

Deblurred of Image with Wiener Filter in MATLAB

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Abstract - This paper represents how to de-blurred image with Wiener filter with information of the Point Spread Function (PSF) corrupted blurred image with different values and then corrupted by additive noise. Image is restored using Wiener deconvolution (it works in the frequency domain, attempting to minimize the impact of deconvoluted noise at frequencies which have a poor signal-to-noise ratio). Noise-to-signal ratio is used to control of noise. For better restoration of the blurred and noisy images, there is use of full autocorrelations functions (ACF). ACF is recovered through fast Fourier transfer shifting.

Keywords - Point Spread Function (PSF), Wiener filter, Signal-to-noise ratio, Autocorrelation function (ACF), Fourier transfer

I. INTRODUCTION

As in image enhancement, the goal of restoration technique is to improve an image in some predefined sense. Restoration attempts to reconstruct or recover an image that has been degraded by using a priori knowledge of the degradation phenomenon [1]. There is small difference between image enhancement and image restoration. Image enhancement is largely subjective process, while image restoration is for the most part an objective process. For example, contrast stretching is considered an enhancement technique because it is based primarily on the pleasing aspects it might present to the viewer, whereas removal of image blur by applying a deblurring function is considered a restoration technique.

Let $f(x, y)$ is input image; $g(x, y)$ is degraded image with some degraded function H and additive noise $\eta(x, y)$. so in spatial domain, degraded image is

$$g(x, y) = h(x, y) * f(x, y) + \eta(x, y) \quad (1)$$

The model of the image degradation/ restoration process is as [1]:

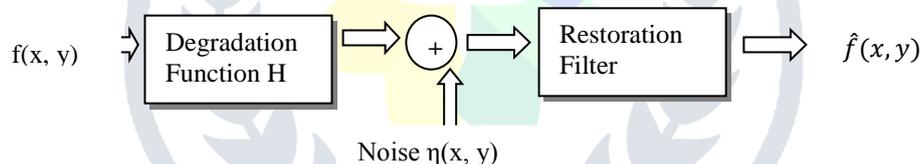


Fig. 1 Image degradation/ restoration model

Image is degraded with addition of noise as Rayleigh noise, Gamma noise, Exponential noise, uniform noise, impulse noise, periodic noise.

Base on this estimation of noise parameters and to restore image back, we use mean filter, Order-Statistics filter, adaptive filter, frequency domain filter, Optimum notch filter, Wiener filter etc.

II. BLURRING AND DEBLURRING OF IMAGE

S.S. Al-Amri [2] introduce blur is unsharp image area caused by camera or subject movement, inaccurate focusing, or the use of an aperture that gives shallow depth of field. He introduced three types of blurring: Average blur, Gaussian blur, and motion blur.

Y. Yitzhaky [10] introduces motion blur phenomena. Result of relative motion between the camera and the object of interest, adjacent points in the image plane are exposed to the same point in the object plane during the exposure time. The intensity of an image of an original point is shared between these image plane points according to the relative duration in which each point is exposed to light from the original point. The smearing tracks of the points determine the PSF in the blurred image.

Using MATLAB, blurring of image is applied through average filter, disk filter, Gaussian filter, Laplacian filter, motion filter, log filter, prewitt and sobel operator, unsharp of image.

In image deblurring, to recover of original image, sharp image by using a mathematical model of the blurring process [8]. The key issue is that some information on the lost details is indeed present in the blurred image- but this information is "hidden" and can only be recovered if we know the details of blurring process.

As equation (1), PSF (Point Spread Function) and ACF (Auto correlation function) are used as $h(x, y)$. The PSF describes the response of an imaging system to a point source or point object. The PSF is the degree of which an optical system blurs (spreads) a point of light [2]. The PSF is the inverse Fourier Transform of Optical Transfer Function in the frequency domain. The PSF is useful concept in Fourier optics, astronomical imaging, electron microscope, and other imaginary techniques such as 3D

microscopy and fluorescent microscope. In MATLAB, PSF is measure with special function which is used length and theta for variation of image.

Autocorrelation is the cross-correlation of a signal with itself. Informally, it is the similarity between observations as a function of the time separation between them. It is a mathematical tool for finding repeating patterns, such as the presence of a periodic signal which has been buried under noise, or identifying the missing fundamental frequency in a signal implied by its harmonic frequencies.

In MATLAB, ACF is control of noise power and original image power with fast Fourier transfer shifting.

A. Linear Motion blur

Many types of motion blur can be distinguished all of which are due to relative motion between the recording device and the scene. This can be in the form of a translation, a rotation, a sudden change of scale, or some combinations of these. Here only the important case of a global translation will be considered. When the scene to be recorded translates relative to the camera at a constant velocity $v_{relative}$ under an angle of \emptyset radians with the horizontal axis during the exposure interval $[0, t_{exposure}]$, the distortion is one-dimensional. Defining the "length of motion" by $L = v_{relative} \cdot t_{exposure}$, the PSF is given by [14]:

$$d(x, y; L, \emptyset) = \begin{cases} \frac{1}{L} & \text{if } \sqrt{x^2 + y^2} \leq \frac{L}{2} \text{ and } \frac{x}{y} = -\tan\emptyset \\ 0 & \text{elsewhere} \end{cases} \quad (2)$$

The discrete version of (2) is not easily captured in a closed form expression in general. For the special case that $\emptyset = 0$, an appropriate approximation is:

$$d(n_1, n_2; L) = \begin{cases} \frac{1}{L} & \text{if } n_1 = 0, |n_2| \leq \lfloor \frac{L-1}{2} \rfloor \\ \frac{1}{2L} \left\{ (L-1) - 2 \lfloor \frac{L-1}{2} \rfloor \right\} & \text{if } n_1 = 0, |n_2| = \lfloor \frac{L-1}{2} \rfloor \\ 0 & \text{elsewhere} \end{cases} \quad (3)$$

III. WIENER FILTER

The Wiener filter is a filter proposed by Norbert Wiener during the 1940s and published in 1949. Its purpose is to reduce the amount of noise present in a signal by comparison with an estimation of the desired noiseless signal. A Wiener filter is not an adaptive filter because the theory behind this filter assumes that the inputs are stationary [11].

The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on a statistical approach. Typical filters are designed for a desired frequency response. However, the design of the Wiener filter takes a different approach. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the linear time-invariant filter whose output would come as close to the original signal as possible.

Wiener filters are characterized by the following: [12]

1. Assumption: signal and (additive) noise are stationary linear stochastic processes with known spectral characteristics or known autocorrelation and cross-correlation
2. Requirement: the filter must be physically realizable/causal (this requirement can be dropped, resulting in a non-causal solution).
3. Performance criterion: minimum mean-square error (MMSE)

This filter is frequently used in the process of deconvolution. Thus, the Wiener filter is the Minimum Square Error (MSE)-optimal stationary linear filter for images degraded by additive noise and blurring. Calculation of the Wiener filter requires the assumption that signal and noise processes are second-order stationary. It works in the frequency domain, attempting to minimize the impact of deconvoluted noise at frequencies which have a poor signal-to-noise ratio.

The method is founded on considering images and noise as random processes, and the objective is to find an estimate \hat{f} of the uncorrupted image f such that the mean square error between them is minimized and error measure is given by

$$e^2 = E\{(f - \hat{f})^2\} \quad (4)$$

Where $E\{\cdot\}$ is the expected value of the argument. The minimum of the error function in eq. (1) is given in the frequency domain, by the expression

$$\hat{F}(u, v) = \left[\frac{1}{H(u, v)} \frac{|H(u, v)|^2}{|H(u, v)|^2 + S_\eta(u, v) / S_f(u, v)} \right] G(u, v) \quad (5)$$

Where

$H(u, v)$ = degradation function

$H^*(u, v)$ = complex conjugate of $H(u, v)$

$|H(u, v)|^2 = H^*(u, v) H(u, v)$

$S_\eta(u, v)$ = power spectrum of the noise

$S_f(u, v)$ = power spectrum of the undegraded image.

If the noise $S_{\eta}(u, v)/S_f(u, v)$ is zero then the noise power spectrum vanishes and the Wiener filter reduces to the inverse filter. If the noise $S_{\eta}(u, v)/S_f(u, v)$ is large, the Wiener filter become zero, so that frequency is ignored. The main advantage is the short computational time it takes to find solution.

Advantages of wiener filter are as below:

1. Begins to exploit signal
2. Controls output error
3. Straightforward to design

Disadvantages of wiener filer are as below:

1. Results often too blurred
2. Spatially invariant

IV. EXPERIMENT RESULTS

Using MATLAB7.5.0 (R2007b), blurring of image and deblurred of images is as below:

Figure 2 shows results of deblurring of images using Wiener filter without addition of noise. Since the PSF is varying in the motion direction, it is not correlated perpendicularly to the motion direction. If we increase length and theta of PSF, then blurring of image is increased. Image is restored using Wiener deconvolution.

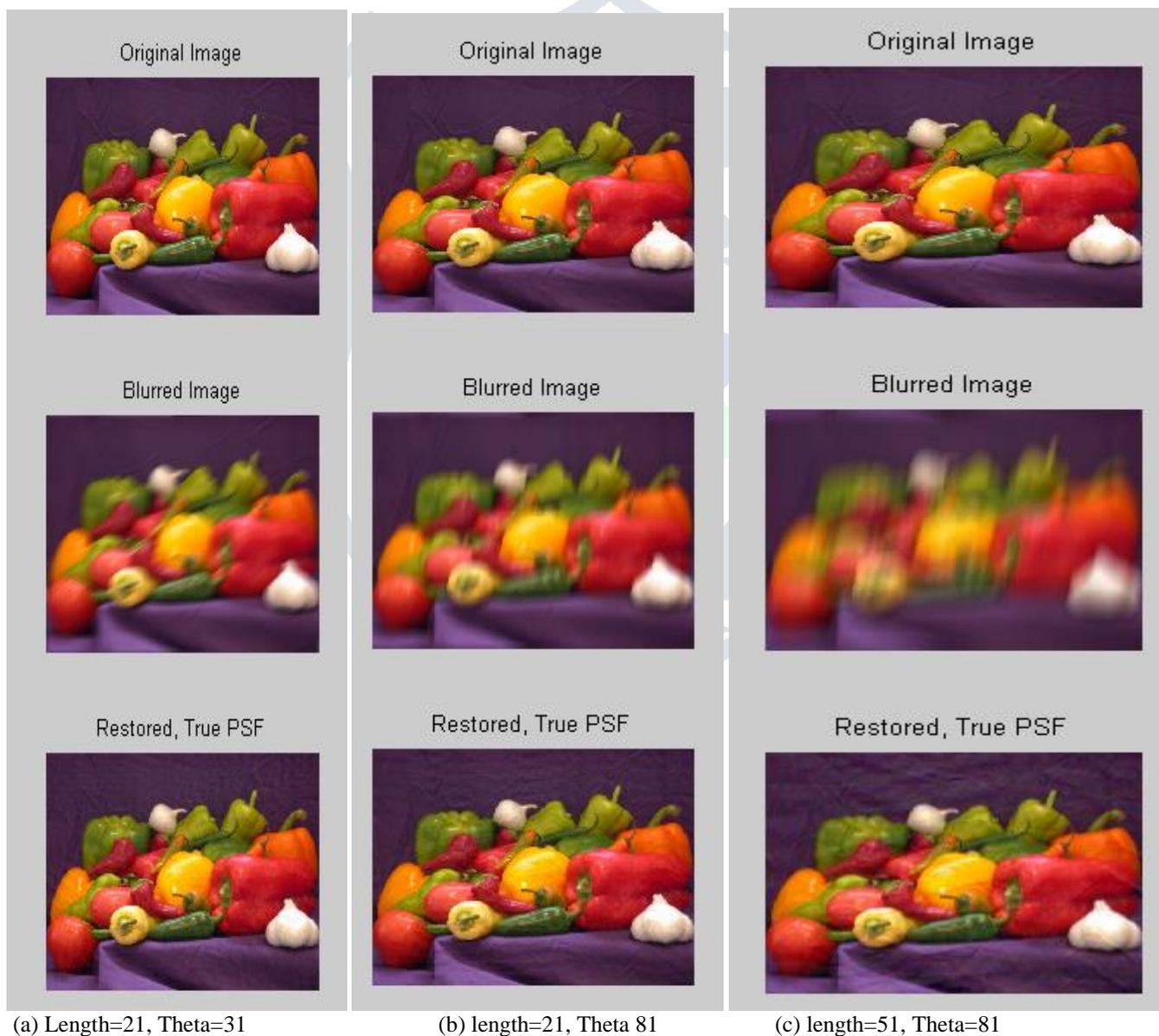


Fig.2 Deblurred image with Wiener Filter

Deblurred image with Wiener filter with addition of noise. Steps are as:

1. Read the image.
2. Create a PSF.
3. Create a simulated blur in the image.

4. Deblurred the image using Wiener Filter
5. Add noise by using distributed random numbers.
6. Restored the blurred and noisy image using an inverse filter.
7. Apply Noise to Signal Ratio (NSR) to control of noise.
8. Use Autocorrelation function ACF to improve image restoration.

Figure 3 and 4. Shows blurred image, noises are added on image. To control the noise amplification, provide the noise-to-signal power ratio, NSR to restore back an image. Vary the NSR value to affect the restoration results. The small NSR value amplifies noise. To improve the restoration of the blurred and noisy images, supply the full autocorrelation function (ACF) for the noise. Implementing the ACF to all to image derivative lines in the motion direction and then averaging them, will suppressed the noise stimulated by fast Fourier transfer shifting.

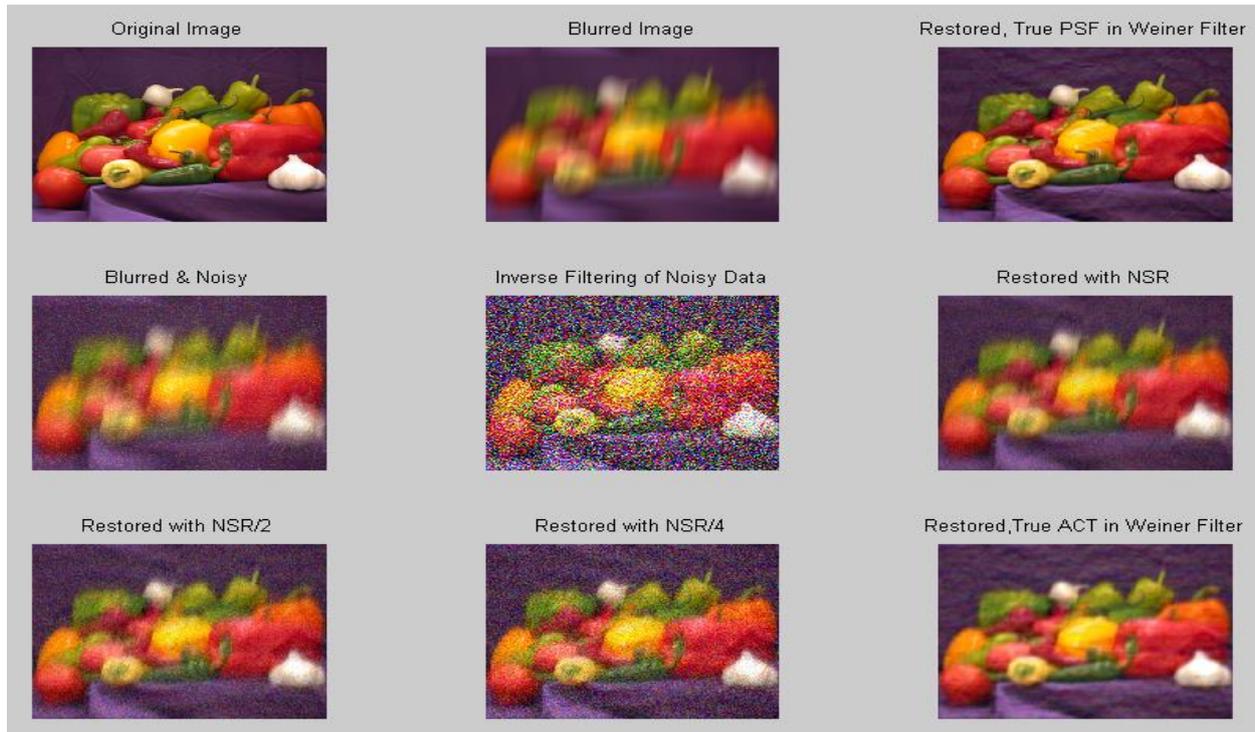


Fig.3 Deblured image with additive noise. Noise is four times in NSR

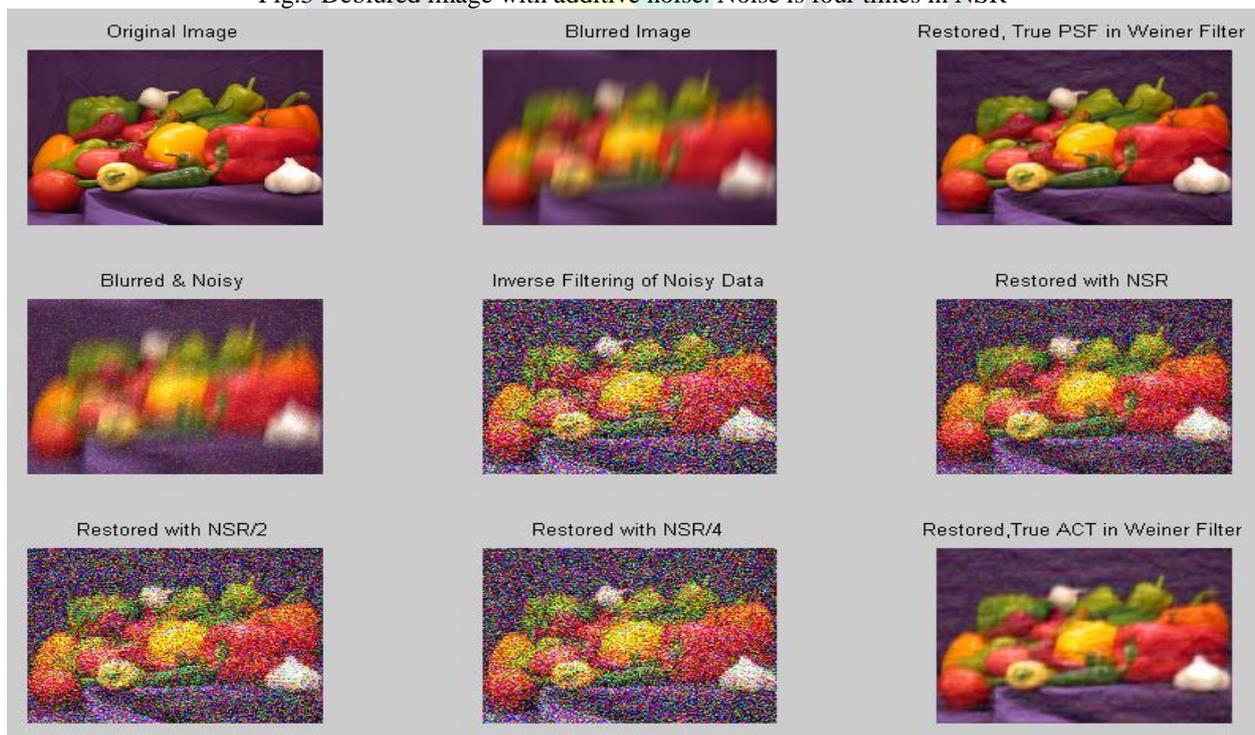


Fig. 4 Deblured image with additive noise. Noise is two times in NSR

V. CONCLUSION

Image is blurred by motion or noise are added in image. Direct image is deblurred with using of true PSF (Point Spread Function) in Wiener Filter, if noises are not added in degraded image. Wiener filter works in the frequency domain, attempting to minimize the impact of deconvoluted noise at frequencies which have a poor signal-to-noise ratio. If noise are added in degraded image, then to recover of blurred and noise image, ACF (Autocorrelation Function) is used in Wiener Filter. ACF control noise power and original image power.

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