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Image Denoising Based On Wavelet for Satellite Imagery: A Review

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Abstract: *In this paper studied the use of wavelet and their family to denoising images. Satellite images are extensively used in the field of RS and GIS for land possession, mapping use for planning and decision support. As of many Satellite image having common problem i.e. noise which hold unwanted information in an images. Different types of noise are addressing different techniques to denoising remotely sense images. Noise within the remote sensing images identifying and denoising them is big challenge before the researcher. Therefore we review wavelet for denoising of the remote sensing images. Thus implementing wavelet is essential to get much higher quality denoising image. However, they are usually too computationally demanding. In order to reduce the computational cost, we need to develop an efficient filter by using the wavelet for denoising the images.*

Keywords*: Remote Sensing Image, Wavelet, Denoising, Shrinking*

I. Introduction

Wavelets have been widely used in signal and image processing for the past 20 years [1]. Many systems are monitored and evaluated for their behavior using time signals. Additional information about the properties of a time signal can be obtained by representing the time signal by a series of coefficients, based on an analysis function. One example of a signal transformation is the transformation from the time domain to the frequency domain. The oldest and probably best known method for this is the Fourier transform developed in 1807 by Joseph Fourier. An alternative method with some attractive properties is the wavelet transform, first mentioned by Alfred Haar in 1909. Since then a lot of research into wavelets and the wavelet transform is performed [2].The basic concepts in remote sensing via satellites which show how characteristics of the satellites and onboard sensors affect the amount and quality of data collected. A sampling of ways to use the data for activities such as weather forecasting and scientific research still challenging task [3].

II. Motivation

The need of Remote Sensing Image Analysis trusted area according NASA, Temporal Resolution, Weather Forecasting, and Adjusting Contrast for Feature Identification, Lagrangian Animation, Channel Combination and color enhancement [23].

2.1 Digital library and met data analysis

The massive amount of data obtained from remote sensing sensors requires us to properly archive them and catalog for various purposes. One of the first concerns of data analysis is to see that the data is properly archived and accessed. It is being increasingly appreciated that the old methods of storing the data on digital tapes in 1600 or 6250 bpi are now obsolete for the reason that both the physical media as well as the storage pattern are inefficient. In order to see that the content and historical value of millions of RS images are not lost to future generations, research into storage media and processing for archival is pursued in the world vigorously [13].

2.2 Need of denoising satellite image

Satellite images are usually degraded by noise during image acquisition and transmission process. The main purpose of the noise reduction technique is to remove impulse noise by retaining the important feature of the images. For example, Synthetic Aperture Radar (SAR) imagery uses microwave radiation so that it can illuminate the earth surface. Synthetic Aperture Radar provides its own illumination. The intensity of impulse noise has the tendency of being either relatively high or low thereby causing loss of image details. It is important to eliminate noise in images before using them for other image processing techniques like edge detection, segmentation, registration etc. [14].

A sample MOD11 Level-2 Land Surface Temperature (LST) image generated from Terra MODIS data in bands 31 and 32 on April 4, 2000 (19:15 UTC) in California and Nevada, is displayed in an original color composite with LST, and brightness temperatures in bands 31 and 20 as RGB components. The dark area in lower left corner is Pacific Ocean. The noisy spots in grey are broken clouds as shown in Figure -1 [15]. Therefore, still satellite image processing is a challenging task for researchers.

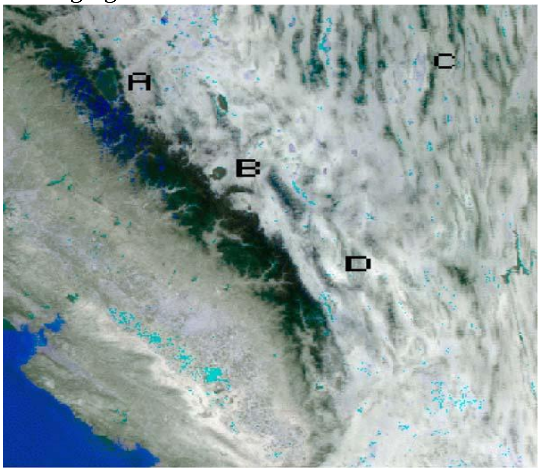


Figure: 1. MODIS Product: MOD11; Product Level: 2; MODIS Data Type: MODIS-PF.

III. Work Done So For

Jung C.R, Scharcanski J. and *et.al* [2010], In the proposed a new method for image denoising with edge preservation, based on image multiresolution decomposition by a redundant wavelet transform. In this approach, edges are implicitly located and preserved in the wavelet domain, while noise is filtered out. At each resolution, the coefficients associated to noise and coefficients associated to edges are modeled by Gaussians, and a shrinkage function is assembled. The shrinkage functions are combined in consecutive resolution, and geometric constraints are applied to preserve edges that are not isolated. Finally, the inverse wavelet transform is applied to the modified coefficients. This method is adaptive, and performs well for images contaminated by natural and artificial noise. However, these parameters could be fine-tuned to each individual image to produce optimal results. Future work will concentrate on improving our model for the wavelet coefficients, and extending our work to enhancement of noisy images [4].

Guo-shi Yang , Yun-xia Liu According [2010], they proposed new noise reduction method based on Wavelet modulus maximum for Chaotic signals and Noise, the numerical experiment results confirm the effectiveness of noise reduction for chaotic signals observed [5].

Hancheng Yu, Li Zhao and *et.al* [2009], in this paper they address an efficient algorithm for removing Gaussian noise from corrupted image by incorporating a wavelet-based trivariate shrinkage filter with a spatial-based joint bilateral filter. And In the wavelet domain, wavelet confidents are modeled as trivariate Gaussian distribution then a trivariate shrinkage filter is derived by using the maximum a posteriori (MAP) estimator. Although wavelet-based methods are efficient in image denoising, they are prone to producing salient artifacts such as low-frequency noise and edge ringing which relate to the structure of the underlying wavelet. On the other hand, most spatial-based algorithms output much higher quality denoising image with less artifacts. However, they are usually too computationally demanding. In order to reduce the computational cost, we develop an efficient joint bilateral filter by using the wavelet denoising result rather than directly processing the noisy image in the spatial domain. The filter could suppress the noise while preserve image details with small computational cost. Extension to color image denoising is also presented. We compare our denoising algorithm with other denoising techniques in terms of PSNR and visual quality. The experimental results indicate that our algorithm is competitive with other denoising techniques [10].

Sudha, S.,Suresh, G.R. and *et.al* [2007], the author has studied that the denoising of a natural image corrupted by Gaussian noise is a long established problem in signal or image processing. Even though much work has been done in the field of wavelet thresholding, most of it was focused on statistical modeling of wavelet coefficients and the optimal choice of thresholds. They proposed new method for suppression of noise in image by fusing the wavelet denoising technique with optimized thresholding function, improving the denoised results significantly. Simulated noise images are used to evaluate the denoising performance of proposed algorithm along with another wavelet-based denoising algorithm. Experimental result shows that the proposed denoising method outperforms standard wavelet denoising techniques in terms of the PSNR and the preservation of edge information. They are compared with various denoising methods like Wiener filter, Visu shrink, Oracle shrink and Bayes shrink [11].

Zhen-Xian Lin, and *et.al* [2007], the Wavelet image denoising has been well acknowledged as an important method of denoising in Image Processing. In this paper, the principle of several wavelet denoising methods are described including the Mallat forced denoising, the wavelet transform modulus maximum method, the nonlinear wavelet threshold denoising method and the denoising based on the interrelation of wavelet domain. Also they compare with these methods and give two kinds of improved methods. The results show that it is practicable and effective for image Denoising [12].

Bingsheng Wu, Chaozhi Cai and *et.al* [2013], In the process of signal testing, often exposed to interference and influence of all kinds of noise signal, such as data collection and transmission and so may introduce noise. So in practical applications, before analysis of the data measured, the need for de-noising processing. At present, there are two de-noising methods, the traditional Filtering method and the wavelet denoising method, when in the actual test, different noise and signal with the choice of different denoising methods. Wavelet methods using denoising is an important aspect of wavelet analysis applied to the actual. This article described several commonly used principles of wavelet denoising methods, and achieved wavelet denoising method based on threshold in the Lab VIEW Which is a develop software of virtual instrument. Finally, compared to the wavelet denoising and traditional FFT denoising, and verified the superiority of the wavelet denoising [16].

Di Zhigang , Zhang Jingxuan , Jia Chunrong and *et.al* [2013], in this paper they took the hard threshold method is discontinuous on thethreshold value, and soft threshold method also has defects, A new threshold function is presented to overcome the deffects, and the Simulation results indicate that the new method has improved the effect of Denoising [17].

Yan Wang, Haibin Wang and *et.al* [2010], they studied to compensate for the deficiencies of traditional wavelet threshold shrinkage denoising algorithm and obtain the heart sounds with high SNR, an improved wavelet threshold shrinkage algorithm is proposed in this paper. Finally, the improved threshold shrinkage denoising algorithm is used to do noise reduction for 20 cases of the clinical heart sounds. The results indicate that the improved wavelet threshold shrinkage demonizing algorithm can eliminate noise more effectively, and has strong clinical value [18].

Ma Liyuan, Duan Yonggang , Li Yongjun and *et.al* [2010], A new threshold demonizing method is presented in this paper, which is based on the soft and hard-threshold denoising method and named by `high-order approach method'. This method is flexible and extensively applicable. The principle and applicability of the new method is analyzed. Two common signals in Matlab are chosen to compare the demonizing effect between the new method and others. The result shows that the new method has better demonizing effect and higher SNR [19].

Wei Liu, Zhengming Ma and *et.al* [2006], In this paper, they most commonly used denoising methods use low pass filters to get rid of noise. However, both edge and noise information is high-frequency information, so the loss of edge information is evident and inevitable in the demonizing process. Edge information is the most important high-frequency information of an image, so we should try to maintain more edge information while denoising. From this comes the thesis of this paper. Moreover, they present a newimage denoising method: wavelet image threshold denoisingbased on edge detection. Before denoising, those wavelet coefficients of an image that correspond to an image's edges are first detected by wavelet edge detection. The detected wavelet coefficients will then be protected from denoising set the denoising thresholds based solely on the noise variances, without damaging the image's edges. The theoretical analyses and experimental results presented in this paper show that, compared to commonly-used wavelet threshold demonizing methods, our method can keep an image's edges from damage and can increase the PSNR up to 1~2 dB. Finally, they draw the conclusion that edge detection and denoising are two important branches of image processing. If we combine edge detection with demonizing, we can overcome the shortcomings of commonly-used denoising methods and do demonizing without notably blurring the edge [20].

Donoho, D.L. (1995), In this paper they studied that all the general procedures related to de-noising and compression of one- or two-dimensional signals, using wavelets or wavelet packets [8,9, 23].

IV. Denoising

Denoising should not be confused with smoothing. Smoothing removes high frequencies and retains low frequencies whereas denoising attempts to remove whatever noise is present and retain whatever signal is present regardless of the spectral content of the noisy signal.

In many signal or image processing applications, the input data is corrupted by some noise which needs to be removed or at least reduced [25-27]. Wavelet denoising techniques work by adjusting the wavelet coefficients of the signal in such a way that the noise is reduced while the signal is preserved.

The accuracy of this technique depends on data type and its quality: wave-band, perpendicular and temporal baselines, ground conditions (such as vegetation and snow coverage), tropospheric noise, various techniques have been developed in order to minimize atmospheric and ionographic noise [23].

4.1 Potential disadvantages of noise filters in images

Many types of distortions limit the quality of digital images during image acquisition, formation, storage and transmission. Often, images are corrupted by impulse noise. The intensity of impulse noise has the tendency of being either relatively high or low thereby causing loss of image details. It is important to eliminate noise in images before using them for other image processing techniques like edge detection, segmentation, registration etc. Several filtering methods have been proposed in the past to address impulse noise removal (Wang &Hang 1999). One of the more famous filters for gray scale images is the standard median filter which rank orders the pixel intensities within a filtering window and replaces the center pixel with the median value. Extending the idea of a scalar median filter to color images is not straightforward due to the lack of a natural concept of ranking among the vectors. Color distortion may occur when the scalar median filter is applied separately to every single component of the color vectors. A method called Vector Median Filter (VMF) which considers all the three color components and rank orders the vectors. Various modifications of the standard VMF have been introduced like Directional Median Filter and Central Weighted Vector Median Filter. The biggest drawback of the conventional vector median approaches is that they apply median operation to each pixel, irrespective of it being corrupted or not. An intuitive solution to overcome this disadvantage is to first detect the corrupt pixels and then to apply filtering on those pixels alone [Trygve &Hakon 1999]. One of the main problems with impulse noise detection is that it is difficult to differentiate between an edge and an impulse noise. In the intensity space, both these stand as peaks in their neighborhood. The difference between the center pixel with the minimum and maximum gray value in the filtering window is taken and if greater than a certain threshold, the center pixel is considered as noise. The disadvantage of this method is that the false positive rate is very high and most of the edges also get detected as noise. Coherent processing of synthetic aperture radar (SAR) data makes images susceptible to speckles (Lee,Jukervish 1994). Basically, the speckles are signal-dependent and, therefore, act like multiplicative noise. This report develops a statistical technique to define a noise model, and then successfully applies a local statistics noise filtering algorithm to a set of actual SEASAT SAR images. The smoothed images permit observers to resolve fine detail with an enhanced edge effect. Several SEASAT SAR images are used for demonstration.

V. Wavelet Analysis

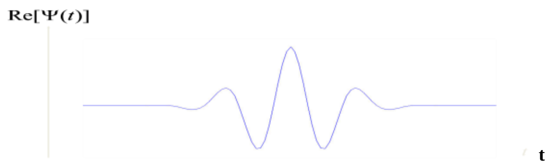
When asked to justify the values of mathematics, mathematicians often point out that idea developed to solve a pure mathematical problem can lead to unexpected applications years later. But the story of wavelet paints a more complicated and somewhat more interesting picture. In a specific applied research led to new theoretical synthesis, which in turn opened scientist eyes to new application. Good science requires us to see both the theoretical forest and practical trees. Through wavelet is organized research topic, it is only decades old, and has been in use for long time in various disciplines under different names. Morlet and Grossman were first to use word ‘wavelet. Stephan Mallat brought out the realtion between wavelet methodology used by Morlet and filter bank theory used in image processing applications. One such dimension of progress is in our recent ability to look beyond Fourier analysis. Fourier analysis has coped up well with naturally occurring sinusoidal behavior like ocean waves, but has not performed well in tackling discontinuities - such as edges of image features. In the recent times, a new form of mathematical technique called wavelet analysis has stormed the corridors of data analysis and its entry into remote sensing information synthesis is also dominant and certain. In contrast to the Fourier sinusoid~ which oscillates forever, a wavelet is localized in time - lasting for a few cycles. The efficiency of wavelets in depicting discontinuities has helped in solving problems of data compression and noise removal Singularities [13].

The main advantage of wavelet analysis is that it allows the use of long time intervals where more precise low frequency information is wanted, and shorter intervals where high frequency information is sought.

- Wavelet analysis is therefore capable of revealing aspects of data that other image analysis techniques miss, such as trends, breakdown points, and discontinuities in higher derivatives and self-similarity.
- Wavelets are also capable of compressing or de-noising a image without appreciable degradation of the original image.

Instead of an infinite sine wave for the transform, use a wavelet:

$$\Psi(t) = e^{jw_0 t} e^{-t^2/2}$$



TYPE OF WAVELET

In this below table given list of wavelet families.

List wavelets families	
Haar	haar
Daubechies	db
Symlets	sym
Coiflets	coif
BiorSplines	bior
ReverseBior	rbio
Meyer	meyr
DMeyer	dmey
Gaussian	gaus
Mexican_hat	mexh
Morlet	morl
Complex Gaussian	cgau
Shannon	shan
Frequency B-Spline	fbsp
Complex Morlet	cmor
Lemarie	lem

Table 1. Wavelets families

Haar is the compactly support wavelet, oldest and simplest wavelet. It also supports orthogonal, symmetry, Biorthogoanl, DWT and CWT [22].

Finding a solution for denoising in Satellite imagery using wavelet

The wavelet transform is a mathematical tool widely used in image processing. Some applications of the transform to remote sensing images have been investigated in the literature. It was found useful for texture analysis, image compression and noise reduction. The transform allows representation of a signal onto an orthonormal basis. Each term of the basis represents the signal at a given scale. In order to decompose the signal onto the basis, the algorithm developed is applied to the signal. It consists of iterations of one-dimensional highpass and low-pass filtering steps. The algorithm creates a pyramid of low-resolution approximations as well as a wavelet pyramid in which the details a stored as wavelet coefficients [6].

Hard Thresholding:

- Ignore signals below noise threshold.
- Sharp transition from on/off.

Soft Thresholding:

- Ignore signals below noise threshold.
- Attenuates low-level signals.
- Smooth transition between on/off.

The denoising estimator is then defined as Set the threshold value [21].

VI. Conclusion And Future Scope

Image denoising has a significant role in image pre processing. As the application areas of image denoising are more, there is a big demand for efficient denoising algorithms. The intention behind this study is to reduce the convergence time of conventional filter and thereby increase its performance. Wavelet based methods are always a good choice for image denoising and has been discussed widely in literatures for the past two decades. Wavelet shrinkage permits a more efficient noise removal while preserving high frequencies based on the disbalancing of the energy of such representation. The technique denoises image in the orthogonal wavelet domain, where each coefficient is thresholded by comparing against a threshold; if the coefficient is smaller than the threshold, it is set to zero, otherwise it is kept or modified. The future scope of study to seek or design robust wavelet filter to remove noise from satellite images very efficiently.

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