Noise Removal Technique Using Curvelet Transform and Filtering approach of Satellite Images

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Abstract : *Noise removal from Satellite Images is a major area of research and there are many techniques used for this process. Due to the presence of noise the images are corrupted and the information present in the image is not clearly visible.Many transform techniques and filters were used for removal of noise and enhancement of images.In this paper we use Curvelet transform which is a multiscale directional transform that allows an almost optimal nonadaptive sparse representation of the object with edges. Curvelet transform has the advantage of handling curve discontinuities very well. Curvelet transform is used in this paper to remove the noise present in the image and also to improve the edges. Filters like Gabor filter and Unsharp filter is also used along with curvelet to remove the noise and to increase the sharpness of the image. Quantitative parameters like PSNR,Entropy is used to measure the quality of the image.The results shows the superiority of the proposed method.*

Keywords : Curvelet, Gabor, Unsharp, Noise,Edge.

I INTRODUCTION

Image enhancement process is used widely in many applications. The images required for this purpose is to be of high quality , but most of the images are corrupted by different types of noises due to which the information present in the image is clearly not visible ie. the image is degraded .There are many techniques used for Satellite image enhancement , but still the some improvement is needed to get a high quality images.
So this paper discusses the method of noise removal from the satellite image using Curvelet transform and also by filters like Gabor and unsharp filters.

During the last two decades, wavelet-based enhancement approaches have been used extensively. However, the wavelet transform is not capable of diagnosing the direction of any line shaped discontinuity in the image because of its isotropy. The curvelet transform which developed by candes and donoho, allows an optimal sparse representation of objects, due to its high directional sensitivity and anisotropic property. It has been shown that the curvelet-based enhancement method has presented better performance than wavelet-based method [8].

Curvelets form an effective model that not only considers a multiscale time frequency local partition but also uses geometric feature direction.This transform was designed to represent edges and other singularities along edged and curves much more efficiently than traditional transforms(i.e.) using many fewer coefficients for a given accuracy of reconstruction.

The paper is organized as follows: Section 2 describes about the different types of noise models, description of curvelet transform is given in section 3, section 4 describes about the different filters used for noise removal, proposed methodology is described in section 5 and finally in section 6 results and conclusion are given.

II NOISE MODELS

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image
noise is generally regarded as an undesirable by product of image capture[2].

* Random noise

It is a form of random stochastic process, characterized by large number of overlapping transient disturbances occurring at random, such as thermal noise and shot noise. Random noise is characterized by intensity and color fluctuations above and below the actual image intensity [2].

* Gaussian noise

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity. Additive white Gaussian noise is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of amplitude. Wideband Gaussian noise comes from many natural sources such as thermal vibrations of atoms in conductors, shot noise, black body radiation from the earth and other warm objects. This channel is a good model for many satellite and deep space communication links [2].

* Salt and Pepper Noise

It represents itself as randomly occurring white and black pixels. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching take place [2].

* Speckle noise

It is a granular noise that inherently exists in and degrades the quality of the active radar and Synthetic Aperture Radar images. The signal and the noise are statistically independent of each other. The sample mean and variance of a single pixel are equal to the mean and variance of the local area that is centered on that pixel[2].

* Poisson Noise

Many images such as those from radiography, contains noise that satisfies a poisson distribution. The magnitude of Poisson noise varies across the image, as it depends on the image intensity. This makes removing such noise very difficult. Poisson images occur in many situations where image acquisition is performed using the detection of particles (e.g) counting photons being emitted from a radioactive source is applied in medical imaging like PET and SPECT and hence Poisson noise reduction is an essential problem[2].

III CURVELET TRANSFORM

The curvelet transform is a multiscale directional transform that allows an almost optimal nonadaptive sparse representation of objects with edges [1].The various steps followed in Curvelet transform are
* Subband Decomposition
* Smooth Partition and Renormalization
* Ridgelet Analysis

In the subband decomposition the image or the object is divided into several subband layers of different frequencies (low pass and high pass). In Smooth Partitioning a window function is defined and the function is multiplied by the window function. The image becomes smooth after multiplying by the window function. The partitioning of the image makes much easier to analyze local lines or curve singularities. In Renormalization procedure each square resulting from the previous stage of smoothening is renormalized to unit square (i.e.) centering each dyadic square to the unit square [10].

Ridgelet Analysis: Each normalized square is analyzed in the ridgelet system. Windowing procedure defined earlier creates ridges of certain width and length. These edges are encoded efficiently by ridgelet transform. In Inverse curvelet transform procedures like Ridgelet synthesis, Renormalization, Smooth Integration and Subband recomposition is
 performed. Curvelet transform is used in many applications like Image denoising, Image Enhancement, Compressed Sensing [10].
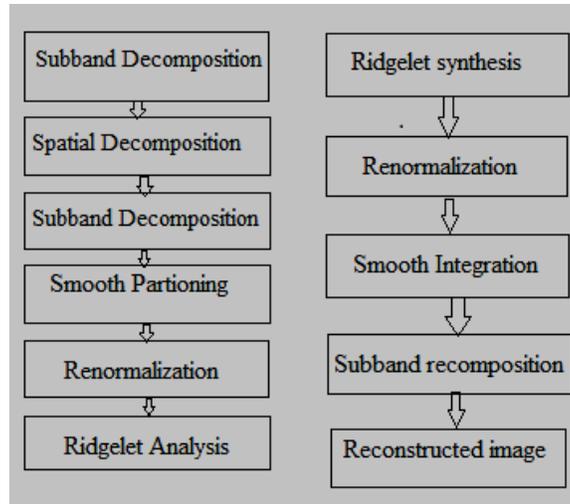
Fig:1 Curvelet transform process

The above diagram indicates the process of curvelet transform.

IV FILTER USED FOR NOISE REMOVAL PROCESS

*Gabor filter

Curvelet Gabor filters are mainly recognized as one of the best choices for obtaining frequency information locally. The Log-Gabor filter function always has zero DC components which not only improve the contrast ridges but also edges of images [3].

*Unsharp Filter

The unsharp filter is a simple sharpening operator which derives its name from the fact that it enhances edges (and other high frequency components in an image) via a procedure which subtracts an unsharp, or smoothed, version of an image from the original image. The unsharp filtering technique is commonly used in the photographic and printing industries for crispening edges [11] .

*Median filter

Median filter is a best order static, non- linear filter, whose response is based on the ranking of pixel values contained in the filter region [4].

* Order-Statistics filters

Order-Statistics filters are non-linear filters whose response depends on the ordering of pixels encompassed by the filter area. When the center value of the pixel in the image area is replaced by 100th percentile, the filter is called max-filter [4].

*Adaptive filter

These filters change their behavior on the basis of statistical characteristics of the image region, encompassed by the filter region [4].

V PROPOSED METHODOLOGY

In the proposed method noise is removed from satellite images using combination of curvelet transform and filtering techniques.

First the satellite image is taken as the input and noise is added to the input image.Noises like Gaussian noise, Salt & Pepper noise is added to the input image and then curvelet transform is applied to the input image.Gabor filter is also used in addition with curvelet for effective noise removal and then inverse curvelet transform is applied to the image. As the image should look better in terms of sharpness finally unsharp filter is applied so that the image is sharpened and we get the output enhanced image in terms of noise removal and sharpness.

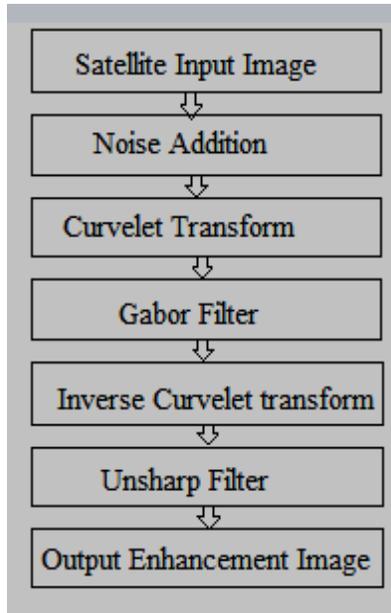The below diagram describes the process of the proposed methodology

Fig:2 Process followed in the proposed methodology for noise removal.

Quantitative parameters like PSNR, Entropy is used to evaluate the quality of the satellite output image obtained.

VI RESULTS

The image obtained at the output looks better visually and the quantitative value like PSNR is also high for both the types of noises (Gaussian,Salt & Pepper) added .The Entropy of the image i.e the information content present in the image is sufficiently good and these values are given in the below mentioned table and output images are also given below.
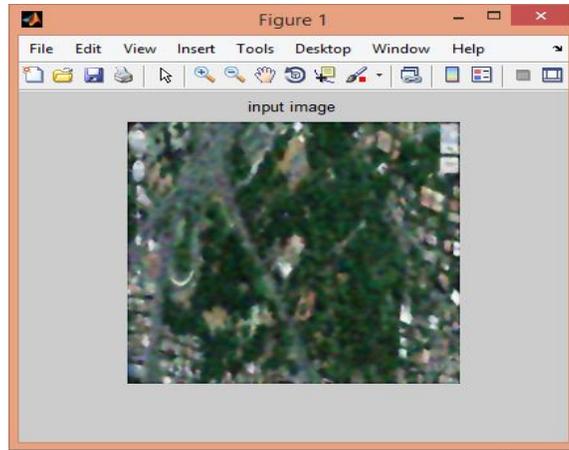
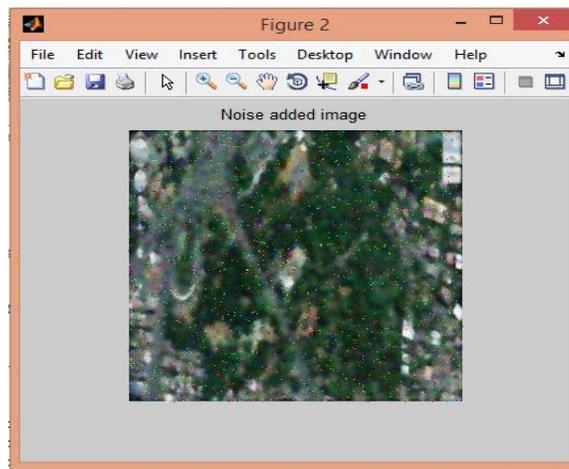### FOR SALT AND PEPPER NOISE

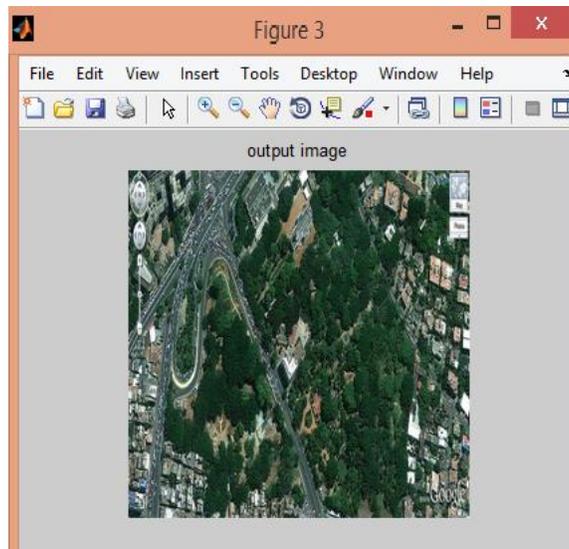**Fig:3 Input satellite image.**

Fig:4 Noise added image.

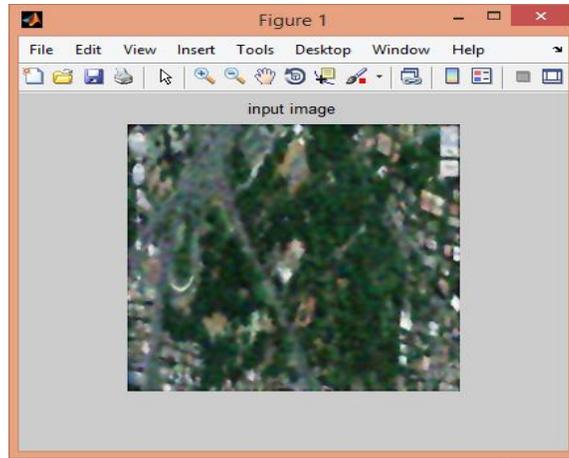**Fig:5 Output enhanced satellite image.**

FOR GAUSSIAN NOISE

Fig:6 Input satellite image.
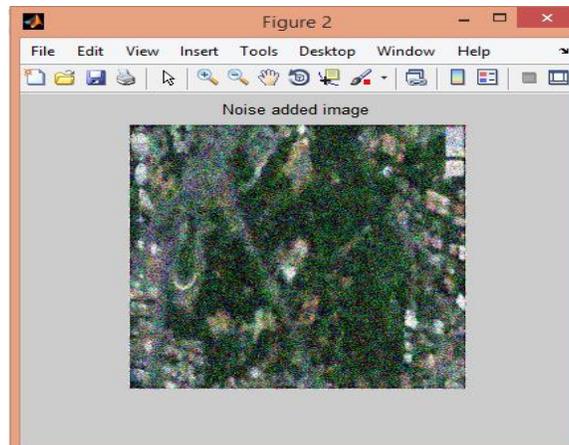
Fig;7 Noise added image..
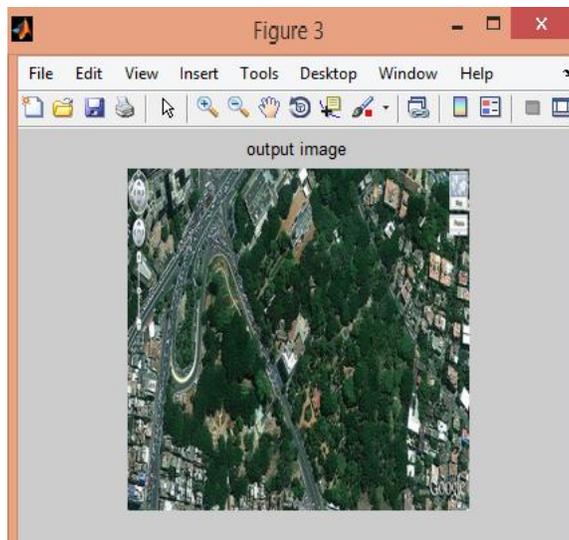
Fig:8 Output enhanced satellite image.

TYPES OF NOISE	P.S.N.R	ENTROPY
1.SALT AND PEPPER	75.3696	7.1426

2.GAUSSIAN	75.3265	7.2039

Table 1: PSNR and Entropy values of the different types of noises

VII CONCLUSION

From the above results (Image and quantitative values) it is clear that the proposed method performs better and there is an improvement in the quality of the image.The image is enhanced by the process of removal of noise and increase in sharpness of the image.

VIII REFERENCES

[1]. .Jianwei   Ma   and   Gerlind   Plonka, "The Curvelet Transform-A review of recent applications"IEEE Signal Processing Magazine –March 2010.

[2]. . D. Mary sugantharathnam ,. D. Manimegalai, "The Curvelet Approach for Denoising in various Imaging Modalities using Different Shrinkage Rules" International Journal of Advanced Research in Computer Engineering & Technology(ISSN: 2278 – 1323) Volume 29– No.7, September 2011.

[3]. . Vishal Garg, Nisha Raheja, "Image Denoising Using Curvelet Transform Using Log Gabor Filter" International Journal of Advanced Research in Computer Engineering & Technology(ISSN: 2278 –1323) Volume 1, Issue 4, June 2012.

[4]. . Rohit Verma , Jahid Ali, "A Comparative Study of Various Types of Image Noise and Efficient Noise Removal Techniques" International Journal of Advanced Research in Computer Science and Software Engineering(ISSN: 2277 128X) Volume 3, Issue 10, October 2013.

[5]. . Pawan Patidar, "Image De-noising by VariousFilters for Different Noise" International Journal of Computer Applications (0975 – 8887) Volume 9– No.4, November 2010.

[6]. . Jean-Luc Starck, Fionn Murtagh, Emmanuel J. Candès, and David L. Donoho, "Gray and Color Image Contrast Enhancement by the Curvelet Transform" IEEE transactions on image processing, vol. 12, no. 6, june 2003.

[7]. . Jean-luc starck, Emmanuel J. Candès, and David l. Donoho, "The Curvelet Transform for Image Denoising" IEEE transactions on image processing, vol. 11, no. 6, june 2002.

[8]. . Ying Li, Huijun Ning Yanning Zhang and David Feng, "Nonlinear Curvelet Diffusion for Noisy Image Enhancement"2011 18th IEEE international conference on image processing.

[9]. Charles Boncelet (2005)."Image Noise Models". in Alan C. Bovik. Handbook of Image and Video Processing.

[10]. Tutorial on Directional Wavelet Transform:Curvelet R00943129, 電子所 林祐民.

[11]. homepages.inf.ed.ac.uk/rbf/HIPR2/unsharp.htm

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