Методы и средства Цифровой Обработки Сигналов

Изображения

Круглов Евгений Владимирович, аспирант МИФИ
Решетов Владимир Николаевич, к.ф.-м. н. доцент МИФИ.

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ПЗС-матрица

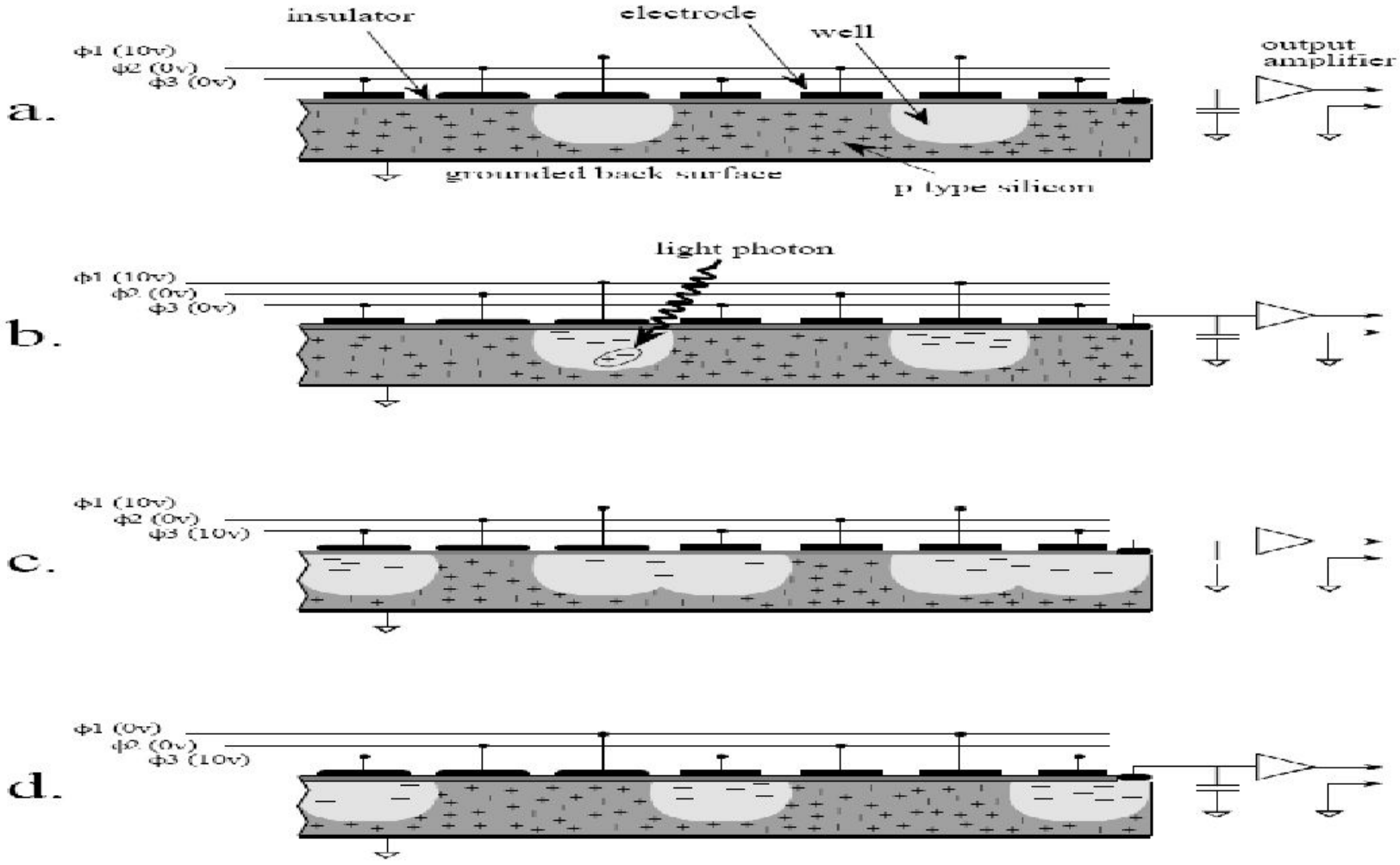


FIGURE 23-7
Operation of the charge coupled device (CCD). As shown in this cross-sectional view, a thin sheet of p-type silicon is covered with an insulating layer and an array of electrodes. The electrodes are connected in groups of three, allowing three separate voltages to be applied: ϕ1, ϕ2, and ϕ3. When a positive voltage is applied to an electrode, the holes (i.e., the positive charge carriers indicated by the "+") are pushed away. This results in an area depleted of holes, called a *well*. Incoming light generates holes and electrons, resulting in an accumulation of electrons confined to each well (indicated by the "–"). By manipulating the three electrode voltages, the electrons in each well can be moved to the edge of the silicon where a charge sensitive amplifier converts the charge into a voltage.

Считывание

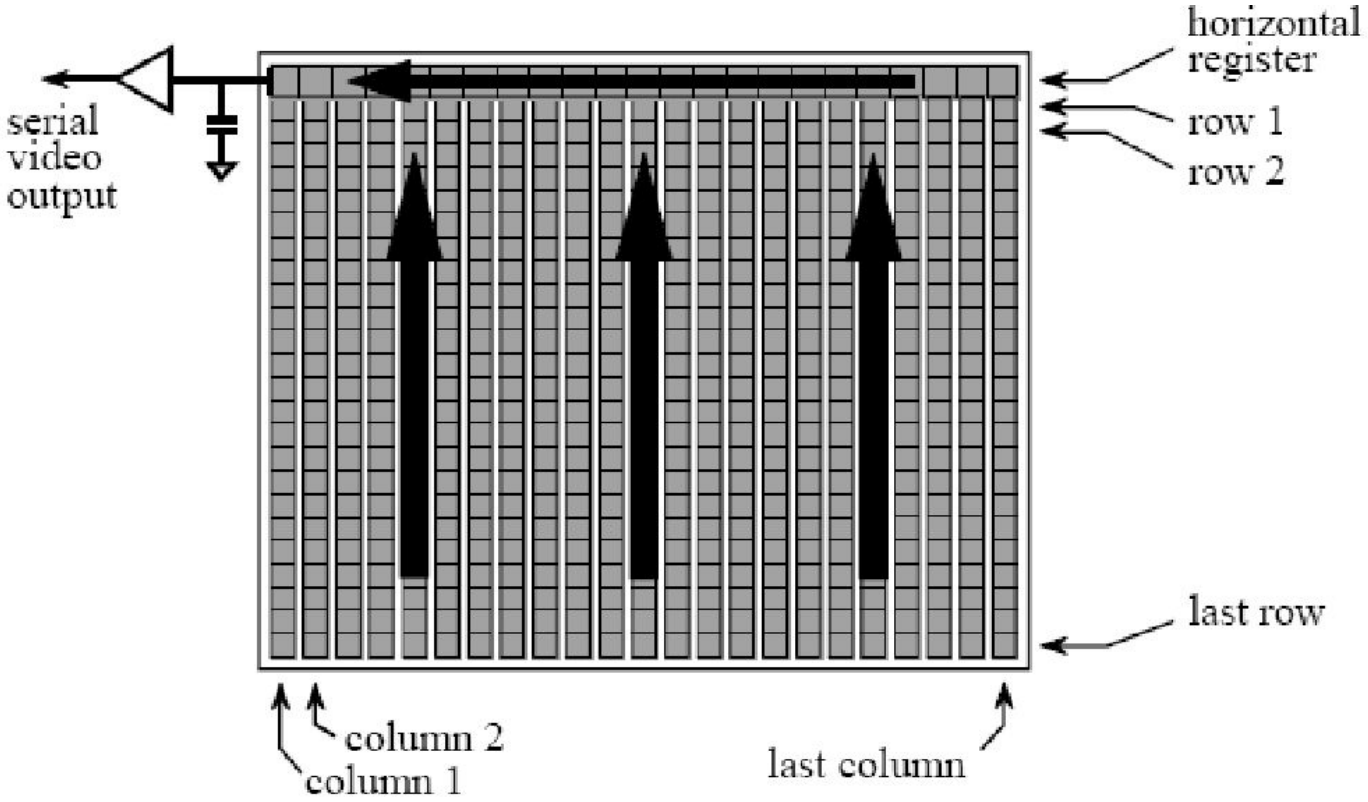


FIGURE 23-8
Architecture of the CCD. The imaging wells of the CCD are arranged in columns. During readout, the charge from each well is moved up the column into a horizontal register. The horizontal register is then readout into the charge sensitive preamplifier.

Строка изображения

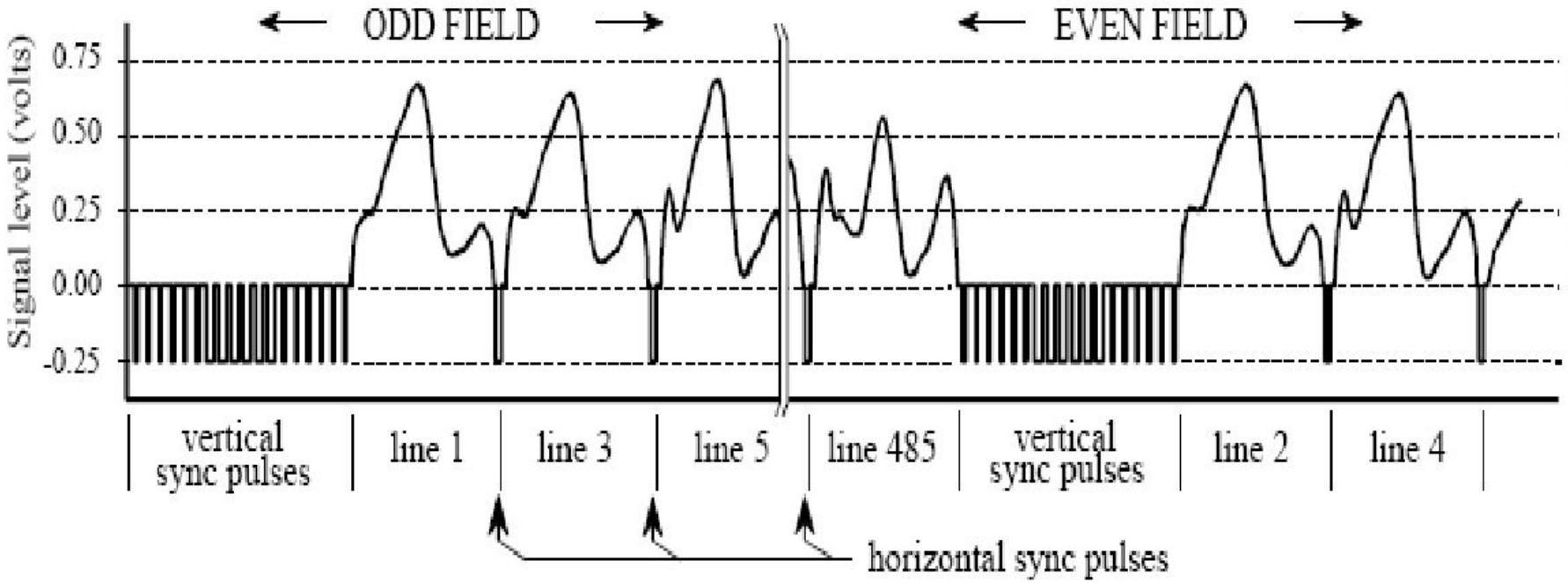


FIGURE 23-9
Composite video. The NTSC video signal consists of 30 complete frames (images) per second, with each frame containing 480 to 486 lines of video. Each frame is broken into two fields, one containing the odd lines and the other containing the even lines. Each field starts with a group of vertical sync pulses, followed by successive lines of video information separated by horizontal sync pulses. (The horizontal axis of this figure is not drawn to scale).

Характер реакции

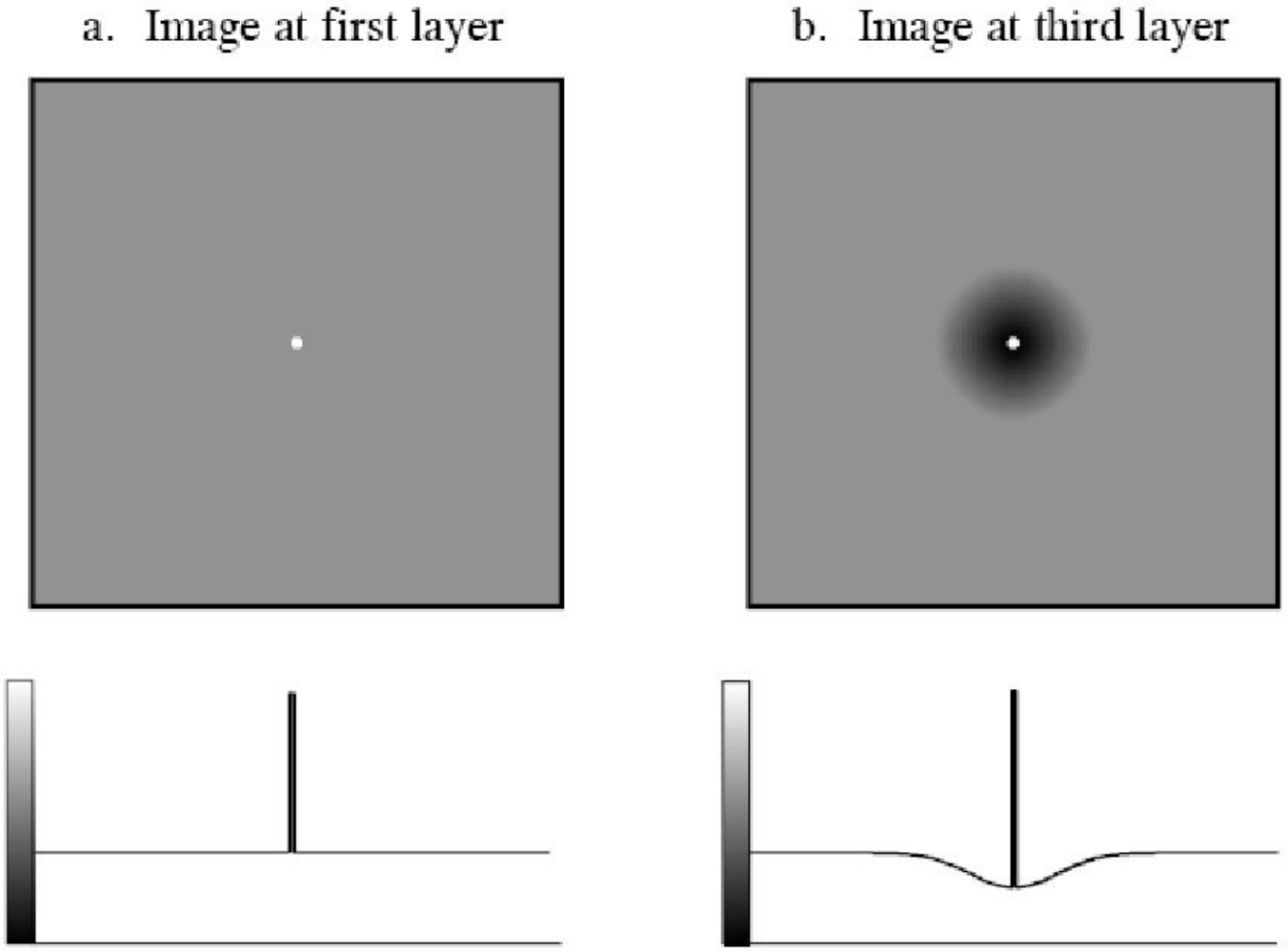


FIGURE 24-1
The PSF of the eye. The middle layer of the retina changes an impulse, shown in (a), into an impulse surrounded by a dark area, shown in (b). This point spread function enhances the edges of objects.

Резкая граница

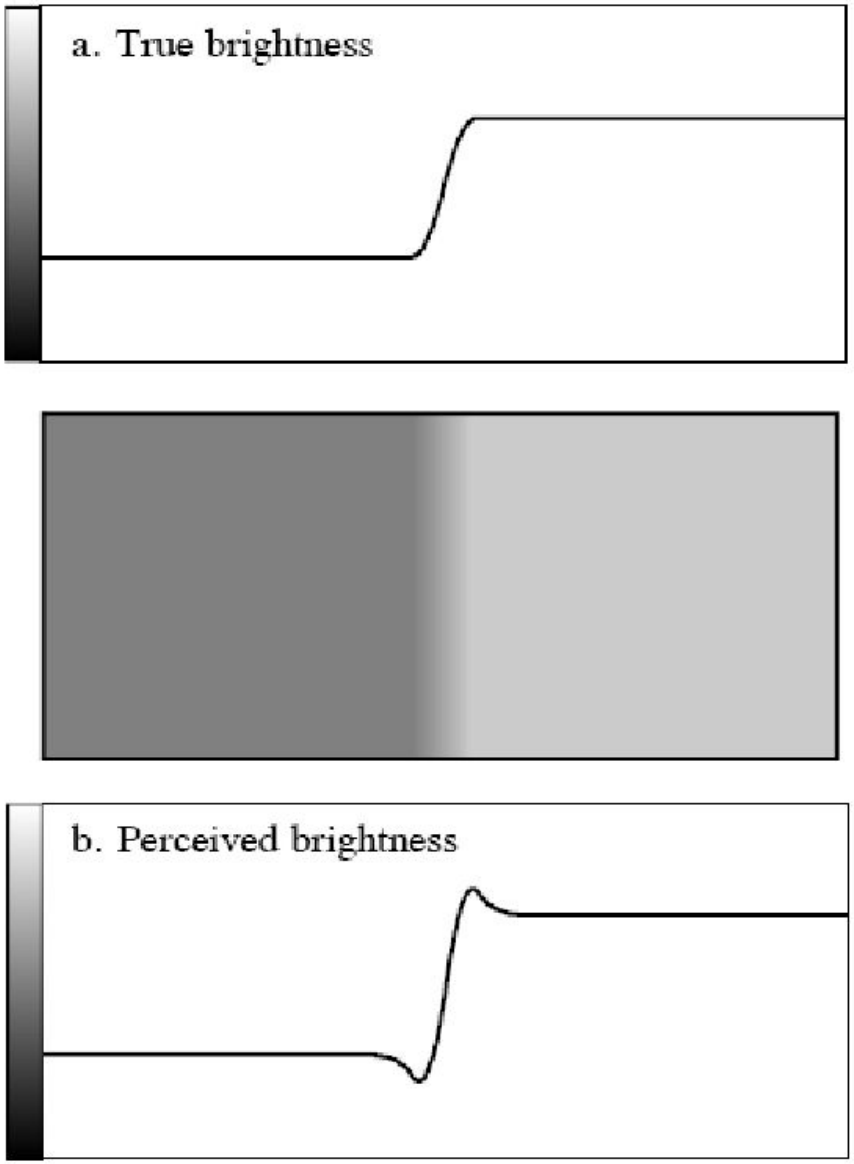


FIGURE 24-2
Mach bands. Image processing in the retina results in a slowly changing edge, as in (a), being sharpened, as in (b). This makes it easier to separate objects in the image, but produces an optical illusion called *Mach bands*. Near the edge, the overshoot makes the dark region look darker, and the light region look lighter. This produces dark and light bands that run parallel to the edge.

Двумерные сигналы

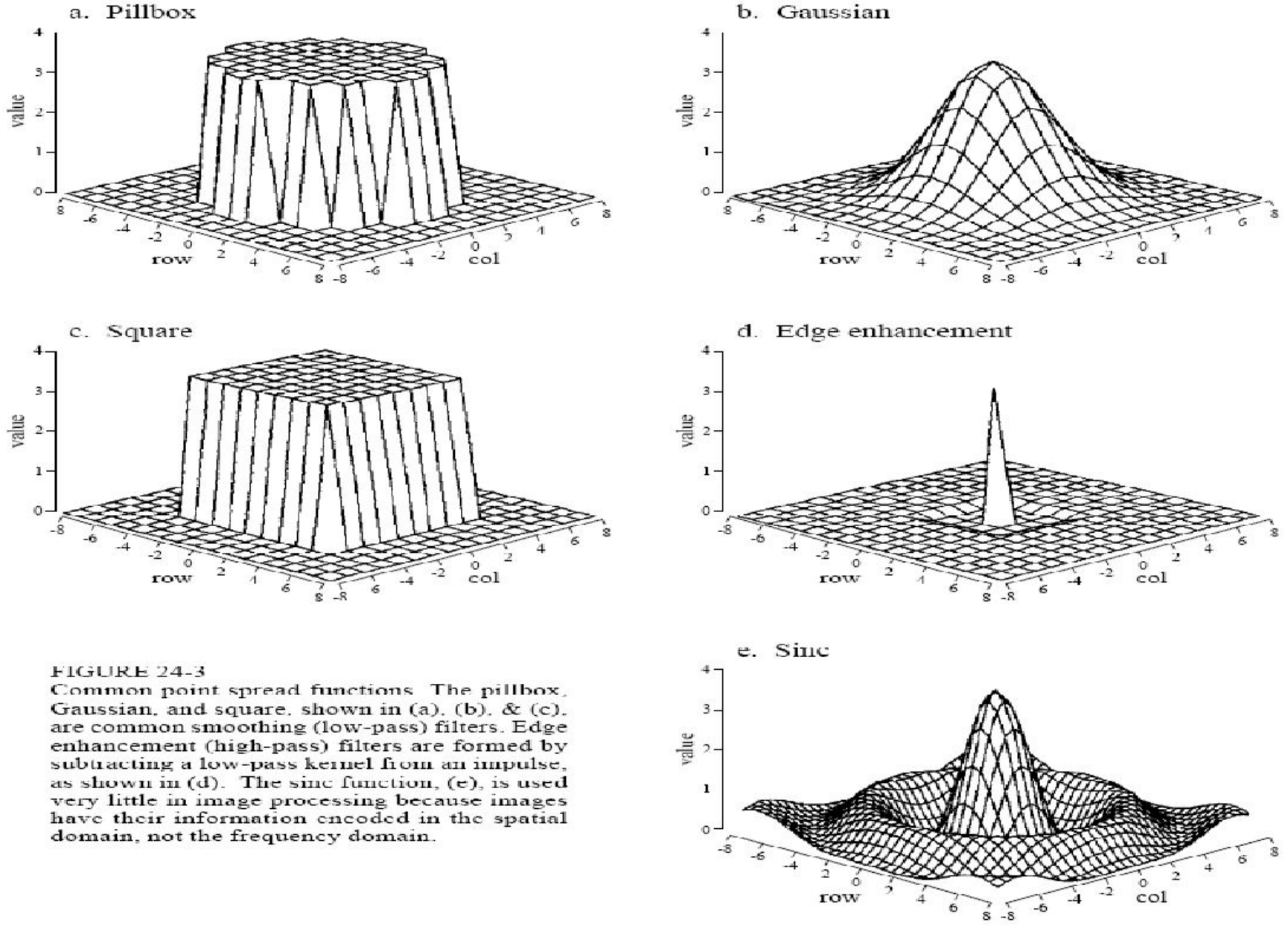


FIGURE 24-3
Common point spread functions. The pillbox, Gaussian, and square, shown in (a), (b), & (c), are common smoothing (low-pass) filters. Edge enhancement (high-pass) filters are formed by subtracting a low-pass kernel from an impulse, as shown in (d). The sinc function, (e), is used very little in image processing because images have their information encoded in the spatial domain, not the frequency domain.

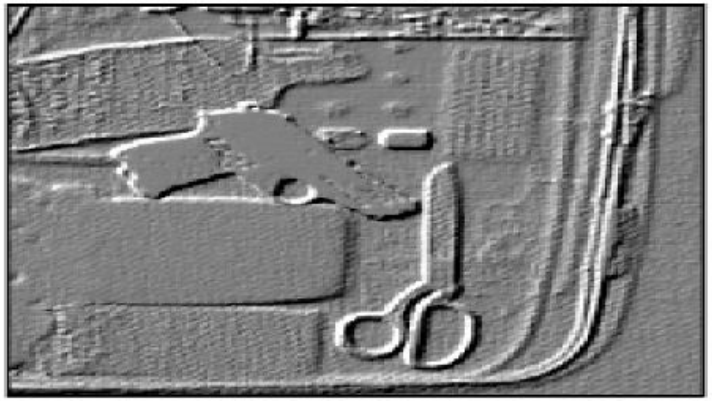
Просвечивание с фильтрацией

a. Delta function

0	0	0
0	1	0
0	0	0

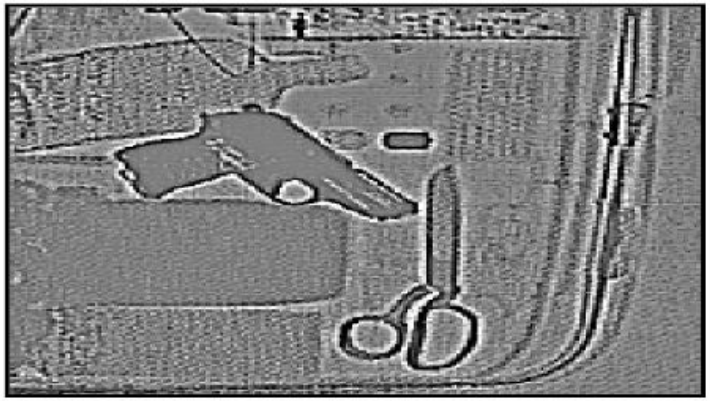
b. Shift and subtract

0	0	0
0	1	0
0	0	-1



c. Edge detection

-1/8	-1/8	-1/8
-1/8	1	-1/8
-1/8	-1/8	-1/8



d. Edge enhancement

-k/8	-k/8	-k/8
-k/8	k+1	-k/8
-k/8	-k/8	-k/8

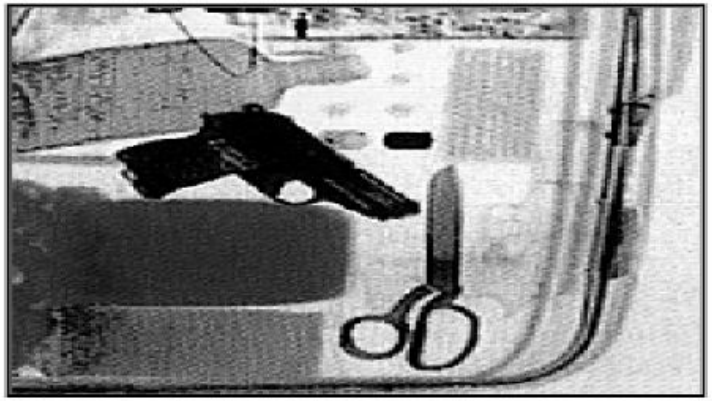


FIGURE 24-4
3×3 edge modification. The original image, (a), was acquired on an airport x-ray baggage scanner. The shift and subtract operation, shown in (b), results in a pseudo three-dimensional effect. The edge detection operator in (c) removes all contrast, leaving only the edge information. The edge enhancement filter, (d), adds various ratios of images (a) and (c), determined by the parameter, k. A value of $k = 2$ was used to create this image.

Острый пик

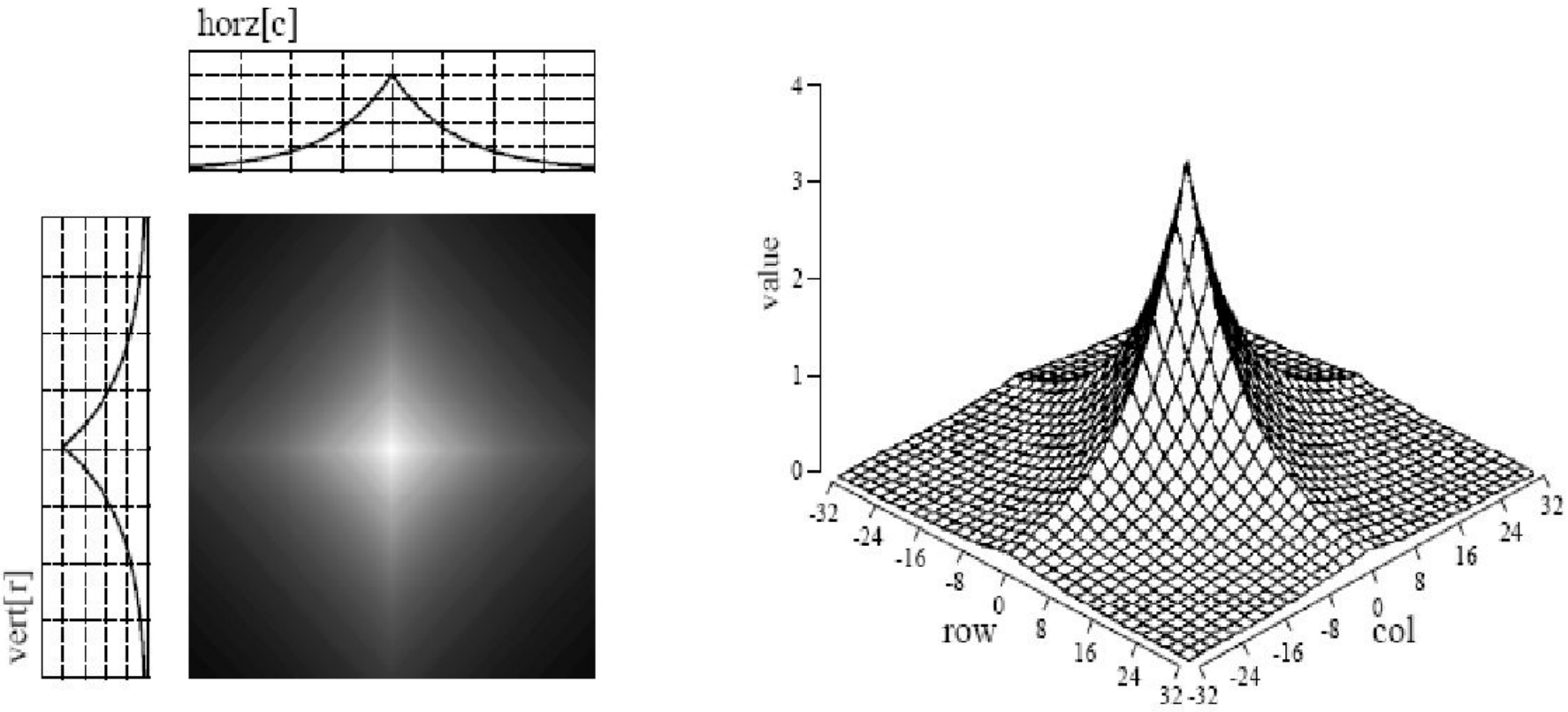


FIGURE 24-6
Creation of a separable PSF. An infinite number of separable PSFs can be generated by defining arbitrary projections, and then calculating the two-dimensional function that corresponds to them. In this example, the profiles are chosen to be double-sided exponentials, resulting in a diamond shaped PSF.

Тестовые структуры

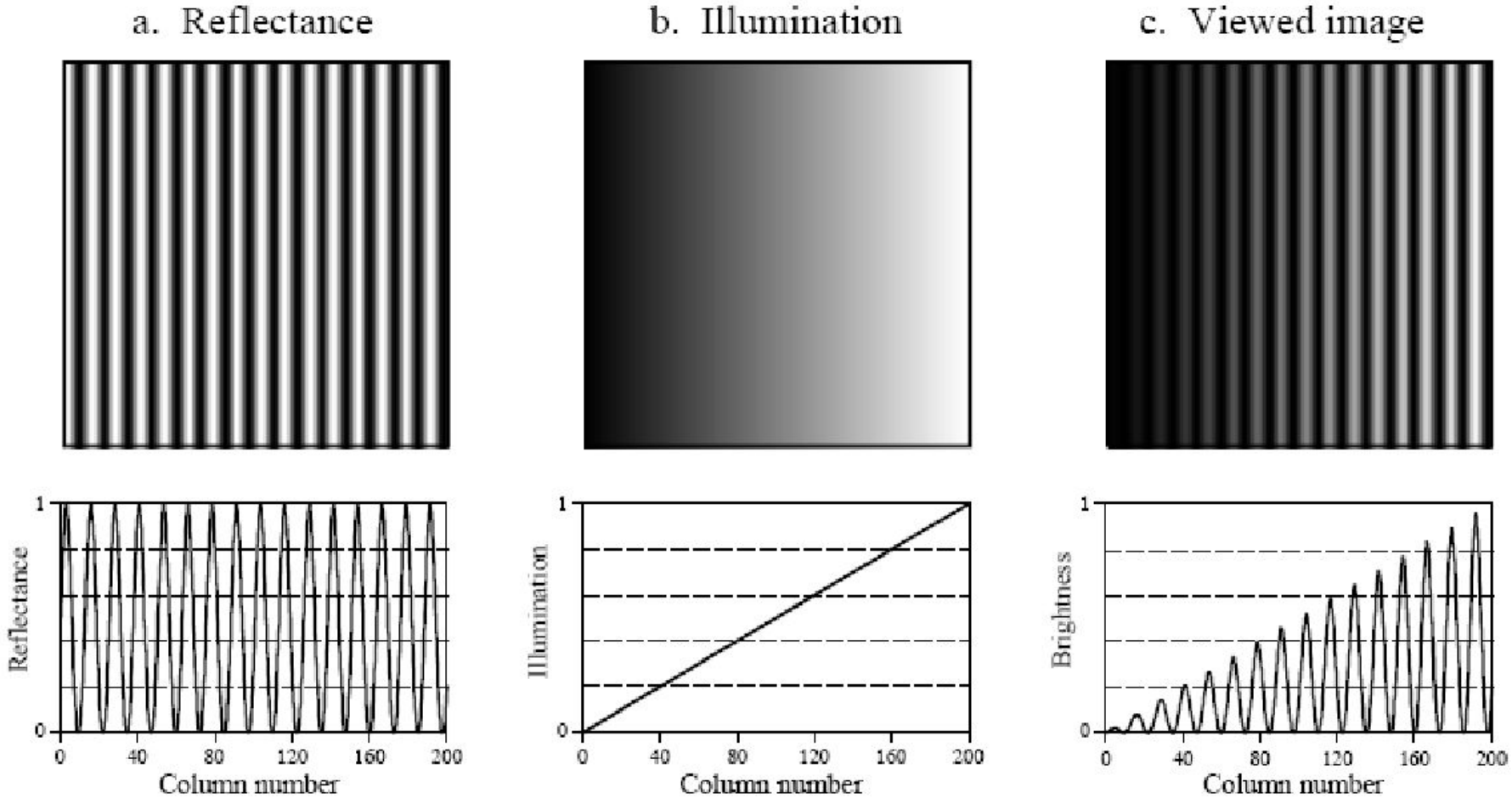


FIGURE 24-8
Model of image formation. A viewed image, (c), results from the multiplication of an illumination pattern, (b), by a reflectance pattern, (a). The goal of the image processing is to modify (c) to make it look more like (a). This is performed in Figs. (d), (e) and (f) on the opposite page.

Испорченные изображения

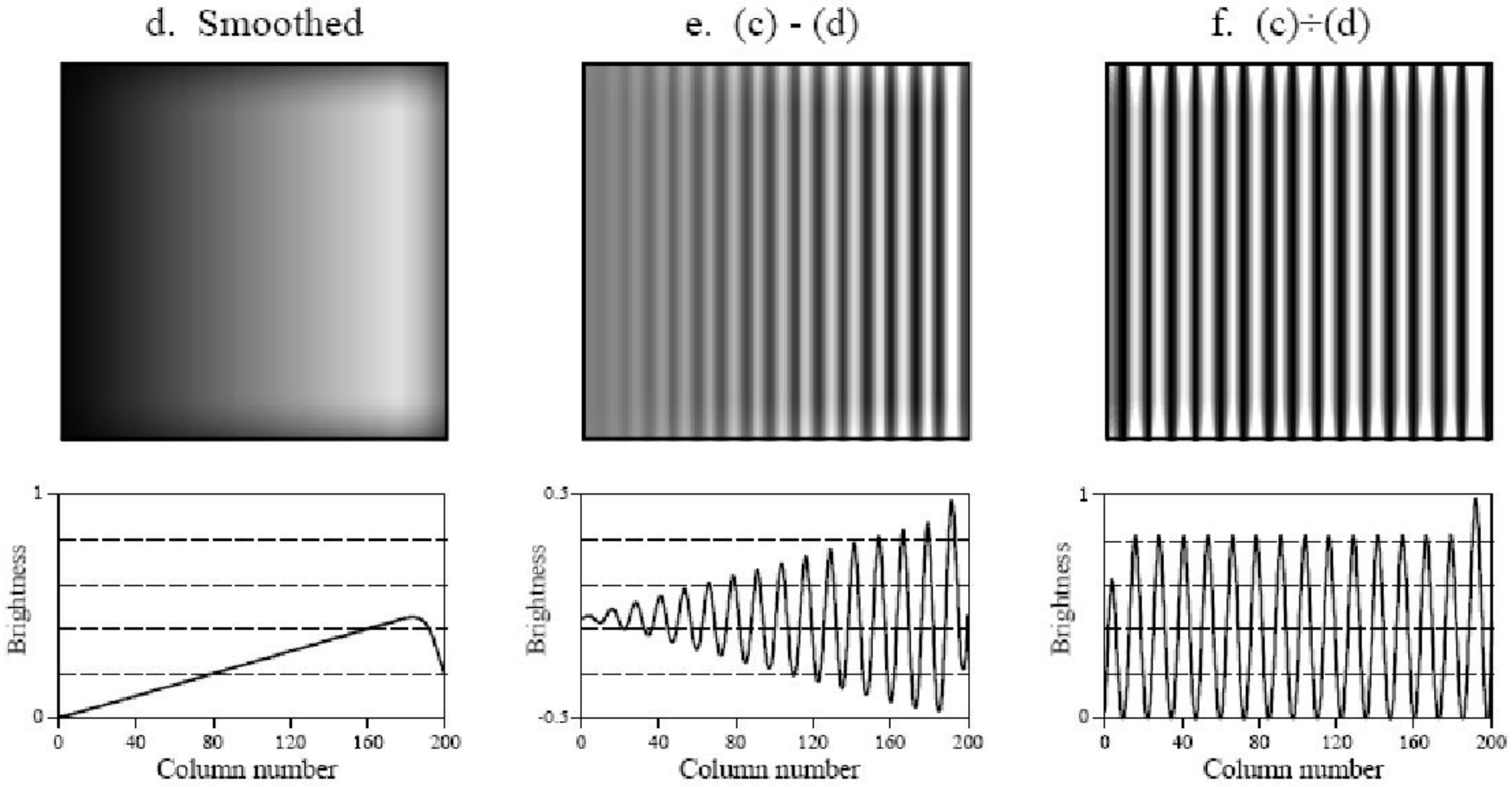
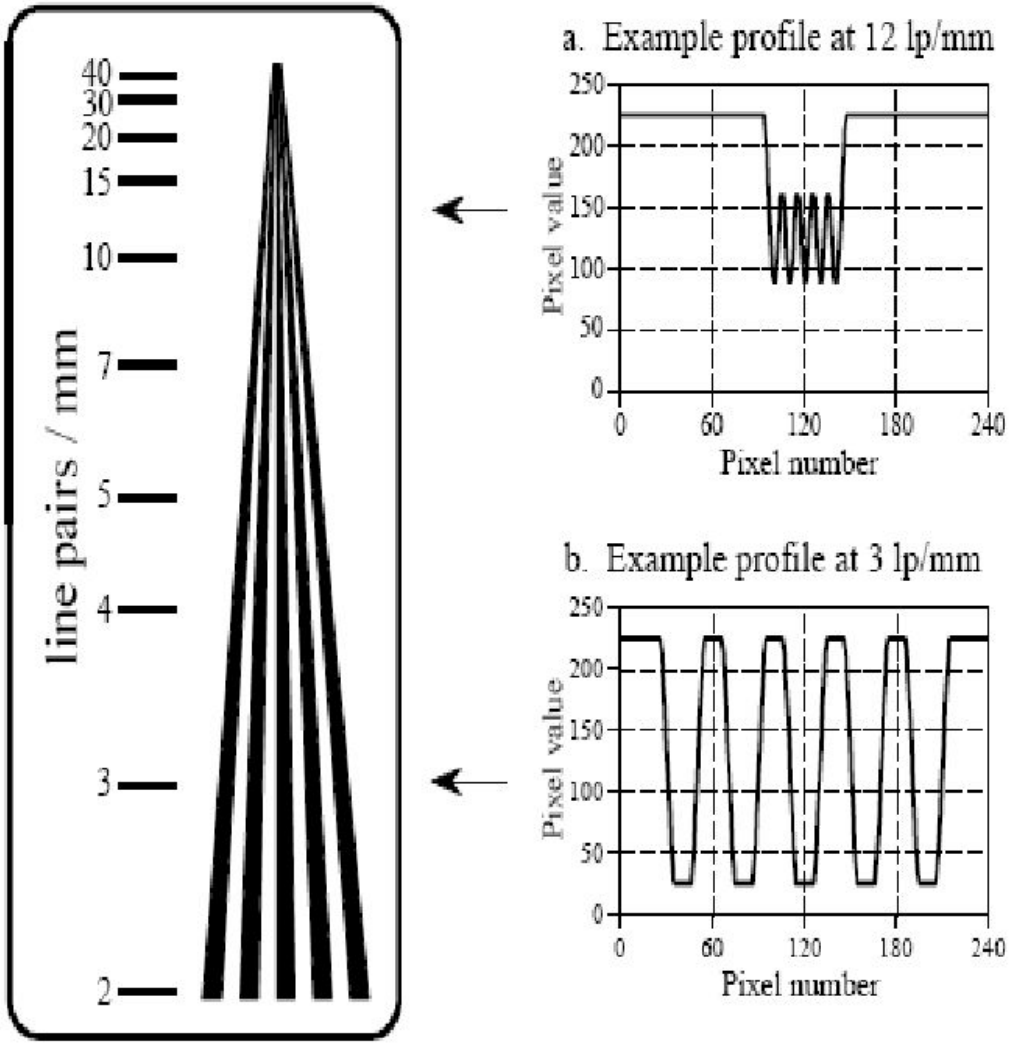


FIGURE 24-8 (continued)
Figure (d) is a smoothed version of (c), used as an approximation to the illumination signal. Figure (e) shows an approximation to the reflectance image, created by *subtracting* the smoothed image from the viewed image. A better approximation is shown in (f), obtained by the nonlinear process of *dividing* the two images.

Тест структура

FIGURE 25-2
Line pair gauge. The line pair gauge is a tool used to measure the resolution of imaging systems. A series of black and white ribs move together, creating a continuum of spatial frequencies. The resolution of a system is taken as the frequency where the eye can no longer distinguish the individual ribs. This example line pair gauge is shown several times larger than the calibrated scale indicates.



Импульс и ступенька

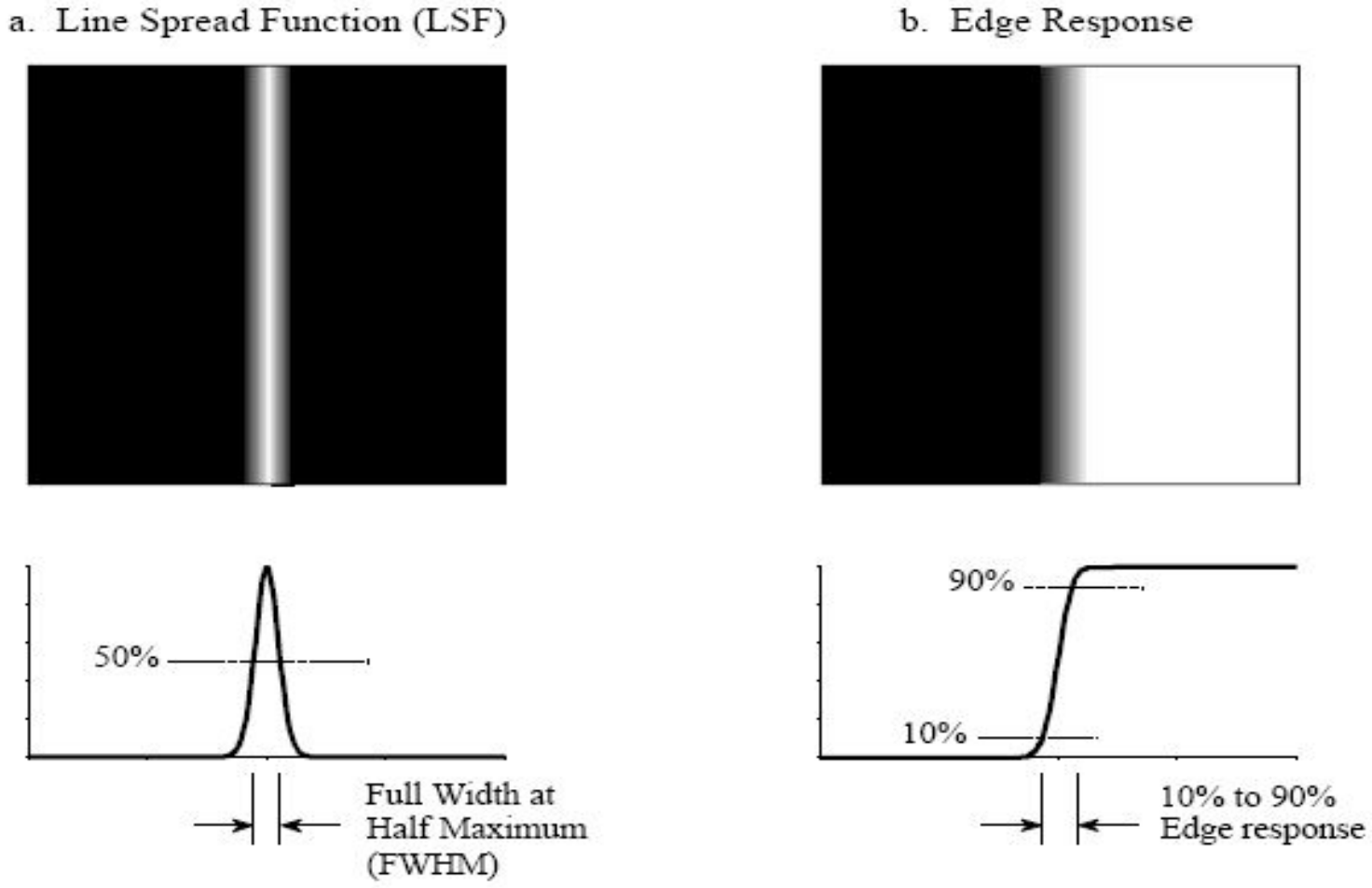
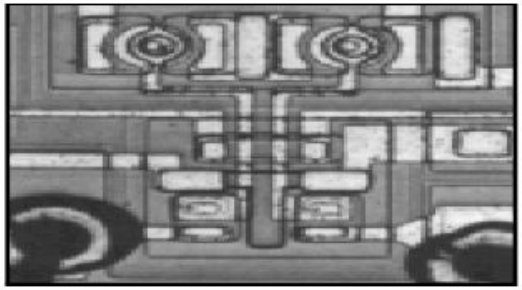
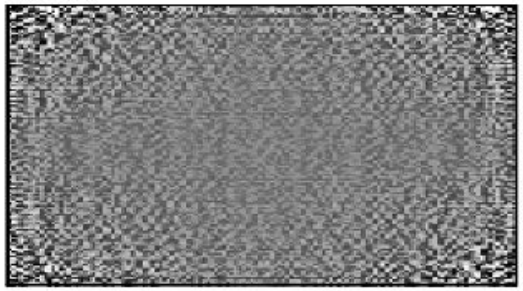


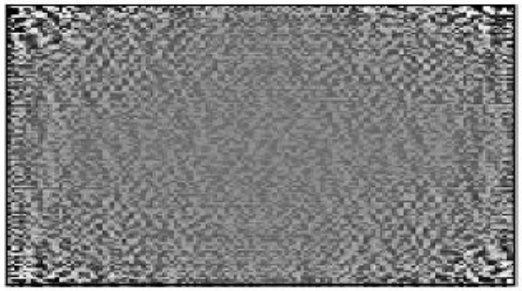
FIGURE 25-3
Line spread function and edge response. The line spread function (LSF) is the derivative of the edge response. The width of the LSF is usually expressed as the Full-Width-at-Half-Maximum (FWHM). The width of the edge response is usually quoted by the 10% to 90% distance.

FIGURE 24-9
Frequency spectrum of an image. The example image, shown in (a), is a microscopic photograph of the silicon surface of an integrated circuit. The frequency spectrum can be displayed as the real and imaginary parts, shown in (b), or as the magnitude and phase, shown in (c). Figures (b) & (c) are displayed with the low-frequencies at the corners and the high-frequencies at the center. Since the frequency domain is periodic, the display can be rearranged to reverse these positions. This is shown in (d), where the magnitude and phase are displayed with the low-frequencies located at the center and the high-frequencies at the corners.

a. Image

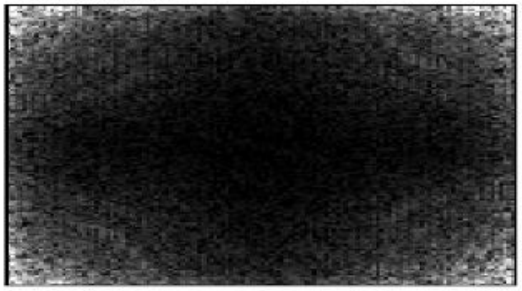


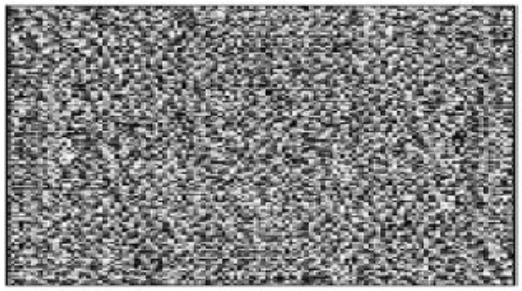




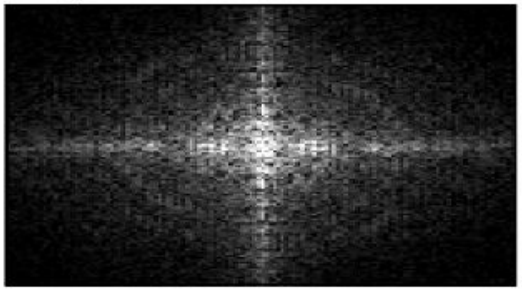
b. Frequency spectrum displayed in rectangular form (as the real and imaginary parts).

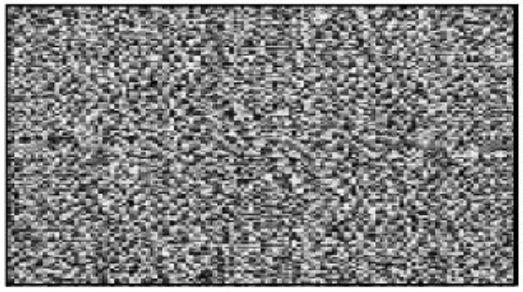
Двумерное Фурье





c. Frequency spectrum displayed in polar form (as the magnitude and phase).





d. Frequency spectrum displayed in polar form, with the spectrum shifted to place zero frequency at the center.

Двумерное Фурье

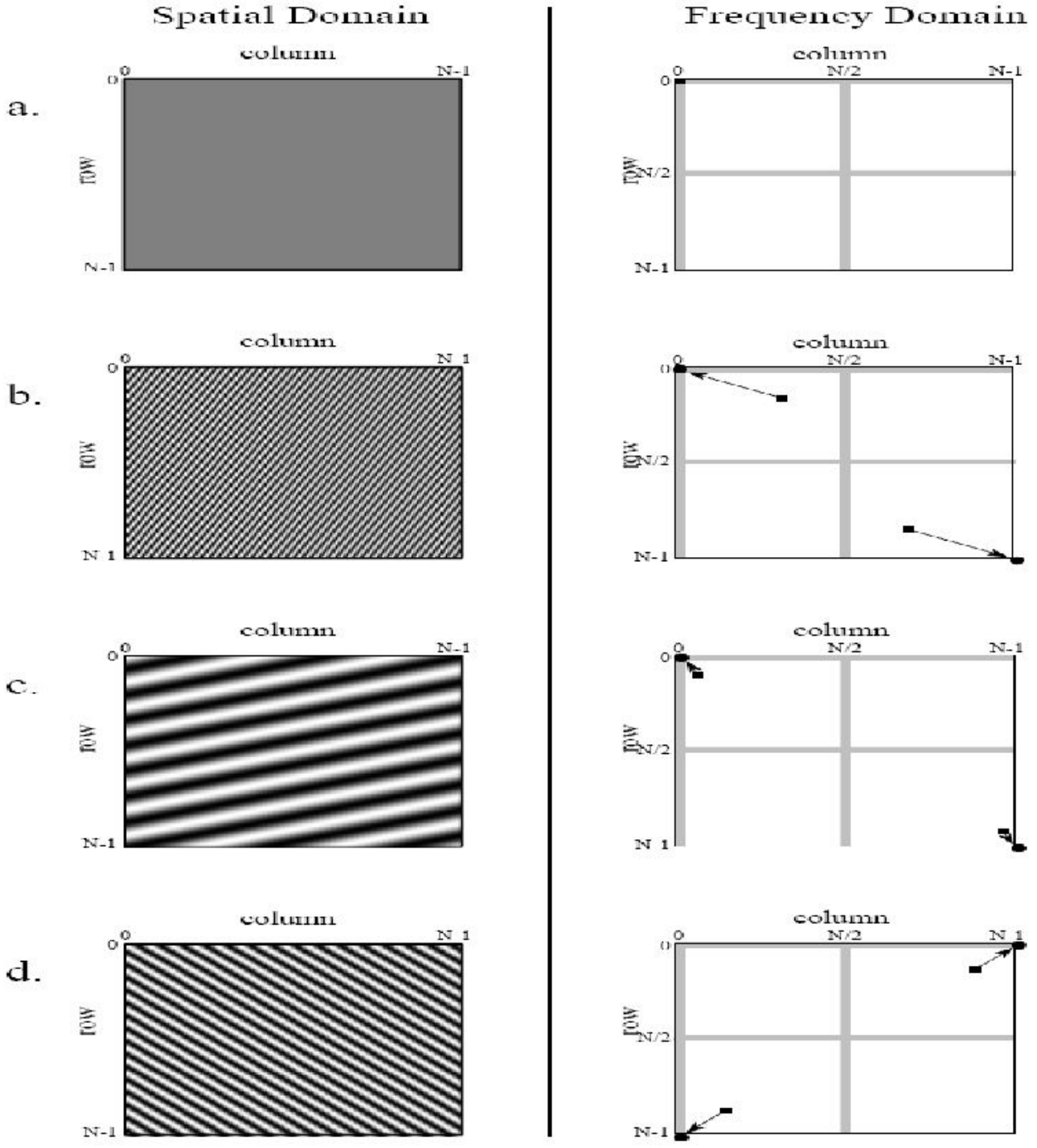


FIGURE 24-10
Two-dimensional sinusoids. Image sine and cosine waves have both a *frequency* and a *direction*. Four examples are shown here. These spectra are displayed with the low-frequencies at the corners. The circles in these spectra show the location of zero frequency.

Тест контраста

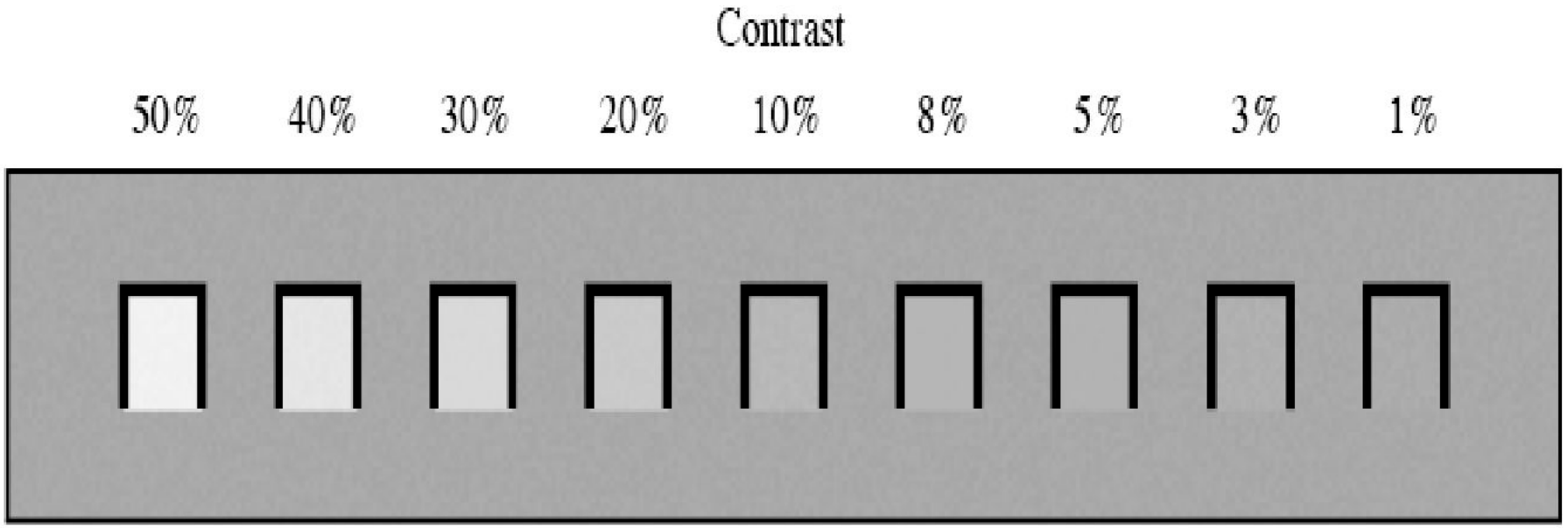
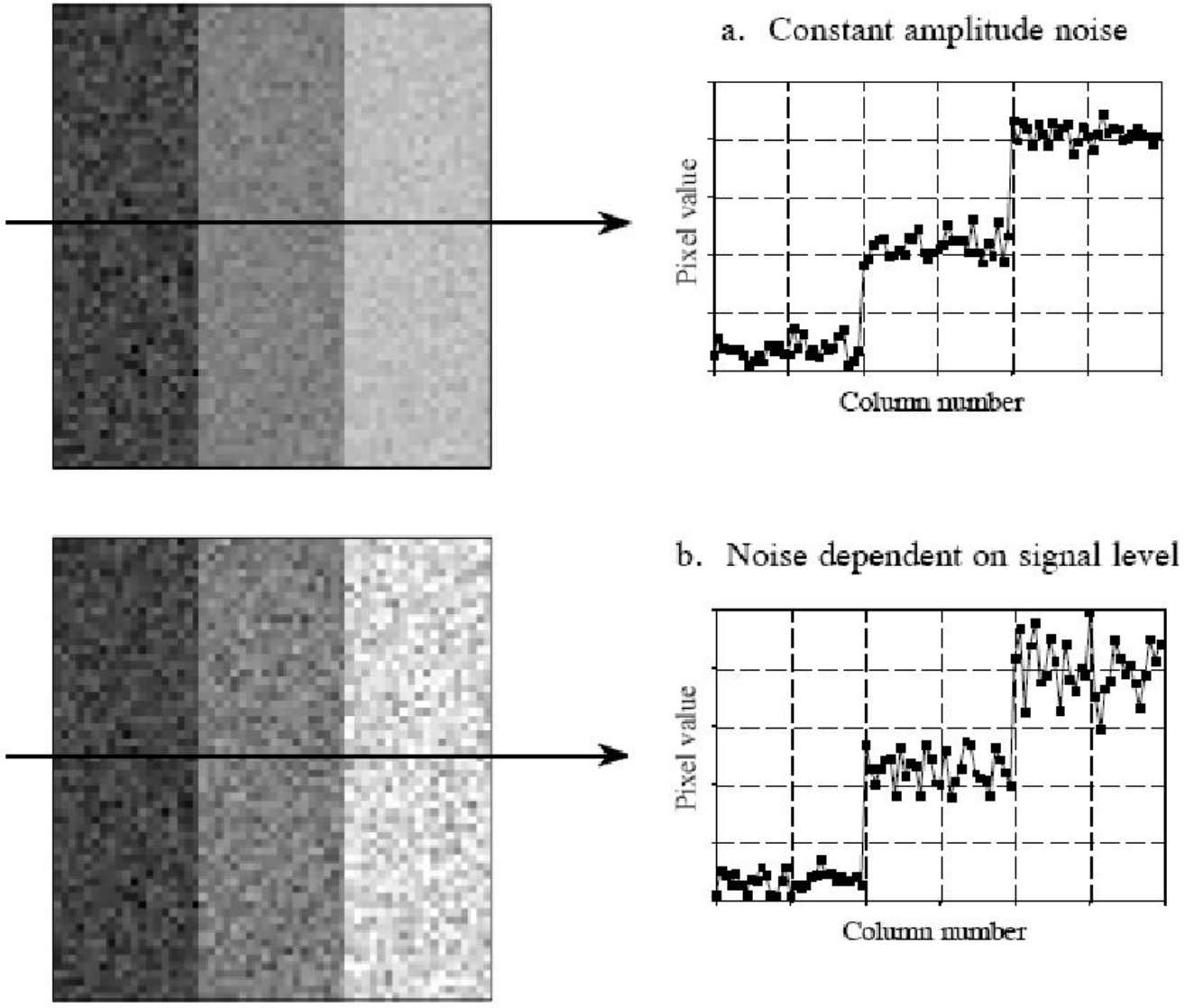


FIGURE 25-7
Contrast detection. The human eye can detect a minimum contrast of about 0.5 to 5%, depending on the observation conditions. 100% contrast is the difference between pure black and pure white.



Сечения изображений

FIGURE 25-9
Image noise. Random noise in images takes two general forms. In (a), the amplitude of the noise remains constant as the signal level changes. This is typical of electronic noise. In (b), the amplitude of the noise increases as the square-root of the signal level. This type of noise originates from the detection of a small number of particles, such as light photons, electrons, or x-rays.

Скелет отпечатка

a. Original fingerprint

b. Skeletonized fingerprint

FIGURE 25-11
Binary skeletonization. The binary image of a fingerprint, (a), contains ridges that are many pixels wide. The skeletonized version, (b), contains ridges only a single pixel wide.

Томография

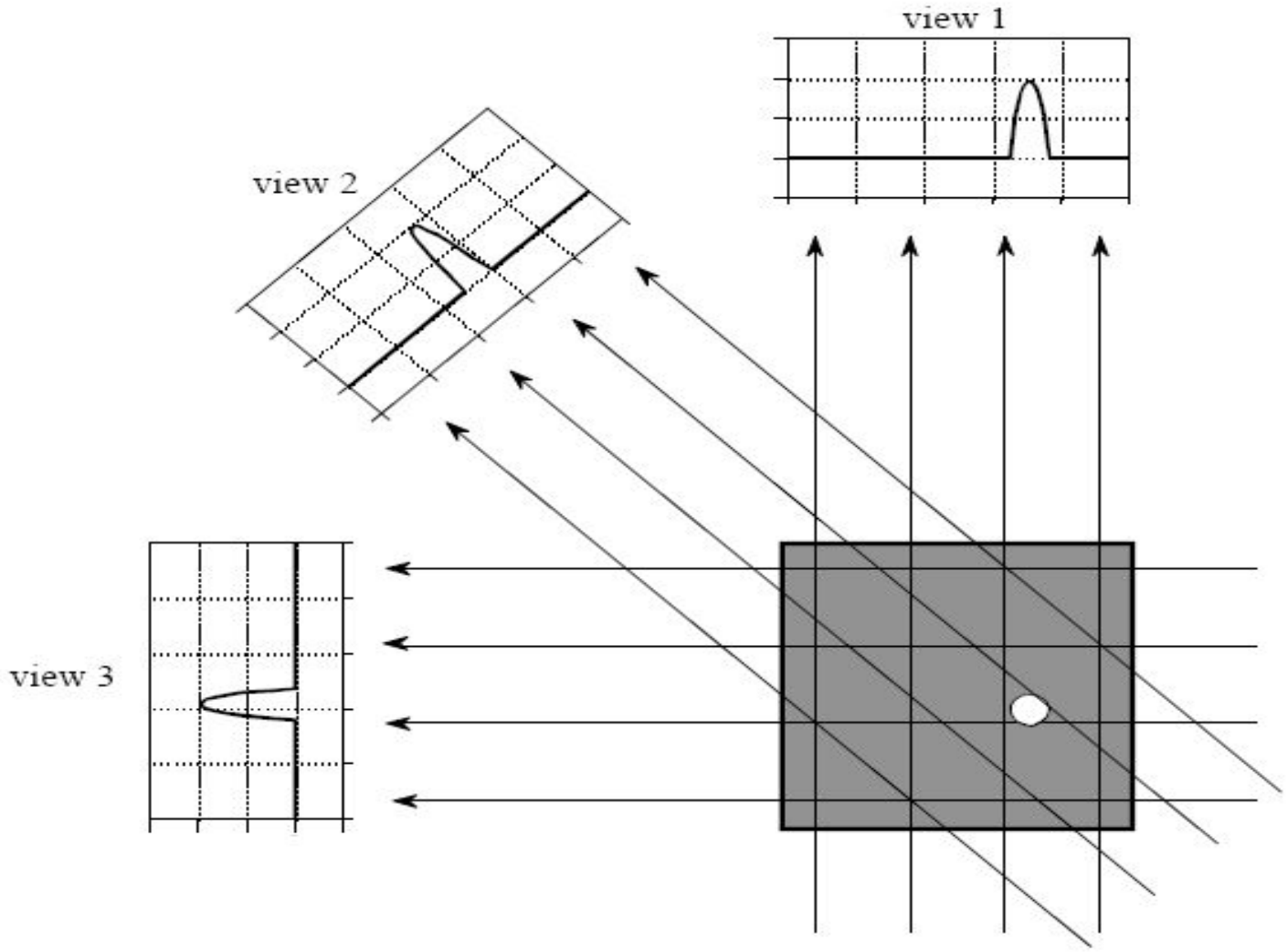


FIGURE 25-15
CT views. Computed tomography acquires a set of views and then reconstructs the corresponding image. Each sample in a view is equal to the sum of the image values along the ray that points to that sample. In this example, the image is a small pillbox surrounded by zeros. While only three views are shown here, a typical CT scan uses hundreds of views at slightly different angles.

Томография

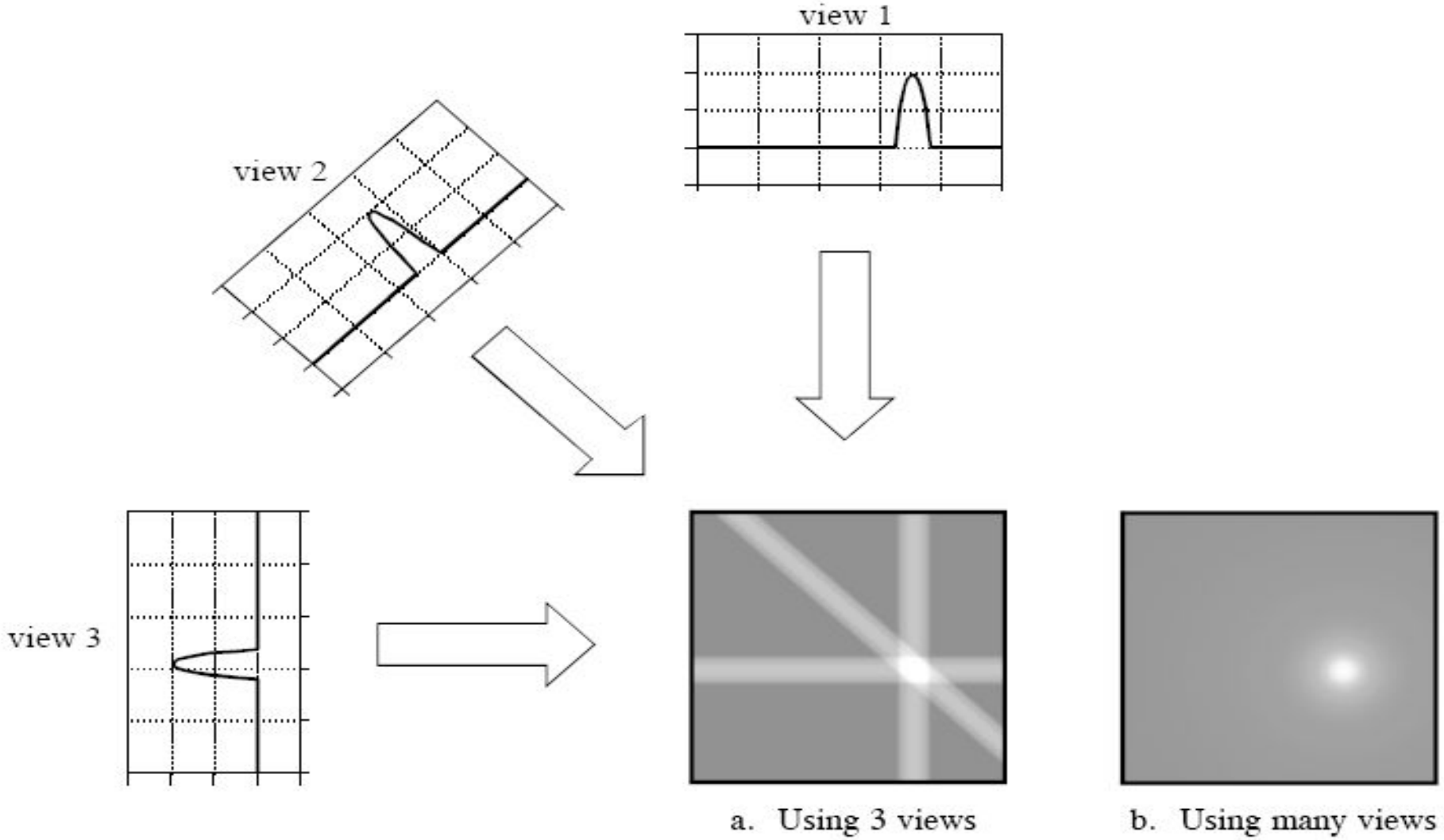


FIGURE 25-16
Backprojection. Backprojection reconstructs an image by taking each view and *smearing* it along the path it was originally acquired. The resulting image is a blurry version of the correct image.

Томография

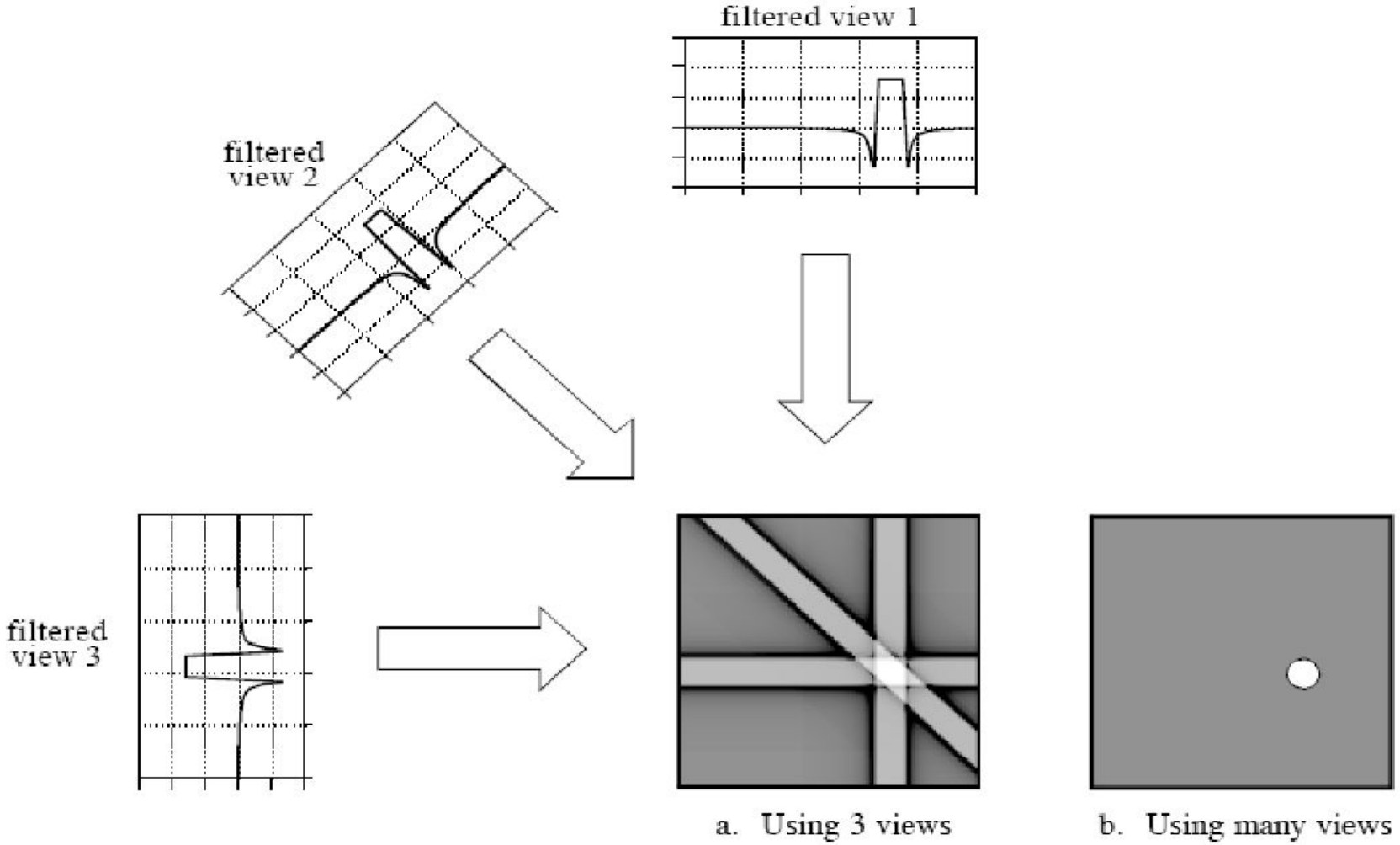


FIGURE 25-17
Filtered backprojection. Filtered backprojection reconstructs an image by filtering each view before backprojection. This removes the blurring seen in simple backprojection, and results in a mathematically exact reconstruction of the image. Filtered backprojection is the most commonly used algorithm for computed tomography systems.

Томография

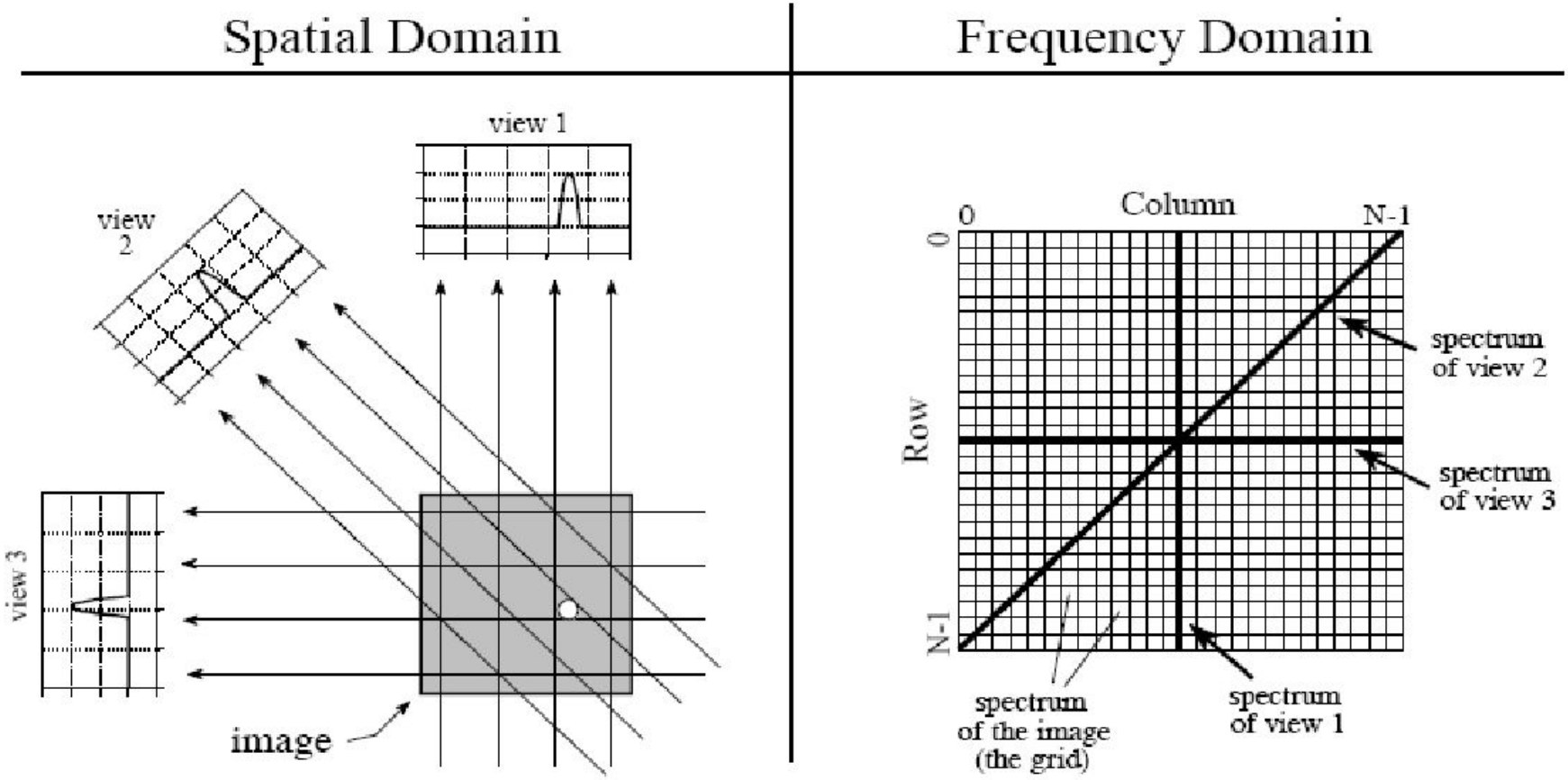
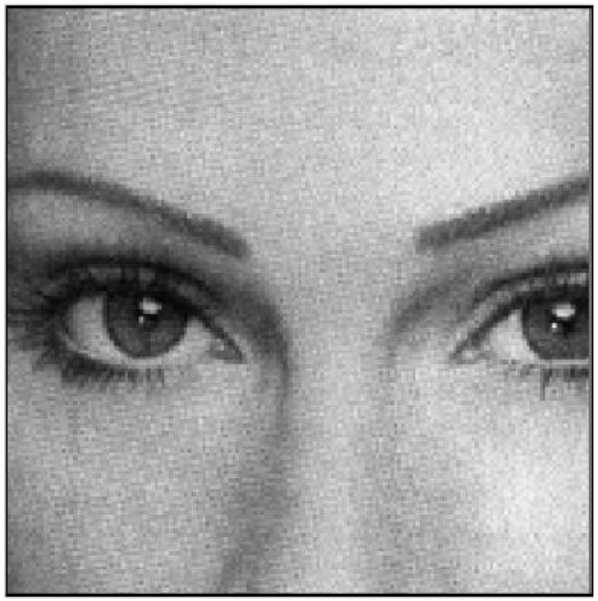
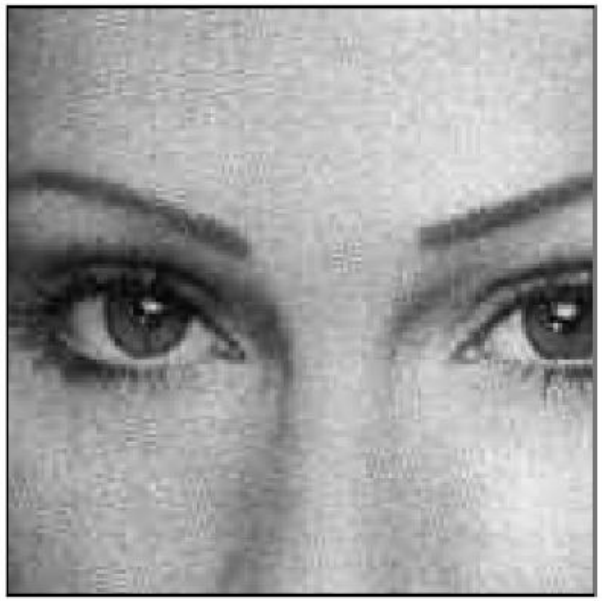


FIGURE 25-18
The Fourier Slice Theorem. The Fourier Slice Theorem describes the relationship between an image and its views in the frequency domain. In the spatial domain, each view is found by integrating the image along rays at a particular angle. In the frequency domain, the spectrum of each view is a one-dimensional "slice" of the two-dimensional image spectrum.

Сжатие



a. Original image



b. With 10:1 compression

c. With 45:1 compression

FIGURE 27-15
Example of JPEG distortion. Figure (a) shows the original image, while (b) and (c) shows restored images using compression ratios of 10:1 and 45:1, respectively. The high compression ratio used in (c) results in each 8×8 pixel group being represented by less than 12 bits.