COMPARATIVE SURVEY ON IMAGE DENOISING OF HYPERSPECTRAL IMAGES

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ABSTRACT: Removing noise from the original image is a major problem for researchers. Image denoising is a major area of research to get the clear images in the field of simple photography, medical image recognition, satellite image processing etc., Hyper spectral image(HSI) denoising is very essential to the quality assessment of the image. This paper compares the three different methods for denoising the HSI. The methods are multidimensional filtering, wavelet transform and shearlet transform. Shearlet transform is one of the emerging technique and is better in terms of quality measured through the performance evaluation technique such as PSNR (Peak signal to noise ratio), MSE(Mean Square Error) and so on.

Keywords: HSI, PSNR, MSE

I. INTRODUCTION

Hyperspectral imaging collects and processes the information from across the electromagnetic spectrum. The hyperspectral imaging is used to obtain the spectrum of each pixel in the image of a particular scene to find the objects and to identify the materials etc., Hyperspectral image analysis is fastest growing technology in the field of remote sensing based on sensing the scattered and reflected electromagnetic signals from the earth surface. Hyperspectral images used in different fields such as agriculture, material identification, forest monitoring, remote sensing and environmental studies.

Hyperspectral images are obtained from hyperspectral sensors. The images are taken from airborne hyperspectral images such as AVIRIS or HYDICE data set. The hyperspectral sensor are very sensitive to noise. The noise may affect the information and the scene interpretation in an image. So the hyperspectral image denoising is needed for processing the image. Several methods are existing to denoise the image.

Several techniques exist to denoise the each hyperspectral image. Tensor decomposition is one of the method to remove the noise from the signal dependent and signal independent signal of the hyperspectral image. This method is used to remove photon noise from the image. In this method multilinear algebra model is used for removing the noise[4]. Uniqueness of decomposition is problem in tensor decomposition method. To overcome this problem parallel factor analysis (PARAFAC) is used. This model is well suitable for when the hyperspectral image is affected by the additive white Gaussian noise (AWGN) [5]. Noise reduction using genetic kernel tucker decomposition (GKTD) algorithm is used to achieve maximum PSNR[6]. Principle component analysis (PLA) is the method to reduce the noise from the image without harm to the image[7]. Multiple spectral band- conditional random field denoising algorithm reduce the noise from the image. This algorithm is implemented through two training procedure one is CRF-T (conditional random field training) and another method is CRF-IT (conditional random field training and interference)[8].Conditional random field and multinomial logistic regression (MLR) model is for reduce the noise and used for nonlinear measurement[9].

One of the method to denoise the hyperspectral image is a multidimensional filter , which is used to separate noise band and signal band[1]. Other method is used to denoise the hyperspectral image using first order spectral roughness penalty in wavelet domain. It is used to improve the signal to noise ratio[2]. Hyperspectral image denoising using shearlet transform is used to reduce the noise from the image and also prevent the low level of noise band in an image[3].

II. BACKGROUND REVIEW

In hyperspectral noise is distinguished into two types they are random noise such as photon noise, thermal noise and fixed pattern noise such as striping noise, periodic noise, interference noise. Widely available noise in the hyperspectral image is Gaussian noise. To remove the Gaussian noise there are many methods. They are compared here. This paper proceeds as follows. Chapter three deals with denoising of hyperspectral image using multidimensional wiener filter. Chapter four deals with denoising using first order spectral roughness penalty in wavelet domain. Chapter five discusses about the denoising using shearlet transform. Performance evaluation is discussed in the chapter six whereas conclusion is given in the seventh chapter.

III. DENOISING USING MULTIDIMENSIONAL FILTER

Multidimensional wiener filtering is one of the technique is used to denoise the image. When the noisy bands are closed to the signal band which is very difficult to separate. This technique is used to separate the signal bands from the noisy band and it used to improve the signal to noise ratio. Denoising using multidimensional filter is based on the factorization or matricization.

The HSI image is divided into vectors or matrices and processed separately. Straight lines can model the main directions around which most of information is focused. In order to estimate the main direction of the image using straight line detection (SLIDE) algorithm and also used Hough transform. The image discontinuities is achieved by the quad tree based partitioning. This filter method is used to reduce the rank of matrices and also used to improve the signal to noise ratio. This method is suitable for small targets. Fig 1 shows the graph of quality criterion (QC) component with respect to SNR. Here the signal to noise level is varying from 4 to 16 dB, this is very useful to denoise the soft noisy and also improve the QC component.

IV. DENOISING USING FIRST ORDER SPECTRAL ROUGHNESS PENALTY IN WAVELET DOMAIN

First order spectral roughness penalty in wavelet domain (FORP) method is used to remove the noise from the image and is used for multi resolution analysis (MRA). Tuning parameters are chosen by Steins unbiased risk estimator (SURE) algorithm. First order spectral roughness penalty method is used to increase the quality of the image. Very large size of the hyperspectral image can be denoised using this method in very effective manner. When compare to the other denoising methods this techniques is very useful to reduce the time and is used to improve the signal to noise ratio. Fig 2 shows the decomposition level with respect to SNR. Here SNR is improving after third levels, after fifth levels there is no improvement in SNR.

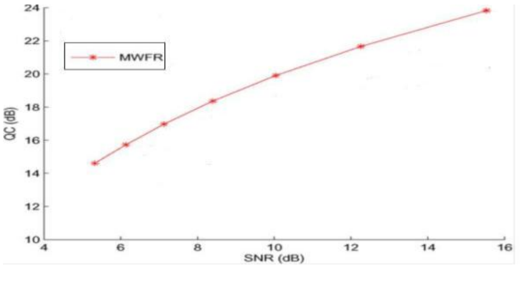

Fig1. QC with respect to the SNR for filter model.

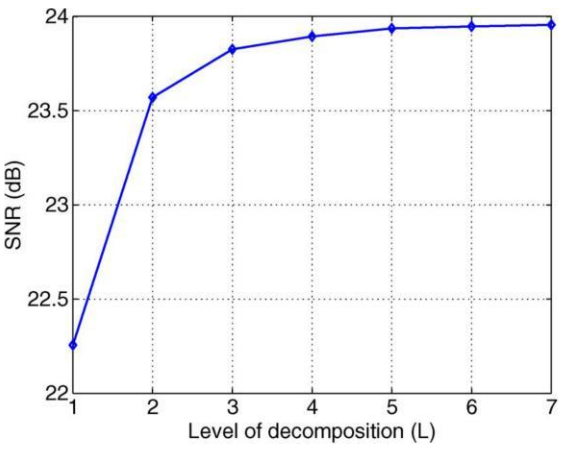

Fig2 shows the decomposition level(L) on SNR

V. DENOISING USING BAND SPECIFIC BASED SHEARLET TRANSFORM

Hyperspectral image noise is different from band to band. When denoising is applied to the whole image the low level of noise band will affect, so better to use different methods for different band. HSI into two bands based mean correlation the bands are Low level of Gaussian noise band (LGN) and mixed noise band (MN). Mean correlation is lower than the threshold value, then the band is MN band. Otherwise LGN band.

Mean correlation for differentiating MN bands and LGN band

P(i) = ——— i=i……,I3

If correlation coefficient of LGN band is close to one means, whereas MN band has the low correlation coefficient.

The threshold value is
defined as, Thr = median(P)

Additive noise model is used for LGN bands. LGN bands are de-noised using Bayes Shrink threshold method. For MN bands shearlet coefficient of adjacent LGN bands are fused into the MN bands.

Bayes shrink algorithm

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 02 Issue: 08 | Nov-2015 www.irjet.net p-ISSN: 2395-0072

$T_{p,q} = \sigma^2_{N,p,q} / \sigma_{p,q}$

$\sigma^2_{N,p,q}$ indicate the noise variation at scale p and direction q. $\sigma_{p,q}$ indicates the standard deviation of the signal.

Here hyperspectral image are denoised using non subsampled shearlet transform (NSST). NSST is implemented into two types they are non subsampled pyramid (NSP) and non subsampled shearing (NSS). NSP filter banks create the decompose of original image to the high frequency or low frequency. NSS filter banks are used to decompose the high frequency into directional image.

Hyperspectral image is divided into sixteen blocks using the shearlet transform which is used to denoise the hyperspectral image very easily. This shearlet transform is used to denoise the image in very effectively. The flow diagram will show the denoising steps of hyperspectral image using shearlet transform.

1. ALGORITHM

Input image: hyperspectral image with noise X (size $I1 \times I2 \times I3$) Step1: differentiating the bands using

S(i) < threshold, then the band is a MN band

S(i) ≥ threshold, then the band is a MN band

Step2: apply the NSST for HSI

For implement NSST through two steps

(i)NSS

(ii)NSP

Step3: apply inverse NSST

These are the algorithm of band specific based hyperspectral image denoising. The flow diagram shows the flow of the denoising of hyperspectral image using shearlet transform.

2. FLOW DIAGRAM OF THE SYSYTEM

In band specific based shearlet transform, first the input image is taken to denoise the image. The appropriate noise is added to the input image. There are many noise present in the hyperspectral image such as speckle noise, white Gaussian noise, poission noise. In a noisy image, the noise band have low level of noise and high level of noise band, using the threshold technique the noisy bands are separated from the signal band to get the denoise the image. The threshold technique is used to divided the bands into low level of Gaussian noise and mixed noise band.

In this method the image dividing into sixteen coefficients to denoise the hyperspectral images which will not affect the quality of the image. The non subsampled shearlet transform is applied to the noisy bands. The two steps are used to implement NSST, they are non subsampled pyramid and non subsampled shearing. Then the image is divided into sixteen blocks according to the shearlet transform. Each and every block of the hyperspectral image is denoised. The inverse NSST is applied to the image to get the reconstructed image. Finally to get the denoised hyperspectral image. The ultimate step is calculate the signal to noise ratio for the reconstructed denoised image. The fig 5 image shows completely removing the noise form the image without losing any edge information from the image.

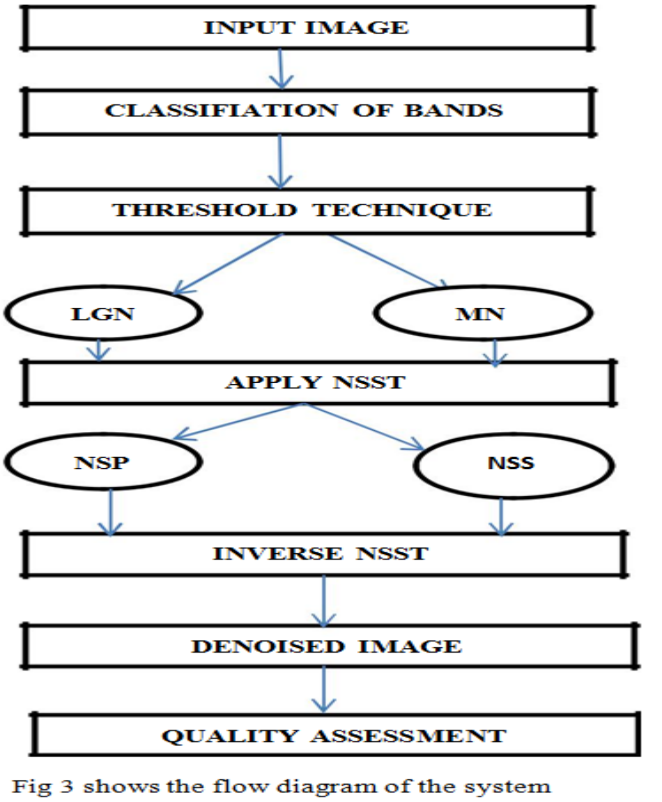

Fig 3 shows the flow diagram of the system

When applying the shearlet transform the image is divided into eight coefficients then it is again divided into sixteen coefficients. These coefficients are used to improve the quality of the image. Then the image is denoising using NSST. This transform is better than the wavelet transform because this will give the high peak signal to noise ratio and low mean squared error. This performance evaluation is better than other denosing methods of hyperspectral image denosing.

fig4 shows the original HYDICE image.

Fig5 shows the result image using shearlet transform

VI PERFORMANCE EVALUATION OF DENOISED IMAGE

S.NO	METHODS	PSNR
1.	Multidimensional wiener filter	16
2.	First order spectral roughness penalty in wavelet domain	23.95
3.	Shearlet transform	33.59

VII. CONCLUSION

In this paper three methods were discussed. On comparing these three techniques, shearlet transform is better to denoise the hyperspectral image. Shearlet transform is used to divide the hyperspectral image is divided into LGN and MN band. Different techniques are used to denoise these bands. LGN bands are used to denoise by the threshold techniques. MN bands are denoised using shearlet coefficients of adjacent LGN bands. The signal to noise ratio is higher when using shearlet transform when compared to the other methods of denoising techniques.

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