Implementation of various digital filter for image processing

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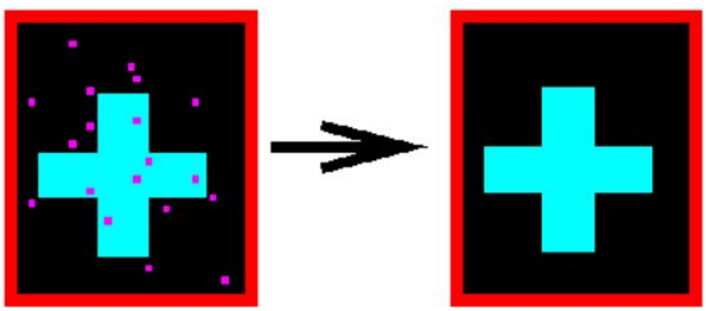
1 Abstract

Filtering is a technique used for modifying or enhancing an image like highlight certain features or remove other features.Image filtering include smoothing, sharpening, and edge enhancement.In image processing filters are mainly used to suppress either the high frequencies in the image, i.e. smoothing the image, or the low frequencies, i.e. enhancing or detecting edges in the image.

An image can be filtered either in the frequency or in the spatial domain.



fig(1).An example of digital Image filtering

2 Introduction

In modern day, many applications need large number of images for solving problems.Image filtering involves the application of window operations that perform useful functions, such as noise removal and image enhancement. This chapter is concerned particularly with what can be achieved with quite basic filters, such as mean, median, and mode filters. Interestingly, these filters have significant effects on the shapes of objects; in fact, the study of shape took place over a long period of time and resulted in a highly variegated set of algorithms and methods, during which the overarching formalism of mathematical morphology was set up. This chapter steers an intuitive path between the many mathematical theorems, showing how they lead to practically useful techniques.

3 Methodology

In this project we work on two types of image filtering techniques which are :

(a). SPATIAL DOMAIN FILTERS
(b)FREQUENCY DOMAIN FILTERS

4 SPATIAL DOMAIN FILTERS

Spatial domain operation or filtering (the processed value for the current pixel processed value for the current pixel depends on both itself and surrounding pixels). Hence Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel.

w(-1,-1)	w(-1,0)	w(-1,1)
w(0,-1)	w(0,0)	w(0,1)
w(1,-1)	w(1,0)	w(1,1)

fig(2). spatial mask

4.1 LINEAR SPATIAL FILTERING

For Linear spatial filtering, Result = sum of product of filter coefficient and the corresponding image pixels.

$$R[x,y] = W[-1,-1]*f[x-1,y-1]+w[-1,0]*f[x-1,y]+.....+w[0,0]*f[x,y]+...w[1,1]*f[x+1,y+1] \quad (1)$$

R=result or response of linear filtering

Linear filter of an image f of size M×N with a filter mask size of m × n is given by the expression

$$g(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s,y+t)$$

4.2 SMOOTHING SPATIAL FILTERS

Smoothing filters are used for blurring and for noise reduction.Blurring is used in preprocessing steps, such as removal of small details from an image prior to (large) object extraction,and bridging of small gaps in lines or curves. Noise reduction can be accomplished by blurring with a linear filter and also by non-linear filtering. linear spatial filter is simply the average of the pixels contained in the neighborhood of the filter mask.These filters sometimes are called averaging filter By replacing the value of every pixel in an image by the average of the gray levels in the neighborhood defined by the filter mask This process results in an image with reduced "sharp" transitions in gray levels

4.3 AVERAGING FILTER

A major use of averaging filters is in the reduction of"Irrelevant" detail in an image. A spatial averaging filter in which all coefficients are equal is sometimes called a box filter. Also known as low pass filter. m x n mask would have a normalizing constant equal to 1/ m n.

$$\frac{1}{9} \times \begin{array}{|c|c|c|} \hline 1 & 1 & 1 \\ \hline 1 & 1 & 1 \\ \hline 1 & 1 & 1 \\ \hline \end{array}$$

$$R = \frac{1}{9} \times \sum_{i=1}^{9} z_1,$$

fig(3). Averaging filter

4.4 MEDIAN FILTER

Median filters used for noise-reduction with less blurring than linear smoothing filters of similar size.Median filters are particularly effective in the presence of impulse noise also called salt-and-pepper noise because of its appearance as white and black dots superimposed on an image.

fig(4). EXAMPLE FOR MEDIAN FILTER

5 FREQUENCY DOMAIN FILTERS

filters process an image in the frequency domain. The image is Fourier transformed, multiplied with the filter function and then re-transformed into the spatial domain. Attenuating high frequencies results in a smoother image in the spatial domain, attenuating low frequencies enhances the edges frequency filters can also be implemented in the spatial domain and, if there exists a simple kernel for the desired filter effect, it is computationally less expensive to perform the filtering in the spatial domain. Frequency filtering is more appropriate if no straightforward kernel can be found in the spatial domain, and may also be more efficient.

filtering is based on the Fourier Transform. (For the following discussion we assume some knowledge about the Fourier Transform, therefore it is advantageous if you have already read the corresponding worksheet.) The operator usually takes an image and a filter function in the Fourier domain. This image is then multiplied with the filter function in a pixel-by-pixel fashion:

$$G(k,l) = F(k,l)H(k,l)$$

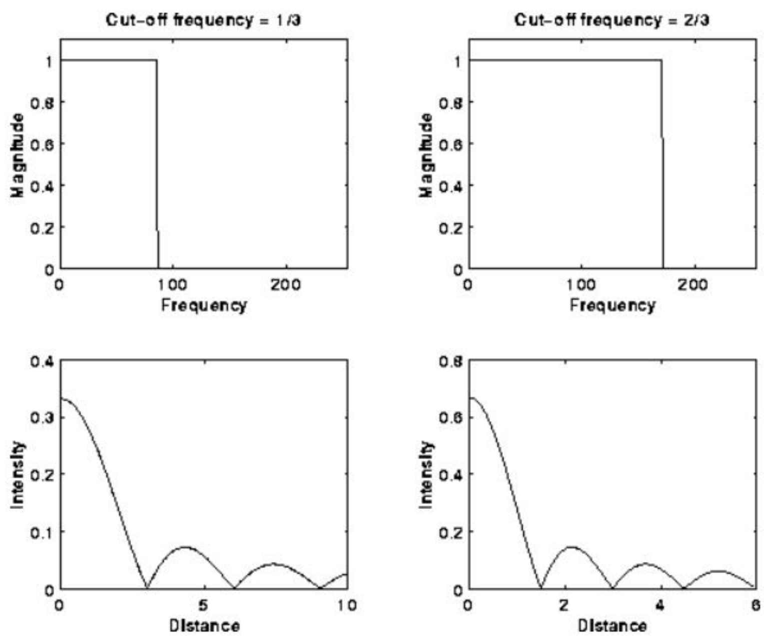
F(k,l) is the input image in the Fourier domain, H(k,l) the filter function and G(k,l) is the filtered image. To obtain the resulting image in the spatial domain, G(k,l) has to be re-transformed using the inverse Fourier Transform.

5.1 Low pass filter

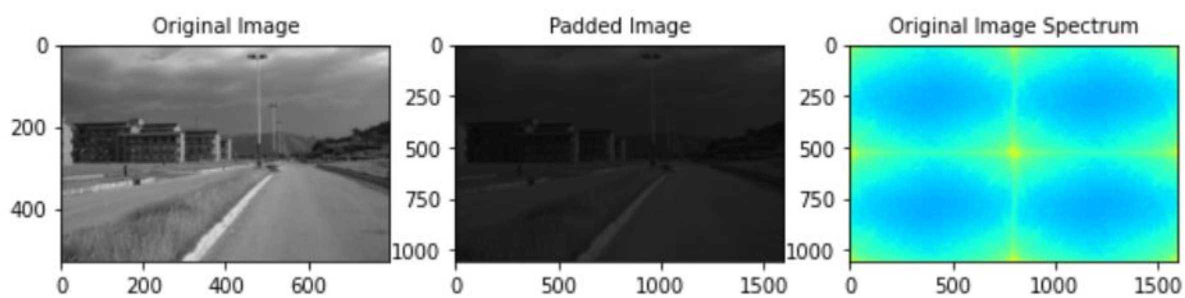
The most simple lowpass filter is the ideal low pass. It suppresses all frequencies higher than the cut-off frequency and leaves smaller frequencies unchanged:

$$H(k,l) = \begin{cases} 1 & if \sqrt{k^2+l^2} < D_0 \\ 0 & if \sqrt{k^2+l^2} > D_0 \end{cases}$$

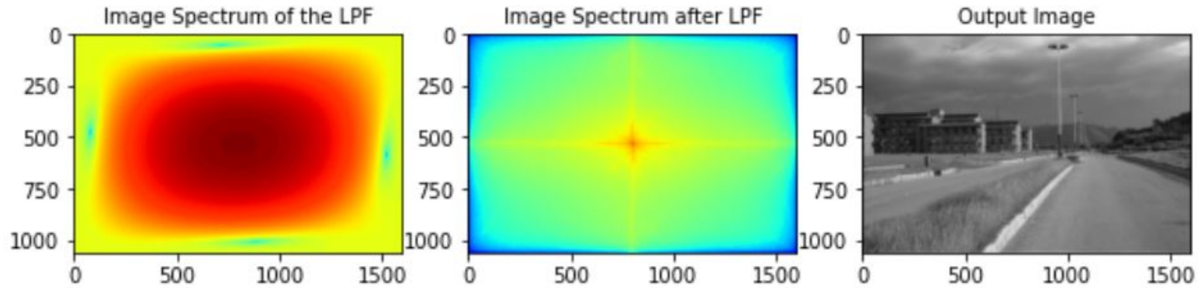
most implementations,D0 is given as a fraction of the highest frequency represented in the Fourier domain image. drawback of this filter function is a ringing effect that occurs along the edges of the filtered spatial domain image. This phenomenon is illustrated in Figure 1, which shows the shape of the one-dimensional filter in both the frequency and spatial domains for two different values of D0. We obtain the shape of the two-dimensional filter by rotating these functions about the y-axis. As mentioned earlier, multiplication in the Fourier domain corresponds to a convolution in the spatial domain. Due to the multiple peaks of the ideal filter in the spatial domain, the filtered image produces ringing along intensity edges in the spatial domain.



fig(5).Ideal lowpass in frequency and spatial domain



fig(6).image in frequency domain

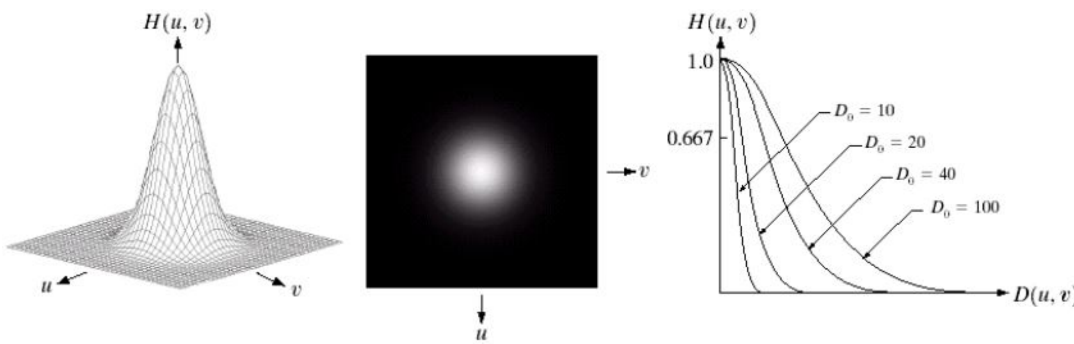


fig(7).LPF on image

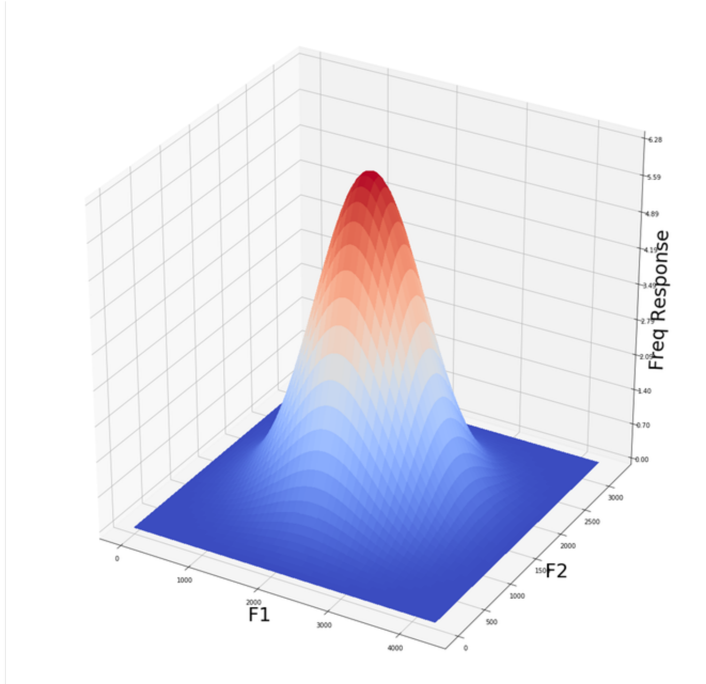
5.2 Frequency Domain Gaussian Filter

transfer function of a Gaussian low pass filter is defined as

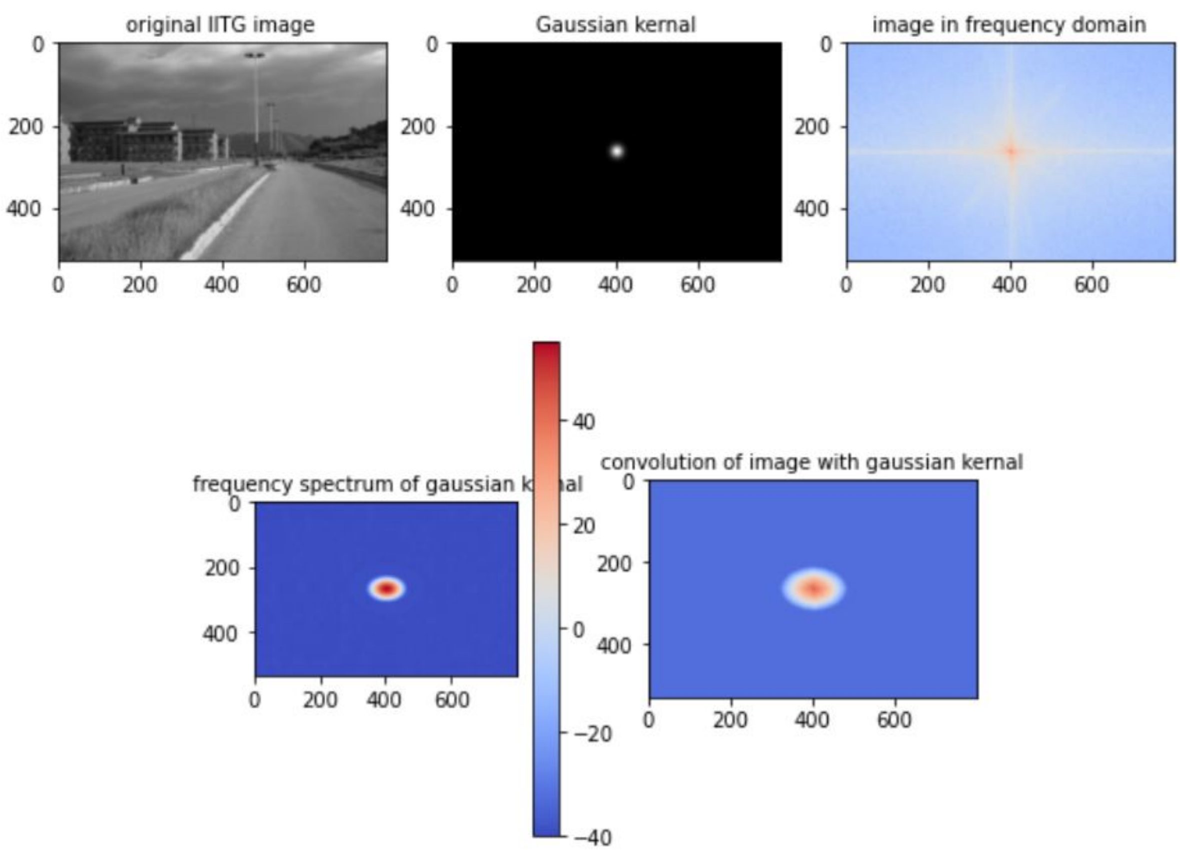
$$H(u,v) = e^{-D^2(u,v)/2D_0{}^2}$$



fig(8).Gaussian filter in frequency domain



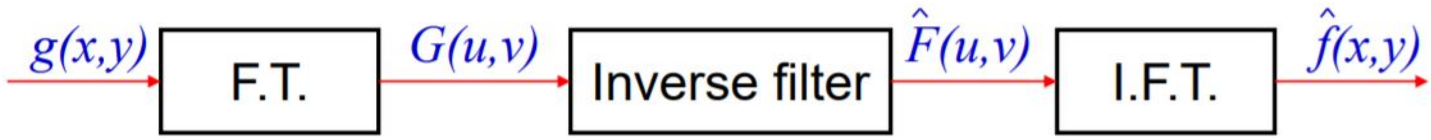
fig(9),The Gaussian Kernel LPF (frequency domain)

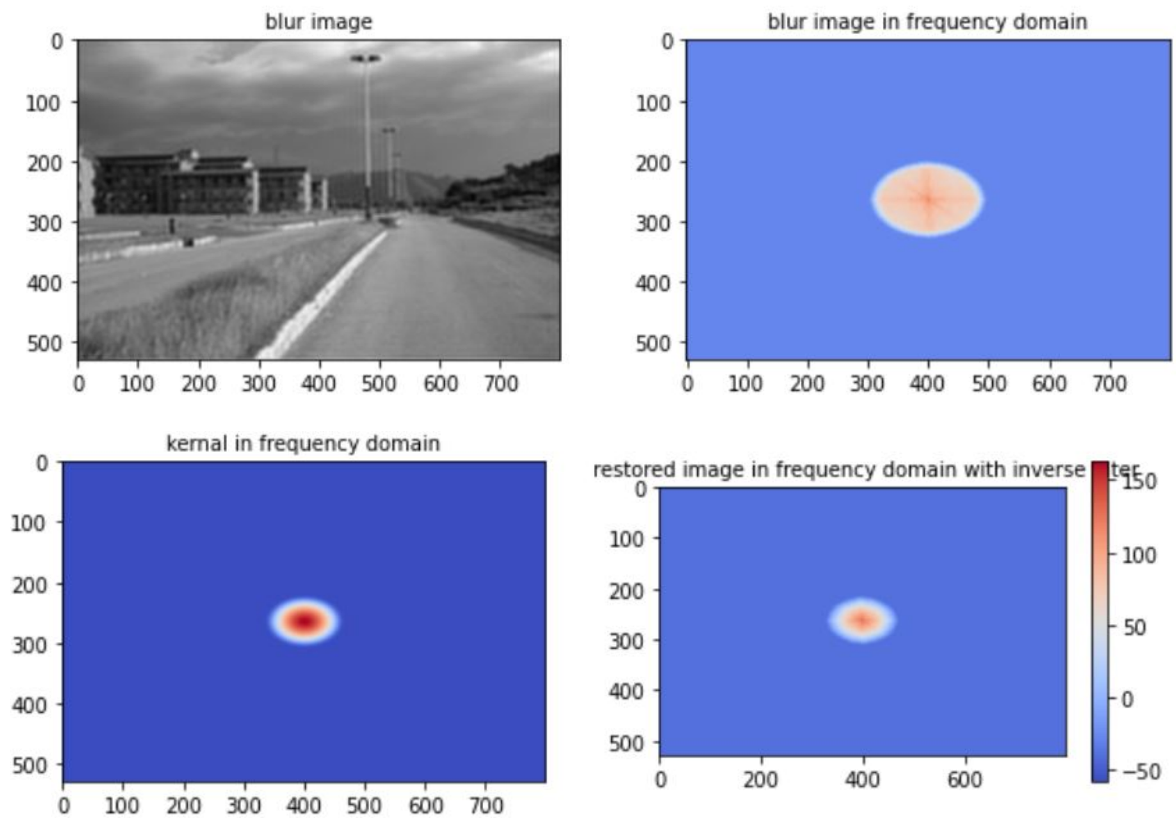


fig(10).Image with Gaussian kernal

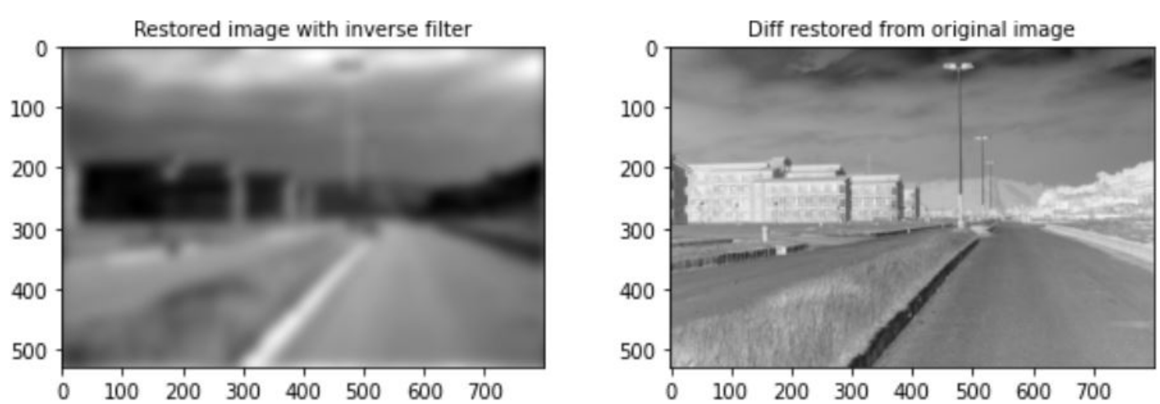
5.3 inverse filter to restore a motion-blurred image

with an inverse filter



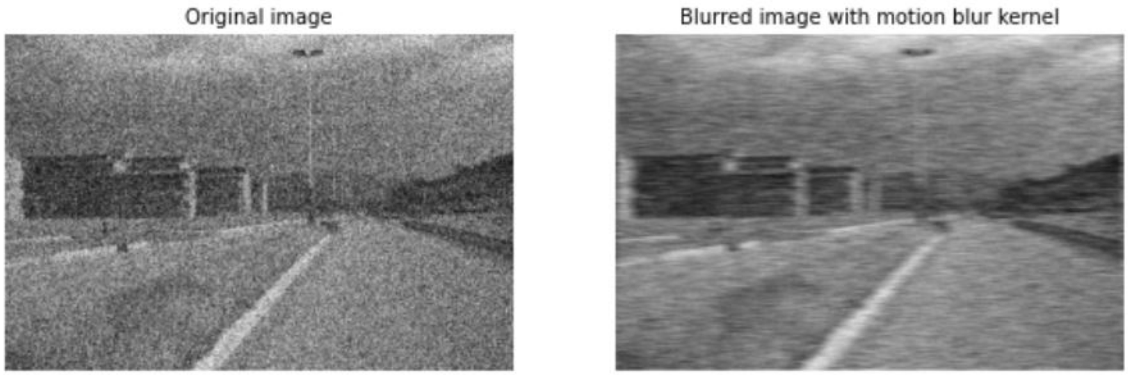


fig(11).Inverse filter spectrum

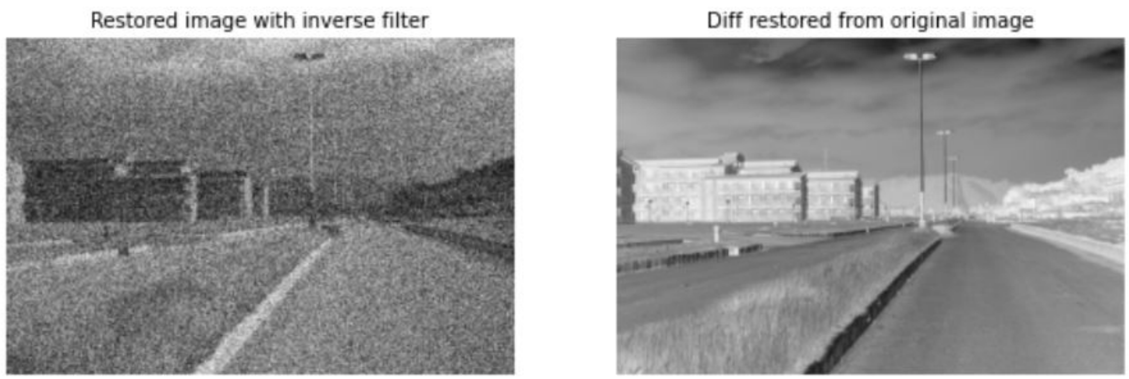


fig(12).Restored image from Inverse filter

5.4 Impact of noise on the inverse filter

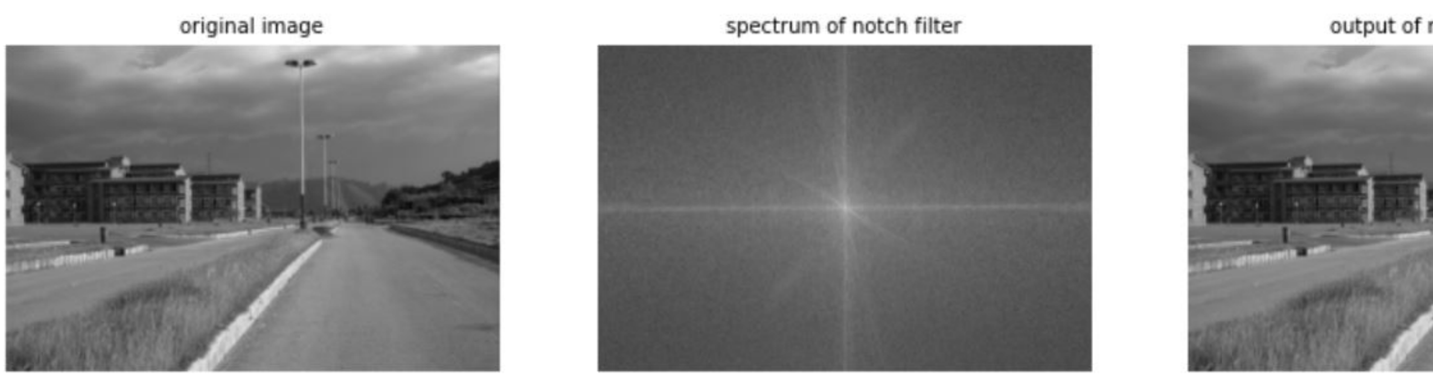


fig(13).Bluring image



fig(14).Reconstruct Image From Blured Image

5.5 Use a notch filter to remove periodic noise from the image



fig(15). Notch filter output

6 References

(1). Gonzalez and R. Woods Digital Image Processing, Addison-Wesley Publishing Company, 1992, Chap. 4.
(2)Trans. Circuits and Systems Special Issue on Digital Filtering and Image Processing, Vol. CAS-2, 1975.
(3). Jain Fundamentals of Digital Image Processing, Prentice-Hall, 1986, Chap. 8.