SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE NAME : 19EC513 – IMAGE PROCESSING AND COMPUTER VISION

III YEAR / V SEMESTER

Unit II- **IMAGE ENHANCEMENT AND RESTORATION**

Topic : Noise model and inverse filtering

Noise model

The principal sources of noise in digital images arise during image acquisition and/or transmission.

The performance of imaging sensors is affected by a variety of factors, such as environmental conditions during image acquisition, and by the quality of the sensing elements themselves.

For instance, in acquiring images with a CCD camera, light levels and sensor temperature are major factors affecting the amount of noise in the resulting image.

Images are corrupted during transmission principally due to interference in the channel used for transmission.

For example, an image transmitted using a wireless network might be corrupted as a result of lightning or other atmospheric disturbance.

Spatial and Frequency Properties of Noise

Relevant to our discussion are parameters that define the spatial characteristics of noise, and whether the noise is correlated with the image. Frequency properties refer to the frequency content of noise in the Fourier sense (i.e., as opposed to frequencies of the electromagnetic spectrum). For example, when the Fourier spectrum of noise is constant, the noise usually is called white noise. This terminology is a carryover from the physical properties of white light, which contains nearly all frequencies in the visible spectrum in equal proportions. From the discussion in Chapter 4, it is not difficult to show that the Fourier spectrum of a function containing all frequencies in equal proportions is a constant.

With the exception of spatially periodic noise, we assume in this chapter that noise is independent of spatial coordinates and that it is uncorrelated with respect to the image itself (that is, there is no correlation between pixel values and the values of noise components). Although these assumptions are at least partially invalid in some applications (quantum- limited imaging, such as in X-ray and nuclear-medicine imaging, is a good example), the complexities of dealing with spatially dependent and correlated noise are beyond the scope of our discussion.

Some important Noise probability density function

Gaussian noise

The PDF of a Gaussian random variable, z, is given by

$$p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(z-\bar{z})^2/2\sigma^2}$$

where z represents intensity, $\bar{z}$ is the mean† (average) value of z, and σ is its standard deviation. The standard deviation squared, σ^2, is called the *variance* of z. A

Rayleigh noise

The PDF of Rayleigh noise is given by

$$p(z) = \begin{cases} \frac{2}{b}(z-a)e^{-(z-a)^2/b} & \text{for } z \geq a \\ 0 & \text{for } z < a \end{cases}$$

The mean and variance of this density are given by

$$\bar{z} = a + \sqrt{\pi b/4}$$

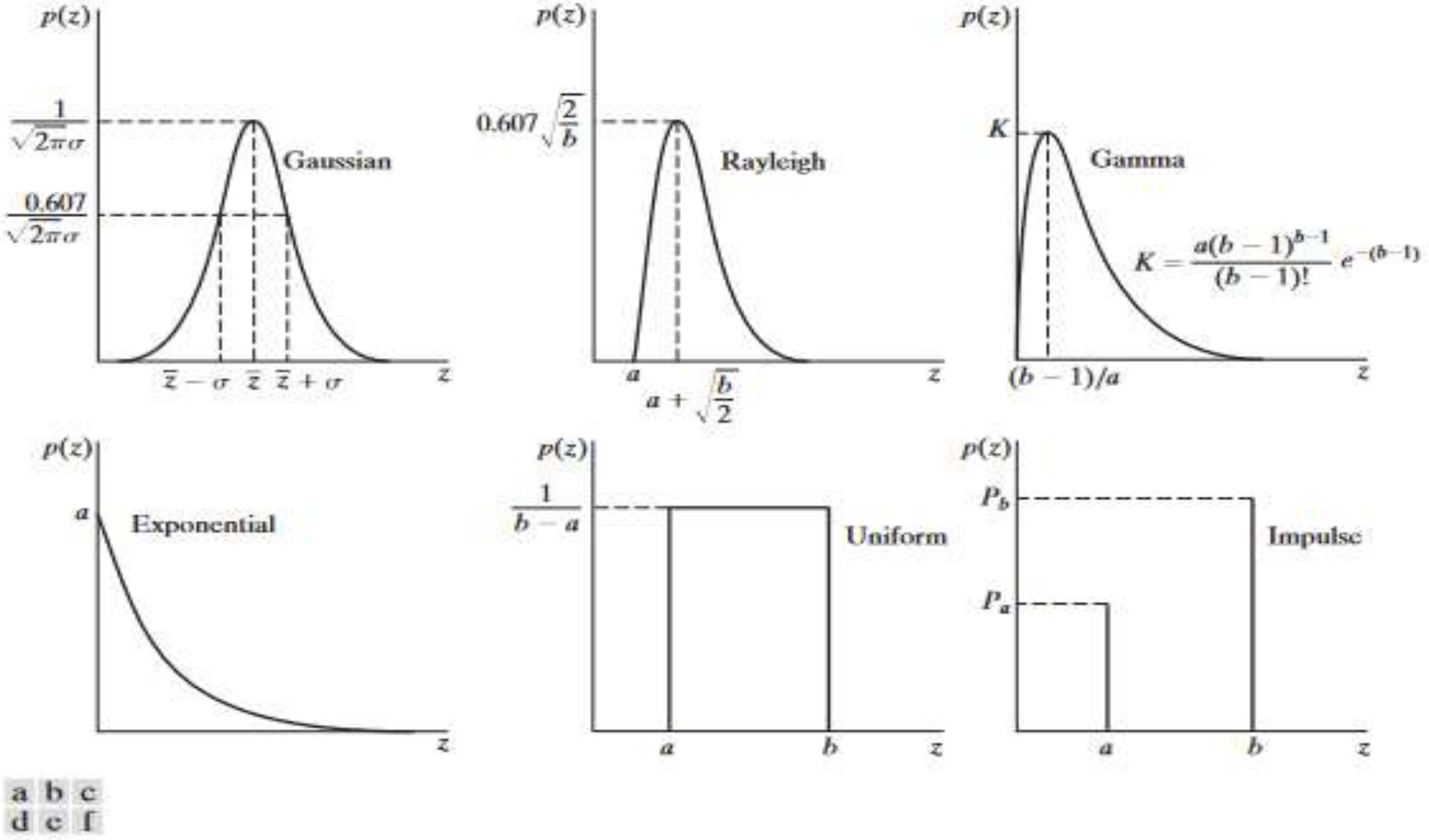


FIGURE 5.2 Some important probability density functions.

Exponential noise

The PDF of *exponential* noise is given by

$$p(z) = \begin{cases} ae^{-az} & \text{for } z \geq 0 \\ 0 & \text{for } z < 0 \end{cases}$$

where $a > 0$. The mean and variance of this density function are

$$\bar{z} = \frac{1}{a}$$

and

$$\sigma^2 = \frac{1}{a^2}$$

Note that this PDF is a special case of the Erlang PDF, with $b = 1$. F
shows a plot of this density function.

Uniform noise

The PDF of *uniform* noise is given by

$$p(z) = \begin{cases} \dfrac{1}{b - a} & \text{if } a \leq z \leq b \\ 0 & \text{otherwise} \end{cases}$$

The mean of this density function is given by

$$\bar{z} = \frac{a + b}{2}$$

and its variance by

$$\sigma^2 = \frac{(b - a)^2}{12}$$

Figure 5.2(e) shows a plot of the uniform density.

Impulse (salt-and-pepper) noise

The PDF of (*bipolar*) *impulse* noise is given by

$$p(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases} \quad (5.2\text{-}14)$$

If $b > a$, intensity b will appear as a light dot in the image. Conversely, level a will appear like a dark dot. If either P_a or P_b is zero, the impulse noise is called *unipolar*. If neither probability is zero, and especially if they are approximately equal, impulse noise values will resemble salt-and-pepper granules randomly distributed over the image. For this reason, bipolar impulse noise also is called *salt-and-pepper* noise. *Data-drop-out* and *spike* noise also are terms used to refer to this type of noise. We use the terms *impulse* or *salt-and-pepper* noise interchangeably.

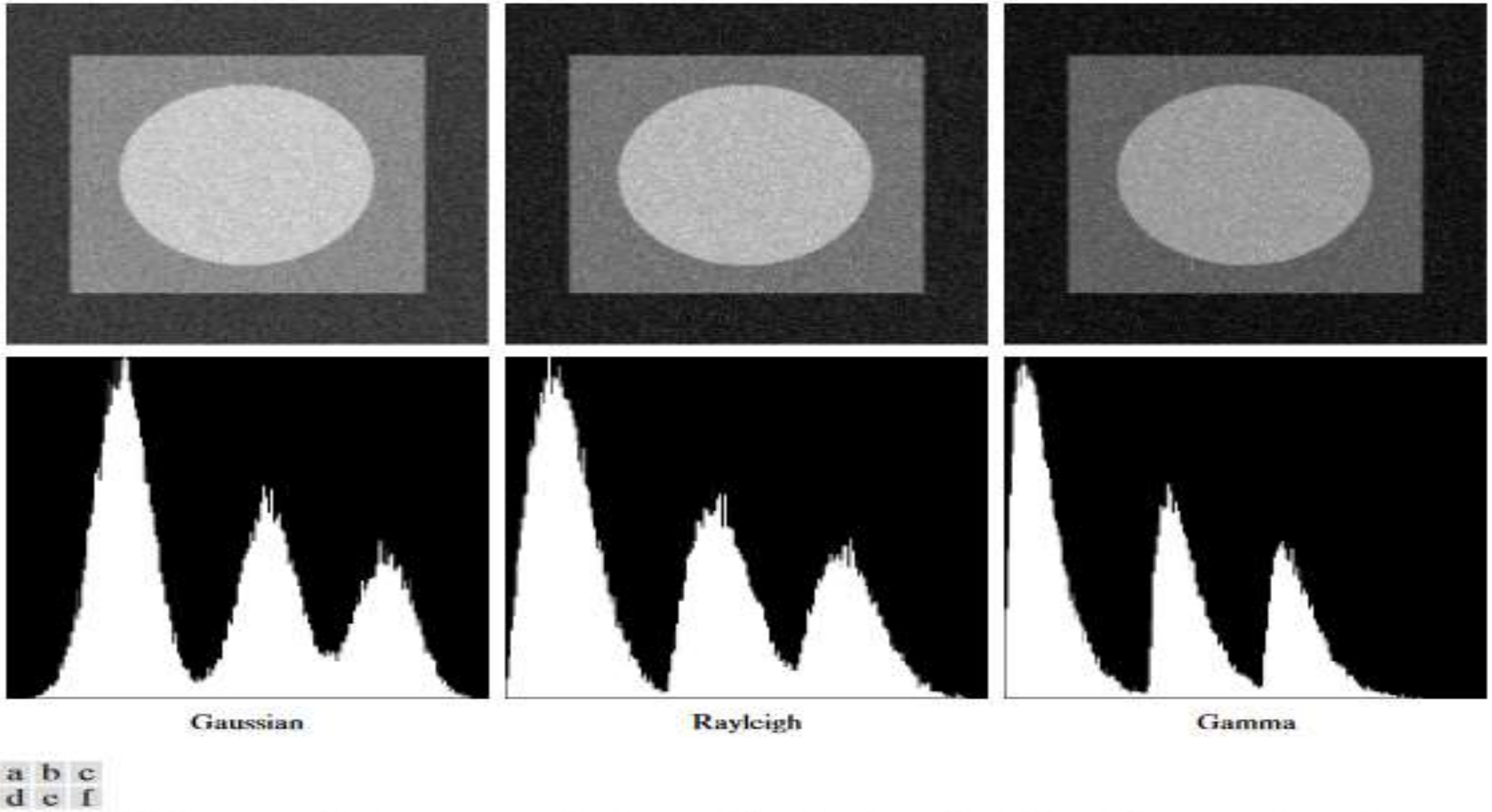


FIGURE 5.4 Images and histograms resulting from adding Gaussian, Rayleigh, and gamma noise to the image in Fig. 5.3.

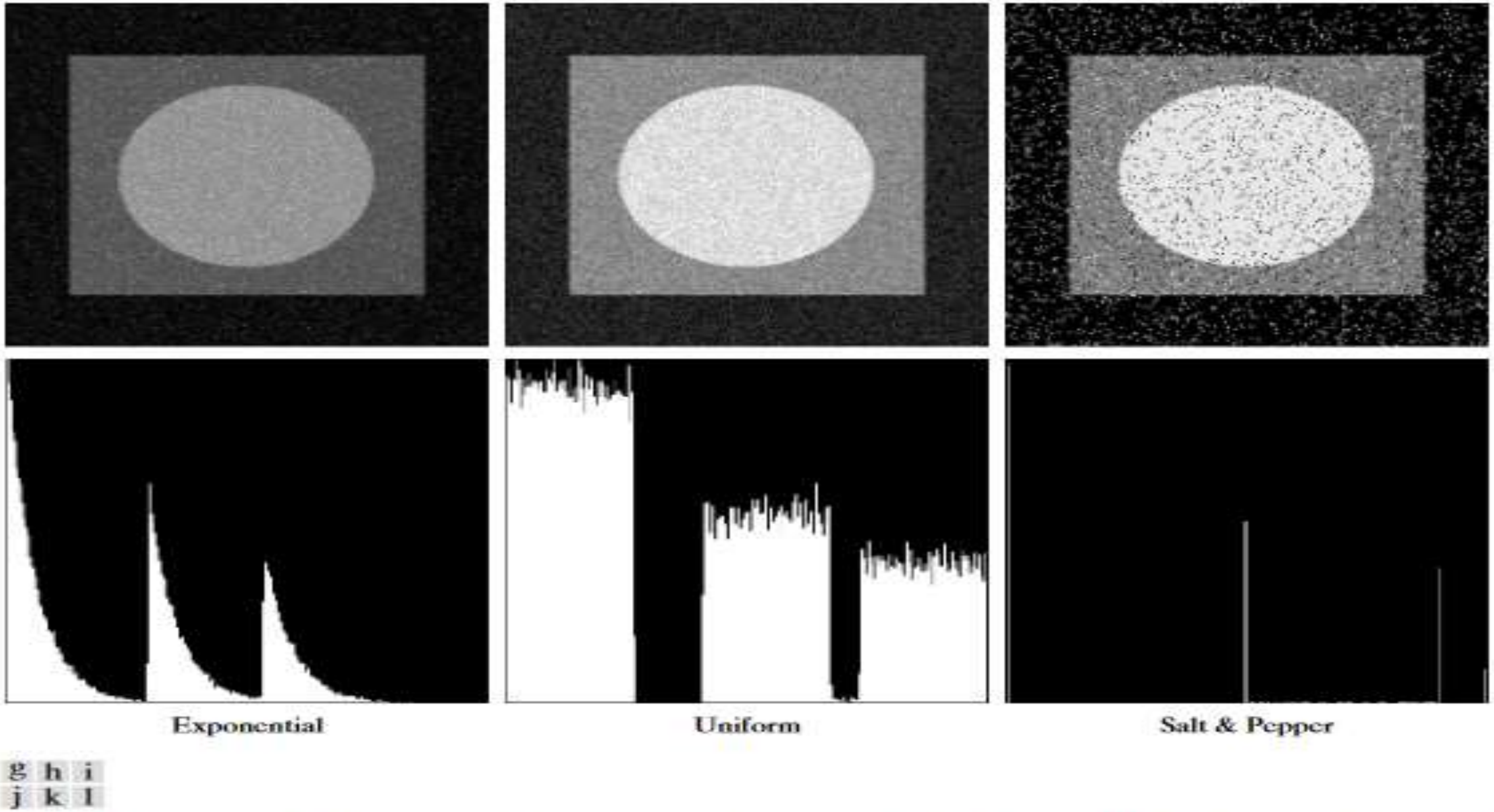


FIGURE 5.4 *(Continued)* Images and histograms resulting from adding exponential, uniform, and salt-and-pepper noise to the image in Fig. 5.3.

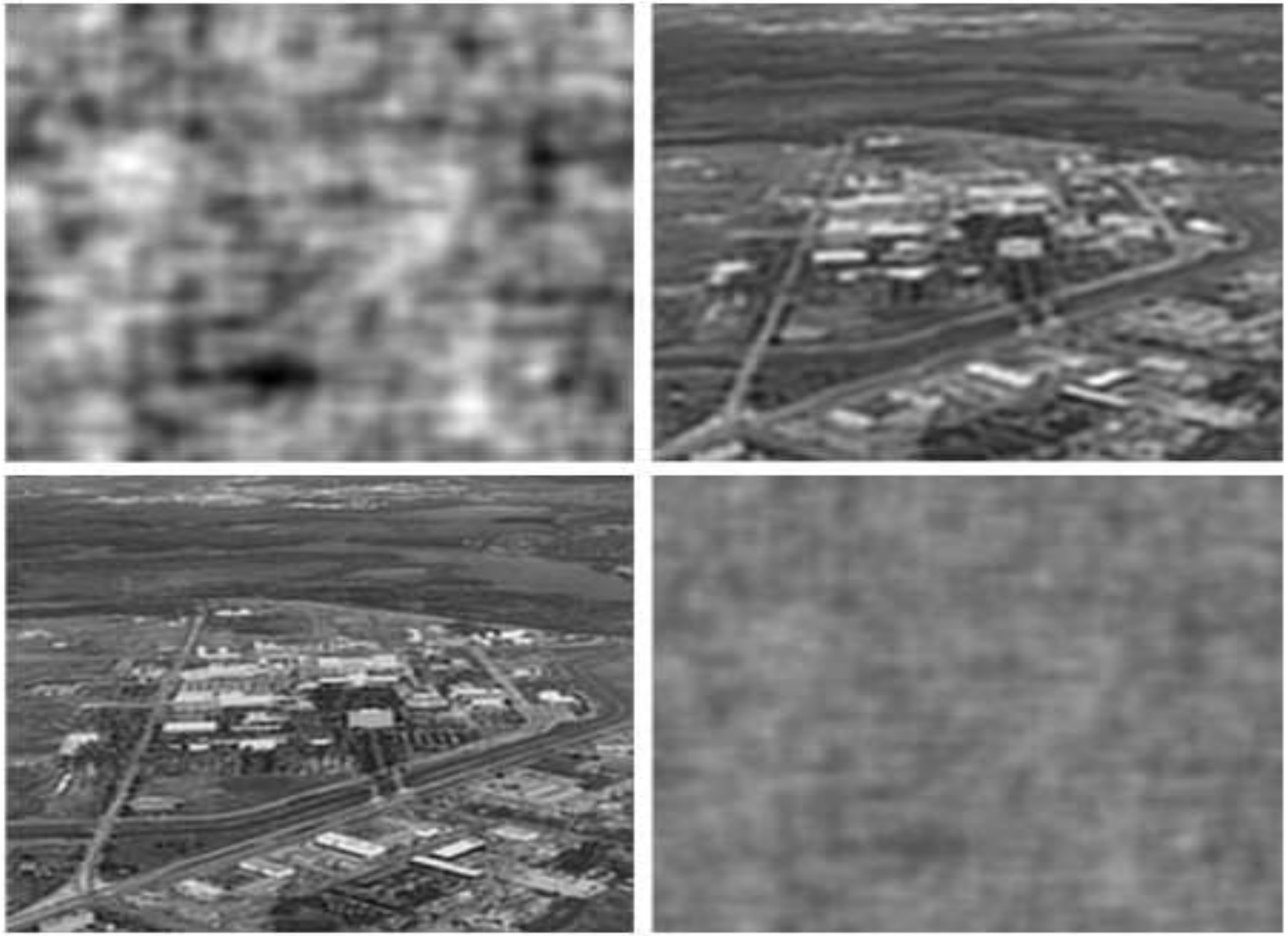
Inverse filtering

The material in this section is our first step in studying restoration of images degraded by a degradation function H, which is given or obtained by a method such as those discussed in the previous section. The simplest approach to restoration is direct inverse filtering, where we compute an estimate, $\hat{F}(u, v)$, of the transform of the original image simply by dividing the transform of the degraded image, $G(u, v)$, by the degradation function:

$$\hat{F}(u, v) = \frac{G(u, v)}{H(u, v)} \tag{5.7-1}$$

The division is an array operation, as defined in Section 2.6.1 and in connection with Eq. (5.5-17). Substituting the right side of Eq. (5.1-2) for $G(u, v)$ in Eq. (5.7-1) yields

$$\hat{F}(u, v) = F(u, v) + \frac{N(u, v)}{H(u, v)} \tag{5.7-2}$$



a b
c d

FIGURE 5.27 Restoring Fig. 5.25(b) with Eq. (5.7-1). (a) Result of using the full filter. (b) Result with H cut off outside a radius of 40; (c) outside a radius of 70; and (d) outside a radius of 85.

Any Query????

Thank you……