International Journal of Computer Applications (0975 – 8887)
Volume 35– No.7, December 2011

# Satellite Image Contrast Enhancement using Multiwavelets and Singular Value Decomposition (SVD)

Sulochana S
Research Scholar
Institute of Remote Sensing
Anna University, Chennai-25

Vidhya R
Associate Professor
Institute of Remote Sensing
Anna University, Chennai-25

## ABSTRACT
In this letter, a new satellite image contrast enhancement technique based on M- band wavelet transform and singular value decomposition has been proposed. The images decomposed into one low frequency and fifteen high frequency sub bands using M-band wavelet transform and estimates the singular value matrix of the low frequency subband, and, then reconstructs the enhanced image by applying inverse transform. This technique is compared with conventional image equalization techniques such as DWT and generalized histogram equalization (GHE). The experimental results show the proposed method gives good results over conventional methods**.**

## Keywords
Discrete wavelet transform (DWT), M-band wavelet transform, Singular value Decomposition (SVD)

## 1. INTRODUCTION
Satellite images are essential in many areas of remote sensing. Image enhancement is a process involving changing the pixels intensity of the input images. The quality of the images depends on many factors. one of the most impartment factor is contrast which is created by the difference in luminance reflected from two adjacent surfaces . The main objective of image enhancement is to improve the interpretability (or) perception of information contained in the image for automated image processing applications.

There are many image enhancement methods have been proposed. The most common techniques for global contrast enhancements like global stretching and histogram equalization[1] which do not always produce good results. To overcome this issues, many number of local contrast enhancement methods have been proposed in which some form of image segmentation either in spatial (or) frequency domain followed by contrast enhancement operators on the segments [1].

Wavelets have been used in many areas of image processing such as feature extraction, image denoising, compression, face recognition and satellite image super resolution. The most commonly used implementation of the wavelet transform is critically sampled discrete wavelet transform (DWT) [7] is shift variant and is unsuitable in many image processing applications. Multiwavelets [4] may be considered as generalization of scalar wavelets. However, some important differences exist between these two types of multiresolution transforms. In particular, whereas scalar wavelets have a single scaling function $\varphi(t)$ and wavelet function $\psi(t)$ . Multiwavelets may have two or more scaling and wavelet functions. Multiwavelets have several advantages in comparison with scalar wavelet. The features such as compact support, Orthogonality, symmetry, and high order approximation are the base features for this transformation. A scalar wavelet cannot possess all these properties at the same time. On the other hand, a multiwavelet system can simultaneously provide perfect representation while preserving length (Orthogonality), good performance at the boundaries (via linear-phase symmetry), and a high order of approximation (vanishing moments). Thus multiwavelets offer the possibility of superior performance [6] [5] and high degree of freedom for image processing applications, compared with scalar wavelets. When a multiresolution analysis is generated using multiple scaling functions and wavelet functions, it gives rise to the notion of multiwavelets. During a single level of decomposition using a scalar wavelet transform, the 2- D image data is replaced by four blocks corresponding to the subbands representing either low pass or high pass in both dimensions. These sub bands are illustrated in figure. 1.

The multi-wavelets used here have two channels, so there will be two sets of scaling coefficients and two sets of wavelet coefficients. Since multiple iteration over the low pass data is desired, the scaling coefficients for the two channels are stored together. Likewise, the wavelet coefficients for the two channels are also stored together. The multi-wavelet decomposition subbands are shown in Figure.2. For multi-wavelets the L and H have subscripts denoting the channel to which the data corresponds. For example, the sub band labeled L1H2 corresponds to data from the second channel high pass filter in the horizontal direction and the first channel low pass filter in the vertical direction. This shows how a single level of decomposition is done. In practice, there is more than one decomposition performed on the image.

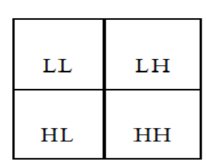



**Figure.1.Subband Decomposition of DWT**

| | | | |
|---|---|---|---|
| $L_1L_1$ | $L_1L_2$ | $L_1H_1$ | $L_1H_2$ |
| $L_2L_1$ | $L_2L_2$ | $L_2L_1$ | $L_2H_2$ |
| $H_1L_1$ | $H_1L_2$ | $H_1H_1$ | $H_1H2$ |
| $H_2L_1$ | $H_2L_2$ | $H_2H1$ | $H_2H_2$ |

**Figure.2.Subband Decomposition of Multiwavelets**

Successive iterations are performed on the low pass coefficients from the pervious stage to further reduce the number of low pass coefficients. Since the low pass coefficients contain most of the original signal energy, this iteration process yields better energy compaction. After a certain number of iterations, the benefits gained in energy compaction becomes rather negligible compared to the extra computational effort.

Singular value decomposition (SVD)[10] as a general linear algebra technique is used in variety of applications. Modifying the singular singular value decomposition of the image is one important technique in contrast enhancement applications [8] [9]. Singular value decomposition (SVD) is applied on image A of size P×Q such that

$$A = U_A \Sigma_A V_A{}^T \quad (1)$$

Here $V_A{}^T$ is a P×Q orthogonal matrix whose columns are the Eigen vectors of $AA^T$ and $U_A$ is a Q×Q orthogonal matrix whose columns are the eigen vectors of $AA^T$ and $\sum$ is a Q×Q diagonal matrix with non-negative diagonal element in decreasing order of magnitudes whose entries are the square roots of the corresponding eigen values of $AA^T$. In this case SVD is used to deal with the illumination problem. The SVD of this new image is calculated and the maximum singular $\max(\overline{A})$ is used to calculate the transformation factor $\xi$ as the ratio of the largest singular value of the generated matrix over maximum value of the image.

$$\xi = \frac{\max(\overline{A})}{\max(A)} \quad (2)$$

Now new singular value matrix

$$\overline{\Sigma}_A = \xi \Sigma_A \, . \quad (3)$$

$\overline{\Sigma}_A$ Can be referred as singular value matrix of the equalized image. Using this equalized matrix, a new image $\overline{A}$ can be calculated.

$$\overline{A} = U_A \overline{\Sigma}_A V_A{}^T \quad (4)$$

In this singular value equalization (SVE) method intensity of the image has been equalized by equalizing the singular value matrix. [7]

## 2. PROPOSED IMAGE CONTRAST ENHANCEMENT

In this letter, we have proposed a new method for satellite image equalization which is based on the SVD of an LL subband image obtained by multiwavelets. Multiwavelets are used to separate the input low contrast satellite images into one low frequency subband and 15 high frequency subbands. The illumination information concentrated in the low frequency subband which undergoes SVD process. Inverse transform is performed to get contrast enhanced image. In this letter, the proposed method has been compared with GHF, DWD-SVD [2] [7] based methods which shows the superiority of our proposed methods. The general procedure of the proposed technique is as follows.

1. The input image I is first processed by using General histogram equalization (GHE) The resultant image is Ī.

2. (I & Ī) both images are transformed by M band Wavelet transform into subbands.

3. The correction coefficient for the singular value matrix is calculated by using the following equation

$$\xi = \frac{\max(\Sigma_{L1L1_{\bar{I}}})}{\max(\Sigma_{L1L1_I})} \quad (5)$$

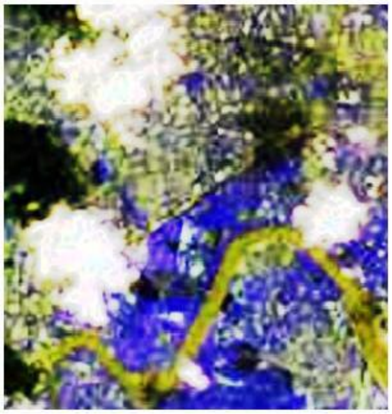
Where, $\Sigma_{L1L1_I}$ is the L1L1 singular value matrix of the input image and $\Sigma_{L1L1_{\bar{I}}}$ is the singular value matrix of the output of the GHE.

4.The new singular value matrix of L1L1 image and new L1L1 image is composed by

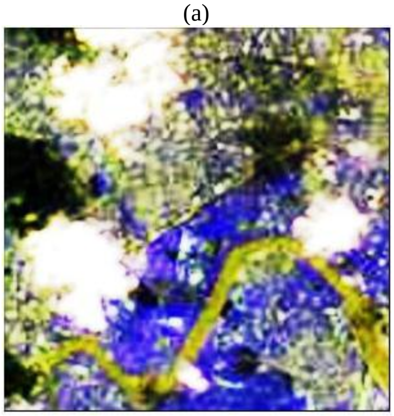
$$\overline{L1L1}_I = U_{L1L1_I} \overline{\Sigma}_{L1L1_I} V_{L1L_I} \quad (6)$$

5. Subband images are recombined by applying inverse M band Wavelet transform to generate the resultant equalised image $\hat{I}$ which is shown in figure.3.

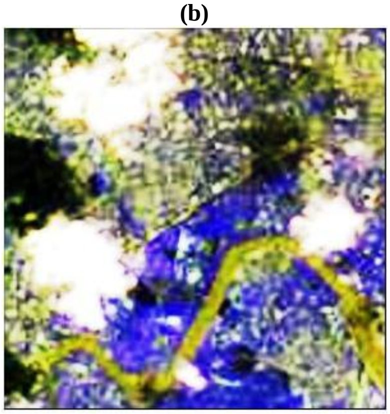
$$\bar{\text{I}} = (\overline{L\ 1L1}_I, L1L2_I, L1H1_I, L1H2_I, L2L1_I, L2L2_I, L2L1_I, L2H2_I, H1L1_I, H1L2_I, H1H2_I, H2L1_I\ H2L2_I\ H2H1_I\ H2H2_I) \quad (7)$$



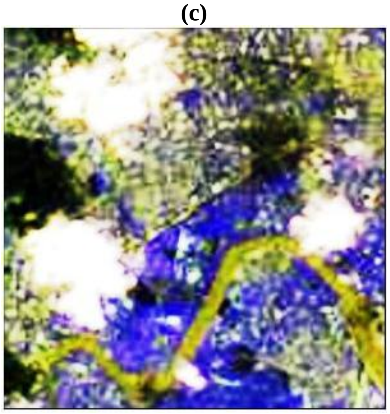
(a)



**(b)**

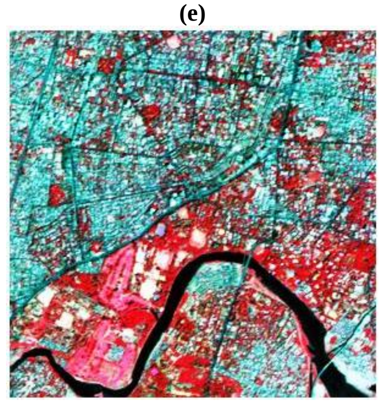


**(c)**

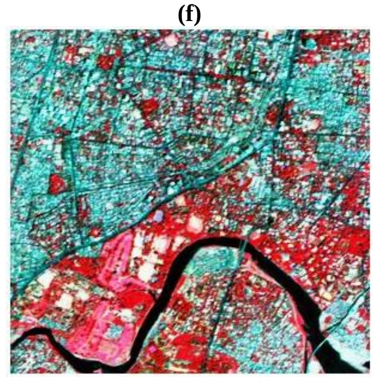


**(d)**

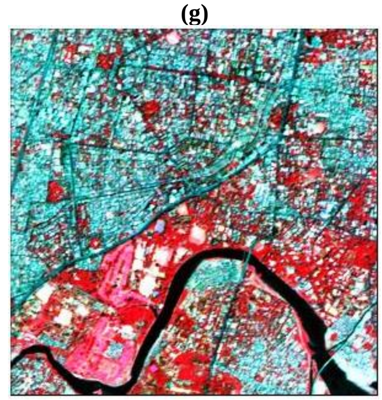
**(e)**



**(f)**



**(g)**



**(h)**

**Fig.3**

**(a) & (e) LISS III and LISS IV images**
**(b)& (f) Contrast Enhancement using GHE**
**(c)& (g) Contract Enhancement using DWT-SVD**
**(d)& (h) Contract Enhancement using MWT-SVD**

## 3. EXPERIMENTAL RESULTS

Low contrast images LISS III and LISSIV were used to test our proposed method .These images have been equalized by GHE, DWT-SVD and proposed method. The quality of the visual results indicated that the proposed equalizations gives good results compared with GHE and DWT-SVD. Experiments were performed over various low contrast images which confirmed the qualitative results. To start our analysis, for each image, we compute the brightness (*i.e.*, the mean) and contrast (*i.e.*, the standard deviation) of the original and the output images obtained by the proposed methods. Table. 1 shows values of the brightness and contrast obtained for the enhanced images.

Let us first analyze the results in Table1, regarding the brightness of the original and the processed images. By observing the absolute difference between the value of the brightness in the original and processed images (*i.e.*, the brightness preservation), we state that the images produced by our proposed method are better in preserving the brightness of the original images. We perform a similar analysis to the one performed in Table1 by observing the contrast values, we state that the images produced by the GHE methods gives good results. Observing brightness and contrast our proposed methods produces good results.

**Table 1 Brightness and contrast for LISS III and LISS IV**

| Image | Method | Brightness | Contrast |
|---|---|---|---|
| LISS III | INPUT | 188.22 | 74.21 |
| LISS III | GHE | 191.42 | 83.38 |
| LISS III | DWT-SVD | 193.66 | 85.45 |
| LISS III | MWT-SVD | 198.74 | 87.63 |
| LISS IV | INPUT | 189.85 | 75.15 |
| LISS IV | GHE | 192.95 | 84.90 |
| LISS IV | DWT-SVD | 195.40 | 86.69 |
| LISS IV | MWT-SVD | 199.27 | 89.80 |

## 4. QUALITY METRICS

Image Quality is a characteristic of an image that measures the perceived image degradation. In order to estimate the quality, the enhanced image is compared with the original image. The value obtained for different quality metrics[11][12][13][14][15] such as Mean Squared Error (MSE) , Peak Signal to Noise Ratio (PSNR), Maximum Difference (MD),8. The Universal Image Quality Index (*UQI*) Structural Similarity index matrix (SSIM) are shown in Table2.

**Table 2 (a) Image metrics readings for LISS III Image**

| METHOD | MSE | PSNR | MD | UQI | SSIM |
|---|---|---|---|---|---|
| GHE | 835.61 | 19.98 | 95 | 0.9225 | 0.7441 |
| DWT-SVD | 743.92 | 21.47 | 120 | 0.9422 | 0.7684 |
| MWT-SVD | 600.35 | 27.99 | 154 | 0.9975 | 0.9520 |

**Table 2 (b)Image metrics readings for LISS IV Image**

| METHOD | MSE | PSNR | MD | UQI | SSIM |
|---|---|---|---|---|---|
| GHE | 78.69 | 22.32 | 104 | 0.9566 | 0.7312 |
| DWT-SVD | 640.98 | 25.44 | 133 | 0.9744 | 0.7533 |
| MWT-SVD | 450.73 | 29.79 | 165 | 0.9922 | 0.9816 |

## 5. CONCLUSION

In this paper a new satellite image contrast enhancement techniques was proposed based on M-band Wavelet transform. The proposed technique decomposed the input image into one approximation subband and fifteen detailed subbands. Then SVD of the approximation subband is updated and inverse transform was performed to get the enhanced image. The proposed techniques were compared with the DWT-SVD and GHE. Brightness and contrast was calculated which shows the superiority of the proposed method over conventional methods. Finally various quality metrics were calculated for evaluating the performance of the proposed method.

## 6. ACKNOWLEDGMENTS

The authors wish to thank Institute of remote sensing (IRS),Anna University , Chennai for providing image samples used in this paper.

## 7. REFERENCES

[1] R.C. Gonzalez, and R. E. Woods, Digital Image Processing, Prentice Hall, ISBN 013168728X, 2007.

[2] *Hasan Demirel, Gholamreza Anbarjafari and Mohammad N. Sabet Jahromi," Image Equalization based on singular value decomposition*". 978-1-4244-2881-6/08/$25.00 ©2008 IEEE.

[3] Haidi Ibrahim, *Member*, IEEE, and Nicholas Sia Pik Kong, *Member*, IEEE," *Brightness Preserving Dynamic Histogram Equalization for Image Contrast Enhancement*". IEEE Transactions on Consumer Electronics, Vol. 53, No. 4, November 2007.

[4] Jo Yew Tham, Lixin Shen, Seng Luan Lee, and Hwee Huat Tan," *A General Approach for Analysis and Application of Discrete Multiwavelet Transforms*". IEEE Transaction on signal processing, Vol. 48, NO. 2, February 2000.

[5] Prayoth Kumsawat, Kitti Attakitmongcol and Arthit Srikaew," *A Robust Image Watermarking Scheme Using Multiwavelet Tree*". Proceedings of the World Congress on Engineering 2007 Vol I WCE 2007, July 2 - 4, 2007, London, U.K.

[6] Kother Mohideen, Arumuga Perumal, Krishnan , Mohamed Sathik," *Image Denoising And Enhancement Using Multiwavelet With Hard Threshold In Digital Mammographic Images*". International Arab Journal of e-Technology, Vol. 2, No. 1, January 2011

[7] Hasan Demirel, Cagri Ozcinar, and Gholamreza Anbarjafari*," Satellite Image Contrast Enhancement Using Discrete Wavelet Transform and Singular Value Decomposition*". IEEE Geoscience and remote sensing letters.

[8] Srinivasan Selvan, *Senior Member, IEEE*, and Srinivasan Ramakrishnan," *SVD-Based Modeling for Image Texture Classification Using Wavelet Transformation*". IEEE Transactions on image processing Vol. 16, NO. 11, November 2007

[9] Chitwong, S. Phahonyothing , P. Nilas , F. Cheevasuvit ," *Contrast enhancement of satellite image based on adaptive unsharp masking using wavelet transform*" ASPRS 2006 Annual Conference Reno, Nevada  May 1-5, 2006

[10] Kirk Baker," *Singular Value Decomposition Tutorial*". March 29, 2005

[11] G. R. Harish Kumar and D. Singh," *Quality assessment of fused image of MODIS and PALSAR*". Progress In Electromagnetics Research B, Vol. 24, 191 -221, 2010

[12] Nedeljko Cvejic, Artur Łoza, David Bull, and Nishan Canagarajah," A Novel Metric for Performance Evaluation of Image Fusion Algorithms". World Academy of Science, Engineering and Technology 7 2005

[13] A. Łoza, T. D. Dixon, E. Fernandez canga, S. G. Nikolov, D. R. Bull, C. N. Canagarajah, J. M. Noyes and T.Troscianko ," *Methods for Fused Image Analysis and Assessment".*

[14] D.Venkata Rao, N.Sudhakar , B.Ravindra Babu , , L.Pratap Reddy ," *An Image Quality Assessment Technique Based on Visual Regions of Interest Weighted Structural Similarity*". GVIP Journal, Volume 6, Issue 2, September, 2006

[15] Shivsubramani Krishnamoorthy, K P Soman," *Implementation and Comparative Study of Image Fusion Algorithms*"**.** International Journal of Computer Applications (0975 – 8887) Volume 9– No.2, November 2010