Satellite Image Enhancement Using 2D Level DWT

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***Abstract*—Satellite images may have been taken in very dark or a very bright situation, so the information may be lost in those areas which are excessively and uniformly dark or bright. So we have to improve the contrast of a satellite image. Image contrast enhancement is one of the most important issues in image processing. Contrast enhancement has the purpose to improve the quality images..**

Satellite colour images are being used in many research fields. One major issue of these types of colour images are their poor perception. There are several methods used to enhance the perception of these images. Some of these methods are Histogram Equalization Technique, Local Histogram equalization method, Discrete Cosine Transform, and Discrete Wavelet Transform technique. All these methods face problems such as loss of image information, loss of edge details etc.

A new method to enhance the satellite image which using the concept of wavelets and threshold decomposition is discussed here. The proposed enhancement technique uses 2D DWT to decomposed input image into different sub bands such as LL, LH, HL, HH. Then, enhancing the image using threshold decomposition. Threshold decomposition is a powerful theoretical method, which is used in nonlinear image analysis. Here edges are detected through threshold decomposition and these edges are sharpened by using morphological filters. This method will give better quantitative and qualitative results. Then the image is recovered using inverse 2D DWT. This technique can be applied in the fields of astronomy, satellite image processing etc.

Keywords*—*image processing, wavelet transform

I. INTRODUCTION

The main purpose of this project is to enhance satellite images. They may be blurred or unclear due to many reasons. To improve their clarity they must be enhanced. Otherwise minute details in the image will be almost invisible to human eyes. Many techniques have been developed to enhance the satellite images. DWT is the latest one among this. The technique which is proposed in this paper can further improve the clarity of satellite images compared to that of simple DWT.

II. IMAGE PROCESSING

In imaging science, image processing is any form of signal processing for which the input is an image, such as a photo-graph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most of the image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to digital image processing, but optical and analogue image processing also are possible.

III. IMAGE ENHANCEMENT

Enhancement of the image is necessary to improve the visibility of the image subjectively to remove unwanted noise, to improve contrast and to find more details. Mainly there are two major approaches. They are spatial domain, where statistics of grey values of the image are manipulated and the second is frequency domain approach; where spatial frequency contents of the image are manipulated. In spatial domain histogram equalization, rank order filtering, homomorphic filtering, principal component analysis etc are generally used to enhance the image. Although these image enhancement techniques are developed for gray valued images but few of them are also applied to colour image for enhancement purpose.

Image enhancement is simplest and most appealing areas of digital image processing. Basically, the idea behind image enhancement is to bring out detail that is unclear, or simply to highlight certain interesting features of an image. A familiar example of enhancement is when we increase the contrast of an image and it “looks better”. Thus enhancement is a very subjective area of image processing.

Image enhancement can improve a satellite image which has complete information but is not visible. There have been several technique for enhancing a satellite image such as histogram equalization technique, discrete cosine transform technique etc.

Recently, some techniques have been developed [1] based on wavelet or wavelet packets for analysis of satellite images. In this paper, a novel technique based on the 2D Level DWT with different types of morphological filters has been proposed for enhancement of low-contrast satellite images. Along with that we use singular value decomposition technique.

IV. EXISTING SYSTEMS

There are several techniques to improve the contrast of a satellite image, including histogram equalization technique, discrete cosine transform technique etc.

A. Histogram Equalization Technique

Histogram equalization [2] technique is used to enhance images by normalizing image intensities. Let f be the pixel value matrix of the given image. Pixel intensities range from 0 to L 1, where L is the total number of possible intensities. Then

$$P_n = \frac{\text{Number of Pixels having Intensity n}}{\text{Total number of Pixels}}$$

Where, Pn denote normalized histogram for each possible intensity value of the image.

B. Discrete Wavelet Transform

Image consists of pixels that are arranged in two-dimensional matrix, each pixel represents the digital equivalent of image intensities. In spatial domain adjacent pixel values show high interdependencies and hence redundant. In order to enhance images, these redundancies existing among pixels needs to be eliminated. DWT transforms the spatial domain pixels into frequency domain information that are represented in multiple sub-bands. This frequency information is filtered using certain filters in two directions. First the value is filtered row wise using low pass filter, column wise filtered using high pass filter then vice versa. Then both row and column filtered using two low pass filters and then both using two high pass filters.

Human visual system is very much sensitive to low frequency so, the decomposed data available in the lower sub-band region and is selected and is used for enhancement purposes, information in the higher sub-band regions are rejected depending upon required data. In order to eliminate the high frequency sub bands and extract low frequency data, DWT architecture given in figure is used. As shown in the figure 1, input image consisting rows and columns are transformed using high pass and low pass filters. The filter coefficients are predefined and depend upon the wavelets selected. The filters used here for these purposes are haar. These are named under the founder of first DWT Alfred Haar. For 2^n inputs Haar wavelets combine inputs, then, produce their sum and difference. Sum is produced and difference is stored.

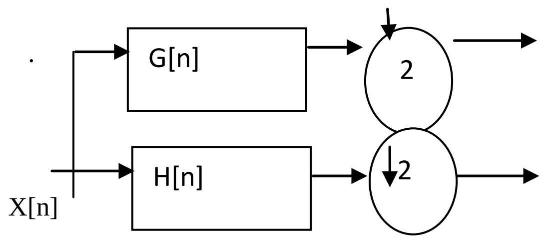


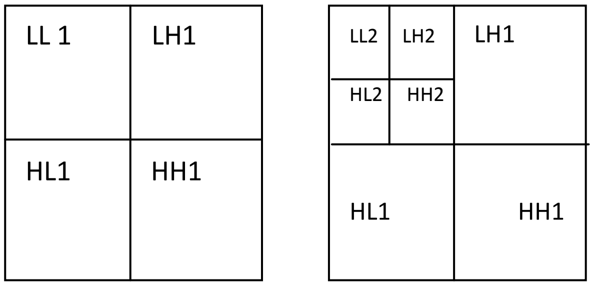
Figure I: 1-Level DWT

The resulting frequency sub bands are shown in figure 2a.

C. 2D Level DWT

DWT has been introduced as a highly efficient and flexible method for sub band decomposition of signals. The two dimensional DWT (2D-DWT) is nowadays established as a key operation in image processing.

The 2D-DWT has received considerable attention in the field of image processing because of its flexibility in representing non-stationary image signals and its ability in adapting to human visual characteristics. This transform method was developed by Mallat and offers orthogonality and leads to a multi-grid representation. The one-level 2D-DWT computation is shown in Figure 1 . Two filters are used, one low pass filter (h(n)) and one high pass filter (g (n)). As the input signal is an image, the filtering is obtained by first filtering the signal vertically then re-filtering the output horizontally by the same set of filters. This leads to 4 different sub-bands HH, HL, LH and LL obtained by a combination of High and Low filtering at each level. Then LL is filtered again to get the next level of representation. In figure 2b the resulting frequency bands are shown.



(a) (b)

Figure II: (a) DWT Sub-bands (b) 2D-Level DWT Sub-bands

V. DRAWBACKS OF EXISTING SYSTEMS

Histogram Equalization [3] based methods was unable to maintain average brightness level since there may be a large difference in intensity values of pixels in histogram. So the average value is not optimum in such case. It may result in either under or oversaturation in the processed image. Also, this technique cannot be used for large images. Satellite images are large images in general.

Techniques using cosine transforms cannot preserve low frequency values since they do not differentiate frequency sub-bands as precisely as Discrete Wavelet transforms does. Also, when using Discrete Wavelet Transform we can improve the precision in which the frequency bands are separated by using 2D-Level DWT.

VI. PROPOSED SYSTEM

Considering the drawbacks of the existing systems, a new technique based on Discrete Wavelet Transforms is proposed. This technique uses 2D-Level DWT for decomposing image pixels into frequency sub-bands. 2D-Level Discrete Wavelet Transform converts the image pixel values to different frequency bands such as LL, LH, HL, HH. Here, LL sub-band will have pixel information that is sensitive to human perception. All other sub-bands represent unnecessary pixel information. In order to filter out the unnecessary information we use threshold decomposition and morphological filtering.

Figure 3 shows the block diagram of the work. As shown in two input is a satellite colour image which has got a large pixel dimension. That image is decomposed into a smaller pixel dimension and it is decomposed into RGB. This is done for the ease of using the image in software tool Matlab. This output image is decomposed to frequency domain using 2D-Level DWT. The resulting image is shown in Figure 4.

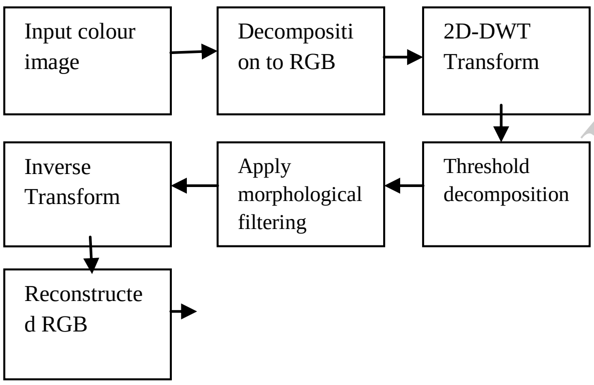


Figure III: Block Diagram

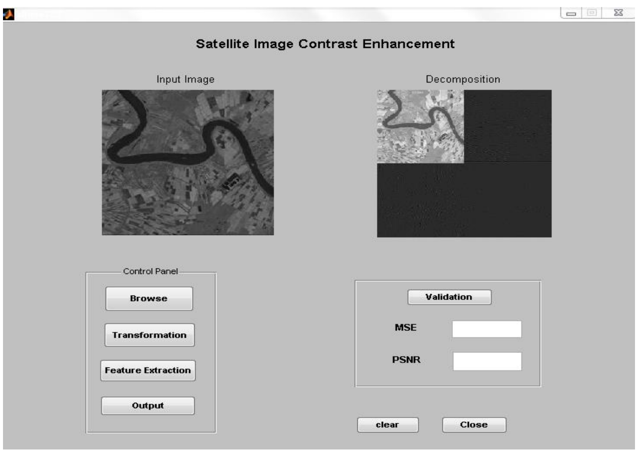


Figure IV: Decomposition using 2D-Level DWT

Then from the decomposed matrix we select the LL2 sub band for the further processing. This matrix is then decomposed again using singular value decomposition [5]. Formally, the singular value decomposition of a mn real or complex matrix M is a factorization of the form

M = USV

Where U is a mm real or complex unitary matrix, s is an mn rectangular diagonal matrix with nonnegative real numbers on the diagonal, and V (the conjugate transpose of V , or simply the transpose of V if V is real) is an nn real or complex unitary matrix. The diagonal entries Si,i of S are known as the singular values of M. The m columns of U and the n columns of V are called the left-singular vectors and right-singular vectors of M, respectively.

Then we set a Threshold value for filtering. The decomposed frequency value above this threshold value is then filtered out using morphological filtering. Morphological filtering and Threshold decomposition using singular value matrices is post-processing technique used here. After all these processes we get enhanced matrix. Now this enhanced frequency components have to be reconstructed using inverse discrete wavelet transform. Thus, we get a clear enhanced satellite image. Figure 5 shows the enhanced version of the image.

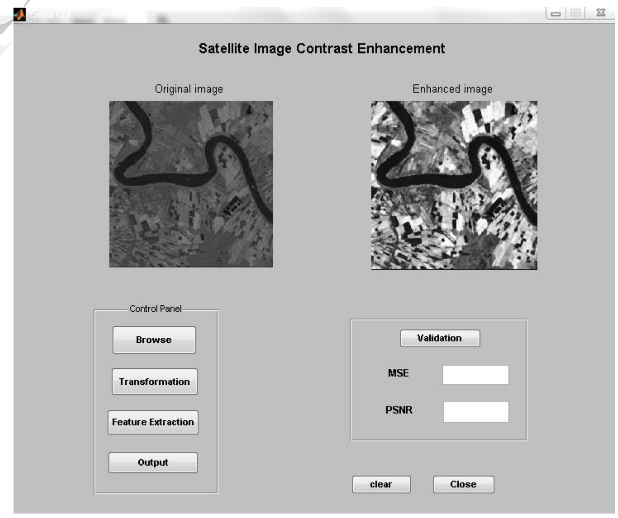


Figure V: Enhanced Image

For the purpose of validation we compare the initial input image and enhanced image. And, we get MSE and PSNR value.

These values show that enhanced image have less MSE and PSNR values compared to input image. Enhanced image is shown 6.

The graphical user interface of Matlab shows the MSN and PSNR value here.

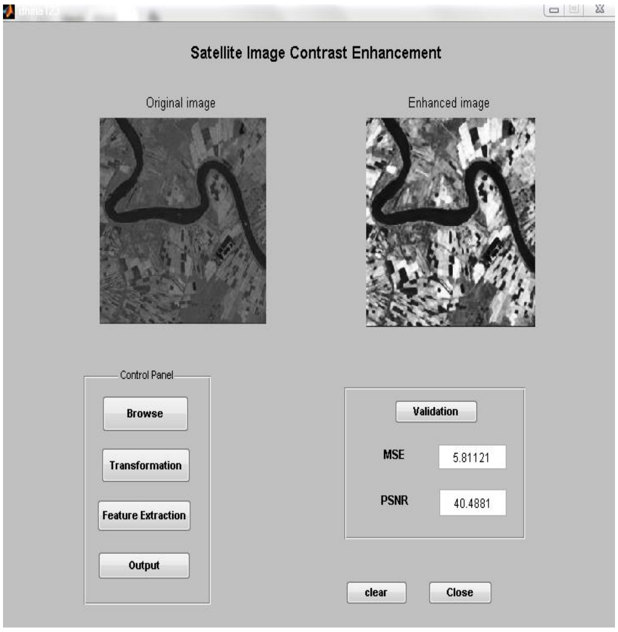


Figure 6: Validation

VII. CONCLUSION

This is a novel enhancement method improves satellite images considerably. Satellite images are decomposed using 2D discrete wavelet transform. By this process we are differentiating unnecessary noise contents of the image and high frequency components from LL sub band. Then, certain image processing such as threshold decomposition and morphological filtering image is enhanced. Then, the enhanced image is reconstructed using IDWT. Compared to previous techniques existed DWT itself is efficient version, here DWT also made some more efficient by making it 2D level DWT. When we are using 2D level DWT image's LL sub band is again decomposed to get more precise pixel values that contain image information. In this paper, haar filters are used to filter the frequency components that are unnecessary. Matlab is the tool that used here to process the image. Matlab does all its operations in matrices. So each and every image pixel is analyzed and processed. For the purpose of understanding we have created a GUI too in mat lab. This enhanced image can be used for several applications.

REFERENCE

[1] Saurabh Chaudhury, Ananta Kumar Roy, “Histogram Equalization—A Simple but Efficient Technique for Image Enhancement” 2013.

[2] Nageswara Rao, Srinivasa Devireddy, “Image Compression Using Dis-crete Cosine Transform” 2008.

[3] cagri ozcinar, Hasan Demirel, “Image Equalization Using Singular Value Decomposition” 2013.

[4] Poth Miklos, Marka Oreskovika, “Image Interpolation Techniques” 1999.

[5] cagri ozcinar, Hasan Demirel, “Image Equalization Using Singular Value Decomposition” 2013.