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LITERATURE SURVEY OF GIS AND STUDY OF FILTERING TECHNIQUES FOR NOISE REMOVAL FROM REMOTELY SENSED IMAGES

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ABSTRACT

This paper presents literature survey of GIS, comparative and analytical study among various filters which are usually used for reducing noise from remotely sensed data. During this study several band images from resoursesat-1/ resoursesat-2 satellite using LISS-3/LISS-4 sensors are taken and passed to various filters such as frequency and spatial domain filter for analyzing them using MSE and PSNR to measure their performance in terms of Gaussian noise, salt and pepper noise, feature extraction as well as in terms of effectiveness and efficiency.

KEYWORDS

Wiener, Homomorphic, Sobel, GIS, LISS, SAR, MSE, PSNR, Gaussian, Gradient etc.

INTRODUCTION

In Digital image processing, reduction of noise from images which are captured by sensors of satellite is a challenging task from decades. Many techniques are implemented for reducing speckle noise, salt and pepper noise, Gaussian noise from satellite or radar images. Feature extraction, edge detection, work over components of GIS is also an interested area in GIS.

LITERATURE SURVEY of GIS or REMOTELY SENSED DATA

Reducing noise from the satellite's images is a challenge for the researchers in digital image processing. Several approaches are available for noise reduction. Generally speckle noise is commonly found in synthetic aperture radar images, satellite images [1][2][3]. In remote sensing, information of objects is acquired using technical methods without physical site observation.[4]. Remote sensing consist of several statistical and mathematical methods for measuring radiation of electromagnetic signals about an object or number of objects which resides in long distance for the extracting useful information about them.[5]. Remote sensors are used to capture information about target, objects or area for processing them to analysis of certain information. Remote sensing is used to obtain information about a target or an area or a phenomenon through the analysis of certain information, which is obtained by the remote sensor [6], [7]. Felix Bachofer and co-writer identified that Paleo-shorelines and ancient lake terraces east of Lake Manyara in Tanzania and they were defected from the backscatter intensity of TerraSAR-X StripMap images. This study compares the performance of different combinations of speckle reduction techniques and edge operator in detecting linear paleo-shorelines. The Roberts, Sobel, Laplacian of Gaussian and the Canny edge detector algorithms were applied to extract and revise those linear structures. The comparison shows that the Canny edge detector is especially suitable for images with strong speckle noise [12]. Through this paper writer analyzed effective filtering methods for enhancement of image taken from LISS4/P6 that is satellite of sensing the remotely images which senses images around infrared band. During this study writer used wiener filter, median filter, Gaussian homomorphic filter, and bilateral filter to reduce gaussian and salt and pepper noise. Writers concluded through MSE and PSNR that homomorphic filtering technique with gaussian method is the best [13]. During this work writers propose a novel despeckling algorithm for synthetic aperture radar (SAR) images based on the concepts of nonlocal filtering and wavelet-domain shrinkage. They told and follow the structure of the block-matching 3-D algorithm, recently proposed for additive white Gaussian noise denoising, but modify its major processing steps in order to take into account the peculiarities of SAR images. A probabilistic similarity measure is used for the block-matching step, while the wavelet shrinkage is developed using an additive signal-dependent noise model and looking for the optimum local linear minimum-mean-square-error estimator in the wavelet domain. [14]. During this study writers proposed a general methodology (PURE-LET) to design and optimize a wide class of transform-domain thresholding algorithms for denoising images corrupted by mixed Poisson–Gaussian noise. They express the denoising process as a linear expansion of thresholds (LET) that they optimize by relying on a purely data-adaptive unbiased estimate of the mean-squared error (MSE), derived in a non-Bayesian framework. [15]. T. M. Lillesand told classification of remote sensing images constitutes a challenging problem because of potentially high dimensionality of images and lower number of training samples, the spatial variability of spectral signature, and presence of noise and uncertainty of data[16]. In this paper proposed a two-phase scheme for removing salt-and-pepper impulse noise. In the first phase, they use an adaptive median filter is used to identify pixels which are likely to be contaminated by noise. In the second phase, the image is restored using a specialized regularization method that applies only to those selected noise candidates. In terms of edge

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preservation and noise suppression, restored images shown a significant improvement compared to those restored by using just nonlinear filters or regularization methods only. This scheme can remove salt-and-pepper-noise with noise level as high as 90% [17]. In this paper writer analyzed and told that Synthetic aperture radar (SAR) images are inherently affected by multiplicative speckle noise, which is due to the coherent nature of the scattering phenomenon. In this paper writer and co-writer proposes a novel Bayesian-based algorithm within the framework of wavelet analysis, which reduces speckle in SAR images while preserving the structural features and textural information of the scene. First, they show that the sub band decompositions of logarithmically transformed SAR images are accurately modeled by alpha-stable distributions, a family of heavy-tailed densities. Consequently, they exploit this a priori information by designing a maximum a posteriori (MAP) estimator. Finally, they compare their proposed method to current state-of-the-art soft thresholding techniques applied on real SAR imagery and they quantify the achieved performance improvement [20]. During this study, writer introduces a total variation (TV) regularization model for synthetic aperture radar (SAR) image despeckling. A dual-formulation-based adaptive TV (ATV) regularization method is applied to solve the TV regularization. The parameter adaptation of the TV regularization is performed based on the noise level estimated via wavelets. The TV-regularization-based image restoration model has a good performance in preserving image sharpness and edges while removing noises, and it is therefore effective for edge preserve SAR image despeckling told by writer [21]. In this work, they have applied various filters on remote sensing images for de noising them. In a simulation, they took remote sensing images and analyzed it with an Average filter, Median filter, un sharp filter and Wiener Filter and using statistical quality measures. The analysis of effect of noise removal technique is given in this paper [22].

MATERIAL AND METHODS

During this study, I have taken band images from resoursesat-1/ resoursesat-2 satellite using LISS-3/LISS-4 sensors through Indian Geo-Platform of ISRO [29]. Self-Scanning Sensor (LISS) capture band images, which operates in three different spectral bands in VNIR named band2, band3, band4 and one band in SWIR with 24-meter spatial resolution and a swath of 141 km. This data is received from Linear Imaging and Self-Scanning Sensor (LISS) we have taken following two images. The first one data is the image of urban area of Agra District in Uttar Pradesh taken on two different dates and the second one data is the image of urban area of Mathura District in Uttar Pradesh. We have cropped three images from data filtering. The detail of images is given as follows:

Figure-1
Uttar Pradesh: Agra District
Taken from Resoursesat-1/Resoursesat-2 through LISS-3/LISS-4, through ISRO.

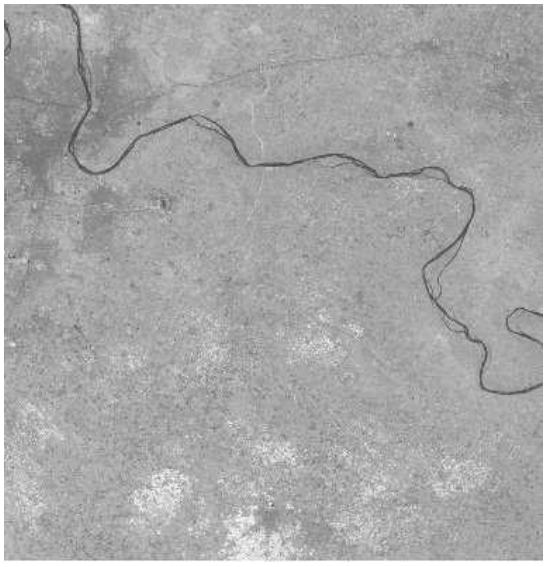
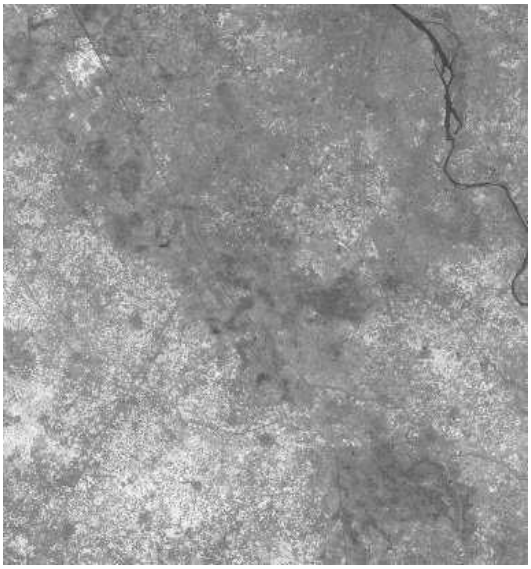


Figure-2
Uttar Pradesh: Mathura District
Taken from Resoursesat-1/Resoursesat-2 through LISS-3/LISS-4, through ISRO.



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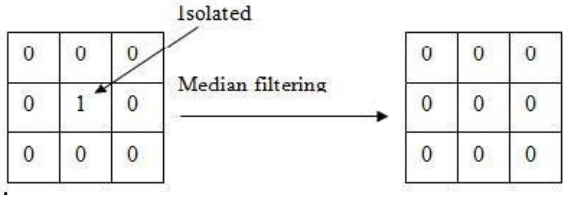
SPECIFICATION OF FILTERS FOR REDUCING NOISE FROM REMOTELY SENSED DATA

Median Filter

Median is the mid value of any given data set. In median filtering every and each pixels is replaced by the grey level median of neighborhood pixels. [24.] We can understand it by $x(n)$ and $y(n)$ as:

$$\text{median}\, x(n)\ \ y(n) \text{ median}\, x(n) \text{ median}\, y(n) \quad \text{.....(i)}$$

Figure-3: Median Filtering
(Taken from *Digital Filters: Analysis and Design[24]*

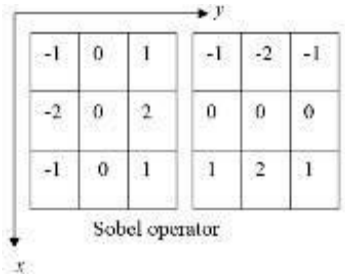


Sources: Authors Compilation

Sobel Operator[25]

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°.

Figure-4: Sobel Filter
(Taken from Digital Filters: Analysis and Design[25.])



Sources: Authors Compilation

The kernels of sobel are designed horizontally and vertically. For input image kernels are applied for measuring the gradient Gx and Gy. These gradients are:

$$G_x \quad x_7 \ 2x_8 \ x_9 \ x_1 \ 2x_2 \ x_3 \quad \text{.....(ii)}$$

$$G_y \quad x_3 \ 2x_6 \ x_9 \ x_1 \ 2x_4 \ x_7 \quad \text{.....(iii)}$$

It is a common practice to approximate the overall gradient by taking the sum of the absolute values of these two:

$$f \quad G_x \quad G_y \quad \text{.....(iv)}$$

The *direction* of the gradient is:

$$\tan^{1} \frac{x}{G_y} \quad \text{.....(iv)}$$

Wiener Filter

The method of wiener filter works between undegraded and original image to find out optimal solution and it enforce a minimum mse constraint. [26][27]. During application of wiener variance and local mean around each pixel is calculated.

$$\mu = \frac{1}{n2)} \sum_{n1,n2\in\eta} (n1, \quad \text{.....(vi)}$$

$$\sigma^2 = \frac{1}{} \sum_{n1,n2\in\eta} ^2(n1,n2) - \quad \text{.....(vii)}$$

here n is N*M neighbourhood pixel. Following estimate is used to create wiener filter using pixel wise:

$$(n_2) = \mu + \frac{^2 - ^2}{^2} ((n_2,) -) \quad \text{.....(viii)}$$

here v^2 is called the variance of noise. If variance noise variance is not given, then two-dimensional uses the average of all local estimates [28].

Gaussian Homomorphic Filter

It is a technique of filtering for frequency domain. It is used for signed and image processing, it is involved in non-linear processing to different domain where we can apply the techniques of linear filtering . Brightness is also normalized and Gaussian noise is also removed.

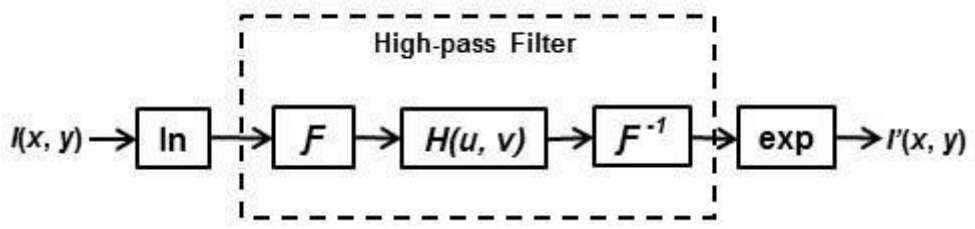
Gaussian Noise

Gaussian noise is statistical noise having a probability density function equal to that of the normal distribution, which is also known as the Gaussian distribution [30], [31]. During the process of acquisition Gaussian noise is arisen. We can understand it through p that is probability density function name and z this is Gaussian random variable, μ is the mean value.

$$P_{} = \frac{1}{\sigma\sqrt{2\pi}} \quad \frac{(Z-)^2}{2^2} \quad \text{.....(ix)}$$

Here we have to take some steps to apply homomorphic at first we make high pass filter may be Gaussian high pass. Then we have to fill image with zeros. Filter size must be (M,N). Than standard deviation for the Gaussian should be filtered out. Then, high-pass filters the log-transformed image in the frequency domain. Calculate the FFT of the Log-transformed image with zero padding using fft2. Then high pass filter is applied to calculate inverse FFT. And finally exponential function is applied to invert the log transformation.

Figure-5: Homomorphic Filtering[32]



Sources: Authors Compilation

Mean Square Error (MSE)

It is the cumulative squared error between the original image and the filtered image and is given by the following equation[23]:

I(x,y) = Image before filtering, I'(x,y) = Image after filtering, M, N = dimensions of the image

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D = 255 (for unit8 data type) or 1 (for double data type).

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}\left[\frac{I(x,y)-I'(x,y)}{D}\right] \quad \text{.....(x)}$$

Peak Signal to Noise Ratio (PSNR)

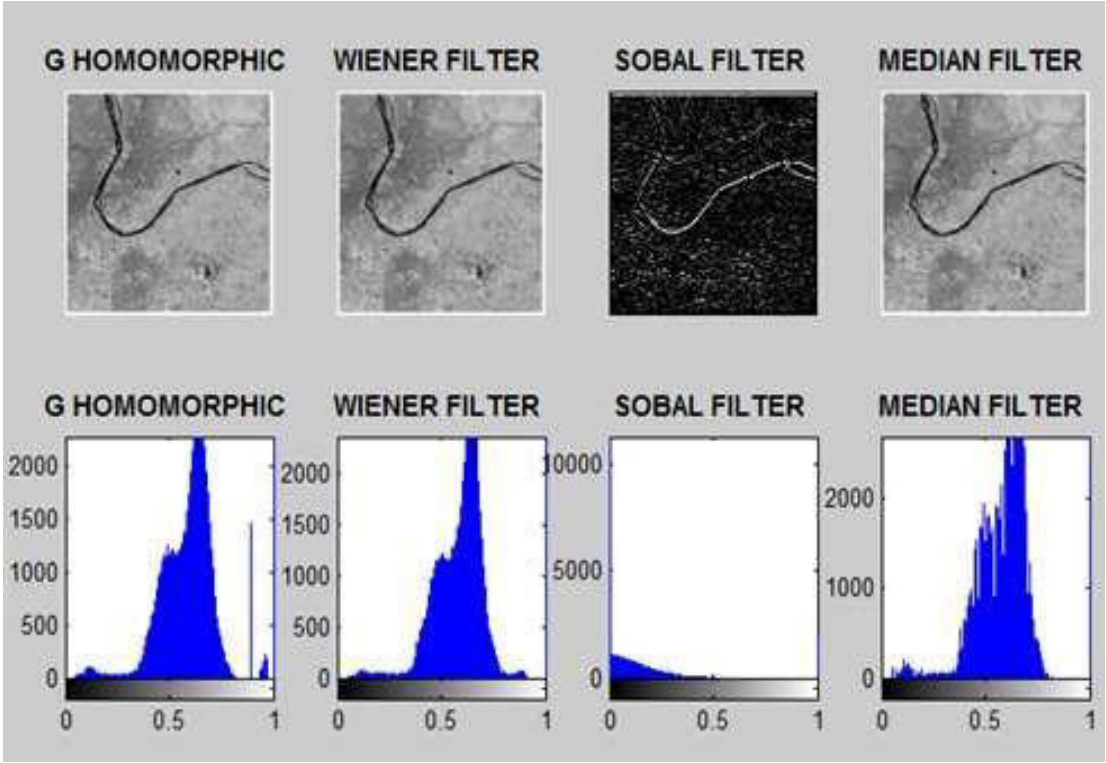
The term peak signal-to-noise ratio (PSNR) is a technique or method for the ratio between power of distorting noise and the maximum possible value that make impact on the quality of representation. Because many signals have a very wide dynamic range, (it is a ratio between smallest values of changeable quantity and the largest values). We can illustrate and express PSNR in the form of logarithmic decibel scale. It is the measure of the peak error in the signal and is expressed mathematically by the following equation[29.]:

$$PSNR \quad 20\log_{10} \quad \frac{D}{\sqrt{\text{MSE}}} \quad \text{.....(xi)}$$

Result and Discussion: After applying filters, Result is given below:

Result 1

Figure-6: Taken from Figure 1



Sources: Authors Compilation

Table-1

Image Filters	Gaussian Homomorphic Filter	Median Filter	Wiener Filter	Sobel Filter
MSE	.0008	.0033	.0066	1.91
PSNR	30.77	24.85	21.81	-2.81

Sources: Authors Compilation

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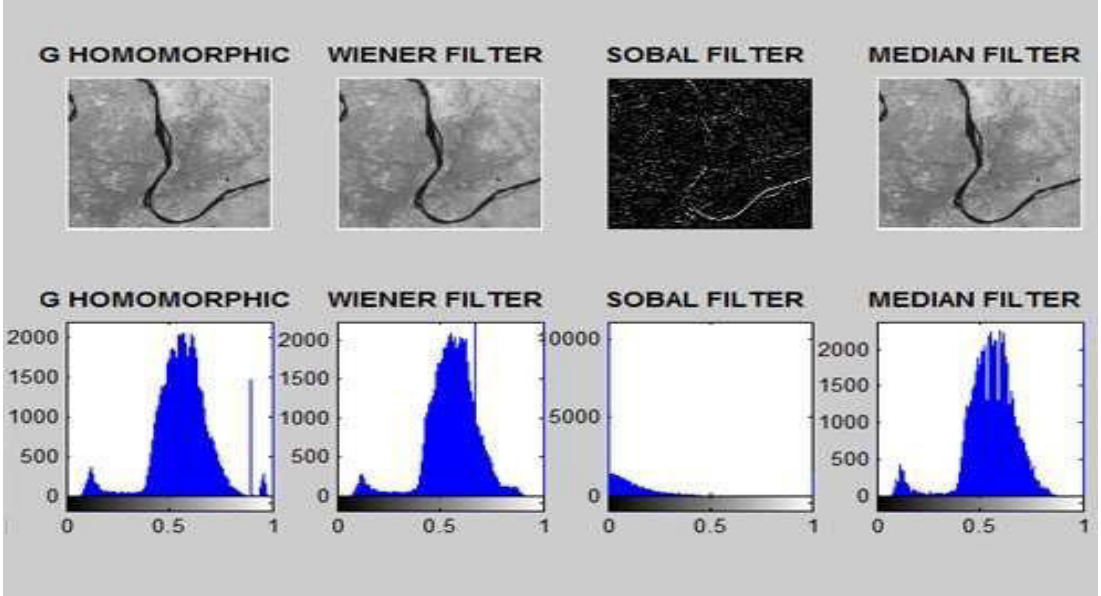
Result 2

Figure-7: Taken from Figure 1



Sources: Authors Compilation

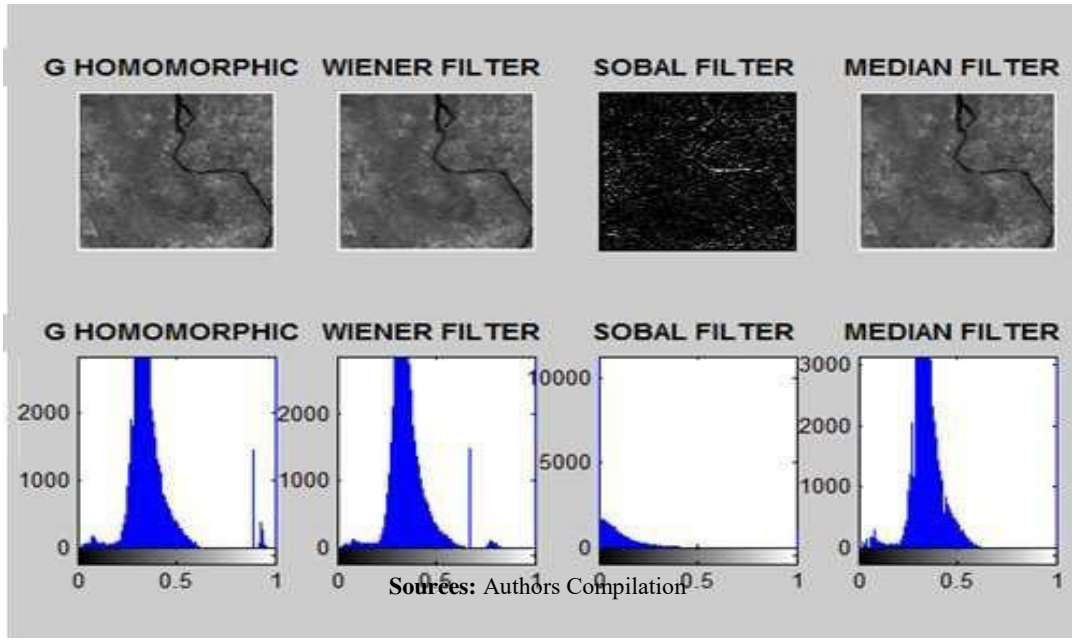
Table-2

Image Filters	Gaussian Homomorphic Filter	Median Filter	Wiener Filter	Sobel Filter
MSE	.0009	.0039	.0071	1.912
PSNR	30.25	24.10	21.46	-2.82

Sources: Authors Compilation

Result 3

Figure-8: Taken from Figure 2



Sources: Authors Compilation

Table-3

Image Filters	Gaussian Homomorphic Filter	Median Filter	Wiener Filter	Sobel Filter
MSE	.00074	.0033	.0058	1.66
PSNR	31.29	24.84	22.38	-2.19

Sources: Authors Compilation

CONCLUSION

During this study I have read various national and international papers about remote sensing and GIS system, selected various remotely sensed images, read lots of algorithm for reducing noise and analyzed them using PSNR and MSE to evaluate their performance. Here I have taken the images Resoursesat-1/Resoursesat-2 through LISS-3/LISS-4, through ISRO and tried to extract edges majorly for roads. During practical implementation of existing filters named Median, Wiener, Sobel, and Gaussian homomorphic for selected images I've seen that the performance of sobel filter is worst and the performance of Gaussian homomorphism is the best in term of extracting edges for roads but what I see they are good for extracting edges of road but blurs or lost other information, may be other minor roads or edges.

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