

# IMAGE ENHANCEMENT USING WIENER FILTRATION

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## Abstract

The degradation of a photographic image can be caused by many factors such as a geometric distortion or a blur. The geometric distortion is often caused by using of a wide-angle lens. The blur is caused by a movement of a camera during the image capture or by the movement of a photographed subject when long exposure time is used. In this paper we present the Wiener filtering as an effective linear image deblurring approach.

## 1 Principles of the Wiener Filter Deconvolution

A degraded image can be approximately described by the expression

$$g = H[f] + n, \quad (1)$$

where:  $g$  is the degraded (blurred) image,  $H$  is the degradation operator,  $f$  is the original image, and  $n$  is an additive noise. In space domain,  $H$  is represented by the PSF – Point Spread Function that describes the distortion or blur. The PSF function, when convolved with the original undegraded image  $f$ , creates the distortion. The reversing process of the effect of convolution is called deconvolution. The deconvolution is often done in frequency domain, where the process becomes a simple matrix multiplication. In the frequency domain the PSF is represented by the optical transfer function (OTF) [1, 2]. The OTF is the Fourier transform of the PSF and it describes the response of a linear, position invariant system to an impulse. To convert the point spread function into an optical transfer function or vice versa you can use the Matlab functions `psf2otf` or `otf2psf` respectively. Wiener filtering [2] is an effective linear image restoration approach. The task is to find the estimate of the “best” image  $\hat{f}$  is done usually in frequency domain:

$$\hat{F}(u, v) = \frac{|H(u, v)|^2}{H(u, v)|H(u, v)|^2 + |N(u, v)|^2 / |F(u, v)|^2} G(u, v), \quad (2)$$

where  $H(u, v)$  is the degradation function,  $G(u, v)$  is the Fourier transform of the degraded image,  $|N(u, v)|^2$  is the power spectrum of noise,  $|F(u, v)|^2$  is the power spectrum of the undegraded image. The Wiener filter performs deconvolution in the sense of minimizing a least squares error i.e.:

$$e^2 = E\{(f - \hat{f})^2\}, \quad (3)$$

where  $E$  is the mean value,  $f$  is the undegraded image which is usually not known. In the case of omitting the noise the Wiener filter changes to a simple inverse filter. Image processing toolbox offers functions such as `imfilter` that can be used to convolve the PSF with the image. When the photograph is blurred the parameters of the original PSF may be partly known or may not be known at all. During the deblurring process attempts or iterations with varying parameters may be needed to achieve an image that is “the best” approximation of the original image. Other methods [2, 3] such as blind deconvolution or Richardson-Lucy restoration algorithms can be also used.

## 2 Results

Experiments were done with photographic images captured at poor lighting conditions. A sample of the image of the ring captured with the shutter speed  $\frac{1}{4}$ s is in Figure 1a). Several modification of PSF has been done before the correct angle and length of the blure were found. Selected results of the Wiener reconstruction are given in Figure 1b).

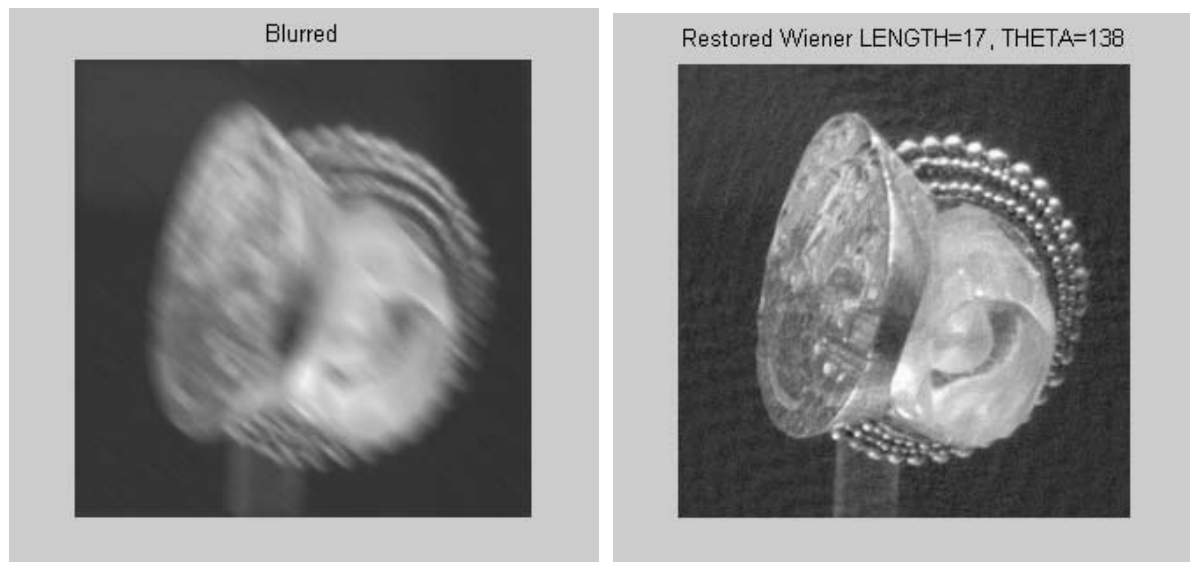


Figure 1 a) The example of the blurred and b) the restored images using the Wiener reconstruction.

## References

- [1] R.C. Gonzales, R.E.Woods. *Digital Image Processing*. Prentice Hall, Upper Saddle River, NJ, 2001.
- [2] R.C. Gonzales, R.E. Woods, S. Eddins. *Digital Image Processing Using MATLAB*. Prentice Hall, Upper Saddle River, NJ, 2004.
- [3] Image Processing Toolbox For Use with Matlab, Users Guide. The Math Works Inc., Natick, MA 2004.

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