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Noise Removal in Remote Sensing Image Using Kalman Filter Algorithm

S. Priyanka[1], Dr.A.S.Naveen kumar[2]

Research Scholar, Department of computer Science, SNR Sons College[1]

Head, M.Com-Finance and Computer Applications, SNR Sons College[2]

Abstract: Noise reduction is a prerequisite step prior to information extraction that attempts from remote sensing images. Reducing Noise in remote sensing Image is an image restoration problem to recover a original image from the corrupted Images. This problem is intractable unless one can make assumptions about the actual structure of the perfect image. Various Noise removing filters make various assumptions depending on the type of image and the goals of the restoration. In this paper Kalman filter is used for gray scale images which is contaminated by Noise. Remote sensing images are affected by different types of Noise like Gaussian Noise, Speckle Noise and impulse Noise. These Noises are introduced in the Remote Sensing image during acquisition or transmission process. In this paper wiener filter and kalman filter is used for reducing the Noise rate, when compare to some other filters. In this the Proposed kalman filter gives better results when compared to Wiener filter.

Keywords: Remote Sensing Image, Wiener filter, Kalman filter, Gaussian Noise.

I. INTRODUCTION

Remote sensing [1] usually refers to the instrument based technology of acquiring information about the earth's surface and atmosphere, using sensors onboard airborne or space-borne platforms. Noise can be systematically introduced into images during acquisition and transmission process. There are several ways through which Noise can be introduced into an image depending on how the image is created. Satellite image containing the Noise signals lead to a distorted image and it is not able to understand and study it properly. Noise reduction helps the possibility of better interpretation of the content of the image. Noise can be defined as any disturbance that changes the original signal information. Image Noise is a random, usually unwanted variation in brightness or color information in an image [2].

Image data recorded by sensors on a satellite or aircraft contain errors related to geometry and brightness values of the pixels. The errors are corrected using suitable(filters) mathematical models. There are so many filters which can be used to reduce Noise a) Weighted Median Filterb) Standard Median Filter c)Adaptive Median filter, d)Wiener Filter and e)Kalman filter. Weighted Median Filter(WMF) selectively gives the multipreserving in the image structure than a median filter. Weighted Median Filter(WMF) is a natural extension of the median filter and has the same advantage of the median filter. Median filter is a simple and powerful non-linear filter, based on statistics and easy to implement for smoothing the image. That is reducing the amount of intensity variation between one pixel and the next Pixel. It is often used to reduce Noise in images[3]. Standard Median Filter(SMF) is a non-linear, low pass filtering method which can be used to remove speckle Noise from an image. Standard Median Filter(SMF) is a simple rank selection filter that attempts to remove Noise from an image by changing the luminance values of the center pixel of the filtering window[4]. Adaptive Median Filter(AMF) has been applied widely as an advance method compared with standard median filter. Adaptive Median Filter perform spatial processing to determine which pixels in an image have been applied by impulse Noise. Adaptive Median Filter classifies pixels as Noise by comparing each pixel in the image to its surrounding neighbour pixel. The size of the neighborhood is adjustable as well as the threshold for the comparison[5]. Adaptive Median Filter(AMF) is designed to eliminate the problems faced by the standard median filter. In this paper kalman filter and wiener filter is used to reduce the Noise rate, when compare to other filters.

II. METHODOLOGY

Noise removal is one of the techniques in image processing. There are various types of Noise in image that can corrupt images. Some of the Noise are gaussian Noise, speckle Noise and salt and pepper Noise. Here the proposed work is represented the architecture as shown the fig-1.

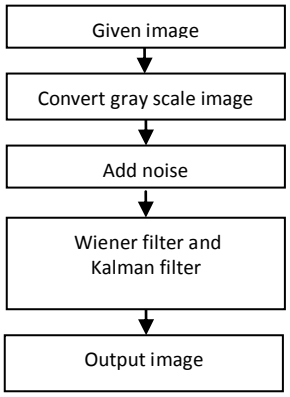

Fig-1 system architecture

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A. GAUSSIAN NOISE

This type of Noise is also called the normal Noise that is randomly occurs as white intensity values. Gaussian distribution Noise can be expressed by

$$P(x) = 1/ (\sigma\sqrt{2\pi}) * e^{(x-\mu)2} /2\sigma^2$$

When P(x) is the Gaussian distribution Noise in an image, μ and σ is the mean and standard deviation respectively.

B. SPECKLE NOISE

Speckle Noise is a ubiquitous that limits the interpretation of optical coherence of remote sensing image. The Noise can be expressed by

$$J = I + n*I$$

Where J is the distributed speckle Noise image, I is the input image and n is the uniform image.

C. SALT & PEPPER NOISE

This type of Noise contains random occurrences of both black & white intensity values, and often caused by threshold of Noise image. Salt & Pepper distribution Noise can be expressed by

$$P(x) = \begin{cases} p1, & x = A \\ p2, & x = B \\ 0, & otherwise \end{cases}$$

Where P_1, P_2 are the Probabilities Density Function (PDF) p(x) is the distribution salt and pepper Noise in image and A, B are the array size image. In this paper salt & pepper Noise in the image is randomly occurred in white and black pixels of an image [6]. The main challenge in removing salt & pepper Noise from image is due to the fact that image data as well as the Noise, share the same small set of values, which complicates the process of detecting and removing the Noise.

III. WIENER FILTER

Wiener filter is one of the earliest and best known approaches to linear image restoration. The most important technique for removal of Noise in an image is due to the linear motion in the Wiener filter. Each pixel has a digital representation of an image that should represent the intensity of a single stationary point in front of the camera. Its main advantage is the short computational time takes to find a solution [10]. Its purpose is to reduce the amount of Noise in an image. A wiener filter seeks an estimate $\hat{f}$ that minimize the statistical error function.

$$e^2 = E\left\{\left(f - \hat{f}\right)^2\right\}$$

Where E is the expected value operator and f is the undegraded image. The solution to this expression in the frequency domain is

$$\hat{f}(u,v) = \left[\frac{1}{H(u,v)} \frac{|H(u,v)|^2}{|H(u,v)|^2 + S_n(u,v) + S_f(u,v)} G(u,v)\right]$$

Where $H(u,v)$ = the degradation function
$|H(u,v)|^2 = H^*(u,v)H(u,v)$
$H^*(u,v)$ = the complex conjugate of $H(u,v)$
$S_n(u,v) = |N(u,v)|^2$ the power spectrum of the Noise
$S_f(u,v) = |F(u,v)|^2$ the power spectrum of the undegraded image.

IV. KALMAN FILTER

The Kalman filter is a mathematical method named after Rudolf E Kalman. Its purpose is used to measure the Noise and other inaccuracies, and produce values that tend to be closer to the true values of the measurements and their associated calculated values. The kalman filter has many applications in technology, and is an essential part of space and military technology development [11]. It is an algorithm which makes optimal use of imprecise data on a linear (or nearly linear) system with Gaussian errors to continuously update the best estimate of the system's current state [12]. The image is considered to spatially depend on the current pixel $x(m,n)$ and the surrounding pixels $x(m-p)(n-q)$ for $(p,q) \in N$ and is represented by the following model:

$$x(m,n) = \sum_{(p,q)\in N} \sum a_{p,q}\, x(m-p)(n-q) + u(m,n)$$

Where N denotes the range of pixels surrounding $x(m,n)$used in the linear sum, and (p,q) denotes the coordinate centred on the current pixel $x(m,n).u(m,n)$ indicates derived Noise and it is considered to be white Noise having a zero mean when a large N is selected. The Noise reduction is improved in the reconstruction of an image, including additive Noise and blurred Noise. The original image model is given by

$$x(k) = AX(k-1) + U(k)$$

Where $X(k) = [X_0(k), X_1(k), \ldots., X_8(k)]^T$ denotes the state variable at time k.

V. DATASET DESCRIPTION

Remote sensing image is defined as an image produced by a recording device that is not in physical or intimate contact with the object under study. Remote sensing image is used to obtained information about a target or an area or phenomenon through the analysis of certain information which is obtain by the remote sensing imagery generally require correction of undesirable sensor characteristics and other disturbing effects before performing data analysis. Images obtained by satellite are useful in many environmental applications such as tracking of earth resources, geographical mapping, prediction of agriculture crops, urban growth, weather, flood and fire control etc. When capturing image using sensors, the resulting image may contain Noise from dirtiness on the image data acquisition process. So in this paper, we have analysed a remote sensing image. It is downloaded from Google sites.

VI. RESULTS

The figure2 shows the experimental results of the proposed work. The test image is taken as Input imge. It has very high frequency components, so the wiener filters and kalman filter is used to reduce Noise in the Image. Both of the Filters leaves lots of residual Noise. When compared to the Wiener filter, Kalman filter produces better intensity level when compared to wiener filter which is shown in fig2.This shows that the Kalman filter has shown good efficiency in noise filtering. The proposed work is done using MATLAB. 2010 version.

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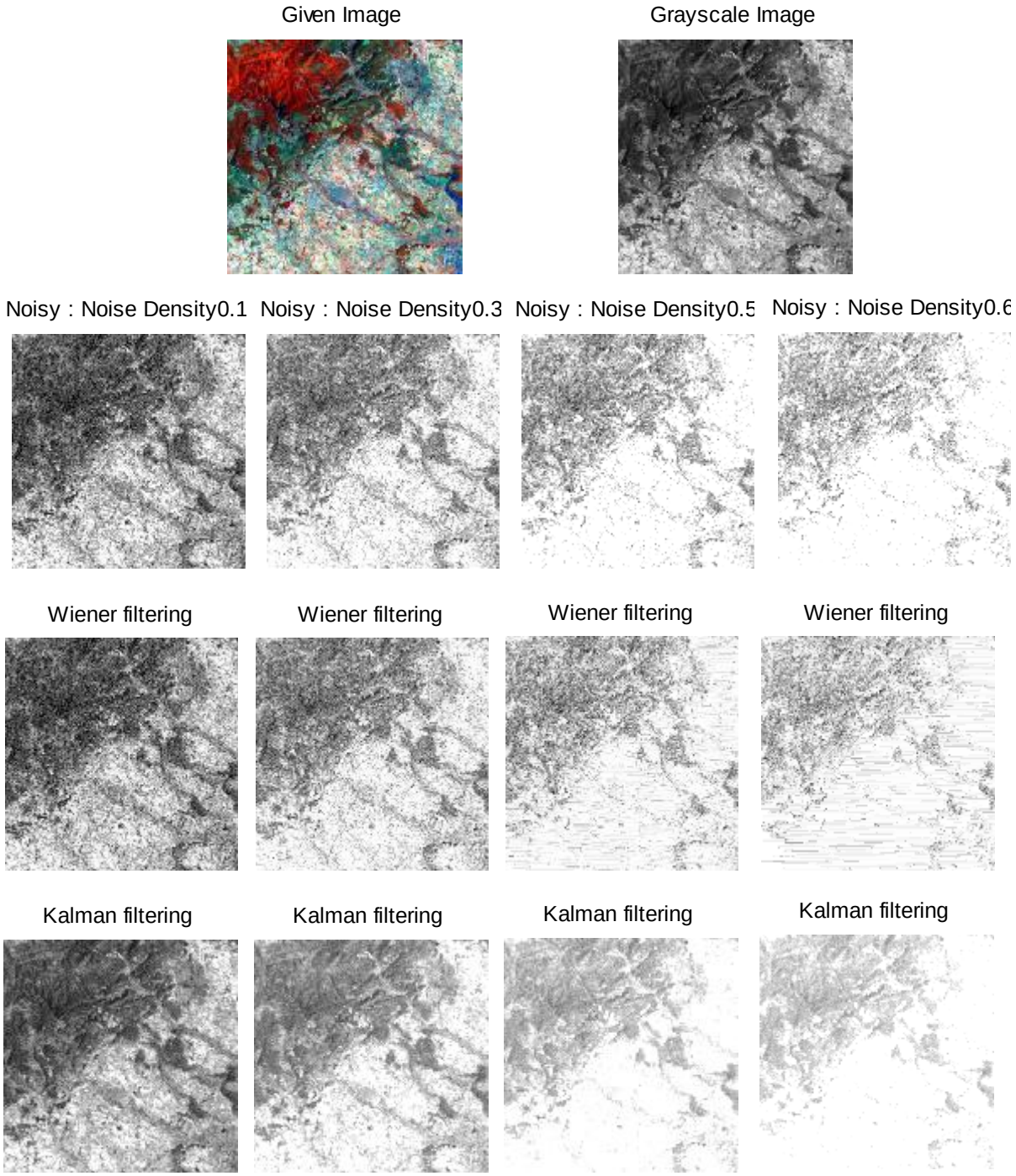

Fig 2: Intensity level for Wiener and Kalman Filter

VII. CONCLUSION

Noise removal is a major problem in Remote sensing Images. The image captured by the sensor undergoes filtering by different smoothing filters and the resultant image is fused to attain high quality image. This paper has described a new principle of Noise reduction in order to preserve the image structure. While capturing the Remote Sensing image it usually have a Gaussian Noise, speckle Noise and salt & pepper Noise. Various filters are used to remove the Noise in the Image. In this Proposed work we have used Wiener filter and Kalman filter to reduce the noise in the Image. Kalman filter works well in reducing the Noise while preserving the underlying structure of an image when compare to the other said filter. Kalman filter performs large amount of Noise and shows better efficiency in filter.

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