transform (UWT) has been proposed. The performance of the proposed algorithm is evaluated using a statistical visual contrast measure (VCM). Experimental results obtained from the proposed algorithm gives improvement in terms of the VCM. Paper concludes comparison with existing algorithm and shows that the proposed method performs quite efficiently.

***Keywords*—** Low Contrast image Enhancement, single scale retinex (SSR), undecimtaed wavelet transform, visual contrast measure

I. INTRODUCTION

Low contrast image enhancement is the task of applying certain transformations to an input image such as to obtain a visually more recovered, more detailed, or less noisy output image. Producing digital images with good contrast and detail is a strong requirement in several areas. The principle objective of enhancement is to process an image so that the result is more suitable than the original image.

Image enhancement approaches fall into two broad categories: spatial domain methods and frequency domain methods. The term spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. Some of the traditional methods which deal with contrast enhancement of an image include histogram equalization which is considered as one of the fundamental processes for contrast enhancement of gray level images which facilitates subsequent higher level operations such as detection and identification. AHE improves this enhancement by transforming each pixel with a transformation function derived from a neighborhood region.

Many proposed algorithms such as Algorithm using directional wavelet transform and Discrete cosine transform(DCT) employs direction WT for transforming the data vector into a different vector and DCT exploits interpixel redundancy to render excellent decorrelation. Algorithm using DWT, DCT and SVD gives better contrast as well as high image quality. Algorithm using DWT, SWT and SVD satisfactorily enhances the contrast but losses some information during interpolation. Undecimated WT (UWT) based enhancement provides high visual quality improving the local contrast. Algorithm using DSR with DWT is highly suitable for contrast enhancement of very dark images but suffers from the problem of bleaching of images. Algorithm using modern retinex techniques (MSR & SSR) provides good dynamic range compression but suffers from color violation and unnatural color rendition.

In this paper a contrast enhancement algorithm is proposed using SSR and UDWT. The rest of the paper is organized as follows: In section II, theory of SSR and UDWT are described. In section III, proposed algorithm is discussed. In section IV, the experimental results are discussed where the effectiveness of our proposed scheme is checked by visual contrast measure (VCM) and finally in section V, conclusion of the work is made.

II. THEORY

A. Single-Scale Retinex (SSR)

The retinex model has undergone many recent enhancements. The single-scale retinex (SSR) model relies on the ratio of the lightness of a small central field in the region of interest to the average lightness of an extended field; a Gaussian filter is generally used to obtain the average lightness of the whole image .

The Single Scale Retinex (SSR) is defined for a point (x, y) in an image as:

$$R_i(x,y) = \log[I_i(x,y)] - \log[F(x,y) * I_i(x,y)] \tag{1}$$

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Where the sub-index i represents the i-th spectral band, S is the number of spectral bands (S =1 for grayscale images, and S =3 for typical colour images); $R_i(x,y)$ is the Retinex output and $I_i(x,y)$is the input image distribution in the i-th spectral band. The symbol "*" denotes the convolution operation; $F(x, y)$ is the normalized surround function; various surround functions could be used, and the Gaussian surround function is one of them,

$$F(x,y) = Ke^{-(x^2+y^2)/c^2} \tag{2}$$

where c is the Gaussian surround constant, that is referred to as the scale of the SSR, and K is selected such that

$$\iint F(x,y)dxdy = 1. \tag{3}$$

A small value of c provides a good dynamic range compression, and a large scale provides better colour rendition.
The image distribution is the product of scenes reflectance and illumination:

$$I_i(x,y) = S_i(x,y) \quad r_i(x,y) \tag{4}$$

Where $S_i(x,y)$ is the spatial distribution of illumination, and r_i(x,y)is the distribution of scene reflectances.

$$R_i(x,y) = \log[S_i(x,y)r_i(x,y)/\overline{S_i(x,y)r_i(x,y)}] \tag{5}$$

As the illumination generally has slow spatial variation $S_i(x,y) \approx \overline{S_i(x,y)}$ then:

$$R_i(x,y) = \log[r_i(x,y)/\overline{r_i(x,y)}]. \tag{6}$$

Above Equation (6) means that colour constancy (independence from source Illumination spectral and spatial variation) is achieved [4].

B. Undecimated Discrete Wavelet Transform (UDWT)

This algorithm is based on the idea of no decimation. It applies the wavelet transform and omits both down-sampling in the forward and up sampling in the inverse transform. More precisely, it applies the transform at each point of the image and saves the detail coefficients and uses the low-frequency coefficients for the next level. The size of the coefficients array does not diminish from level to level. By using all coefficients at each level, we get very well allocated high-frequency information. With this transform the number of pixels involved in computing a given coefficient grows slower and so the relation between the frequency and spatial information is more precise.

The Undecimated UWT of a 1D signal c_0, W using the filter bank (h ,g) is a set $W = \{w_1, \ldots\ldots, w_j, c_j\}$ here w_j are the wavelet coefficients at scale j and c_j are the coefficients at the coarsest resolution. The "à trous" (meaning 'with holes' in French) algorithm can be applied in order to obtain wavelet coefficients at one resolution from another using the following equations:

$$c_{j+1}[l] = (\bar{h}^{(j)} * c_j)[l] = \textstyle\sum_k h[k]\, c_j[l + 2^j k] \tag{7}$$

$$w_{j+1}[l] = (\bar{g}^{(j)} * c_j)[l] = \textstyle\sum_k g[k] c_j[l + 2^j k] \tag{8}$$

where '*' is the convolution operator and $\bar{h}[n] = h[-n], n \in Z$ is the time-reversed of the discrete-time filter with an impulse response $h[n]$ and $h^{(j)}[l] = h[l]$ if $l/2^j$ is an integer and 0 otherwise. For example when j=1,
$h^{(1)} =$
$(\ldots\ldots\ldots, h[-2], 0, h[-1], 0, h[0], 0, h[1], 0, h[2], \ldots\ldots.)$
.The reconstruction of the signal $c_j$is realized via:

$$c_j[l] = \tfrac{1}{2}[(\tilde{h}^{(j)} * c_{j+1})[l] + (\tilde{g}^{(j)} * w_{j+1})] \tag{9}$$

Where $\tilde{h}$ and $\hat{g}$ are the filters corresponding to analysis filter pairs h and g, respectively. The only exact reconstruction condition for the filter bank $(h, g, \tilde{h}, \tilde{g})$ is given by

$$H(z^{-1})\tilde{H}(z) + G(z^{-1})\tilde{G}(z) = 1 \tag{10}$$

Where $H(z)$ is the z-transform of a filter h and so on[2].

III. PROPOSED SSR-UWT ALGORITHM

In this section we introduce the proposed algorithm SSR with UWT and explain how effectively it facilitates the process of contrast enhancement with the help of visual contrast measure (VCM) value of the enhanced image. Fig.1 shows the flowchart of the proposed algorithm. In this a low contrast input image is taken and converted to grayscale image using RGB to Gray conversion. The Gaussian smoothening filter parameter F(x,y) is estimated by adjusting the value of the Gaussian constant c using eq.2. c is referred to as the scale of SSR a smaller value of this provides a good dynamic range while a large scale provides better color rendition. Then the illumination is estimated by applying this Gaussian filter F(x,y) to an input image I_i (x, y) as follows:

$$l(x,y) = F(x,y) * I(x,y) \tag{11}$$

Where l(x,y) and $*$ denote the estimated illumination and the convolution operator, respectively.

The output image *R(x,y)* is then obtained by subtracting the log signal of the estimated illumination log l (x, y) from the log signal of input image log I(x, y) using eq.1. The image R(x,y) obtained at the output of SSR is further enhanced using Undecimated wavelet transform (UWT).

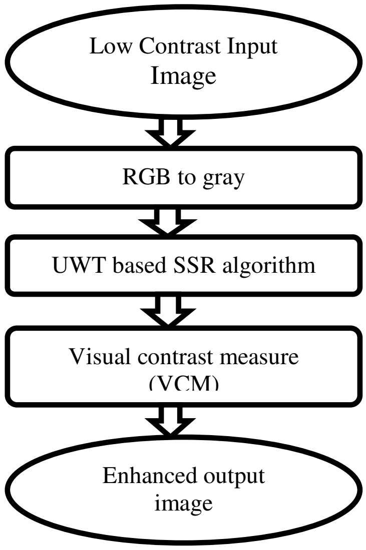


Figure 1 Flowchart of proposed algorithm

For evaluation of the proposed technique, visual contrast measure (VCM) is used. To evaluate low contrast image enhancement there are various fitness functions used as measuring parameter like entropy, fitness function, MSE, VCM etc. Since, we are experimenting on different images whose values are not fixed so we are using VCM as our measuring parameter.

Visual Contrast Measurement (VCM)

The VCM is a standalone external metric that can be used to determine the visual quality. Computationally, the VCM is given by:

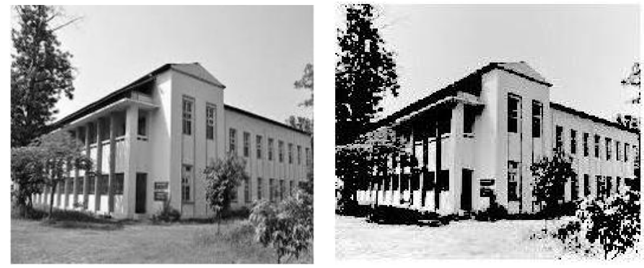
$$VCM = 100\frac{R_v}{R_t}$$

Where *Rv* is the number of regions in an arbitrary image that exceed a specific threshold for regional signal standard deviation, and *Rt* is the total number of regions into which the image has been divided.

IV. EXPERIMENTAL RESULTS

In this section, the proposed algorithm is evaluated by couple of case studies. Two images are considered in case studies: one of size 259×194 of Jabalpur Engineering College premises which is a real time image and other is the inbuilt cameraman image of size 256×256. The parameter *c* (Gaussian constant) in Equation(2) is initialized with a value 350 by test and trial observations and is kept constant throughout the experiments both in Case study 1 & 2. The experiments are performed using MATLAB version 12b.

4.1 Case study 1



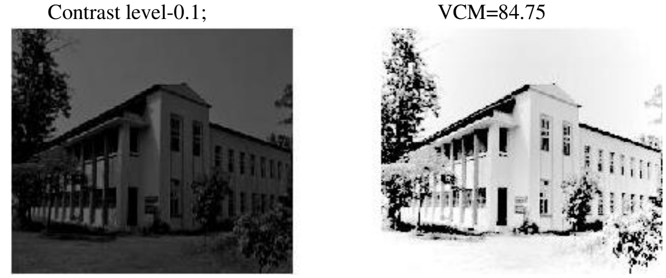
(a) Input image of JEC premises (b) Enhanced Image; VCM=87.5

Figure 2 Images of Case study 1

4.1.1 Parameter based analysis

In this case study, input image taken is shown in fig.2 (a) which when processed results in an image as shown in fig. 2(b). The experiment is performed by changing contrast level (CL) within a range [0.1 0.7]. Thus varying contrast level majorly affects the quality of an image. Fig.3 shows the effect of changing contrast level (CL) on VCM.

Contrast level-0.1; VCM=84.75



Contrast level-0.2; VCM=85.00

Contrast level-0.3; VCM=86.50

Contrast level-0.4; VCM=87.50


Contrast level-0.5; VCM=82.00


Contrast level-0.6; VCM=80.25


Contrast level-0.7; VCM=78.50

Figure.3 Effect of contrast level on VCM

4.1.2 Variation of Error in VCM with contrast level

Performance of the proposed algorithm is measured by VCM. Fig. 4 shows the plot between contrast level and the difference in VCM of the original input image and the enhanced images obtained after corrupting the original image. Lesser the difference in VCM between the original and the enhanced images obtained after corrupting the original one; the closer it is to the original. This plot concludes that at 0.4 contrast level the error is minimum.

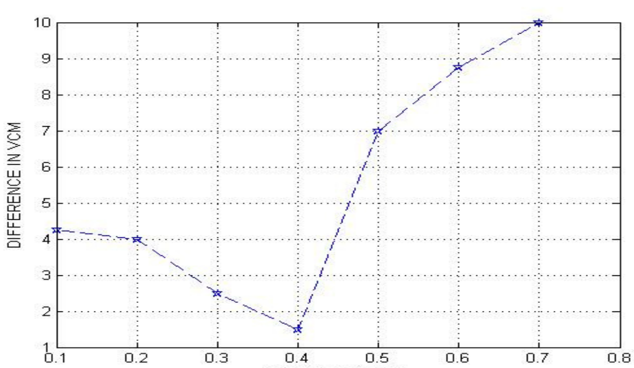


Figure.4 VCM Vs Contrast level Plot

VCM of the original input image is 89 and that of the enhanced image at 0.4 contrast level having minimum difference is 87.50, implies that it is the best result of case study 1.

4.2 Case study 2


(a) Input cameraman image (b) Enhanced image; VCM=96.25

Fig.5 Images of Case study 2

4.2.1 Parameter based analysis

In this case study, input image taken is shown in fig.5 (a) which when processed results in an image as shown in fig. 5(b). The experiment is performed by changing contrast level (CL) within a range [0.1 0.7]. Thus varying contrast level majorly affects the quality of an image. Fig.6 shows the effect of changing contrast level (CL) on VCM.


Contrast level-0.1; VCM=87.50


Contrast level-0.2; VCM=91.00


Contrast level-0.3; VCM=93.75

Contrast level -0.4; VCM=96.25

Contrast level-0.5; VCM=82.25

Contrast level-0.6; VCM=80.75

Contrast level-0.7; VCM=75.00

Figure.6. Effect of contrast level on VCM

4.2.2 Variation of VCM with contrast level

Performance of the proposed algorithm is measured by VCM. Fig. 7 shows the plot between contrast level and the difference in VCM of the original input image and the enhanced images obtained after corrupting the original image. Lesser the difference in VCM between the original and the enhanced images obtained after corrupting the original one; the closer it is to the original. This plot concludes that at 0.4 contrast level the difference is minimum.

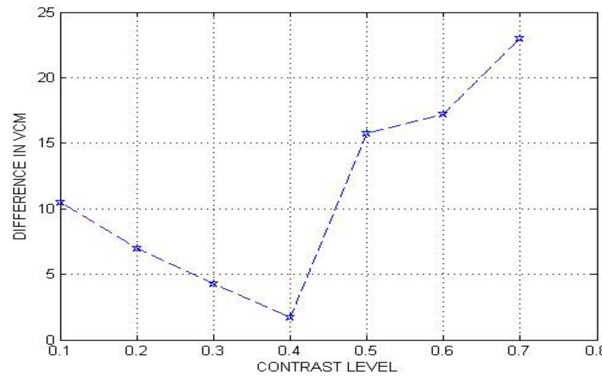


Figure.7 VCM Vs Contrast level Plot

VCM of the original input image is 98 and that of the enhanced image at 0.4 contrast level having minimum difference is 96.25, implies that it is the best result of case study 2.

4.3 Comparison of proposed algorithm with existing algorithm

In this section, the proposed SSR-UWT algorithm is compared with the existing UWT algorithm. Table 1 compares the VCM obtained from UWT algorithm [2] and the proposed algorithm for the two images.

Table.1 Visual contrast measure (VCM) comparison with convention Undecimated Wavelet Transform (UWT) algorithm [2]

Input Image	UWT[2]	UWT+SSR
Case Study 1	86	87.50
Case Study 2	92	96.25

Table 1 concludes that the result obtained from the proposed algorithm is better as compared to the existing algorithm.

V. CONCLUSIONS

The Proposed algorithm has been successfully implemented. The presented work is found efficient in enhancing the contrast of an image. Experiments conducted for evaluating the performance of the proposed technique shows that it is quite better than the existing algorithm and is promising in the contrast enhancement of grayscale image. Thus, SSR is popular of course but in the proposed algorithm single-scale retinex (SSR) with Undecimated Wavelet Transform is quite efficient algorithm and can be used anywhere practically in for the low contrast image enhancement.

REFERENCES

[1] P.Suganya, S.Gayathri, N.Mohanapriya, "Survey on Image Enhancement Techniques", International Journal of Computer Applications Technology and Research", Vol. 2 Issue 5, **2013,** page. **623-627**.

[2] Numan Unaldi, Samil Temel & Suleyman Demirci, "Undecimated Wavelet Based Contrast Enhancement", International Journal of Computer, Information, Systems and Control Engineering, Vol.7, Issue-9, **2013,** page. **571-574.**

[3] In- Su Jang, Tae-Hyoung Lee, Wang –Jun Kyung and Yeong –Ho Ha, " Local Contast Enhancement Based On Adaptive Multiscale Retinex Using Intensity Distribution Of Input Image", Journal of Imaging Science and Technology, Vol.55, Issue-4, **2011**, page. **040502-1-040502-14**.

[4] Violeta Bogdanova, " Image Enhancement Using Retinex Algorithms And Epitomic Representation ", Bulgarian academy of science, cybernetics and information technologies, Vol. 10, Issue-3, Sofia **2010**, page. **10-19**.

[5] Doo Hyun Choi, Ick Hoon Jang , Mi Hye Kim, Nam Chul Kim, " Colour Image Enhancement Based On Single-Scale Retinex With A JND Based Non-Linear Filter", Proceeding of IEEE International symposium on circuits and systems, New Orleans, LA, page. **3948-3951**.

[6] Doo Hyun Choi, Ick Hoon Jang , Mi Hye Kim, and Nam Chul Kim, "Color Image Enhancement Using Single-Scale Retinex Based On An Improved Image Formation Model", 16th European Signal Processing Conference (EUSIPCO 2008), Lausanne, Switzerland, August **2008**, page **25-29**.

[7] Anish Kumar Vishwakarma, Agya Mishra, Kumar Gaurav, Abhishek Kataria, "Illumination Reduction of Low Contrast Image Enhancement with Homomorphic Filtering Technique", International Conference on Communication Systems and Netwrk Technologies, **2012**, page. **171-173**.

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