

## Chapter 6: Image Restoration

### Questions and Exercises

1. What is a point-spread function (PSF) ? Explain its importance and its relationship to the optical transfer function (OTF) and how both can be used to define the quality of an imaging system.
2. Explain what you understand by *deconvolution* and outline its role and importance in problems of image restoration. Briefly describe why the quality of image restoration is limited by the effects of random noise.
3. Write down the *inverse* 2-D Fourier transform for an image  $I(x, y)$
4. Explain clearly but succinctly the basic utility of the Fourier domain representation of an image. In particular, describe the specific advantage(s) over working in the spatial domain.
5. What is the convolution theorem ? In the context of the Fourier domain representations of images, what do you understand by the term *filtering* and for what purposes can it be used ?
6. Briefly describe the purpose of *notch*, *band-pass* and *boost* filters and give an example of situations in which each might be useful.
7. The frequency-domain Wiener filter is given by –

$$Y(k_x, k_y) = \frac{H^*(k_x, k_y)W_F(k_x, k_y)}{|H(k_x, k_y)|^2 W_F(k_x, k_y) + W_N(k_x, k_y)}$$

- Define each of the terms in the filter and explain carefully its treatment of low, mid-range and high spatial frequency components in the image spectrum. What is the main defect of the Wiener filter in practice ?
8. Give an essential account of frequency domain filtering and how it may be used in the restoration of digital images. Use a combination of mathematics, words and diagrams as you find appropriate. In your account you should consider, but not be limited to, the following aspects -
    - i) Explain clearly what frequency domain filtering is and what it tries to achieve.
    - ii) Identify and describe all the major factors that can affect the quality of the image restoration achieved.
    - iii) Describe some of the well-known restoration filters and their strengths and weaknesses.
  9. Write down the linear imaging equation for a shift-invariant point-spread function. What type of integral is it ?
  10. Relating your answer to the previous part, explain the importance of the convolution theorem in linear imaging systems. In the context of the Fourier domain representations of images, what do you understand by the term *filtering* and for what purposes can it be used ?
  11. Consider the image below which simulates the effect of mains signal interference in the amplifying electronics of the image sensor. How do you think this interference signal might manifest itself in the Fourier representation of the image ? Outline an image processing procedure to eliminate the interference signal.

Load the image `stripy_cameraman.png` and implement this procedure in Matlab.

The following functions will be useful (*fft2*, *ifft2*, *fftshift*, *ginput*)



12. Describe an image processing procedure to achieve the restoration of an image which has been subject to blurring as the result of convolution with a known point-spread function. Explain carefully the problems which can arise in trying to remove the blurring by inverse filtering and what must generally be done to restore the image if it is also subject to random additive noise.