Satellite Image Enhancement Using DWT – SVD and Segmentation Using MRR –MRF Model

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Abstract – Satellite image is used in many applications such as geosciences studies, astronomy and geographical information systems. The most important quality factors in images come from its resolution. The satellite image enhancement technique using Discrete Wavelet Transform and Singular Value Decomposition. This Techniques decomposes the input image into four frequency sub band by using Discrete Wavelet Transform and also calculate the Singular Value Matrix of the Low-Low Sub band images and equalize the enhanced images through Inverse Discrete Wavelet Transform. After the enhancement process the image segmentation technique is applied to the image the model incorporates the multiregional Resolution and the Markov Random Field techniques to improve the segmentation accuracy, improve the quality of an image and it reduce the noise of the satellite images.

Index Terms – Discrete Wavelet Transform, Singular Value Decomposition, Multi Region Resolution, Markov Random Field, Generalized Histogram Equalization.

1. INTRODUCTION

The aim of this project is to enhance the contrast of the satellite image using Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) and segment the images by using the model Multi Region Resolution (MRR) and Markov Random Field (MRF). The image enhancement is a process of improve the quality of an image. One of the most important quality factors in satellite images comes from its contrast. Contrast enhancement is one of the most important problem in image processing. Contrast is developed by the difference in luminance reflected from two adjacent surfaces. Contrast is the difference in the color and brightness of the image. If the contrast of an image is highly concentrated on a particular range, the information may be lost in those areas which are excessively and uniformly concentrated.

The main problem is to optimize the contrast of an image to represent all the information in the input image. There are several techniques, such as Generalized Histogram Equalization (GHE) and Singular Value Decomposition (SVE). As the rising demand for high quality remote sensing images, contrast enhancement techniques are having better visual perception and color reproduction Histogram Equalization (HE) is the to enhance the contrast. It is not necessary that contrast will always increase in this. There may be some cases were histogram equalization can be worse. To overcome this problem these problem, bi-histogram equalization (BHE) and dualistic sub image HE methods have been proposed by using decomposition of two histograms. For further improvements, the Recursive Mean-Separate Histogram Equalization (RMSHE) method iteratively performs the BHE and produces separately equalized sub histograms.

The optimal contrast enhancement cannot be achieved since iterations converge to null processing. The most common problem in existing contrast enhancement methods are drifting brightness saturation and distorted details need to be minimized because pieces of important information are widespread throughout the image in the sense of both spatial locations and intensity levels. The enhancement algorithms not only improve the contrast but also minimize pixel distortion in the low and high intensity regions. The dominant brightness level analysis and adaptive intensity transformation are the novel contrast enhancement method to achieve this goal. The proposed contrast enhancement algorithm performs the DWT to decompose the input image into HH, HL, LH and LL sub bands. After the image is enhanced by using those techniques such as Discrete Wavelet Transform and Singular Value Decomposition, it equalize the pixel into same level, and it improve the low contrast of an image. After that the image segmentation is performed to the satellite images. The techniques such as Multi Region Resolution and Markov Random Field are used to enhancement and segmentation.

2. RELATED WORK

In 2009 Tarik Arici, SalihDikbas and Yucel Altunbasak proposed a protocol which uses histogram equalization for image contrast enhancement is presented. Contrast enhancement minimizes cost function. The method histogram equalization is an efficient method for contrast enhancement. Conventional histogram equalization (HE) gives desirable contrast. The image has an unnatural look and creates visual artifacts. It will enhance the level of contrast and can the noise robustness, white or black stitching and mean-brightness preservation [1].

In 2010 Hasan Demirel et al. proposed technique which uses a new satellite image contrast enhancement technique that is based on the discrete wavelet transforms (DWT) and singular value decomposition. The Discrete Wavelet Transform is the technique that captures both low frequency coefficient and high frequency coefficient of an image and it decomposes the input image into the four frequency sub bands and estimates the singular value matrix of the low- low sub band image after that the image get deconstructed by inverse DWT. Standard general histogram equalization and local histogram. The techniques such as brightness preserving dynamic histogram equalization and singular value equalization prove the better equalization [2].

In 2010 Yen-Ching Chang et al. proposed a simple histogram modification technique. Two boundary values for histogram are found and set to the corresponding values, respectively. It recomputed the probability density function of an image and the renovate mapping function is used to perform histogram equalization. The technique should be effectively improve the quality of images enhanced by histogram equalization and specification methods [4].

In 2011 DebashisSen, Member and Sankar K. Pal proposed an automatic exact histogram specification technique. It is used for global and local contrast enhancement of images. The image histogram is a different type of histogram that functions like a graphical representation of the tonal distribution in a digital image. It measures image contrast based upon local band-limited approach and center surround retinal receptive field model approach. The approach is used in multiple scales frequency band [7].

Luiz F. S. Coletta, Lucas Vendramin, Eduardo Raul Hruschka (2012) proposed some extension of the two FCM-based clustering algorithms. The proposed modeling is used to cluster the distributed data by arriving at some positive ways of determining important parameters of the algorithms including the large number of clusters and forming a set of systematically structured guidelines. The nature of the data environment is depending on a selection of the specific algorithm and the assumptions being made about the number of clusters. A partial complexity analysis, including time, space and communication aspects is reported.

Ken Xu, Wen Yang, Member, Gang Liu, and Hong Sun (2013) presented to classify the high resolution satellite image by using an efficient unsupervised semantic method. The iterative algorithm is based on label cost and BIC can automatically evaluate the number of classes in the classification. It can keep the consistency of the semantics as well. The consideration over four scenes shows that the method achieves better classification performance.

3. PORPOSED METHOD

3.1. Singular Value Decomposition

A novel technique based on the singular value decomposition (SVD) and discrete wavelet transform (DWT) has been proposed for enhancement of low contrast satellite images. SVD technique is based on a theorem from linear algebra which says that a rectangular matrix A, that can be broken down into the product of three matrices, as follows: (i) an orthogonal matrix UA, (ii) a diagonal matrix ΣA and (iii) the transpose of an orthogonal matrix VA. The singular value decomposition is a factorization of a real or complex matrix. SVD of an image can be interpreted as a matrix is written as follows:

$$A=uA\Sigma AvAT \qquad (1)$$

Where UA and VA are orthogonal square matrices and ΣA matrix contains singular values on its main diagonal. The intensity information of input image and any change on the singular values are represented at the singular value matrix which will change the intensity of the input image. The main advantage of using SVD for image equalization, ΣA has the intensity information of the image.

3.2. Discrete Wavelet Transform

A Discrete Wavelet Transform is a wavelet transform which uses wavelet coefficients. The DWT technique which captures both frequency and location information of an image. Resolution is an important feature in satellite imaging. The remote sensing images have high frequency contents as well as low frequency contents. And the image may have losing of high frequency contents. So, the DWT technique for resolution to maintain the high frequency components of the satellite images [10].

The satellite input image needs to be divided into four sub bands. They are Low-Low (LL), Low-High (LH), High- Low (HL), High-High (HH). Then the high frequency sub bands are estimated. The high frequency sub band images and the low resolution input images are interpolated and using inverse DWT we can get a resolution enhanced image [4]. The interpolation process is used to preserve high frequency contents of the image. The DWT technique is mainly used to produce the sharper enhanced image.

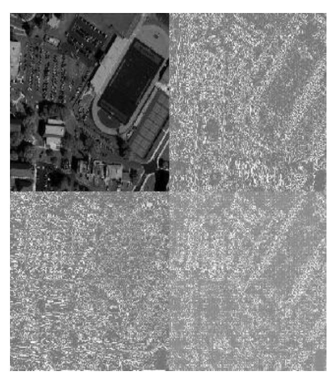


Figure 1 LL, LH, HL and HH sub bands of a satellite image obtained by DWT.

3.3. Algorithm

Step1: A low contrast input satellite image has been taken for the analysis.
Step2: The satellite image is equalized using general histogram equalization technique.
Step3: After the equalization, compute the discrete wavelet transform for the contrast enhancement.
Step4: DWT of an image decomposed four sub band images referred to as (LL, LH, HL, and HH).
Step5: calculate U, ∑ and V for LL sub band image.
Step6: calculate ξ.

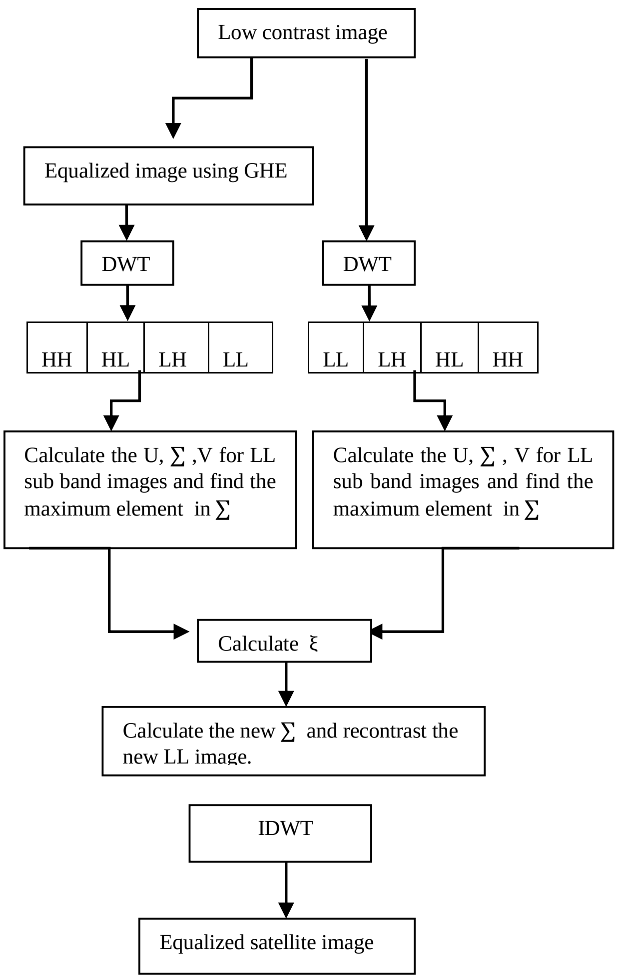


Figure 2 Flow chart for DWT – SVD

From the above Figure 2, the input image given as the low contrast satellite image. The satellite image is divided into two packets one that apply DWT directly from the satellite image into another packet,then applying the histogram technique the result is given to DWT. Above from both packets the frequency sub bands are similarly divided into four frequency as LL, HL, LH, HH taking LL sub bands and applying the SVD technique. After that apply the Inverse DWT to the resultant image.Then the final resultant image is the contrast image.

4. IMAGE SEGMENTATION TECHNIQUES

After the enhancement process the image segmentation technique is applied to the image the model incorporates the Multi Region Resolution and the Markov Random Field techniques to improve the segmentation accuracy improve the quality of an image and it reduce the noise of the satellite images.

4.1. Multi Region Resolution

The multi resolution representation is the fundamental step for multi resolution segmentation approaches. It decomposes the original image Y into vector images on each resolution Y (n) and obtains an N-level representation Y = {Y (1), Y (2), . . . Y (N)}. The vector image Y (n) is usually composed of a low frequency coefficient image Y(n)L and a high frequency coefficient image Y (n)H, Y (n)L describes the rough information about a given image on the nth resolution and Y(n)H describes the detail information. The representations are usually obtained at the pixel level. The image can only consider the local texture pattern of images.

4.2. Steps in MRR Model

The Figure 3 shows the decomposition of an image into high frequency and low frequency coefficient image and initially the image is segmented based on region based segmentation R (0).

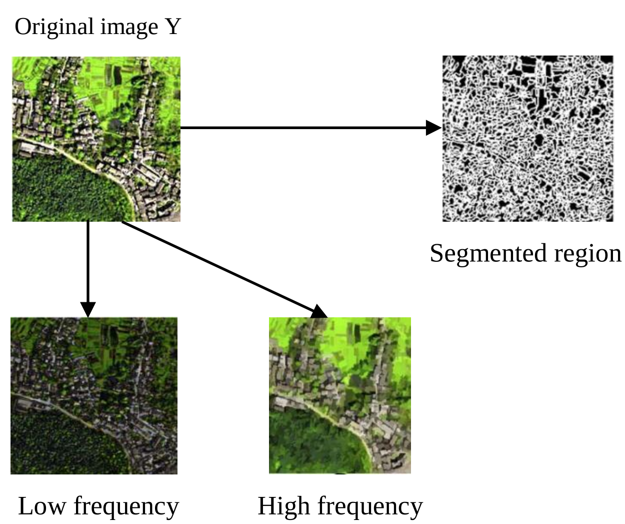


Figure 3 Decomposition of an image without enhancement.

1. The low-frequency coefficient image Y(n-1)L is divided into an initially over segmented region using mean shift method such that
   R (n-1)={n-1)1R(n-1)2…R(n-1) m(n-1).

2. In order to consider the spatial adjacency of region, define the neighborhood system. N={$N_{i|i=}1,2,\ldots,m(n-1)$}.
3. Calculate the set F={fi|i=1,2,…,m(n-1)} to obtain the feature for each R(n-1) fi is the average spectral value of pixels in R(n-1)i.
4. Obtain Y(n)'s low frequency coefficient image Y(n)L=$m(n-1)_{i=1}R(n)_i$.Each $R(n)_i$ is a low frequency coefficient region.
5. Y (n)'s high frequency coefficient image is divided into Y (n) =(Y (n) L,Y(n)H).
6. The decomposition is a iterative process, until the larger and clear texture pattern appear.
7. The low frequency coefficient image describes the rough information of an image high frequency coefficient image describes the detailed Information of an image.

4.3. Markov Random Field

The MRF model is a graphical model for describing spatial consistency of an image. Classifying image pixels into different regions under the constraint of both local observation and spatial relationship. Let's S denote a as set of sites. I={ $I_{S|S}$ ∈ S} is the original image defined on where k is the number of texture pattern appearing in the image.

In the MRF model, image segmentation is achieved by finding an optimal realization x that maximizes the probability given I in the equation.

$$x^{\wedge}=\text{arg } max_{x\in\Omega}\ P(X = x|\ I) \quad (2)$$

Ω is the set of realization x. Based on the Bayesian rule the equation can be converted to function in the equation.

$$x^{\wedge}= \text{arg } max_{x\in\Omega}P\ (I\ |X = x).P(X = x) \quad (3)$$

The likelihood function P (I |X = x) is used to model the feature of the label.

4.4. MRR-MRF Model

The combination of both Multi Region Resolution and Markov Random Field is used to reduce the noise of the satellite image.

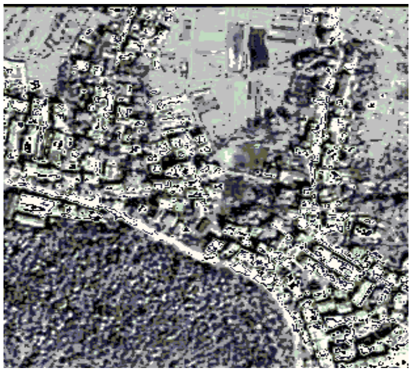
4.4.1. The Steps in MRR-MRF Model

- Obtain the multi region-resolution represent representation Y = {$Y_H^{(1)}, Y_H^{(2)},\ldots Y_H^{(N)}, Y_L^{(N)}$} of original image Y.
- Get the initial segmentation result E(0) using MRF to segment $Y_L^{(N)}$.
- Set i=1
- If I ≤ N+1,go to step else output $E_0^{(i)}$ and exit. Use $E_0^{(i-1)}$as the a priori label field and $Y^{(N+1-i)H}$ as the I.
- Obtain the segmentation result $E_0^{(i)}$ of the (N+1-i)th resolution based on the MRF model.

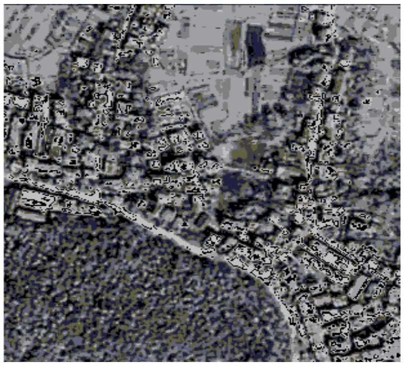
5. RESULTS

Experimental results shows that the proposed algorithm can enhance the low-contrast satellite images and is suitable for various imaging devices such as consumer camcorders, real-time 3-D reconstruction systems and computational cameras.

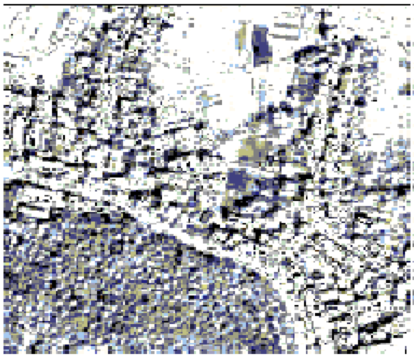
(a) Low contrast original image



(b) Generalized histogram equalization



(c) Enhanced images using SVD-DWT



(d) Low frequency image

(e) High frequency image

6. CONCLUSION

In this paper, a satellite image contrast enhancement technique based on DWT and SVD has been proposed. This techniques decompose the input image into the DWT subbands and after upadating the singular value matrix of the LL sub bands, it reconstructed the image by using IDWT and the techniques equalized the satellite image into the uniform pixel. After that, segment the enhanced image by using MRR – MRF model. The combined approach decomposes the image into Low frequency and high frequency. In low frequency it describes the rough information of the image and the high frequency describes the detailed information of the image. The experimental result shows that the better performance and high accuracy when compared with other methods.

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