International Journal of Science and Modern Engineering (IJISME)
ISSN: 2319-6386, Volume-1 Issue-3, February 2013

DWT and PCA Based Image Enhancement with Gaussian Filter

R. Vani, K. Soundara Rajan

Abstract* A new satellite image contrast enhancement technique based on the Discrete Wavelet Transform (DWT) and Principal Component Analysis has been proposed. By the use of discrete wavelet transform, the input image decomposed into four frequency sub-bands and estimates the eigen values and eigen vectors (PCA) of the low–low subband image and reconstructs the enhanced image by applying inverse DWT. The technique is compared with conventional image equalization techniques such as standard general histogram equalization and local histogram equalization, as well as state-of-the-art techniques such as brightness preserving dynamic histogram equalization and Principal Component Analysis. The experimental results show the superiority of the proposed method over conventional and state-of-the-art techniques.

Keywords: Discrete wavelet transform, image equalization, satellite image Contrast enhancement.

I. INTRODUCTION

Satellite images are used in many applications such as geosciences studies, astronomy and geographical information systems. One of the most important quality factors in satellite images come from its contrast. Contrast enhancement is frequently referred to as one of the most important issues in image processing. Contrast is created by the difference in luminance reflected from two adjacent surfaces. In visual perception, contrast is determined by the difference in the color and brightness of an object with other objects. Our visual system is more sensitive to contrast than absolute luminance; therefore, we can perceive the world similarly regardless of the considerable changes in illumination conditions.

In many image processing applications, the GHE technique is one of the simplest and most effective primitives for contrast enhancement [7], which attempts to produce an output histogram that is uniform [8]. One of the disadvantages of GHE is that the information laid on the histogram or probability distribution function (PDF) of the image will be lost. Demirel and Anbarjafari [9] showed that the PDF of face images can be used for face recognition; hence, preserving the shape of the PDF of an image is of vital importance. Techniques such as BPDHE or SVE are preserving the general pattern of the PDF of an image. BPDHE is obtained from dynamic histogram specification [10] which generates the specified histogram dynamically from the input image.

II. PROPOSED IMAGE ENHANCEMENT

There are two significant parts of the proposed method. The first one is the use of PCA. As it was mentioned, the Eigen value matrix obtained by PCA contains the illumination information. Therefore, changing the Eigen values will directly affect the illumination of the image; hence, the other information in the image will not be changed. The second important aspect of this work is the application of DWT. As it was mentioned in Section I, the illumination information is embedded in the LL sub band. The edges are concentrated in the other sub bands (i.e., LH, HL, and HH). Hence, separating the high frequency sub bands and applying the illumination enhancement in the LL sub band only will protect the edge information from possible degradation. After reconstructing the final image by using IDWT, the resultant image will not only be enhanced with respect to illumination but also will be sharper.

2.1 DISCRETE WAVELET TRANSFORM:

The decomposition of images into various frequency ranges permits the isolation of the frequency components introduced by "intrinsic deformations" or "extrinsic factors" into certain subbands [17]. This process results in isolating small changes in an image mainly in low-frequency sub band images. The 2-D wavelet decomposition of an image is performed by applying 1-D DWT along the rows of the image first, and, then, the results are decomposed along the columns. This Decomposition results in four decomposed subband images referred to as low–low (LL), low high (LH), high–low (HL), and high–high (HH).

We have proposed a new method for satellite image equalization which is an extension of Histogram Equalization, and it is based on the PCA of an LL subband image obtained by DWT. DWT is used to separate the input low-contrast satellite image into different frequency subbands, where the LL subband has approximation co efficient . For that, LL subband takes for Histogram Equalization process, which preserves the high-frequency components (i.e., edges). Hence, after inverse DWT (IDWT), the resultant image will have sharper edges with high-quality contrast. In this letter, the proposed method has been compared with the various histogram equalization like conventional GHE technique as well as LHE and some state-of-the-art techniques such as BPDHE and SVE.

2.2 PRINCIPLE COMPONENT ANALYSIS:

PCA is the way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension,

Manuscript received on February, 2013.
R.Vani, Research Scholar / J.N.T.U.A.C.E.A, Anantapur, Andhra Pradesh, India.
K.Soundara Rajan, M.Tech. PhD / J.N.T.U.A.C.E.A, Anantapur, Andhra Pradesh, India.

where the magnificence of graphical representation is not available PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once you have found these patterns in the data and you compress the data i.e. by reducing the number of dimensions without much loss of information.

III. BLOCK DIAGRAM

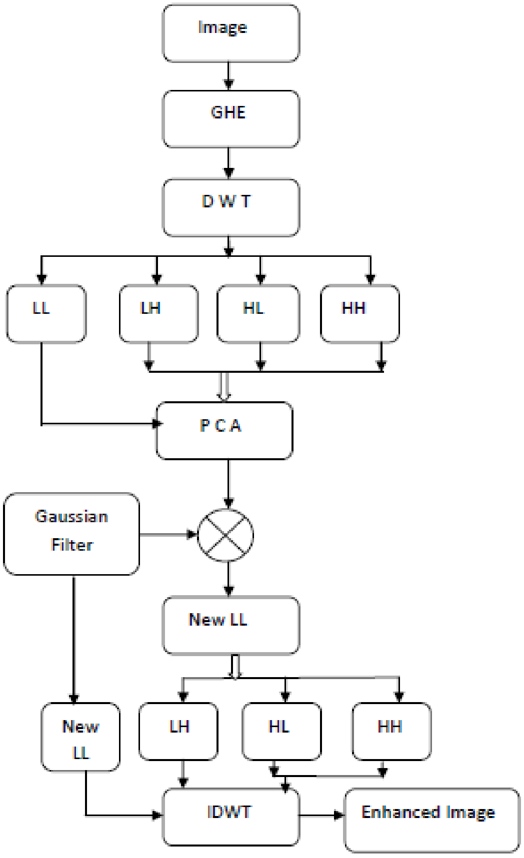

Fig. 1 Block Diagram of Dwt and PCA Based Image Enhancement with Gaussian Filter

This technique used in image compression. To improve the image quality image enhancement is an essential step. As a primary low-level image processing procedure, random noise removal has been extensively studied and many enhancement schemes have been proposed, from the earlier smoothing filters and frequency domain denoising methods [1] we use wavelet PCA.

Wavelets are an efficient and practical way to represent edges and image information at multiple spatial scales. Image features at a given scale, such as houses or roads, can be directly enhanced by filtering the wavelet coefficients. Wavelets may be a more useful image representation than pixels. Hence, we consider PCA dimensionality reduction of wavelet coefficients in order to maximize edge information in the reduced dimensionality set of image.

3.1 Steps of Implementation:

Step 1: Read the Input Image
Step 2: Apply GHE for that Image
Step 3: Apply DWT for histogram image.

Step 4: Finding PCA for LL Band of DWT

Convert the LL band image into 1 Dimension vector (a)

$$a = [x1, x2, x3, \ldots.] \quad (i = 1\ to\ (m * n) \qquad (1)$$

Where,

m = row;
n = column.

Finding the mean value a by using this formula

$$k = 1/(m * n) \sum_{i=1}^{m\,x\,n} ai \qquad (2)$$

3. Subtract the mean.
4. Calculate the covariance matrix.
5. Calculate the eigenvectors and Eigen values of the covariance matrix.

Step 5: Finding Gaussian Factor with 5 x5 Mask

$$h = \frac{1}{sqrt\ (2*3.14)} e\ (x^2 + y^\wedge 2) / \ 2^{\ 1} \qquad (3)$$

Step 6: Finding maximum value of Gaussian co – efficient (s1) and Eigen values(s)
Step 7: Multiply s1 with s this value will be the enhanced factor
Step 8: Multiplying all sub bands with this enhanced factor
Step 9: Applying inverse DWT

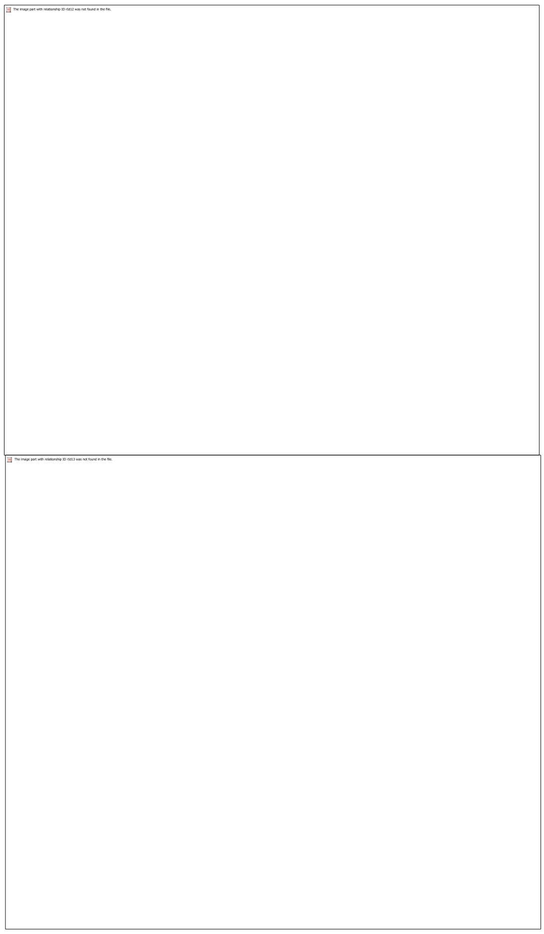

Fig. 2 (a) Original low-contrast image from Satellite Imaging Corporation. Equalized image by using (b) the proposed technique.

IV. EXPERIMENTAL RESULTS

In this section, simulation is carried out to evaluate the performance of the proposed wavelet PCA. Fig 2a shows Original low-contrast image from Satellite Imaging Corporation. In our experiments, wavelet-SVD is compared against wavelet-PCA methods. As we expected, general combination of wavelet and SVD causes loss of detail, resulting in burring artifacts. While wavelet-PCA can achieve the sharpest enhancement result compared to other enhancement methods.

Peak signal-to-noise ratio (PSNR) and root mean square error (RMSE) have been implemented in order to obtain some quantitative results for comparison. PSNR can be obtained by using the following formula

$$MSE = \left(\frac{1}{M*N}\right)(Input\ Image - Output\ Image)^2 \qquad (4)$$

$$PSNR = 10log10(255 * 255)/MSE) \qquad (5)$$

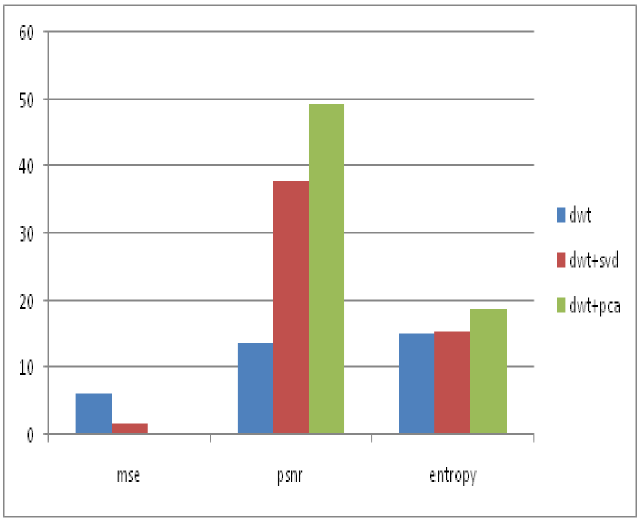

Fig.3 Graphical representation and comparison of existing method of DWT, DWT+SVD and proposed method of DWT+PCA.

Fig. 3, show the low-contrast images taken from several aerospace and geosciences resources mentioned in the acknowledgment section. These images have been equalized by using GHE and the proposed equalization technique. The quality of the visual results indicates that the proposed equalization technique is sharper and brighter than the one achieved by BPDHE, SVE, GHE, and LHE. Experiments have been performed on over 100 randomly selected images from various sources which confirmed the qualitative results.

V. CONCLUSION

In this letter, a new satellite image contrast enhancement technique based on DWT and PCA was proposed. The proposed technique decomposed the input image into the DWT sub bands, and, after updating the Eigen value matrix of the LL sub band, it reconstructed the image by using IDWT. The technique was compared with the GHE, LHE, BPDHE, and SVE techniques. The visual results on the final image quality show the superiority of the proposed method over the conventional and the state of-the-art techniques. It brings good PSNR Values and Reduce the MSE Value.

REFERENCES

1. K. Kinebuchi, D. D. Muresan, and T.W. Parks, "Image interpolation using wavelet based hidden Markov trees," in *Proc. IEEE ICASSP*, 2001, vol. 3, pp. 7–11.
2. M. S. Crouse, R. D. Nowak, and R. G. Baraniuk, "Wavelet-based statistical signal processing using hidden Markov models," *IEEE Trans. Signal Process.*, vol. 46, no. 4, pp. 886–902, Apr. 1998.
3. S. Zhao, H. Han, and S. Peng, "Wavelet domain HMT-based image super resolution," in *Proc. IEEE ICIP*, Sep. 2003, vol. 2, pp. 933–936.
4. A. Temizel and T. Vlachos, "Image resolution upscaling in the wavelet domain using directional cycle spinning," *J. Electron. Imaging*, vol. 14, no. 4, p. 040501, 2005.
5. A. Gambardella andM.Migliaccio, "On the superresolution of microwave scanning radiometer measurements," *IEEE Geosci. Remote Sens. Lett.*, vol. 5, no. 4, pp. 796–800, Oct. 2008.
6. V. A. Tolpekin and A. Stein, "Quantification of the effects of land-coverclass spectral separability on the accuracy of Markov-random-field-based superresolution mapping," *IEEE Trans. Geosci. Remote Sens.*, vol. 47, no. 9, pp. 3283–3297, Sep. 2009.
7. A. Temizel and T. Vlachos, "Wavelet domain image resolution enhancement using cycle-spinning," *Electron. Lett.*, vol. 41, no. 3, pp. 119–121,Feb. 3, 2005.
8. L. A. Ray and R. R. Adhami, "Dual tree discrete wavelet transform with application to image fusion," in *Proc. 38th Southeastern Symp. Syst. Theory*, Mar. 5–7, 2006, pp. 430–433.
9. A. Temizel, "Image resolution enhancement using wavelet domain hidden Markov tree and coefficient sign estimation," in *Proc. ICIP*, 2007, vol. 5, pp. V-381–V-384.