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Satellite Image Resolution Enhancement Using DWT And Contrast Enhancement Using SVD

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Abstract*—In this letter, a new satellite image contrast enhancement technique based on the discrete wavelet transform (DWT) and singular value decomposition has been proposed. Resolution and contrast are the two important attributes of an image. In this paper we developed a method to enhance the quality of the given image. The enhancement is done both with respect to resolution and contrast. The proposed technique uses DWT and SVD. The technique decomposes the input image into the four frequency sub bands by using DWT and estimates the singular value matrix of the low–low sub band image, and, then, it reconstructs the enhanced image by applying inverse DWT. The experimental results show the superiority of the proposed method over conventional techniques.

***Index Terms*—Discrete wavelet transform (DWT), Singular value decomposition (SVD)**

I.INTRODUCTION

Satellite images are used in many applications such as geosciences studies, astronomy, and geographical information systems. image enhancement is the process of improving the quality of the digital image without knowledge about the source of degradation. The source may be a low resolution camera or aliasing due to improper selection of sampling rate or poor illumination. These sources affect the resolution and contrast of the image. Basically spatial resolution is the smallest discernible detail in an image. Sampling is the principal factor determining the spatial resolution.

Images are being processed in order to obtain more enhanced resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. One of the most important quality factors in satellite images comes from its contrast. Contrast enhancement [7] 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.

We can use 2-D discrete wavelet transform to decompose the image into four sub-bands, namely LL, LH, HL and HH bands. We know that the stationary wavelet transform can also be applied to the same image, whose result is also the frequency components of the image. Here the LL sub-band consists of illumination information, where as the remaining sub-bands constitutes the information of edges. Manipulating these sub-bands gives the enhancement in resolution. Coming to the contrast enhancement we have some basic operations like general histogram equalization (GHE), Local histogram equalization (LHE) and brightness preserving Dynamic histogram equalization (BPDHE) [8]. General histogram equalization is one of the widely used and simple contrast enhancement techniques, in which the output histogram is uniformly distributed. 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. Similarly the other methods have their own disadvantages. In this paper, we use a combination of DWT and SVD [4] algorithm. Singular value decomposition (SVD) of an image, which can be interpreted as a matrix, is written as follows:

$$A = U_A \Sigma_A V^T_A$$

Where *UA* and *VA* are orthogonal square matrices known as Hanger and aligner, respectively, and the Σ*A* matrix contains the sorted singular values on its main diagonal. The idea of using SVD [4] for image equalization comes from this fact that ΣA contains the intensity information of a given image [5]. SVD can be used to deal with an illumination problem. The method uses the ratio of the largest singular value of the generated normalized matrix, with zero mean and unity variance of, over a normalized image which can be calculated according to

$$\xi = \frac{\max(\Sigma N)}{\max(\Sigma A)}$$

Where ΣN is the singular value matrix of the synthetic intensity matrix at zero mean and unity variance. This coefficient can be used to regenerate an equalized image using [1]

$$\Xi \text{equalized} A = U_A\,(\xi \Sigma A)\,V_A^T$$

Here we take the help of DWT to decompose this image into different sub-bands. The resultant can be obtained by combining the sub-band images using IDWT.

The rest of this paper is organized as follows. Section II describes the proposed enhancement technique. Section III Experimental result. Conclusions are finally drawn in Section IV.

II.PROPOSED IMAGE ENHANCEMENT TECHNIQUE

Basically there are two steps involved in this image enhancement operation. In the first step, we do resolution Enhancement using DWT. And the second step is the contrast enhancement using SVD.

A.RESOLUTION ENHANCEMENT:

We know that the low resolution image can be obtained by passing the high resolution image through a low pass filter in wavelet domain, which implicitly means that the LL sub-band is the low resolution of the original image.

The proposed enhancement process is based on the interpolation of HF sub-band images obtained by DWT and input image. The edge detail is enhanced by using intermediate stage using SWT. DWT can be used to decompose the input image into different sub-bands, and then the HF sub-bands are interpolated. HF sub-bands obtained by SWT of input are incremented into interpolated HF sub-bands in order to correct the estimated co-efficient. In parallel input image is also interpolated separately and corrected HF sub-bands and interpolated input image are combined through IWDT, to achieve high resolution output.

Here the main role of wavelet transforms is to preserve the HF components. One level DWT can be used to decompose the input image to different sub-bands [6]. While interpolating the HF components, we used bi-cubic interpolation with enlargement factor of 2. Down sampling in each of DWT sub-bands causes information loss in respective sub-bands. So we use SWT to minimize the error. It can be observed that interpolated HF sub-bands and the SWT HF sub-bands have same size, and hence they can be added together. Basically the LL sub-band is the illumination information of low resolution image. Instead of using LL sub-band, which contains less information than the original image we are using input image itself. Use of input image instead of LF sub-band increases the quality of super resolved image when compared with the conventional techniques. This is due to the fact that, the interpolation of HF components in HF sub-bands and using the corrections obtained by HF components of SWT of the input image will preserve more HF components than the ordinary interpolation.

B. CONTRAST ENHANCEMENT:

The output of the resolution enhancement module will be taken as the input to this module. The main tools that we use here are SVD and DWT. It is already known that singular value matrix obtained by SVD contains the illumination information. So we have to change this matrix to change the contrast of the image. Any changes made to this matrix will not affect the other attributes of the image. The DWT is used to divide the image into sub-bands. We know that the edges are concentrated on LH, HL, HH sun-bands. Hence even if we separate the HF components and apply some transformations on the LF will not cause any damage to the edge components. Hence after reconstruction the image looks sharper too. The key steps involved in this process are as follows: First we will apply DWT on the input image and in parallel we improve its contrast using GHE and find its DWT. Now calculate the hanger (U), aligner (V) and singular value matrix (SVM) for the LL sub-bands obtained above. Find the maximum element in both the SVMs and take their ratio (ξ). Now calculate the new STM and estimate the new LL sub-band.

$$LL_{A(new)} = U_{LLA} \sum\nolimits_{LLA} V^T_{\ LLA}$$

The estimated LL sub- band and the HF components of actual input image are now used to re-produce the contrast enhanced image. From the close observation we can see that the HF components are not disturbed. We manipulated the illumination information alone. Hence we can be sure that there is no harm to edge components.

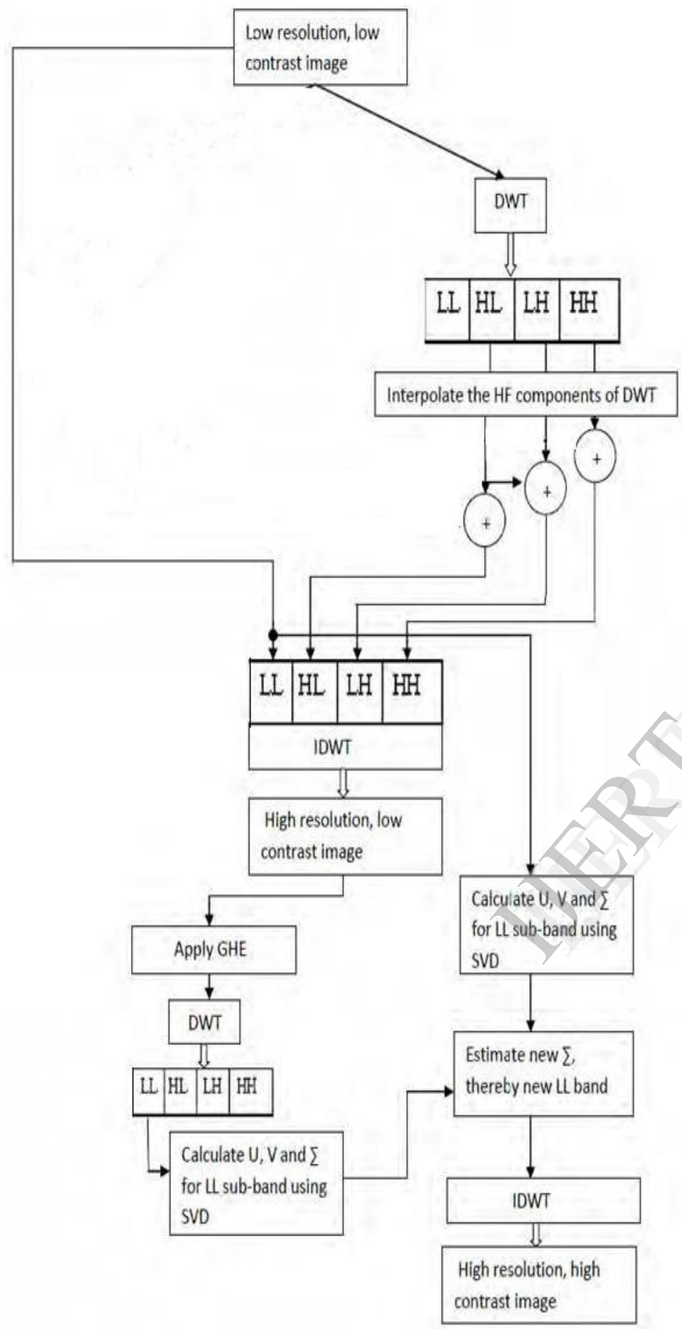

Fig.: Detailed steps in proposed algorithm

Fig.2: DWT processed image

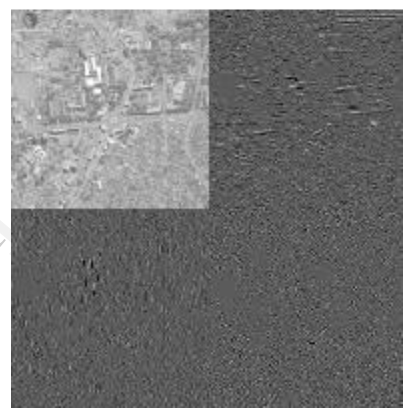

Fig.3: Output image

III. EXPERIMENTAL RESULTS

A.RESOLUTION ENHANCEMENT

Fig.1: Input image

B.CONTRAST ENHANCEMENT

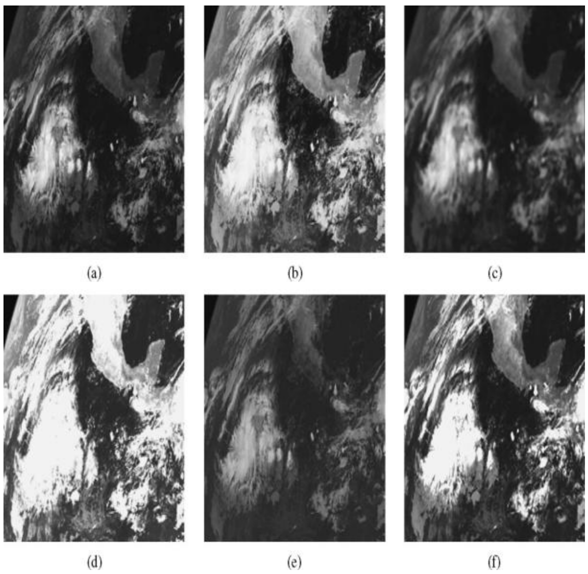

Fig. 4. (a) Original low-contrast images from the Antarctic Meteorological Research Centre. Equalized image by using (b) GHE, (c) LHE, (d) SVE, (e) BPDHE, and (f) the proposed technique.

IV.CONCLUSION

From the results obtained it is clear that the application of the algorithm is successful. And this application is more prominent in satellite image processing.. For the resolution enhancement, we corrected the HF components using DWT components. For contrast enhancement we have taken the help of SVD, in which singular value matrix gives the illumination content. By modifying that value, we succeeded in improving the contrast of the given image.

V.REFERENCES

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