Denoising Algorithm for Liss - Iii Remotely Sensed Data Using Filters and Wavelet Transform

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Abstract:- Denoising is a tremendous application of Remote sensing. Noise in remote sensing images occurs during the data acquisition. The prime focus of this paper is to denoise using filtering and wavelet approach. As a further matter, we have showed the performance of these filters which has been analyzed by providing a short interpretation of Peak Signal to Noise Ratio, Mean Square Error, L2rat, Maxerr. The satellite image data which has been chosen consists of four spectral bands of Salem region. The image which is being selected for the process of denoising is put through conversion to JPEG format and then subjected to Impulse noise comprising both Gaussian noise and Salt and pepper noise. The filtering techniques are then applied for denoising which includes Median 3x3, Median 5x5, Wiener 3x3, Wiener 5x5, Adaptive Median 3x3, Adaptive Median 5x5. For achieving a better image quality, Multilevel 2D Haar wavelet transform is used. Thus, this work furnishes the simulated results and a clear comparison of the efficiency of the above-mentioned filters on noisy remote sensing images.

Key Words: Wiener, Median, Adaptive Median, Haar.

I. INTRODUCTION

Satellite images provide information about an area, object or phenomenon. Earth observation satellites are satellites specifically designed for environmental applications which include gathering of information about planet Earth's physical, chemical and biological systems via remote sensing technologies. The preprocessing technique is a preparatory phase to improve image quality. Denoising is one of the preprocessing techniques to remove the noise in order to maintain accuracy of original data for better interpretation of data. Noise in satellite images occurs due to the factors such as sensor characteristics, atmosphere, weather, geometry of the earth and acquisition methods. Impulse noise in satellite images is classified as Gaussian noise and Salt and pepper noise. Gaussian noise occurs during data acquisition. It is also known as additive noise since it is a representation of the sum of the original pixel value and the noisy pixel value. Salt and pepper noise is represented by equal probability of white and black pixels. It will have dark pixels in bright regions and bright pixels in dark regions.

II. FILTERING TECHNIQUES

A. Median Filter

It is a non - linear filter and is efficient in removing salt and pepper noise. The median filter considers each pixel in the image and takes into account the matrix of neighboring pixels corresponding to the window size mentioned. The median is calculated by sorting all the pixel values from the neighborhood into numerical order and then replacing the pixel which is being considered by the middle pixel value. The median value is the brightness value. The median is more robust than mean filter. It is also much better in preserving the edges since the new value is replaced by the median value which is already present in the matrix.

B. Adaptive Median Filter

Adaptive median filter is a linear type of filter which is used to preserve the fine details and smooth non- impulsive noise of the image. Adaptive median filter performs spatial processing to determine the pixels affected by noise by noise by comparing each pixel in the image to its surrounding neighbor pixels. The advantages of this type of filter is that they do not erode away edges or any other small structure. It works well for impulsive noise greater than 0.2 and overcomes the drawbacks of median filter.

C. Wiener Filter

Wiener filtering technique is a linear estimation of the original image and works efficiently in removing the additive noise and reduces the Mean Square Error (MSE) value as much as possible. Thus the difference between the original signal and the new signal will become as low as possible. It also delivers high Peak Signal to Noise Ratio (PSNR) value. It is not an adaptive filter as it assumes input to be stationary.

D. Haar Wavelet Transform

Wavelet transform is a mathematical tool for processing and analyzing the image. Haar wavelet is the simplest possible wavelet and is a type of Discrete wavelet function and sequence of rescaled square shaped functions. It calculates the sums and differences of adjacent horizontal elements and then adjacent vertical elements. It does not have overlapping windows and has a total of 2 coefficients namely scaling and wavelet. It takes a very short computation time and is memory efficient.

III. EXPERIMENTAL WORK

A. Data used

Our work starts with the collection of image for the process of denoising. We have chosen the Multispectral image captured by the LISS-III sensor in ResourceSat-1. The image gets downloaded in four bands B2, B3, B4, B5 in which the first 3 spectral bands has a resolution of 24m in the region of Visible and near Infrared (VNIR) and the fourth band has a resolution of 70.5m in the region of Short Wave Infrared (SWIR). The wavelength range of the four bands is given below.

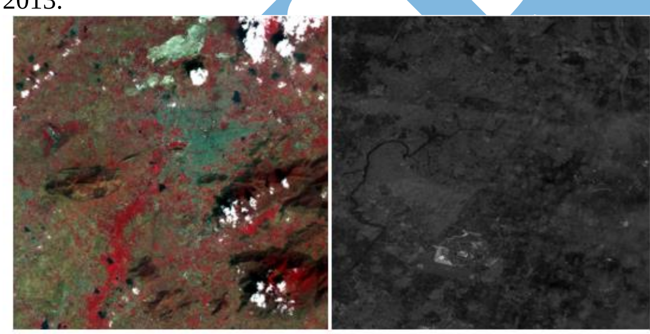
$B_2 \rightarrow 0.52 - 0.59$

$B_3 \rightarrow 0.62 - 0.68$

$B_4 \rightarrow 0.77 - 0.86$

$B_5 \rightarrow 1.55 - 1.70$

The image downloaded is in Geotiff format. Hence it is subjected to JPEG conversion using ENVI software so that it is possible to view in an ordinary image viewer. Dimension of the image is 1151 x 1151. The horizontal and vertical resolution of the image is 96 dpi. Size [Byte] 278,811 bytes. Coverage [Lon/Lat], Upper left: X=78E; Y=11.75N, Upper right: X=78.25E; Y=11.75N, Lower right: X=78.25E; Y=11.5N, Lower left: X=78E; Y=11.5N. Image captured on January 19 2013.



a) b)

Fig. 1. (a) RGB image of LISS-III Remote Sensing Image of Salem Region (b) Grayscale image of LISS – III Remote Sensing Image of Salem Region

B. Filters and Wavelet

The input image is subjected to simulation using MATLAB for denoising using the filtering and wavelet transform techniques. First of all, we add impulse noise to the image and the resizing of the image is done. Then the Gray conversion module for the image is implemented. First of all, median filtering is applied to the image and corresponding Haar wavelet is applied to enhance the image quality. The wiener filter is also known as smooth filter. The wiener filter can be implemented in terms of power spectra of the original image and the additive noise. A direct estimate is the periodogram estimate of the power spectrum and the computation is given by the formula

$$S_{yy}^{per} = \frac{1}{N^2}\left[\,Y(k,l)\;Y(k,l)^*\right] \qquad (1)$$

Where, Y (k, l) is the DFT of the observation.

Next the adaptive median filter. It is also known as sharp filter since it removes the noise and also sharpens the details of the image. The adaptive median filter uses a windowing scheme to identify the impulse noise pixels. The equation used to calculate the weight of each window is given by

$$d^k = \frac{\left|\sum w_{i+s,j+t} * \left(f_{i+s,j+t} - f_{i,j}\right)\right|}{\sum w_{i+s,j+t}} \qquad (2)$$

Haar wavelet transform is famous for its simplicity and speed of computation and the matrix is said to be real and orthogonal. Two types of coefficients are obtained from Haar wavelet transform namely scaling coefficients and wavelet coefficients. In Haar transform, input and output length are the same. Haar transform will be applied first column by column and the row by row.

Let us consider two numbers x and y for which the forward Haar wavelet transform is given by

$$Average, a = \left(\frac{x+y}{2}\right) \qquad (3)$$

$$Difference, d = \left(\frac{x-y}{2}\right) \qquad (4)$$

Inverse Haar wavelet transform is applied to get the original sample values and the formula is given by

$$x = \left(\frac{a-d}{2}\right) \qquad (5)$$

$$y = \left(\frac{a+d}{2}\right) \qquad (6)$$

The above formulas will be used for the image matrix. At each step, the matrix elements are replaced by the new values column by column and then row by row.

C. Performance measure

The performance parameters are most important criteria to justify the simulation results. The Performance metrics considered in our work are Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Ratio of Squared Norm (L2rat), Maximum Absolute Squared Deviation (Maxerr).

Let, X → Real valued image

XAPP → Image approximate with a size equal to that of input data, X

BPS → Bits per Sample in the data

Peak Signal to Noise Ratio (PSNR) is the measure of quality of the image by comparing denoised image with original image. It is only meaningful for data encoded in terms of bits per pixel. Higher the PSNR, better the quality of the compressed or reconstructed image. Mean Square Error (MSE) is the squared norm of the difference between the data and the approximation divided by the number of elements. Maxerr is the maximum absolute squared deviation of the data X. L2rat is the ratio of the squared norm of the image approximation XAPP, to the input image X.

The Peak Signal to Noise Ratio is given by the formula

$$PSNR = 10log_{10}\left(\frac{255^2}{MSE}\right) \quad (7)$$

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[g(i,j) - f(i,j)]^2 \quad (8)$$

Where,

M, N → Total no of pixels in the Horizontal & Vertical dimensions of image.

g → Noise image

f → Filtered image

Maxerr is the maximum absolute squared deviation of the data X, which is given by the formula given below

$$S = \sum_{i=1}^{n} f(x_i)(x_i - x_{i-1}) \quad (9)$$

IV. SIMULATION RESULTS

The experiments were conducted on the Multispectral LISS – III, remote sensing image of Salem region with impulse noise combined with various Filters such as Median 3x3, Median 5x5, Wiener 3x3, Wiener 5x5, Adaptive Median 3x3, Adaptive Median 5x5. The proposed filtering techniques prove to be efficient in each aspect. Wiener filter is efficient in removing Gaussian noise and delivers high PSNR and reduces MSE as much as possible. Median filter delivers good results in removing salt and pepper noise. Adaptive median filter plays a good role in preserving the fine details of the image besides removing the noise from the images. The comparison of the above mentioned filters is clearly portrayed in our work. Haar wavelet transform is applied for the purpose of enhancing the quality of the image, after removing the noise using filtering techniques. The wiener filter is mentioned as smooth filter and adaptive median filter is expressed as sharp filter.

The performance parametric values comparison table for salt and pepper noise is given below in table 1 and the values for Gaussian noise are listed in table 2 and for combined form of impulse noise in table 3. Also the images after the addition of noise and the implementation of filtering and wavelet techniques are also shown here.

A. Salt and Pepper noise

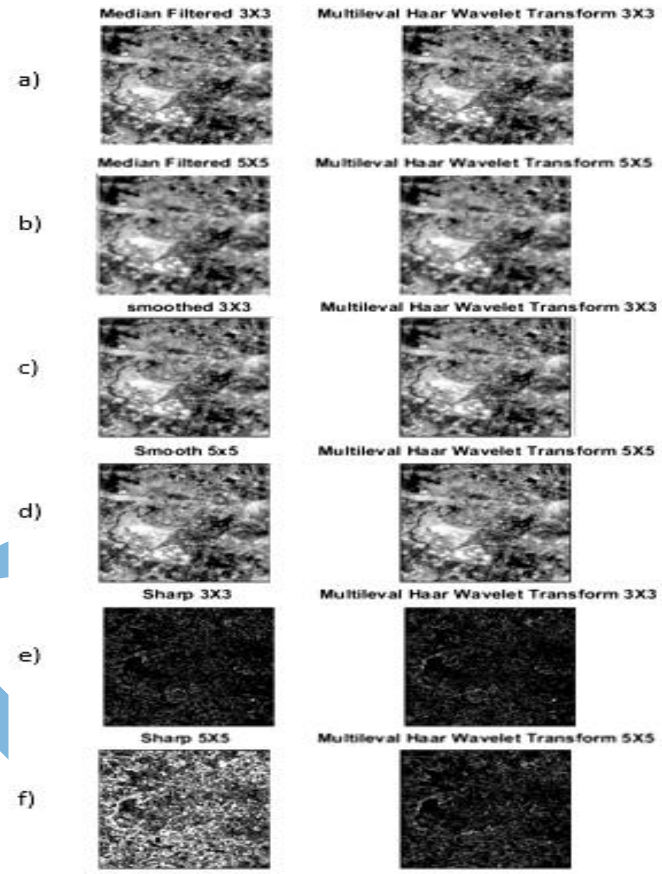


Fig 3: Simulation results for Salt and pepper noise (a) median 3x3 (b) median 5x5 (c) wiener 3x3 (d) wiener 5x5 (e) adaptive median 3x3 (f) adaptive median 5x

B. Gaussian noise

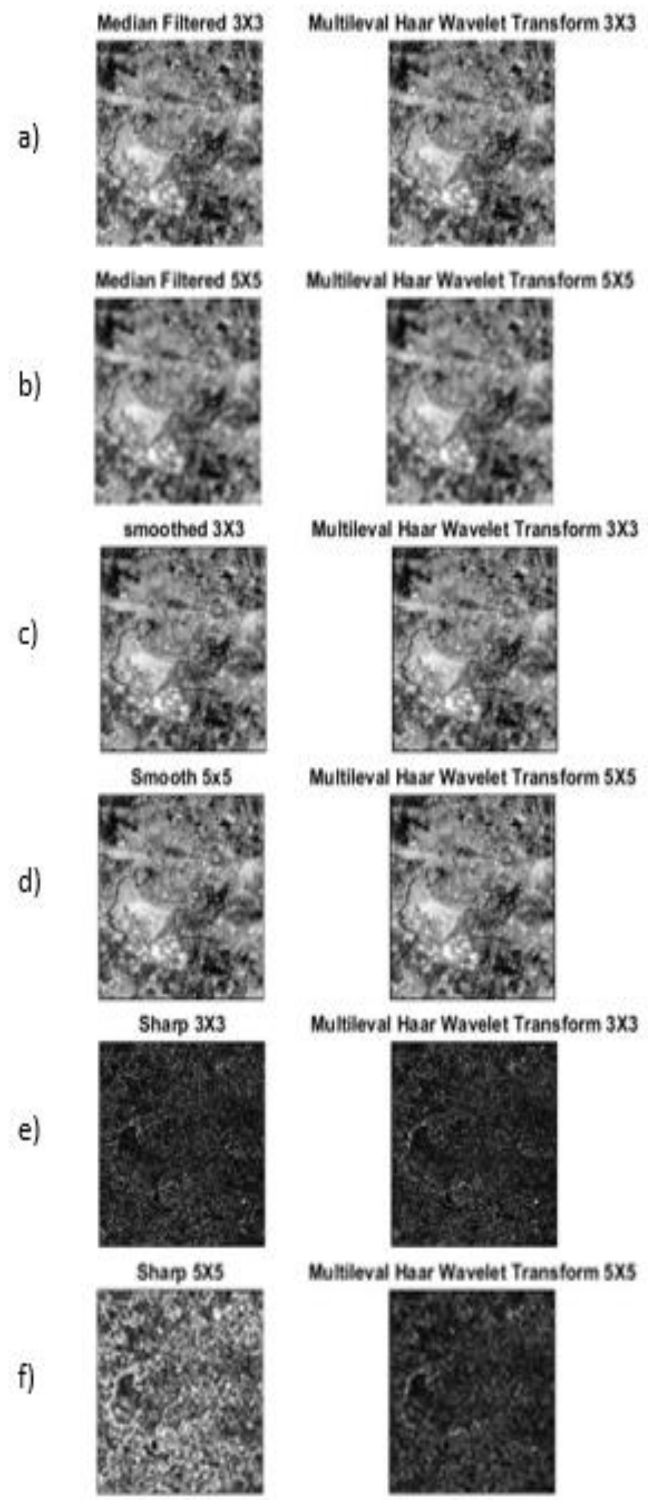


Fig 4: Simulation results for Gaussian noise (a) median 3x3 (b) median 5x5 (c) wiener 3x3 (d) wiener 5x5 (e) adaptive median 3x3 (f) adaptive median 5x5

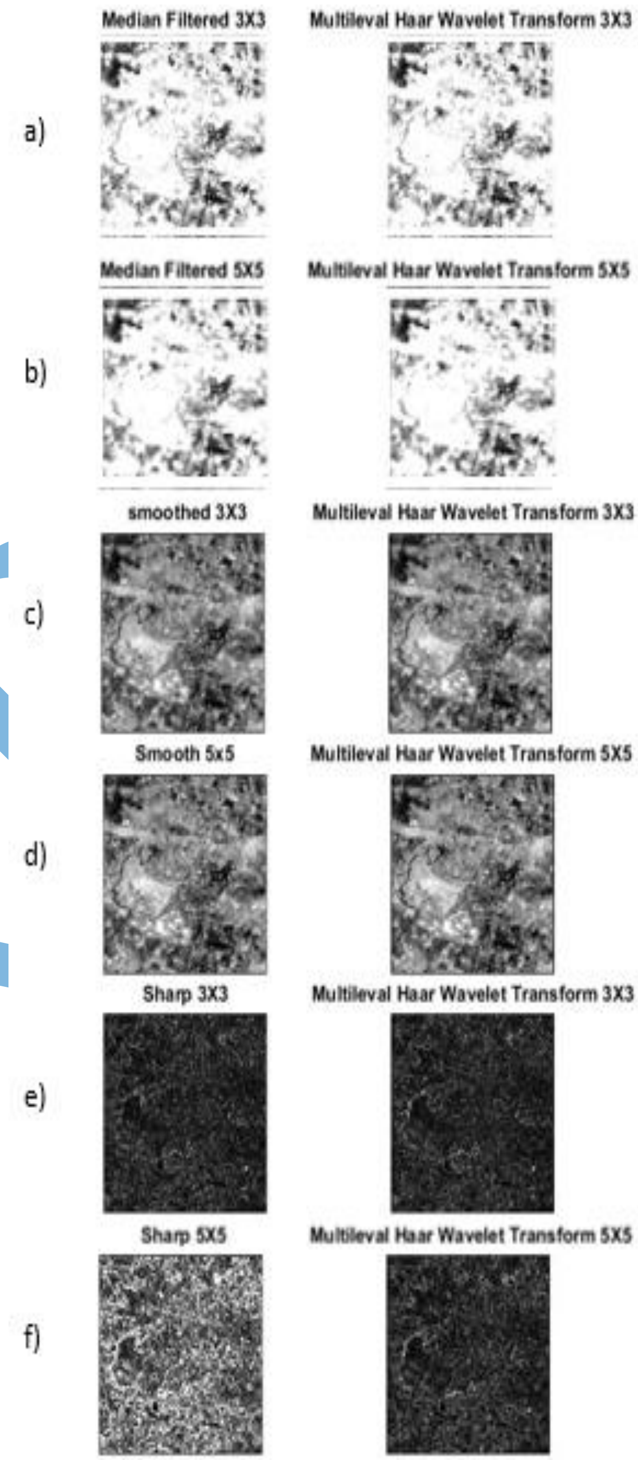


Fig 5: Simulation results for combined form of noise (a) median 3x3 (b) median 5x5 (c) wiener 3x3 (d) wiener 5x5 (e) adaptive median 3x3 (f) adaptive median 5x5

C. Combined form of noise

	PSNR	MSE	Maxerr	L2rat
Median 3X3	34.7901	3.0093	9.1735	0.8204
Median 5X5	33.8511	3.0144	8.4030	0.6397
Smooth 3X3	28.3909	3.3517	8.4811	0.0804
Smooth 5X5	32.1086	3.3490	8.9729	0.0808
Sharp 3X3	26.8990	3.3536	15.7535	0.0802
Sharp 5X5	27.6180	3.3521	12.5921	0.0803

Table 1: Performance measure of Salt and Pepper noise

	PSNR	MSE	Maxerr	L2rat
Median 3X3	35.5583	3.0065	8.9943	0.8902
Median 5X5	34.0602	3.0130	8.1800	0.6714
Smooth 3X3	28.3909	3.3517	8.4811	0.0804
Smooth 5X5	32.1086	3.3490	8.9729	0.0808
Sharp 3X3	26.8990	3.3536	15.7535	0.0802
Sharp 5X5	27.6180	3.3521	12.5921	0.0803

Table 2: Performance measure of Gaussian noise

	PSNR	MSE	Maxerr	L2rat
Median 3X3	28.3987	3.1768	8.4710	0.5681
Median 5X5	28.2466	3.1896	7.7439	0.4590
Smooth 3X3	28.3909	3.3517	8.4811	0.0804
Smooth 5X5	32.1086	3.3490	8.9729	0.0808
Sharp 3X3	26.8990	3.3536	15.7535	0.0802
Sharp 5X5	27.6180	3.3521	12.5921	0.0803

Table 3: Performance measure of Combined noise

V. CONCLUSION

In this paper, we have clearly depicted the comparison of various filters in denoising the Remote sensing images. First, we have added the Gaussian and Salt and pepper noise separately and then in a combined form. We have also portrayed a clear picture of the comparison of filters for impulse noise in separate and combined form Filtering techniques are applied in order to provide a denoised image for high accuracy and better interpretation of data. Each filter plays a very good role in removing the noise efficiently. The image quality is enhanced by applying Haar wavelet transform. The future scope of this work is to implement the proposed denoising techniques in FPGA to analyze the complexity.

VI. ACKNOWLEDGMENT

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