International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 12 | Dec 2020 www.irjet.net p-ISSN: 2395-0072

Restoration Techniques Available for Satellite Image Sensing Applications – A Review

Tamilselvi. K[1], Prof. T. Thenmozhi[2]

[1]PG scholar, Department of ECE, Government College of Engineering, Salem-11
[2]Assitant Professor, Government College of Engineering, Salem-11

Abstract - *Image restoration is important in the field of satellite image processing, weather forecasting and remote sensing, where accurate details of the image are needed. Most of the satellite images are degraded by physical phenomenon such as relative motion of the object before captured by image capturing devices such as camera or due to atmospheric disturbances. To restore the original image from the degradation, various restoration techniques are available. This paper surveys various degradation models used for satellite images and presents the inferences from the survey, which helps the readers to choose specific restoration for specific degradation model, as each restoration technique will have its own advantages and disadvantages.*

Key Words: survey, satellite images, degradation, blur, noise, restoration, Non-Blind deconvolution, Blind deconvolution, inference table.

1. INTRODUCTION

Satellite images plays vital role in various fields of life such as agriculture, fishery, remote sensing, weather forecasting and so on. It is important that the satellite image should be precise, in order to obtain various inferences in various fields. Satellite images are prone to various degradations due to the atmospheric disturbances and weather conditions, in order to overcome such effects; image restoration has become inseparable part. Image restoration may be further added by image enhancement to achieve better image clarity. Various restoration techniques are available for different degradation blurs and noises. The following sections will provide the details on the restoration techniques available in the literature and how could it be used effectively.

2. DEGRADATION

Degradation is the loss in quality of satellite images which occurs due to various degradation process such as poor lighting, image defocus, relative motion of object or satellite, atmospheric and weather conditions. Mathematically, this can be written as,

$$g(x, y) = f(x, y) * h(x, y) + n(x, y).$$

where $g(x, y)$ is the degraded image, $f(x, y)$ is the input image, $h(x, y)$ is the transfer function of the degradation function and $n(x, y)$ is the noise function.

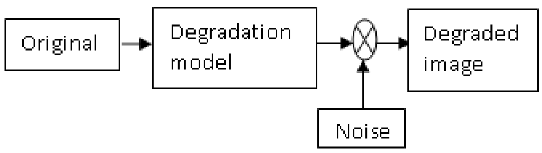

FIGURE 2.1 IMAGE DEGRADATION MODEL

2.1 Reasons for Degradation in images

Degradation in satellite images occurs due to relative motion of the object before capturing, physical interferences, atmospheric conditions such as fog and haze. The degradation which occurs due to motion of the object or the camera is often referred to as Blur. The other physical interferences usually modelled as noise. The following section discusses the types of blur and motion in present in the satellite images.

2.1.1 Types of Blur:

Motion blurs:

Blur in images may be due to relative motion of the object before captured on the capturing device, referred as motion blur.

Out of focus blur:

Out of focus blur occurs when capturing device is improperly focused on an image. For the output image to have high resolution defocus should be minimized.

Atmospheric turbulence blurs:

This type of blur occurs when the image is corrupted by the external atmospheric conditions such as fog, haze, humidity and rainfall. This type of blur is predominant in satellite and remote sensing images which are unavoidable.

Average blurs:

Average blur is the smoothing effect induced on the sharp edges thereby failing to preserve the sharp edges. This may be distributed in horizontal and vertical axis and can also be circularly distributed given by the function $R=\sqrt{g2+f2}$

Where 'g' and 'f' are the horizontal and vertical axis respectively.

Gaussian Blur:

Blurring an image by Gaussian function gives Gaussian blurring. It is the most often used blur model since the modelling of Gaussian function is similar to the normal distribution and easy to implement. Generally low pass filter is applied to attenuate high frequency signals resulting in Gaussian blur; reversing blur involves using high pass filter to remove the blur effects.

2.1.2 Types of Noise:

Noise in images can be a result of the nonlinearities present in the modern sensor devices. Noise can additive or multiplicative in nature. The most predominant noises in satellite images are of the additive and multiplicative and impulse noise.

Additive noise:

The noise is independent of the intensity of the pixel value at each point. Most commonly occurring noise is the Gaussian noise where the noise function is uniformly distributed and statistically independent.

Multiplicative Noise:

The noise of this type is the multiplication of random noise values to the intensity of each pixel in the image. Speckle noise is an example for multiplicative noise and they are widely seen in most of the satellite images

Impulse noise:

The most common Impulse noise is the salt and pepper noise. The noise pixels are statistically independent and randomly distributed. These are termed as salt and pepper noise since the gray values may be either 255 or 0. This type of noise is not uniformly distributed. Noise may be present at some pixels, while others may not have noise.

3. IMAGE RESTORATION

Image restoration is the process of restoring image from the degradation, provided the information on the degradation is already known or can be estimated. It is the deterministic and objective way of reconstructing the image.

The process of Image restoration involves identifying the degradation model and then applying the inverse in order to obtain the original image. It is an objective process where the mathematical and statistical parameters of the degradation are known or can be estimated.

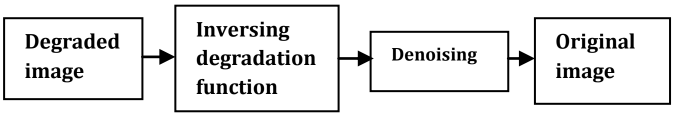

FIGURE 3.1 IMAGE RESTORATION PROCESS

3.1 Image restoration types:

Image restoration can be classified as Blind Deconvolution and Non blind Deconvolution technique. Non-blind deconvolution, where the PSF is known and blind deconvolution where the PSF is not known prior.

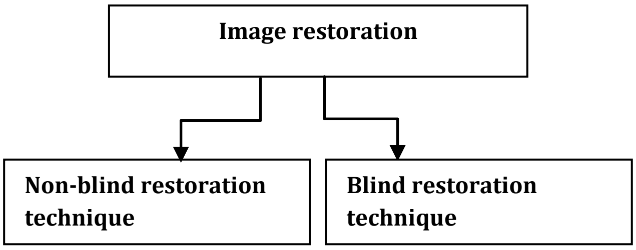

Image restoration techniques can be classified as:

1. Non blind restoration technique
2. Blind de convolution technique

3.1.1 Non blind deconvolution technique:

Non blind de convolution technique can be applied when the details of the degradation are known prior i.e., the point spread function is known. Most widely used filters in Non-Blind De-convolution uses spatial filtering techniques.

Note:

Point spread function: Point spread function is the response of the optical system to the point source. It is the important aspect of measuring the optical system performance. It is the spatial domain representation of the optical transfer function.

[1] Inverse Filter:

Inverse filter is used when the image is corrupted more of the blur effects than the noise effects, this is simply the inverse of the blur function. The blurred image is modelled by a low pass filter and then often recovered using high pass filter. If g (x, y) is the degraded image and f (x, y) is the input image degraded by the impulse response function h (x, y) then the transfer function of the input image can be obtained by taking Fourier transform i.e., $F(u, v) = G(u, v)/H(u, v)$

Where F (u, v) is the transfer function of input image. G (u, v) is the transfer function of degraded image, H (u, v) is the transfer function of the degradation function. The main disadvantage of inverse filter is that it cannot eliminate noise, hence could be used only for blur removal.

[2] Weiner filter:

Weiner filter is the often-used filter for blur removal and noise cancellation, it can be implemented in frequency domain as well, and however wiener filter is suitable only for additive noise such as Gaussian noise. This could not be implemented to remove the other noise effects. Weiner filter restores the degraded image from the known point spread function. $D=g*(f+n)$, Where D is the degraded image, f is the frequency response of the known degradation function and n is the noise function.

[3] Regularized filter:

The intensity variation in the image is reduced by averaging the adjacent pixel values. This averaging is adjusted with the help of the filter window. This technique fails to fails to preserve brightness of the images due to the averaging effect. This type of filters uses the constraint least square algorithm.

[4] Linear quadratic regulator, Kalman filter:

Kalman filter is a statistical filtering technique. Mathematically, Kalman filter can be modelled by forward and feedback equations. Time update equation gives the current state and covariant estimate gives the feedback equation or the prior estimate. State bank of Kalman filter is computation complexity and time consumption. However, one can choose Kalman filter if the atmospheric details such as humidity, optical depth, wind speed (which are responsible for blur) needs to be estimated statistically.

[5] Deconvolution using Lucy Richardson algorithm for a known PSF:

Lucy Richardson algorithm is mainly used when the point spread function is known and can be used to recover the image from the blur model and could also eliminate noises. The pixel value observed is given by d_i=sum $\Sigma_j(p_{ij}*u_j)$ where p_{ij} is the point spread function and uj is the pixel value. Assuming that u_j is Poisson distributed, statistics are calculated.

3.1.2 Blind deconvolution technique:

A blind restoration technique is used when the statistics on the blur and noise are not available or is difficult to interpret. This restoration technique is still under research due to its limitations in preserving the pixels. Blind deconvolution techniques have no prior knowledge on the point spread function; hence various statistics are required in estimating the PSF. More often order statistics filters are used in smoothing the pixels and preserving the edges,

[6] Mean filters:

This filter maintains the pixels to the average mean value by varying the window size and replace the old pixel with the new pixel value. This might yield false results. This drawback is overcome in median filter. Mean filter is efficient in removing the Gaussian noise. Mean filter has some drawbacks such as, shows no effect on blur, and could not preserve image pixel. Averaging effect will result in wrong pixel mean

[7] Median filter:

Median filter is a nonlinear deconvolution algorithm for image restoration, especially useful if the details on degradation cannot be estimated. Median filter replaces the nonlinearities in image by replacing the pixels with the median value of the adjacent pixels. This could provide smoothing effects to the image and original pixel characteristics are maintained in the median filter. Median filter is efficient in denoising the salt and pepper noise. However, could not preserve the sharp edges of the images.

[8] Min and max filters:

Min and max filters are efficient in eliminating the salt and pepper noise. The Max filter preserves the light pixels and the max filter preserves the dark pixels in the image

[9] Bootstrap kernel filter:

Bootstrap kernel filter is a nonlinear filter which uses Bayesian estimate and Monte Carlo estimates, uses the conditional probability distribution function and kernel window to obtain the statistics. It is suitable for the non-Gaussian noise model such as speckle noises, salt and pepper noises. Bootstrap kernel filter provides better PSNR performance than the Extended Kalman Filter

[10] RLS adaptive filter:

Recursive least square adaptive filter models the output in correlation with the input. RLS algorithm is used to achieve fast convergence rate. The filter coefficients are selected such that output signal matches with the desired signal based on the least square estimate. RLS adaptive algorithm is chosen to achieve fast convergence rate. The algorithm uses the following filter weights $W_D=R_D^{-1}(K)\ P_D(K)$ where $R_D(K)$ is the correlation matrix of the input signal and $P_D(K)$ is the cross-correlation matrix of the input signal and the desired signal.

4. INFERENCE FROM THE SURVEY:

Inferences from the survey are elaborated in detail. Each technique has its own advantages and disadvantages; it is up to the need of the user to select particular restoration technique. Blur removal is effective with the spatial filtering techniques as described below in **Table 1** and noise removal is effective with the order statistic filter as listed in **Table 2.**

Table -1: Non-blind restoration techniques

Restoration technique	Filter type	Blur removal	Noise removal	Drawbacks
Inverse filter	Linear	Gaussian blur	Doesn't perform well on noise	Amplify the noise artefacts
Wiener filter	Linear	Motion blur and out of focus blur	Additive noise such as Gaussian noise and salt &pepper noise	Power spectra of the original image should be known prior and smoothing effects
Regularized filter	Linear	Average blur	Additive noise	Have no effect on salt and pepper noise and edges are blurred
Kalman filter	Linear	Atmospheric turbulence blur	Gaussian noise	Implementation algorithm is difficult, have no detailed effect on the mind speed and humidity parameters of the satellite images
Lucy Richardson Algorithm	Iterative	Gaussian blur	Gaussian noise	Poor SNR performance

Table -2: Blind restoration techniques

Restoration filter	Filter type	Noise removal	Drawbacks
Mean filter	Linear	Gaussian noise	Shows no effect on blur, and could not preserve image pixel. Averaging effect will result in wrong pixel mean
Median filter	Non linear	Salt and pepper noise and Gaussian noise	Fails to preserve the sharp edges
RLS Adaptive filter	Linear adaptive	Additive noise	Slow convergence
Bootstrap kernel filter	Non linear	Speckle noise	Implementation is difficult as it requires complex algorithms.

5. FUTURE WORK:

There is a scope for extending the survey to performance evaluation by including the parameters for measurement of restoration (SNR and error performance). This also provides scope for combining various restoration techniques and evaluating the performance of the combined technique with the existing one. Statistical approach needs to be studied further for the blind deconvolution Algorithms.

6. CONCLUSION:

This paper gives a brief detail on the various existing restoration techniques for satellite image restoration. This could be helpful for the user to select the restoration technique based on the type of blur and noise present in the satellite image.

7. REFERENCES:

[1] Israa Hadi Ali and Russell H. Al_Taie," Image deblurring using fusion technique based on inverse filtering", (2016), Research Journal of Applied sciences.

[2] Dr. Sana'a khudayer Jadwa," Wiener Filter based Medical Image De-noising", International Journal of Science and Engineering Applications, Volume 7–Issue 09,318-323, 2018, ISSN: -2319–7560.

[3] Sukhjinder Kaur," Noise Types and Various Removal Techniques", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Volume 4, Issue 2, February 2015

[4] Alain Monfort, Jean-Paul Renne, and Guillaume Roussellet, A Quadratic Kalman Filter, December, 2013

[5] G. Suseela, S. Ahmed Basha K. Prasad Babu K. Sudhakar," Image Restoration Using Lucy Richardson Algorithm for X-Ray Images", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 2, February 2016.

[6] Somasundaram K, Kalavathi P," Performance of Spatial Mean Filters on Denoising Medical Images for Edge Detection", IJCST Vol. 3, Issue 2, April - June 2012.

[7] Abdalla Mohamed Hambal, Dr. Zhijun Pei, Faustini Libent Ishabailu3," Image Noise Reduction and Filtering Techniques", International Journal of Science and Research (IJSR).

[8] Muhammed Sajid and Dr. Khurram Khurshid, "Satellite Image Restoration Using RLS Adaptive Filter and Enhancement by Image Processing Techniques", (2015), IEEE.

[9] Bassel Marhaba and Mourad Zribi, "The bootstrap Kernel-Diffeomorphism Filter for Satellite Image Restoration" (2018), IEEE.

[10] Bassel Marhaba, Mourad Zribi," A Novel Combination Method for Image Restoration Based on Bootstrap Filter and DWT", MATEC Web of Conferences 261, 0 0 (2019).

[11] Aanchal Joseph and Sandeep B. Patil, "Restoration and comparisons of Gaussian Blurred Noisy image using different filtering techniques". (2013), International Journal of Science and Research

[12] Jyotsna and Paru Raj, "A Novel method for removing Gaussian blur from images", July -2018, International journal for Technological Research in Engineering.

[13] Sahlah Abed Ali, "Image Enhancement Techniques for Images at Blur Motion and Different Noises",

[14] More Manisha, Shivale Nitin, "Linear Filtering Based Image Restoration with Image De-Blurring Toolkit", (2015), International Journal of Science and Research (IJSR)

[15] Mr. Salem Saleh Al-amri, Dr. N.V. Kalyankar and Dr. Khamitkar S.D, "A Brief Review on Image Restoration Techniques", (2016), International Journal for Computer Applications

[16] R. C. Gonzalez and R. Woods, "Digital Image Processing", Addison-Wesley Publishing Company, 1993.

[17] Muhammad Syafiq Alza Alias, a, Norazlin Ibrahim, b, Zalhan Mohd Zin," Enhanced Median Filter for Low Density Salt and Pepper Noise Removal in Lead Frame Image". International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12.

[18] Dong-Han Leea, D.C. Seo, J.H. Song, J.H. Chung, S.Y. Park, M.J. Choi, H.S. Lim," Image restoration of calibration and validation for kompsat-2"

[19] A. K. Jain, —Fundamentals of Digital Image Processing, Prentice Hall of India, First Edition, 1989.

[20] M. Mansourpour, M.A. Rajabi and J.A.R. Blais, —Effects and Performance of speckle noise reduction filter on active radar and SAR images.

[21] M. Young, the Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[22] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[23] K. Elissa, "Title of paper if known," unpublished.