Modified Landweber Algorithm for Deblur and Denoise Images

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Abstract*— *In this paper, we introduced modified algorithm based on traditional Landweber deblurring algorithm for reducing amount of blur and noise from satellite images. Blur image is general issue in image processing and it is hard to avoid. Image enhancement in terms of deblurring and denoising are necessary to reduce blur amount as well as noise from the image. There are few deblurring algorithms exist to deblur an image. However, if noise is present, they perform poorly. By using proposed algorithm, we get better results in terms of PSNR, execution time and complexity with blurry as well as noisy images.

Index Terms*— *Image Deblurring, Image Denoising, Convolution, Point Spread Function (PSF), Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE).

I. INTRODUCTION

In image enhancement, a blurred image can be recovered by iterative methods such as the Landweber method [1] and the Richardson–Lucy method [2], [3]. The Landweber method is the less complex of the iterative methods [4]. The method is also referred to as Bially or Van Cittert iteration method, most probably because it has been independently discovered by different researchers [4]. The captured image should be of good quality when taken by camera, but there is some amount of blur and noise present in every image due to out-of-focus, motion of an object or camera [5], sometimes it may happen that due to tilting of camera, captured image may get blurred in some regions of image. Image deblurring is used to make images sharp and retrieve as much as detailed information from the image. A blurred image can be viewed as an unblurred image by applying convolution with Point Spread Function (PSF) on images. The image degradation model is shown in figure 1 [7]. Suppose the original image f(x,y) that we would like to recover from the degraded measurement g(x,y). The imaging process can be express as:

$$g(x,y) = h(x,y) \otimes f(x,y) + n(x,y) \quad (1)$$

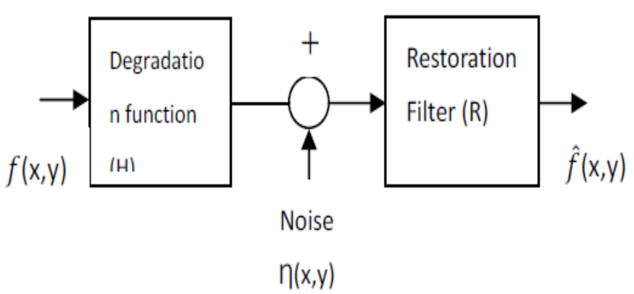

Fig. 1. Image Degradation Model

Where g(x,y) is degraded image, f(x,y) is original image, h is blur operator, n is noise, (⊗) is the convolution process. There are fundamentally two types of restoration methods, blind and non-blind. The blind deconvolution is more complex than non-blind [6] because in blind deconvolution first estimate the PSF. However, blur function h is unknown; it is essential for blur identification and blur estimation [6]. This paper includes proposed algorithm which is type of non-blind method to deblur the image. In non-blind method use PSF [8] that is based on type of blur such as for motion blur 'motion' PSF is used and parameter of motion PSF are length and angle, for out-of-focus blur 'disk' PSF is used and parameter of out-of-focus PSF is radius, Gaussian PSF, etc. For image enhancement, a degraded image can be recovered by iterative algorithms like the Landweber Algorithm, the Richardson–Lucy Algorithm, the Poisson Map Algorithm and the Van Cittert Algorithm [5] [10]. Van Cittert and Landweber Algorithm is the simplest form of the iterative approaches. There are certain limitations of all above algorithms. Poisson Map algorithm has high complexity [5]; Richardson-Lucy algorithm generates more ringing effect after more number of iterations [4]. All above algorithms are sensitive to noise i.e. if noise is present in image, they generate poor results [5] [6]. Therefore, to overcome the limitations of all above algorithms, this paper describes proposed algorithm that is modified version of a Landweber Algorithm. It will generate good result if noise is present in an image. Therefore, different filtering techniques like smoothening filter and sharpening filter are used to recover images which are blurry as well as noisy. The proposed algorithm gives better result in terms of MSE PSNR and Execution time for both types of image. The rest of paper is structured as follows. Section II describes the related research work. In Section III introduce proposed method. Section IV demonstrates the result of the modified algorithm and its comparison with traditional Landweber algorithm. Section V gives direction of future work. And then finally conclude the paper in Section VI.

II. RELATED WORK

Landweber algorithm [1] [9] is an iterative deconvolution method for image deblurring. A more clearly deblurred image is generated after each time of iteration. After several iterations, a sharp and unblurred image can be obtained. Landweber algorithm [5] gives good result in terms of image quality (i.e. Low MSE, High PSNR), less complexity and less execution time. It is an iterative algorithm i.e. output of a previous iteration is used as an input for the next iteration. By using this algorithm, we get more reliable result when performing an additional number of iterations [5]. The equation of this algorithm is below [9]

$$f^{n+1} = f^{n} + \beta H (g - H f^{n}) \quad (2)$$

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Where fn+1 is the new approximation from the previous fn, g is the blurred image, n is the number of the iterations, H is the blur function called PSF, β is a constant that controls the sharpening quantity [5], fn in the first iteration same as blurred image g. The drawback of this algorithm is that it gives poor result in presence of noise. To overcome this limitation, in modified version we used two different filtering techniques such as smoothening filtering and sharpening filtering. We first use smoothening filter to reduce noise effect from an image. Sharpening filter is applied to deblur the image by sharpening the edges or different features. As above mentioned, convolution is applied on an image with different smoothening filter known as PSF according to blur present in an image. If we already have information about which type of blur present in an image, we use PSF according to it and get acceptable result. Modified algorithm gives good result for Gaussian blur, Out-of-focus blur [13] with noisy image using same PSF i.e. Gaussian. Next section describes modified algorithm with all detailed description.

III. PROPOSED METHOD

Modified algorithm is used for satellite images which are taken from tilted camera. This tilting of camera makes some regions of the image blur. The flowchart of proposed system is in fig. In Proposed system first task is to check image is blur or not where we used different approaches such as finding the sharpness of an image, energy, thickness of an edges and amount of high frequency present in an image. From the above four approaches minimum two give blur result that leads to the next step. For this step to decide threshold, find all above parameters for different images and take average of it and use it as a threshold.

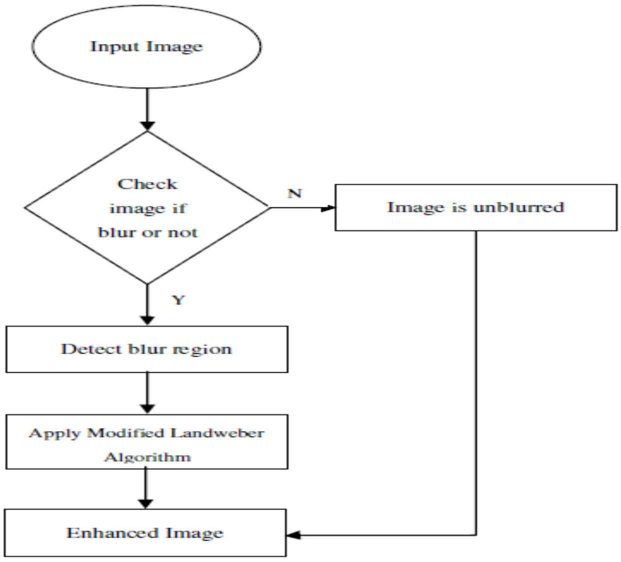


Fig. 2. Modified Landweber Algorithm

Table1. Comparison of Blur measure parameters

Parameters	Accuracy
Sharpness	57%
Energy	52%
Thickness of an edges	60%
Amount of high frequency components	57%

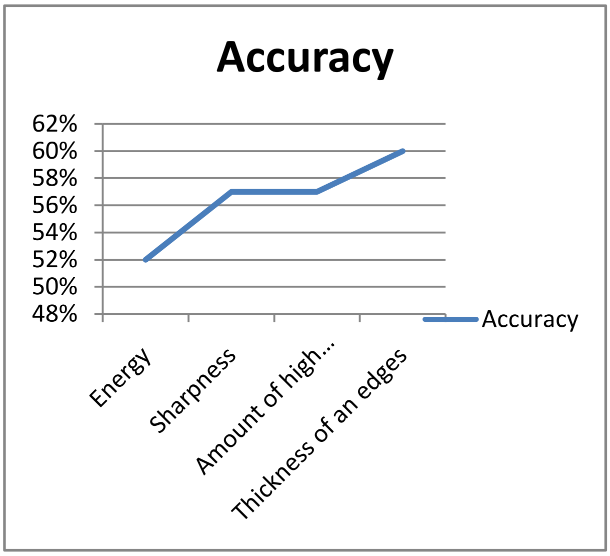
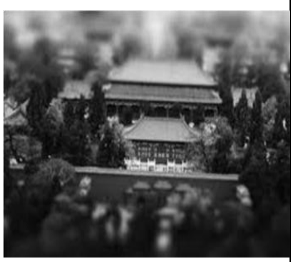
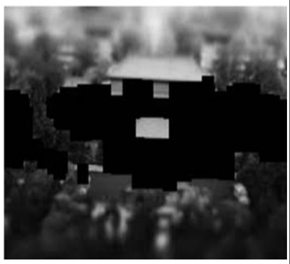


Fig. 3. Graph for accuracy of parameters

To find the blur region by apply sharpening (Laplacian Filter) and thresholding. Result of this step is shown in below table 2:

Table2. Result of Blur region detection step

Original Image	Detected Blur Region
	
	

Then apply modified algorithm to only on blur region.
The steps of modified algorithm are as follows:

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1.) Initialize n=1; H_1 = Smoothening Filter; H_2 = Sharpening Filter
2.) conv1 = $H_1 * X^{(n-1)}$
3.) mul = α x conv1
4.) sub = I-mul
5.) conv2 = H_2*sub
6.) $X^{(n)} = X^{(n-1)}$ + conv2 & n=n+1
7.) If iterations completed, stop or go back to step 2
8.) Stop

Fig. 4. Modified Landweber Algorithm

As described in above figure 4, first step is initialization step in this step initialize the number of iterations (n), Filters (Smoothening, Sharpening), etc. Then apply smoothening filter i.e. Gaussian (3x3) to the input blurred image due to both Gaussian blur or out-of-focus blur (disk blur) to reduce the effect of noise and β is predetermined constant which is different for blurred image and blurred with noisy image. For only blurred image value of β is less than 1 (β =0.7) and for blurred with noisy image value of β is greater than 1 (β=1.3) because less amount of noise is present, the image is high contrast image. In next step take the difference between output of last step image from the input image to minimize the difference between blurred image and predicted image [8]. At the end apply sharpening filter (i.e. 1D Laplacian operator) to retrieve detailed information from an image by getting the edges as sharp as possible. The mathematical equation for modified algorithm is: $f^{n+1} = f^{n} + H_2 (g - \beta H_1 f^{n})$ (3)

Modified version is also an iterative like a traditional algorithm. In traditional algorithm get better result in more number of iterations with compare to modified version. Modified algorithm gives good result only in 2-3 iterations. Therefore, modified algorithm is less complex and less time consuming because of less number of iterations.

IV. RESULT AND ANALYSIS

The main purpose of the modified algorithm is to get better result with blurred and noisy image. Therefore, in this section, we demonstrate the comparison of modified Landweber algorithm with traditional Landweber algorithm. We also verified result with different parameters for only blurred (Gaussian blur, Out-of-focus blur) image and blurred with noisy image (Gaussian noise) too. In this section we take result with value of β is 2 for traditional algorithm and β is 0.7 and 1.3 for modified algorithm for only blurred image and blurred with noisy image respectively. However, the value of β is decided based on best image quality with high PSNR for blur and original image with compare to original and deblur image. Also verify the different values of β. For smoothening filter (H1) used Gaussian size of 3x3 and Sharpening filter (H2) used 1D Laplacian operator. Comparison of Traditional and Modified algorithm in based on number of iterations, quality measures parameters such as PSNR and execution time are shown in below tables:

Table 3. Comparison between the proposed algorithm and traditional algorithm for blurred image (different iterations)

	Image 1(Only Blur Image for different iterations)		
Algorithm	**Iteration(s)**	**PSNR**	**Execution Time(sec.)**
Blur	--	36.2347	--
Traditional Landweber (β=2)	7	53.9067	0.1849
Modified Landweber (β=0.7)	2	40.0078	0.1457

Table 4. Comparison between the proposed algorithm and traditional algorithm for blurred image (same number of iterations)

	Image 1(Only Blur Image for same iteration)		
Algorithm	**Iteration(s)**	**PSNR**	**Execution Time(sec.)**
Blur	--	36.2347	--
Traditional Landweber (β=2)	2	43.0342	0.1431
Modified Landweber (β=0.7)	2	40.0078	0.1457

Table 5. Comparison between the proposed algorithm and traditional algorithm for blurred + Noisy image

	Image 1(Blur + Noisy Image)		
Algorithm	**Iteration(s)**	**PSNR**	**Execution Time(sec.)**
Blur	--	19.9864	--
Traditional Landweber (β=2)	2	17.0474	0.1303
Modified Landweber (β=1.3)	2	23.9209	0.1393

In table 3, table 4 and table 5 demonstrates comparison for the Gaussian blur and Gaussian PSF (3x3). In table 1 and table 2 shows result for only blurred images with different iterations and same iteration respectively. According to PSNR and Execution time it conclude that traditional Landweber gives better result but in 6 iterations whereas modified version gives acceptable result in only 2 iterations. More number of iterations increases complexity and execution time too. It also concludes that for same iteration both give nearly same result. However, noise is present in an image traditional gives poor result whereas modified gives better result with compare to traditional.

Table 6. Comparison of modified algorithm for different type of blurs using same parameters

	Disk(r=1)	Gaussian(3x3)
PSNR (Blur)	31.1432	36.2347
PSNR(Traditional)	32.8654	43.0342
PSNR(Modified)	32.0990	40.0078

Table 7. Comparison of modified algorithm for different type of blurs (with noise) using same parameters

	Disk(r=1)	Gaussian(3x3)
PSNR (Blur)	19.2694	19.9864
PSNR(Traditional)	16.3890	17.0474
PSNR(Modified)	23.3709	23.9209

Table 6 and Table 7 verify the result of modified algorithm with different types of blur by using same parameters like same β value and same PSF. Modified algorithm using same PSF i.e. Gaussian(3x3), β=1.3 for blurred image and blurred + Noisy image both and same number of iterations (2). In figure 2 show the comparison of traditional and modified algorithm for only blur image with different iterations which shows in Table 1 and Table 2 and Blurred with noisy image which shows in Table 3.

V. FUTURE EXTENNSION

This algorithm works better for the Gaussian blur or Out-of-focus blur with noise but for motion blur with noise not give better result. Therefore, to solve this problem will be future work. In the proposed algorithm value of constant parameter β is different for blurred and blurred with noisy image. So, the value of β will be generalized to both the cases is also a future work.

VI. CONCLUSION

In this paper, we proposed modified Landweber algorithm to overcome the limitation (i.e. poor result in presence of noise) of traditional algorithm. Therefore, to get better result with presence of noise in an image used two different filters such as smoothening and sharpening instead of using only one filter (Smoothening). In proposed algorithm used two different β values to get better results with blurred and blurred with noisy image.

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