A Unified Method For Digital Super Resolution and Restoration of IR Microscopy Imaging

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Abstract- *Infrared (IR) imaging systems resulted in degraded imagery since it uses focal plane array and IR sensor in IR microscope. Fixed pattern noise (FPN), resulting from pixel-to-pixel response non uniformity, is a dominant source of error which also occurs due to long exposure of lens to the light. Furthermore, finite detector size coupled with imperfect system optics can introduce blurring effects and aliasing, ultimately reducing resolution in acquired images. In this project, a unified method to reduce FPN and recover high-frequency image content in IR microscopy images is proposed. The proposed method uses regularized nonlocal means to highlight spatial features in the scene while maintaining fine textural image details. Derive an iterative optimization method based upon a gradient descent minimization strategy that applies a Wiener deconvolution in each iteration to estimate the blur artifacts. The main advantage of using wiener deconvolution is it is not sensitive to noise and have high SNR value compared to other restoration techniques. The method is implemented within an embedded mid-wave IR imaging system for microscopy applications and demonstrates a reduction in FPN and blurring artifacts, achieving improved image resolution by using resolution algorithm in the reconstructed images that are apparent in recovered details on scene objects.*

I. INTRODUCTION

Infrared (IR) microscope, also known as infrared micro spectroscopy, is a type of light microscopy that uses a source that transmits infrared wavelengths of light to view an image of the sample. Fixed Pattern Noise (FPN), resulting from pixel-to-pixel response non uniformity occurs due to improper lens focusing in FPA[1]. Two significant Artifacts that resulted in collected digital imagery are blurring and fixed pattern noise. Image blurring results from both imperfections in the system optics and finite nature of Focal plane array detectors. Defocus blur occurs in image when camera is improperly focused on image[5]. The resolution of image medium depends on amount of defocus. If there is more tolerance of image there is low resolution in image[4]. For good resolution of image defocus in image should be minimize. Image restoration is a process of recovering the original images by removing noise and blur from image[2]. Image blur is difficult to avoid in many situations like photography, to remove motion blur caused by camera shake, radar imaging to remove the effect of image system response, etc. Image noise is unwanted signal which comes in image from sensor[6].In this paper a Wiener filter includes both the degradation function and statistical characteristics of noise into restoration process. This method is considered on the basis of images and noise as random processes and the objective is to find an estimate function of the uncorrupted image such that wiener filter minimize the mean square error[5]. It is assumed that the images and the noise are uncorrelated; that one or the other has zero mean and that the grey levels in the degraded image is linear function of estimation wiener deconvolution is an application of the wiener filter to the noise problems inherent in deconvolution. It operates in the frequency domain which attempts to minimize the impact of deconvolution noise at frequencies which has a poor signal to noise ratio.The wiener deconvolution method is widespread used in image deconvolution applicants as the frequency spectrum of most visual images is fairly well behaved and can be estimated easily[7-9].

Gradient descent is a first-order iterative optimization algorithm for finding the local minimum of a differentiable function. DSR algorithm has been developed to estimate the high resolution (HR) scene from an ensemble of Low resolution (LR) IR image frames. Often, these methods exploit inherent aliasing in the LR frames in conjunction with frame to frame motion to recover high frequency content lost through under sampling [10-12].

II. WIENER DECONVOLUTION

Wiener deconvolution is an application of the Wiener filter to the noise problems inherent in deconvolution. It is not sensitive to noise so it produces high SNR. It works in the frequency domain, attempting to minimize the impact of deconvolved noise at frequencies which have a poor signal-to-noise ratio.

The Wiener deconvolution method has widespread use in image deconvolution applications, as the frequency spectrum of most visual images is fairly well behaved and may be estimated easily. The Wiener filtering is optimal in terms of the mean square error shown in the figure 1 given below. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing.

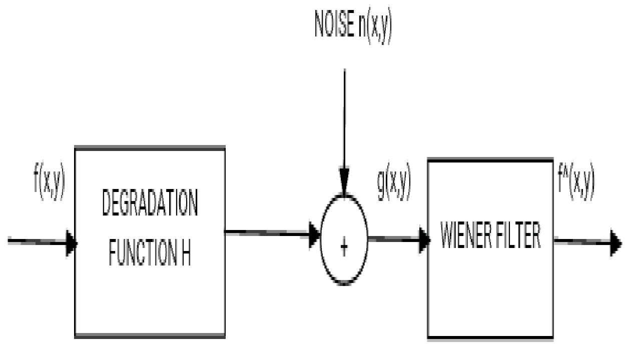

Figure 1 Block diagram of wiener deconvolution

III. POINT SPREAD FUNCTION

The point spread function (PSF) describes the response of an imaging system to a point source or point object. A more general term for the PSF is a system's impulse response, the PSF being the impulse response of a focused optical system. The PSF in many contexts can be thought of as the extended blob in an image that represents a single point object. In functional terms it is the spatial domain version of the optical transfer function of the imaging system. The PSF means that when two objects A and B are imaged simultaneously, the resulting image is equal to the sum of the independently imaged objects.

In other words, the imaging of A is unaffected by the imaging of B and vice versa, owing to the non-interacting property of photons. In space-invariant system, i.e. the PSF is the same everywhere in the imaging space, the image of a complex object is then the convolution of the true object and the PSF shown in figure 2.

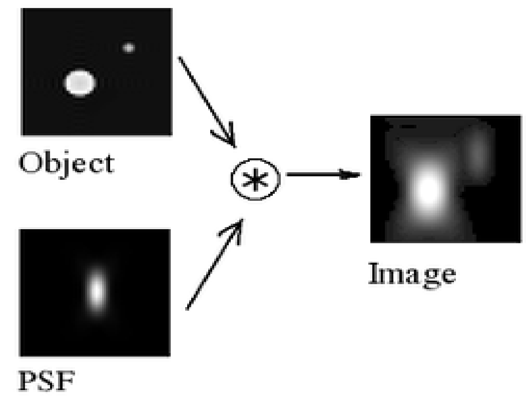

Figure 2 Point spread function

IV. DIGITAL SUPER RESOLUTION

Super-resolution (SR) are techniques that construct high-resolution (HR)images from several observed low-resolution (LR) images, thereby increasing the high frequency components and removing the degradations caused by the imaging process of the low resolution camera. The basic idea behind SR is to combine the non-redundant information contained in multiple low-resolution frames to generate a high-resolution image.

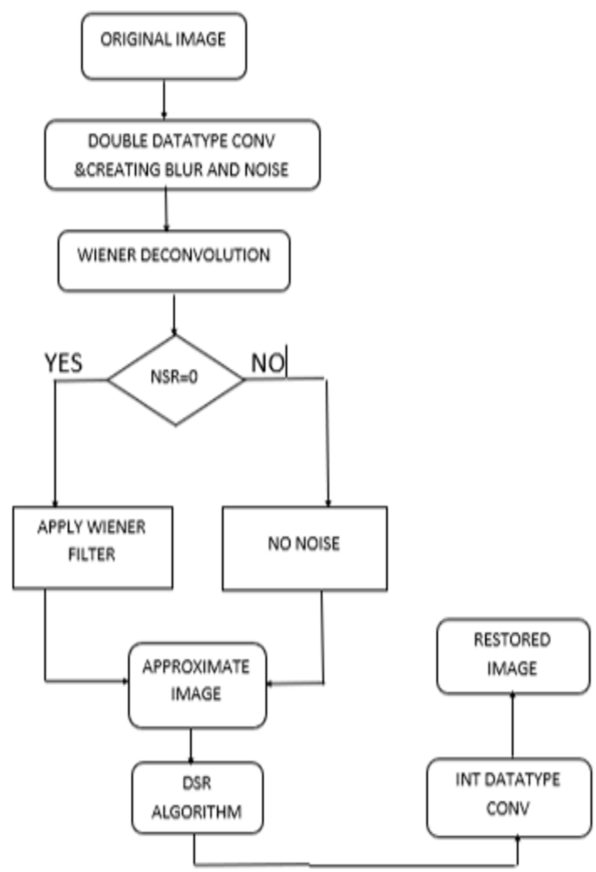

Figure 3Flow chart for DSR and restored image

A closely related technique with SR is the single image interpolation approach, which can be also used to increase the image size. However, since there is no additional information provided, the quality of the single image interpolation is very much limited due to the ill-posed nature of the problem, and the lost frequency components cannot be recovered. In the SR setting, however, multiple

Low-resolution observations are available for reconstruction, making the problem better constrained. The non-redundant information contained in the these LR images is typically introduced by subpixel shifts between them. These subpixel shifts may occur due to uncontrolled motions between the imaging system and scene, e.g., movements of objects, or due to controlled motions, e.g., the satellite imaging system orbits the earth with predefined speed and path.Each low-resolution frame is a decimated, aliased observation of the true scene. SR is possible only if there exists subpixel motions between these low resolution frames. The flow chart for this project is shown in figure 3.

V. RESULT AND DISCUSSIONS

Figure 4 Simulate blurnoise

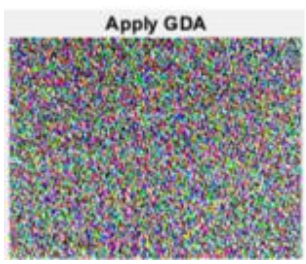

Figure 5 Gradient descent and algorithm

Apply gradient descent optimization technique to the noisy and blurred image (figure 4)and remove those artifacts. Wiener deconvolution is applied to this image is shown in figure 5. Try to restore the blurred noisy image by using deconvwnr without providing a noise estimate in the next stage.

Figure 6 Removing blurring artifacts

Figure 7 Applying fixed pattern noise

By default, the Wiener restoration filter assumes the NSR is equal to 0 is shown in figure 6.In this case, the Wiener restoration filter is equivalent to an ideal inverse filter, which can be extremely sensitive to noise in the input image is shown in figure 7.

Figure 8 Digital super resolution stage 1

Figure 9 Digital super resolution stage 2

Here the DSR(Digital super resolution) algorithm is used. It is applied as iterative stages as DSR stage 1, DSR stage 2 to get the edge details and texture details is shown in figure 8, 9.

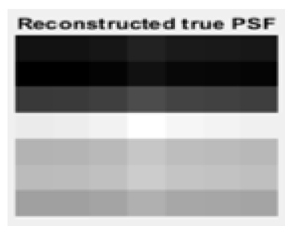

Figure 10 Reconstructed true

Figure 11Restoredimagepoint spread function

In the next stage, point spread function for the image is calculated. PSF is used to measure the degree of blur present in an image and for the noisy image is shown in figure 10. The results obtained from the proposed method exhibit a reduction in FPN and blur when compared with up sampled image. Note that the numbers that are progressively smaller, are easier to resolve with naked eyes when compared with the result. Besides, the outputs of the existing method show good high-frequency reconstruction but still have some noise components and a lack of sharpness when compared with the proposed method.

Table 1 Comparison of existing and proposed

Parameters	Title	SNR value	Edge detection	Noise	Resolution(mean value)	Blur
Existing system	Non blind image restoration scheme combining parametric wiener filtering and denoising technique.	8.873	Fails to give more details about edges in all orientation.	Wavelet filter can't efficiently suppress the noise.	115	Only the focused blur can be removed
Proposed system	A unified method for digital super resolution and restoration in infrared microscopy imaging	13.396	DSR jointly with spatial regularization preserves the edges and textures.	Wiener deconvolution attempts to minimize the noise.	150	Entire blurring artifacts can be removed.

The estimated super resolution result from the proposed method, a significant improvement is observed (due to FPN and blur reduction) that allows for additional structures to be seen .The proposed method appears to produce the sharpest results with the least aliasing compared with the existing methods.The proposed method output appears to provide the best reconstruction with sharp and higher resolution is shown in 11.The table 1 shows the utilization Summary of both Existing system and proposed system .

VI. CONCLUSION

In this paper, a unified method to reduce FPN and recover high-frequency image content for IR microscopy images is presented. The proposed method jointly estimates a DSR image and compensate NU parameters and blurring artifacts using a sequence of observed frames and use regularizations such as the NLM, a Laplacian operator, and the Pearson's correlation coefficient to maintain fine textural image details, highlight spatial features in the scene and estimate FPN. We employ a gradient descent optimization and apply a Wiener deconvolution in each iteration to compensated the blur artifacts . Besides there is edge preservation and the best result is obtained.

REFERENCES

[1] P. A. Coelho, J. E. Tapia, F. Perez, S. N. Torres, and C. Saavedra, ''Infrared light field imaging system free of fixed-pattern noise,'' Sci. Rep., vol. 7, 2017.

[2] Cruz,C., Mehta,R., Katkovnik,V. and Egiazarian,K.O. 'Single image super-resolution based on Wiener filter in similarity domain,' IEEE Trans. Image Process., vol. 27, no. 3, pp. 1376–1389,2018.

[3] Dong,C. , Loy,C.C., He,K. and Tang,X. 'Image super-resolution using deep convolutional networks,' IEEE Trans. Pattern Anal. Mach. Intell., vol. 38, no. 2, pp. 295–307,2015.

[4] R. Hardie, ''Super-resolution using adaptive Wiener filters,'' in SuperResolution Imaging. Boca Raton, FL, USA: CRC Press, 2010.

[5] Jara,A. , Torres,S.N. , Machuca,G. , Ramírez,W. , Gutiérrez,P.A., Viafora,L.A., Godoy,S.E. and Vera,E. 'Joint de-blurring and nonuni- formity correction method for infrared microscopy imaging,' Infr. Phys. Technol., vol. 90, pp. 199–206,2018.

[6] Senthilkumar K K&Seshasayanan R 2014, 'Power Reduction in DCT Implementation using Comparative Input Method',INFORMATION, An International Interdisciplinary Journal, **2014**(Impact Factor = 0.358). Vol.17, No.12(B), pp.6619-6642

[7] Senthilkumar, K.K., Kunaraj, K. &Seshasayanan, R. Implementation of computation-reduced DCT using a novel method. J Image Video Proc. 2015, 34,2015. https://doi.org/10.1186/s13640-015-0088-z

[8] Z. Wang, A. C. Bovik, H. R. Sheikh, and E. P. Simoncelli, ''Image quality assessment: From error visibility to structural similarity,'' IEEE Trans.Image Process., vol. 13, no. 4, pp. 600–612, Apr. 2004.

[9] Wang,N. ,Wang,J. , Zhang,Y. and Sun,X 'Restoration of the infrared image blurred by motion,' Proc. SPIE, vol. 10255, 2017.

[10] YueZhang,L. 'Image super- resolution: The techniques, appli,L. , Shen,H. , Li,J. ,Yuanc,Q. , Zhang,H. and cations, and future,' Signal process.,vol.128,pp.389-408,2016.

[11] V. S. Harshiniand K.K.Senthilkumar, "Design of Hybrid Sorting Unit," 2019 International Conference on Smart Structures and Systems (ICSSS), Chennai, India, 2019, pp. 1-6.doi: 10.1109/ICSSS.2019.8882866

[12] R. Seshasayananand K. K.Senthilkumar, "Reconfigurable Architecture For WTLS," 2006 Annual IEEE India Conference, New Delhi, 2006, pp. 1-4. doi: 10.1109/INDCON.2006.302835