Satellite Image Enhancement using Discrete Wavelet Transform and Morphological Filtering for Remote Monitoring

[1]Dr. Deepa D., [2]Poongodi C., [3]Dr. Bharathi A.

[1]Associate Professor, Department of Information Technology, Bannari Amman Institute of Technology, Sathyamangalam 638401, Tamilnadu, India.
[2]Associate Professor, Department of Information Technology, Bannari Amman Institute of Technology, Sathyamangalam 638401, Tamilnadu, India.
[3]Professor, Department of Information Technology, Bannari Amman Institute of Technology, Sathyamangalam 638401, Tamilnadu, India.

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ABSTRACT

Background: Satellite images are being used in many fields of research mainly for monitoring the remote areas for analyzing the environmental conditions, land and water resource monitoring etc., these images are affected by clouds and electromagnetic radiation which results in poor perception of image. **Objective:** To analyze the satellite image, improvement in the resolution of the image and also the clarity is required. In this paper the input satellite image is decomposed to separate r, g, b images and a discrete wavelet transform is performed for dividing the planes into subbands. Among this low frequency sub band is used for further processing because it contains almost all the information about the image. The threshold decomposition technology is used to detect the edges of the selected sub bands of r, g, b. The morphological filtering is applied to the image to sharpen the edges of sub bands. IDWT is taken for the processed image to reconstruct the image. **Results:** The MSE and PSNR values are calculated for evaluation of the method and the results show that the proposed method gives better improvement in Signal to Noise ratio and it reduces Mean Square Error considerably comparing the values before and after enhancement. **Conclusion:** In the proposed method, DWT and edge detection using morphological filters succeeded in enhancing low contrast satellite images. The detected edges were sharpened by using Morphological filter dilation and erosion process. By utilizing these detected edges, IDWT is obtained and got the enhanced image by reconstruction. From the results it is identified that the proposed method can be well used to monitor the remote areas obtained by the satellite images with high quality and resolution.

INTRODUCTION

Satellite images are the images captured by satellites and it consists of images of Earth or other planets collected by artificial satellites. Images acquired by satellite usually consist of far fewer "shots" than that taken by aircraft. The extra distance means that more area can be covered in one pass at the deficit of detail. Satellites usually capture data in strips similar to a continual video of the area and allow a larger amount of data to be acquired per digital file. Some features of satellite images are Speed, Level of detail, Location, types of data, etc., Satellites are capable of collecting large amounts of data in relatively small amounts of time. A modern satellite can be moved into position in less than 3 days and can take the photographs quickly once locked on to an area. Satellites generally reside several hundred kilometers above the earth's surface. Although satellite imagery has improved greatly over the years it is still lower resolution than aerial photography. High resolution satellite imagery as high as 50cm per pixel is readily available, up to 41cm in the case of GeoEye-1. Military satellites more than likely have a higher resolution but as yet this imagery has not become publically available. Most off-the-shelf satellite imagery is between 250m and 50cm in resolution. The major advantage of satellite imagery is that the satellite can be positioned to take imagery of anywhere on the planet. Being above the earth, it is more efficient for a satellite to allow the earth to revolve below it than to physically move to the necessary location. Satellites still need to take into account the location of the sun to acquire visible light surveys so many satellites try to remain in sun-synchronous orbit.

Many modern satellites can collects a variety of data. These include standard photographic imagery, color infrared and in some cases LiDAR, thermal, radar data. This variety of datasets makes satellites very versatile.

Corresponding Author: Dr. Deepa D, Department of Information Technology, Bannari Amman Institute of Technology, Sathyamangalam 638401, Tamilnadu, India.
E-mail: deepa_dhanaskodi@yahoo.co.in   Phone numbers: +91 4295 226212

However, non-standard data sources such as multi spectral and hyper spectral imagery will likely be expensive to capture or may not even be publically available. The main problem with satellite data types is that when new or improved technology is released it is very difficult to change the sensors and cameras in a satellite but in a plane or helicopter it is simply a case of removing the old device and replacing it with the new one. There are three main types of satellite images available are visible imagery, Infrared imagery and Water Vapor imagery

MATERIALS AND METHODS

Image Enhancement:

Image enhancement techniques are used to emphasize and sharpen image features for display and analysis. Image enhancement is the process of applying these techniques to facilitate the development of a solution to a computer imaging problem. Consequently, the enhancement methods are application specific and are often developed empirically. Fig.1.1illustrates the importance of the application by the feedback loop from the output image back to the start of the enhancement process and models the experimental nature of the development. The range of applications includes using enhancement techniques as preprocessing steps to ease the next processing step or as post processing steps to improve the visual perception of a processed image, or image enhancement may be an end in itself. Enhancement methods operate in the spatial domain by manipulating the pixel data or in the frequency domain by modifying the spectral components.Image enhancement methods are used to make images look better, which works for one application may not be suitable for another application, so the development of enhancement methods require problem domain knowledge, as well as image enhancement expertise. Assessment of the success of an image enhancement algorithm is often "in the eye of the beholder," so image enhancement is as much an art as it is a science.
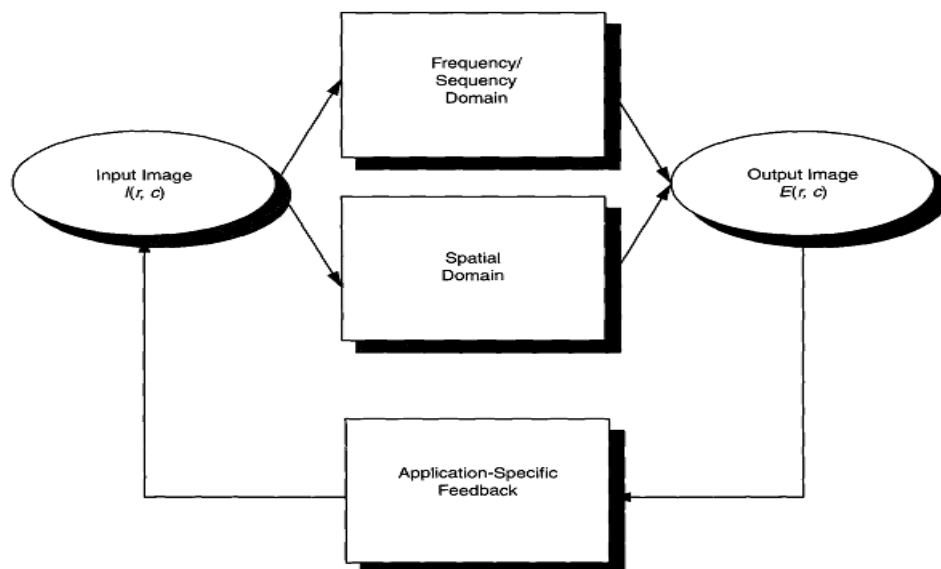

Fig. 1: Image enhancement

The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for a specific application. It accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis. Image enhancement methods can be based on either spatial or frequency domain techniques.

Survey of the work:

Compared with other well-known de noising techniques, such as the Gaussian smoothing model [1], the anisotropic diffusion model, the total variation de noising, the neighborhood filters and an elegant variant, the Wiener local empirical filter, the translation invariant wavelet thresholding, the NL-means method noise looks more like white noise. Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method [16] usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. This method is useful in images with backgrounds and foregrounds that are both bright or both dark. Disadvantage of the method is that it is indiscriminate. It may increase the contrast of background noise, while decreasing the usable signal. Contrast stretching also called Normalization attempts to improve an image by stretching

[11,12,15] the range of intensity values it contains to make full use of possible values. Unlike histogram equalization, contrast stretching is restricted to linear mapping of input to output values. The result is less dramatic, but tends to avoid the sometimes artificial appearance of equalized images. Drawback with this method is that outliers can reduce the effectiveness of the operation. Resolution enhancement (RE) schemes [10] which are not based on wavelets suffer from the drawback of losing high-frequency contents which results in blurring. The discrete-wavelet transform-based (DWT) RE scheme generates artifacts due to a DWT shift-variant property. A wavelet-domain approach based on dual-tree complex wavelet transform DT-CWT and nonlocal means NLM is proposed for RE of the satellite images. The Haar transform is one of the simplest and basic transformation from the space/time domain to a local frequency domain, which reveals the space/time-variant spectrum. The attracting features of the Haar transform, including fast for implementation and able to analyze the local feature, make it a potential candidate in modern electrical and computer engineering applications, such as signal and image compression. In addition to this traditional filters are also used.

Proposed Image Enhancement Technique Using Discrete Wavelet Transform And Morphological Filters System:

Satellite color images are being used in many fields of research. These types of color images are affected by clouds and electromagnetic radiation which results in poor perception of image. In this paper, the concept of wavelet transform and morphological filtering are used to enhance the image. Image enhancement is an important preprocessing technique for satellite images, which makes the image to be of vital importance as increasing the enhancement of these images will directly affect the performance of the system. In this paper, an edge detected morphological filter is used to sharpen the aerial images. The low contrast satellite image is given as input and DWT separates the input image into different sub band images, namely LL, LH, HL, and HH. DWT has been employed in order to preserve the high frequency components of the image. The input low contrast color image is decomposed into R, G, B. The LL sub band of each color component of the image is decomposed into a series of binary levels, each of which may be processed separately. These binary levels can then be recombined to produce the final gray scale image with identical pixel values to those produced by gray scale processing. The success of threshold decomposition, gradient-based operators is used to detect the locations of the edges, by detecting the positions of the edges and then applying a class of morphological filtering. A morphological filter is used to sharpen these detected edges.

Image Acquisition:

The first stage of any image processing system is the image acquisition stage. After the image has been obtained, various methods of processing can be applied to the image to perform different tasks required.

Fig. 2: Input image.

Decomposition of Red, Green and Blue Planes:

An RGB image, sometimes referred to as a "truecolor" image, is stored in MATLAB as an m-by-n-by-3 data array that defines red, green, and blue color components for each individual pixel. RGB images do not use a palette. The color of each pixel is determined by the combination of the red, green, and blue intensities stored in each color plane at the pixel's location. The three color components for each pixel are stored along the third dimension of the data array.
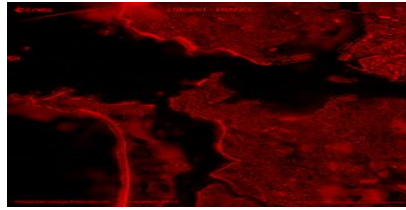
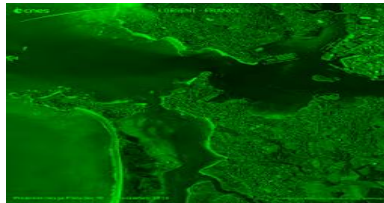**Fig. 3.1:** Decomposed red plane of input image.

Fig. 3.2: Decomposed green plane of input image.
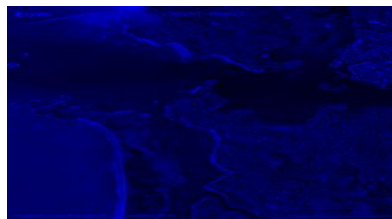

Fig. 3.3: Decomposed blue plane of input image.

Discrete Wavelet Transform:

Wavelet transform decomposes a signal into a set of basic functions. Key advantage of DWT over Fourier transforms is temporal resolution: it captures both frequency *and* location information. The discrete wavelet transform has a huge number of applications in science, engineering, mathematics and computer science. Most notably, it is used for signal coding, to represent a discrete signal in a more redundant form, often as a preconditioning for data compression. Image from previous step is now transformed using DWT and the results are shown below.
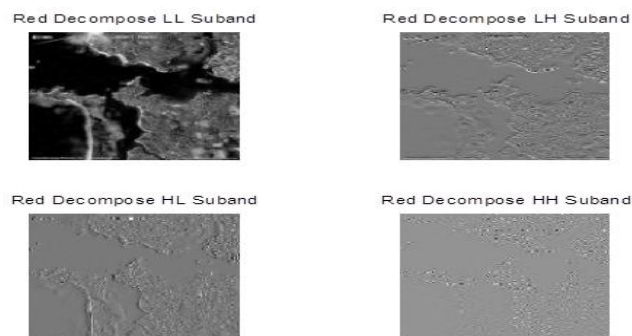

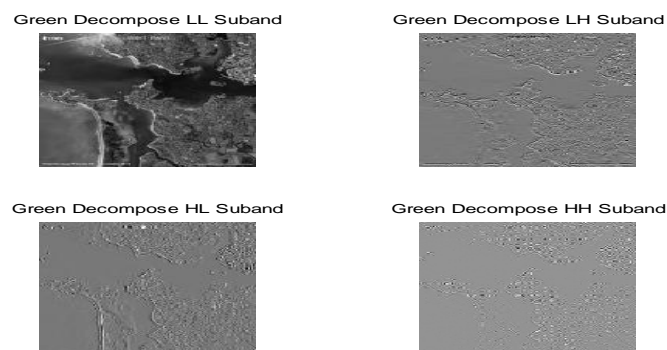**Fig. 4.1:** Decomposed RED image of input image.

Fig. 4.2: Decomposed GREEN image of input image.

Blue Decompose LL Suband   Blue Decompose LH Suband

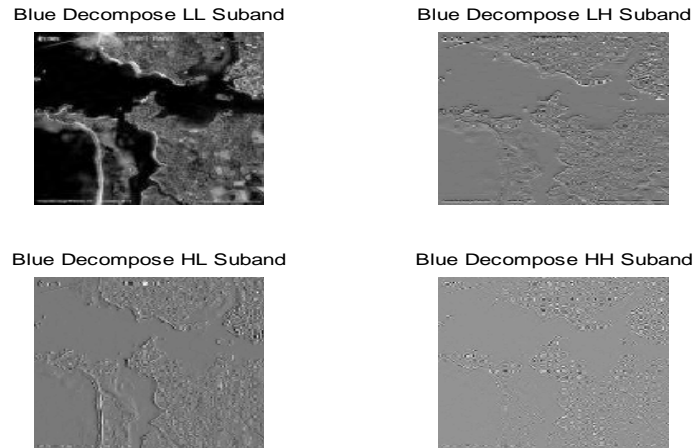Blue Decompose HL Suband   Blue Decompose HH Suband

Fig. 4.3: Decomposed BLUE image of input image.

Threshold Decomposition:

    In an image, an edge is a curve that follows a path of rapid change in image intensity. Edges are often associated with the boundaries of objects in a scene. Edge detection technique is used to identify the available edges in an image. The most powerful edge-detection method that edge provides is the Canny method. The Canny method differs from the other edge-detection methods in that it uses two different thresholds to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edge

edge of r   edge of g   edge of b

Fig. 5.1: Edges of r, g, b of input image.

Morphological Filters

    Morphology is the study of the shape and form of objects. Morphological image analysis can be used to perform 1. Object extraction, 2. Image filtering operations, such as removal of small objects or noise from an image, 3. Image segmentation operations, such as separating connected objects, 4. Measurement operations, such as texture analysis and shape description

The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image.

dilation of cA1   erosion of cA1

Fig. 6.1: Dilation, erosion of LL sub band of input image 1(red plane).
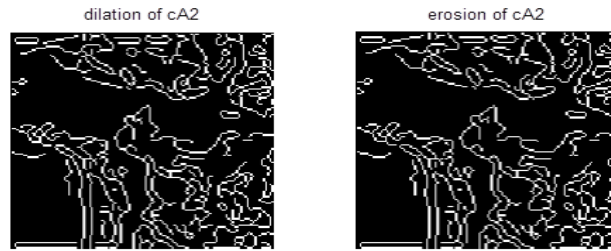
Fig. 6.2: Dilation, erosion of LL sub band of input image (green plane).

Fig. 6.3: Dilation, erosion of LL sub band of input image (blue plane).
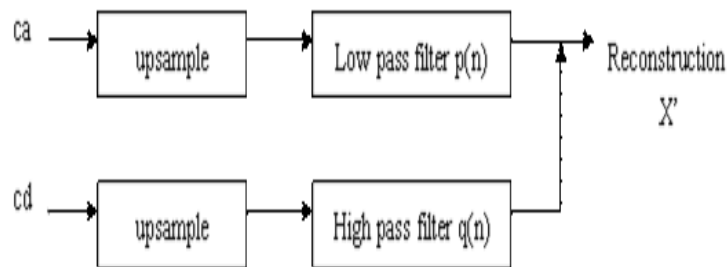
Reconstruction:

Image reconstruction encompasses the entire image formation process and provides a foundation for the subsequent steps of image processing. The goal is to retrieve image information that has been lost in the process of image formation. In contrast to image enhancement, where the appearance of an image is improved to suit some subjective criteria, image reconstruction is an objective approach to recover a de graded image based on mathematical and statistical models. IDWT is the process used to reconstruct the image and it is the inverse process of wavelet decomposition. In contrast to decomposition, the reconstruction process is comprised of up sampling and then filtering. The filters are determined by the wavelet chosen.

RESULTS AND DISCUSSION

Fig. 7: Reconstructed gray scale image.

Fig. 8: Reconstructed colour image.

Table 1: Comparison of MSE values of input and output image.

	Before enhancement	After enhancement
Input image 1	56.6431	43.3418
Input image 2	52.3972	41.3247

Table 2: Comparison of PSNR values of input and output image.

	Before enhancement	After enhancement
Input image 1	19.5348	31.2314
Input image 2	17.8452	28.9673

In the above section images obtained during various phases of processing is given in Fig 1 to Fig 8. It shows the results from the input image (Fig. 2) to the reconstructed image in Fig. 8. Evaluation results by calculating the MSE and PSNR values for the input and the output images are given in Table 1 and 2, from the results it is identified that the proposed method gives better improvement in Signal to Noise ration and reduced Mean Square Error after enhancement compare to the image before enhancement.

Conclusion:

In the proposed method, DWT and edge detection using morphological filters succeeded in enhancing low contrast satellite images. This was done by decomposing the image into r,g,b and applying the wavelet transform for each r, g, b separately , then detecting the positions of the edges through threshold decomposition. The detected edges were then sharpened by applying morphological filter Dilation and Erosion process. By utilizing these detected edges, IDWT is obtained and got the enhanced image by reconstruction. The experimental examples have demonstrated that the proposed method was significantly better than many other well-known sharpener-type filters in respect of edge and fine detail restoration. PSNR value is calculated for the input and the output image. The PSNR improvement of the proposed technique is high. The proposed method can be well used to monitor the remote areas obtained by the satellite images with high quality and resolution.

REFERENCES

Agaian, S.S., B. Silver and K.A. Panetta, 2007. Transform Coefficient Histogram-Based Image Enhancement Algorithms Using Contrast Entropy Image Processing. IEEE Transactions, 16(3): 741-758.

Agaian, S., 1999. Visual Morphology. Proceedings of SPIE Nonlinear Image Processing X, 3646: 139-150.

Arce, G.R., 1998. A general weighted median filter structure admitting negative weights. IEEE Transactions on Signal Processing, 46: 3195-3205.

Bin Wang, D., M. Rose and Aly, A. Farag, 1993. Local Estimation of Gaussian-Based Edge Enhancement Filters Using Fourier Analysis. IEEE Transactions on Acoustics, Speech, and Signal Processing, 5: 13-16.

Christopher, C.J., M. Prabukumar and A. Baskar, 2010. Color Image Enhancement in Compressed DCT Domain. ICGST - GVIP Journal, 10(1): 31-38.

Demirel, H., C. Ozcinar and G. Anbarjafari, 2010. Satellite Image Contrast Enhancement Using Discrete Wavelet Transform and Singular Value Decomposition. IEEE Geosciences and Remote Sensing Letters, 7(2): 333-337.

Fitch, J.P., E.J. Coyle and N.C. Gallagher, 1984. Median filtering by threshold decomposition. IEEE Transactions on Acoustics, Speech and Signal Processing, 32: 1183-1188.

Gonzalez, C.R. and R.E. Woods, 2005. Digital Image Processing. Englewood Cliffs, NJ: Prentice-Hall.

Gonzalez, C.R., R.E. Woods and S.L. Eddins, 2005. Digital Image processing Using MATLAB Pearson Education. Second Indian Reprint.

Prewitt, J.M., 1970. Object enhancement and extraction. Picture Processing and Psychopictorics, pp: 75-149.

Jin Jesse, S., 1990. An Adaptive Algorithm for Edge Detection. MVA'SO IAPR Workshop on Machine Vision Applications, Vol. 9, November 28-30, pp: 14-17.

Khaleel, T.A., 2007. Enhancement of Spatial Structure of an Image by Using Texture Feature Extraction. Al-Rafidain Engineering, 15(1): 27-37.

Li, J., Y.Q. Zhou and D.R. Li, 1999. High-resolution aerial imagery for improving the spatial resolution of spaceborne images. *Pattern Recognition and Artificial Intelligence*, 12: 461-466.

Muna, F., Al-samaraie, 2009. Color Satellites Image Enhancement Using Wavelet and Threshold Decomposition. IJCSI , 8(5): 3.

Sengee, N., A. Sengee and H.K. Choi, 2010. Image contrast enhancement using bi-histogram equalization with neighborhood metrics. IEEE Trans. on Con. El., 56(4): 2727-2734.

Tang, J., X. Liu and Q. Sun, 2009. A direct image contrast enhancement algorithm in the wavelet domain for screening mammograms. IEEE Sel. Top. in Sig. Proc., 3(1): 74-80.

Tang, J., E. Peli and S. Acton, 2003. Image enhancement using a contrast measure in the compressed domain. IEEE Sig. Proc. Let., 10(10):. 289-292.

Temizel, A. and T. Vlachos, 2005. Wavelet Domain Image Resolution Enhancement using Cycle-spinning. *Electronics Letters*, 41(3).

Yang, F., Y. Chang and S. Wan, 2005. Gradient-threshold edge detection based on the human visual system. Opt. Eng., vol. 44, no 2, 020205.