RECOVERY OF SATELLITE IMAGES USING EDGE INFORMATION OF ACTUAL IMAGE

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ABSTRACT

A deblurring algorithm is presented to restore the degraded images by the Atmospheric turbulence or the imaging systems. Coefficients of proposed filter model adaptively converge to the model parameter of blur function in a given time duration. Algorithm estimates the best filter coefficients using edge information of actual image. Results illustrate the performance of the proposed method.

Keywords : Image Restoration, Edge detection, Gaussian model.

I. INTRODUCTION :

A scenery can be visualized as an original from the short distance by using the well-focused imaging systems. Whereas, in the long distance, there are difficulties during the imaging process such as atmospheric turbulence, unfocused lenses of automatic imaging systems etc.. As known, atmospheric turbulence between the imaging system and the scenery nonlinearly change from time to time and place to place via the hot, the warm or the cold weather and its degradation parameters can not be controlled during the imaging process. This type degradation known as blurring is the result of the spreading of the pixels to the neighborhood pixels. Automatic focus arrangement of the imaging systems can partially compensate these effects. But not all.

Many researchers use the remote sensing images for their research areas. Because of the atmospheric turbulence during the imaging, they can not contain enough detail information. As a result of this, the researchers can not obtain correct results using these images. Therefore, the remote sensing images must be handled by using the image processing techniques before they can not be presented to the researchers.

Generally, blurred images are restored in two categories. One of them, statistics of the PSF are known and the blurred image can be restored by using the basic restoration techniques (Cepstrum, Inverse filtering, Blind deconvolution, etc.) [1][2][3]. Also results are very well, as we know the blur function model parameters such as variance mean and blur kernel. In the other category, which includes real world and satellite images, blur function model parameters can not be known and they must be estimated from the blurred image. There are many methods handled in literature using adaptive or iterative methods for the restoration based on estimation of blur parameters.

An adaptive-iterative method [4] based on estimation of blur parameters was proposed to restore the gaussian blurred images. Projections onto convex sets algorithm (POCS) [5] was proposed blur identification and restoration for space varying blurred images An adaptive-recursive 2-D filter [6] was proposed to remove the gaussian noise in degraded images. Approximate inverse preconditioning method [7] and simultaneous multichannel algorithm based on estimation of regularization parameters [8] were proposed to contribute positively the restoration problem in recent years.

This paper presents a method for deblurring of the Atmospherically blurred satellite images. Here, edge information of the blurred image is used estimation of the blur function model parameters. Then, a filter is established from previously estimated filter model parameters. Next chapters explain the proposed algorithm in detail.

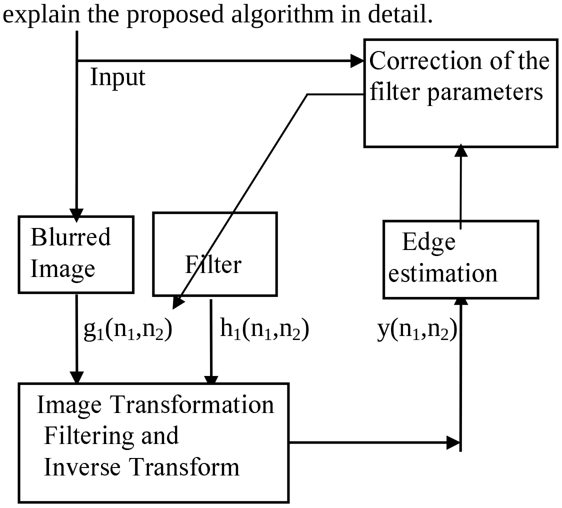

Figure - 1.Restoration algorithm block diagram.

II. PROBLEM IDENTIFICATION AND PROPOSED METHOD:

A satellite image has been modeled in previous works such as,

$$Y = X * h + N \qquad (1)$$

Where X is the original scenery, h is the impulse response of the blur function, N is the additive noise and Y is the observed image respectively. Additive noise comes from the imaging system and its model parameters are known. So, it can be removed from the degraded image by using the some special restoration techniques such as wiener filter etc… before deblurring process. So, re-write the observed image as,

$$Y = X * h \qquad (2)$$

As seen, the degradation given as a result of an observation has been obtained by convolution between original scenery and a blur function.

Blur function given in equation (2) can be statistically introduced by different distribution in the different conditions. But, considering the most general condition, all blurring effects have Gaussian or normal distribution. The Atmospheric turbulence, the unfocused imaging systems, motion effects cause blurring of the original image with a Gaussian distribution modeled as,

$$h_1(n_1, n_2) = \frac{1}{2\pi\sigma^2} e^{-\frac{(n_1^2+n_2^2)}{2\sigma^2}} \qquad (3)$$

Equation (3) is the filter model and it will be used for the real-time restoration of blurred image. Where, the variance with zero mean and the matrix size of the blur function are the critical parameters on the filter performance.

Experimental results show that if the matrix size could be arranged suitably in the algorithm, it become the second important parameter for the real-time applications. In this condition, first, the matrix size is searched and then fixed for given a period. Then, the variance is searched by the algorithm in this period. At the end of the period, the blur matrix size is updated, if it is necessary.

In this work, the edge detection has been used for the estimation of the filter variance accordingly. As known, the edge pixels in a blurred image are spreaded to the neighborhood pixels and the amplitude levels of sharp transitions called edges decrease or some of them completely loss all over the image, as they overcome each other. In this condition, its edge map does not include more edge pixels as in the case of the unblurred original one. So, we can say that, the edge map of an image gives an important information about the degradation. Experiments show that, only, unblurred image has the most edge pixels on the edge map.

Proposed algorithm can be explained as below corresponding to block diagram shown in figure-1.

1. Read digitized image ($y(n_1,n_2)$),
2. Estimate the filter parameter called variance (σ^2) from the edge map of degraded image after 20 iterations steps,
3. Construct a restoration filter using the computed parameter in step (2) ,
4. Compute the Cepstrum transform of filter and image,
5. Apply the designed filter to blurred image ($Y-h_1$),
6. Compute the inverse Cepstrum transform of (6),
7. Repeat the same process from (4),
8. Apply another blurred image for real time application and restore the new blurred image using steps 4,5,6,7
9. Re-estimate the filter parameter continuously and compare it with previous filter parameter.

   If it remains under a critical error, go on restoration.
   Else, refresh the filter parameter with a new value.

The relationship between the variance and the edge algorithm is defined as,

$$\sigma^2 = f(\nabla) = \left\{\sum\sum\left[\nabla y(n_1;n_2) \geq k\right]\right\}_{max.} \quad (4)$$

Where, k is a constant and ∇ is gradient operator. Filtering can be easily handled in the Cepstrum domain [8,9] using the previously estimated filter parameters. Original scene and blur function are additive in Cepstrum domain. If designed filter after the above mentioned iterations is $h_1(n_1,n_2)$, filtering in the Cepstrum domain as,

$$Y' = X' + h' - h'_1 \qquad (5)$$

Here, minimizing of the error between the blur function model parameters and the constructed filter model parameters provide to improvement of the quality in image which has been computed in dB as,

$$I = 20\log_{10}\frac{Energy-of-original-image}{Energy-of-error}$$

III. RESULTS AND CONCLUSIONS

The performance of the proposed algorithm has been tested using satellite images taken by HST (Hubble Space Telescope). Figure-2.a shows an original satellite image (Hubble-1) and 2.b, shows edge map of figure 2.a. Note that, where, some details on the image are not very clear. When we applied the proposed algorithm to the image, some image pixels that have been loss have been recovered (figure-2.d) and the image quality has significantly increased as shown in figure 2.c. Table-1 also shows some experimental results for this image. Here, variance of distribution for Hubble-1 image has been estimated as 4 and improvement in image quality has been computed as 24.86. Figure 3 and 4 also show other examples of restoration algorithm with numerical results in table-1. Table-2. also shows some experimental results on simulated images to be compared of the correctness of the algorithm.

As shown in table-1, improvements in image quality with satellite images have ranged between approximately 20dB and 30 dB. We know that, there are some unmeasured observation noises on the real world images and they affect image quality. These effects have also partially compensated by the proposed algorithm, but not all. So the restoration results given in table-2 do not seem as good as simulated results given in table-3. As known, in the real world images, restoration error can not be computed. On the other hand, the improvement in image quality can be found and it can be compared with the simulated results for an interpretation.

Algorithm needs 20 iteration steps for deblurring process. Algorithm gives a result for a blurred image approximately 1 minutes for the estimation of the blur parameters and approximately 15 second for the restoration on 300MHz personal computer.

In the future, this algorithm can be extended in the real time video processing problems by using the more speed microprocessor that have the parallel processing architecture.

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Table-1. Restoration results on satellite images.

Images	Real Variance	Blur Kernel	Estimated Variance	Improvement in Image Quality (dB)
HST-1	Unknown	15	4	24.86
HST-2	"	15	6	27.38
HST-3	"	15	5	29.89
HST-4	"	15	4	30.15

Table-2 Restoration results on simulated images.

Image	Real Variance	Blur Kernel	Estimated Variance	MSE in Degraded Image	MSE in Restored Image	Improvement in Image Quality (dB)
Child-1	4.65	15	4.55	2258	4.69	76.04
Child-2	4.65	15	4.70	785	0.62	86.69

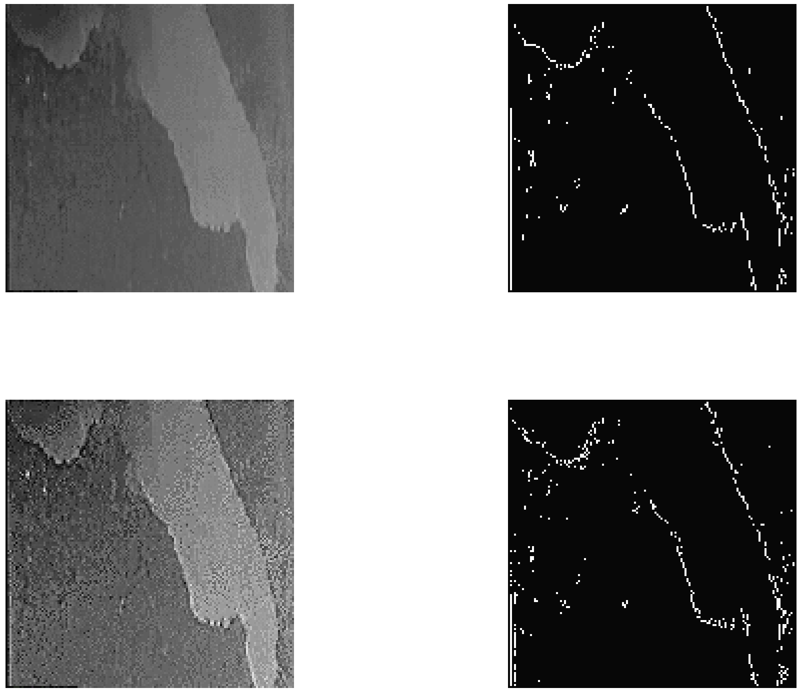

Figure-2.a. A real world HST image(left above), b. Edge map of (a) (right above)
c. Restored image from (a) (left below), d. Edge map of (c) (right below)

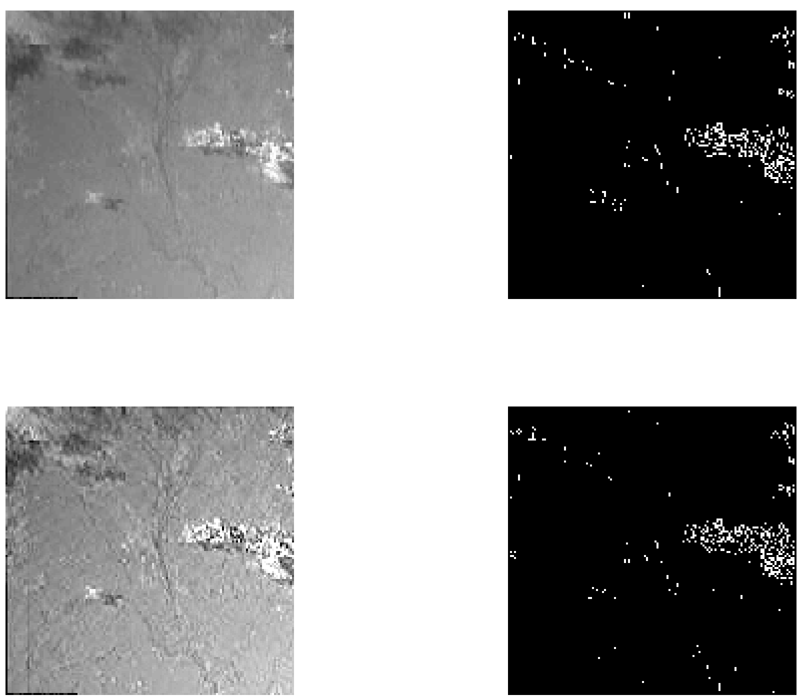

Figure-3.a. A real world HST image(left above), b. Edge map of (a) (right above)
c. Restored image from (a) (left below), d. Edge map of (c) (right below)

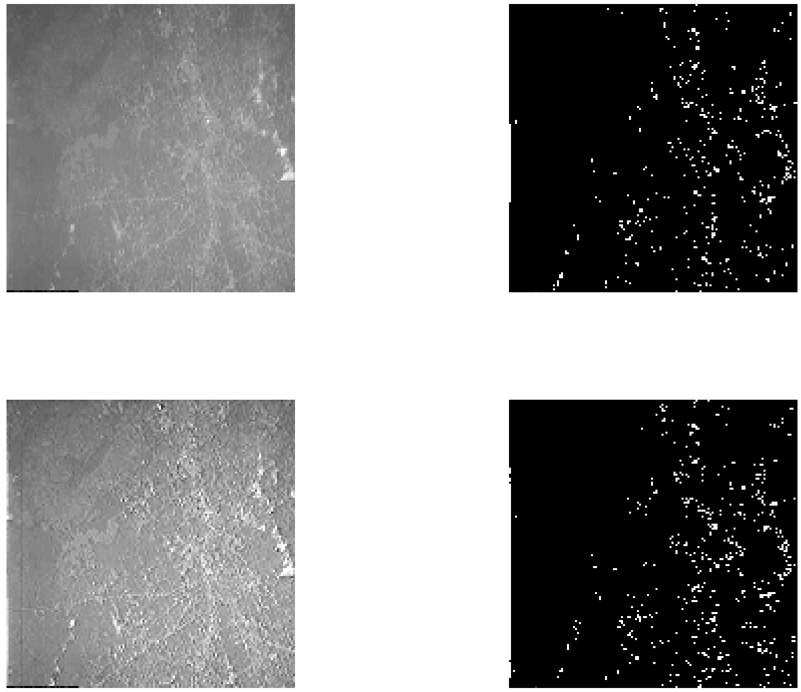

Figure-4.a. A real world HST image(left above), b. Edge map of (a) (right above)
c. Restored image from (a) (left below), d. Edge map of (c) (right below)