Defocus Fuzzy Image Restoration

Chengcheng Li¹,a*, Gongfa Li¹,3,b, Ying Sun¹,2,c, Guozhang Jiang²,4,d, Du Jiang¹,e and Shuang Xu¹,4,f

¹Key Laboratory of Metallurgical Equipment and Control Technology, Ministry of Education, Wuhan University of Science and Technology, Wuhan 430081, China
²Hubei Key Laboratory of Mechanical Transmission and Manufacturing Engineering, Wuhan University of Science and Technology, Wuhan 430081, China
³Research Center of Biologic Manipulator and Intelligent Measurement and Control, Wuhan University of Science and Technology, Wuhan 430081, China
⁴3D Printing and Intelligent Manufacturing Engineering Institute, Wuhan University of Science and Technology, Wuhan 430081, China
Email: a1271693864@qq.com; bligongfa@wust.edu.cn; csunying65@wust.edu.cn; dwhjgz@wust.edu.cn; e1439078161@qq.com; fshuangxu@wust.edu.cn

Abstract. In daily life, if the focus is not on the object to be photographed, the image is blurred. This is the blurred image caused by the defocus. The defocus is a very common factor, and in most cases, the defocus amount is unpredictable, which brings great difficulty to defocus image restoration. In the existing defocus fuzzy image restoration method, the defocused point diffusion function can be estimated by determining the model parameters of the defocus blurred image, and then the reconstructed image can be obtained by inverse filtering or Wiener filtering. This paper introduces the causes of the defocus image, expounds the inverse filtering, Wiener filtering and blind restoration methods, and analyses the different principles of the three methods, and uses inverse filtering, Wiener filtering and blind restoration to deal with the defocus blurred images, and the expected results are obtained.

1. Introduction
With the continuous development of Electronic Science and technology, the market of electronic products is becoming more and more prosperous. The image display equipment and digital technology are becoming more and more popular. In the process of image acquisition, storage, processing and transmission, the image quality will fall under the influence of various factors. Image restoration technology is gradually applied to optical, communication, signal analysis and other fields[1]. Its main purpose is to increase the quality of the degraded image and improve the image in vision. In the study of image restoration, we need to know the causes of image degradation. There are many factors that cause image degradation, including noise interference, illumination change, motion blur, and no focus on focus. According to different reasons, different degradation models and knowledge are used to reconstruct the image and improve the image quality. The difficulty of image restoration lies in the accuracy of the prior knowledge of the process of image degradation. If we are clear about the model parameters and processes of the degraded images, the point diffusion function PSF of the degraded image can be obtained more accurately, and then according to the different image restoration methods, such as Wiener filtering and blindness The restoration method is used to restore the image[2].

2. The cause of the defocus image and the optical model
The defocus blurred image is mainly due to the inaccurate focus between the scene and the camera at
the time of shooting. In the process of imaging, the focal length, the object distance and the distance
do not satisfy the principle of Gauss imaging[3], which causes the blurred image formed on the
photosensitive plate, and the farther the object is from the focus, the more blurred the image is. The
camera lens used in life is a convex lens. We assume that the object to be taken is a point source, and
the point source is located in the focus position so that the light emitted from the point light passes
through a convex lens and then converges to the photosensitive board to form a point, so that the
object will be very clear[4]. But if the object is not located at the focal point, the light will form a
circular spot on the photosensitive plate after a convex lens, which means that the object will be very
blurred, and the specific model is shown in Figure 1.

![Figure 1. Optical imaging model](image)

In general, objects in life can not know the exact location of the focus, so the photographs taken
will basically have a certain degree of blur. The key problem of the defocus image restoration is to
determine the degenerate model and the degenerate parameter. The degenerate model of the defocus
image can be abstracted as a disk function. According to figure 1, the point diffusion function of the
image blurred caused by defocus uses a uniform distribution of light spots[5], and the point diffusion
function is shown by Formula 1.

\[
h(x, y) = \begin{cases} 
\frac{1}{\pi^2} & x^2 + y^2 \leq r^2 \\
0 & \text{other}
\end{cases}
\]  

(1)

3. Research on the method of defocusing image restoration

Image restoration is different from image enhancement. Its purpose is to restore the degraded image of
the observed image to the clear state before the degradation. The main research content is to model the
fuzzy and noise interference in the degraded image, and restore the original image by the reverse
process[6]. The results are generally approximate. The image restoration technology usually includes
parameter estimation and filter design. The parameter estimation is mainly based on different prior
knowledge to obtain some degenerate parameters of the degraded image, and the original image is
estimated by the filter restoration. If the prior knowledge or model is known, the image can be restored
according to the classical algorithm, but if the prior knowledge and the model position, the prior
knowledge is estimated by blind restoration, and then the specific degradation parameters can be
obtained[7].

3.1. Inverse filtering

Inverse filtering is one of the simplest image restoration techniques. Due to the inaccuracy of focus, it
is not the ideal clear image on the photosensitive plate, but the blurred image caused by the defocus. In
the theory of image restoration[8], clear and defocus images satisfy the following formula (2):
Where \( h(x, y) \) is the point spread function of the imaging system, \( n(x, y) \) represents environmental noise. 

The Fourier transform of the formula (2) is obtained.

\[
g(u, v) = F(u, v)H(u, v) + N(u, v)
\]

If \( H(u, v) \) is known, the formula (3) is transformed under the influence of environmental noise.

\[
F(u, v) = \frac{G(u, v)}{H(u, v)}
\]

Since the blurred image is known and \( H(u, v) \) is known, the original clear image can be obtained by inverse Fourier transform of equation (4), which is called inverse filtering restoration[9].

### 3.2 Wiener filtering

Under certain constraints, the mean square error between the output of Wiener filtering and the desired output is minimized. Wiener filtering can make the image as smooth as possible, at the same time it can eliminate a certain noise[10]. Compared to the effect of the inverse filter ignoring the noise, Wiener filtering can well eliminate the noise and get a good image complex. The original effect. Wiener filtering is expected to find a convolution function, so that \( f(x, y) \) can be obtained[11].

\[
\hat{f}(x, y) = t(x, y) * g(x, y)
\]

In the formula, \( \hat{f}(x, y) \) is the minimum mean square estimation of \( f(x, y) \). 

\[
T(u, v) = \frac{H^*(u, v)}{|H(u, v)|^2 + N(u, v)/S(u, v)}
\]

Where \( N(u, v) \) is the power spectrum of noise, and \( S(u, v) \) is the power spectrum of image signal.

\[
F(u, v) = T(u, v) * G(u, v)
\]

The inverse Fourier transform of formula (7) can get the original image after deconvolution[12].

### 3.3 Blind restoration image

The traditional image restoration is usually based on the image degradation model. In the actual situation, it is difficult to understand the specific degradation process of the image. In this way, the degradation model of the image can not be established[13]. The point diffusion function can not be known. The blind restoration technology is used to estimate the PSF of the original image. The blind restoration algorithm does not need to know the specific fuzzy function and model of the image. Through the analysis of the characteristics of the degraded image, the fuzzy function of the original image is estimated. This algorithm has good practicability[14].
According to the blind image restoration process, the image blind restoration is generally based on the fuzzy image features of the observed image, the structure of the degraded model is estimated, the estimated image degradation model is obtained, the related parameters of the model are calculated, and then the point diffusion function of the image is obtained according to the specific parameters \[15\], and then the image restoration method is based on the existing image restoration method. Figure out a clear picture.

4. Analysis of experimental results
The algorithm programming of this paper is realized through MATLAB. As shown in the defocused image, we first take the fuzzy radius \(R=5\) to obtain the point diffusion function PSF of the fuzzy image through the fuzzy radius, and get the image shown in Figure 4 through inverse filtering. The result shows that the original image is very poor, which shows that there are more noise in the original image and need to be removed by other methods.
We assume that a signal to noise ratio is 0.005, and the original image is blurred by Wiener filtering. As shown in Figure 5, we can clearly see that the effect of the image has been significantly changed. However, the ringing effect will appear when Wiener filter is used. Blind restoration method can slow down the ringing effect, as is shown in Figure 6, but the effect of deblurring is not as obvious as Wiener filter.

5. Conclusions
This paper focuses on the influence of the defocus error on the optical system and the inverse filtering and Wiener filtering restoration method of the fuzzy image, and uses the inverse filtering method, Wiener filtering method and the blind restoration method to compare the image restoration experiments. Theoretical analysis and experimental results show that the defocusing error makes the optical transfer function of the imaging system attenuate, and the information transfer ability decreases, resulting in blurred image. By setting up the image fuzzy model and using the image restoration technology, the image blurred problem caused by the defocus error can be solved, and the original image can be recovered well, and the image quality can be improved effectively. In the process of image processing, the ringing effect will appear. The common fuzzy images in life are not only one of the reasons why the focus is not allowed, but also the motion blur and noise interference, so the complex situation will be studied in depth in the future. The quality of the image restoration depends to a great extent on the fuzzy identification, Future research will increase the research on automatic identification of degradation parameters.

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