

Concepto de vecindad

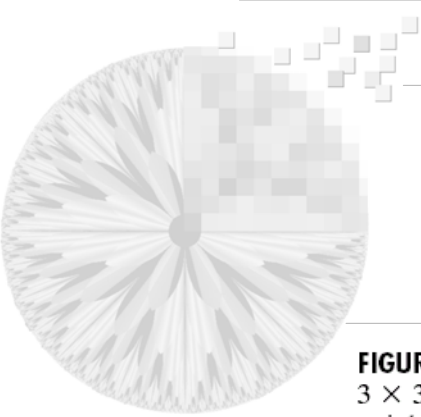
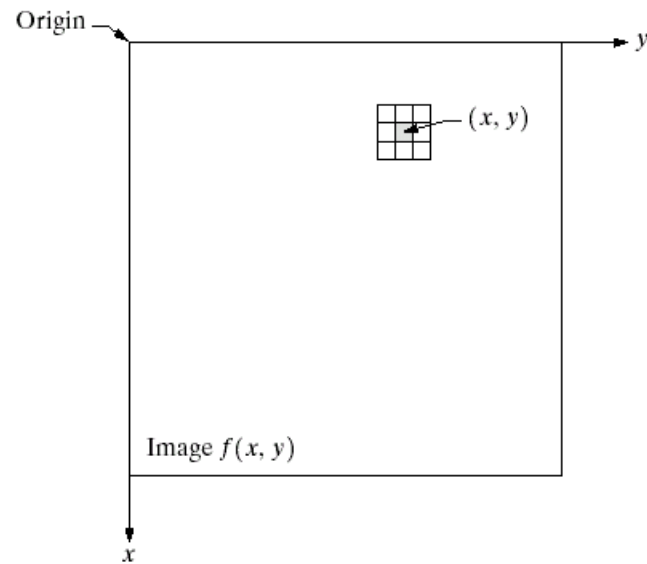
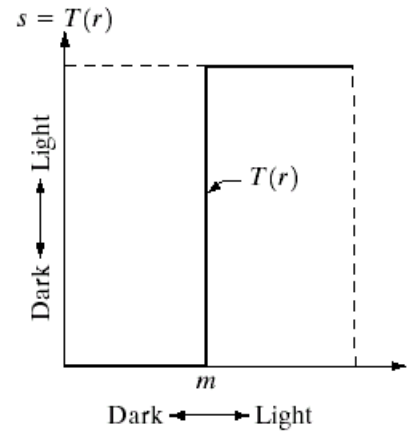
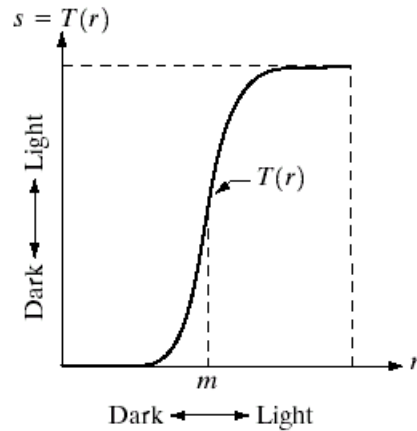


FIGURE 3.1 A 3×3 neighborhood about a point (x, y) in an image.



Compresión de niveles de gris

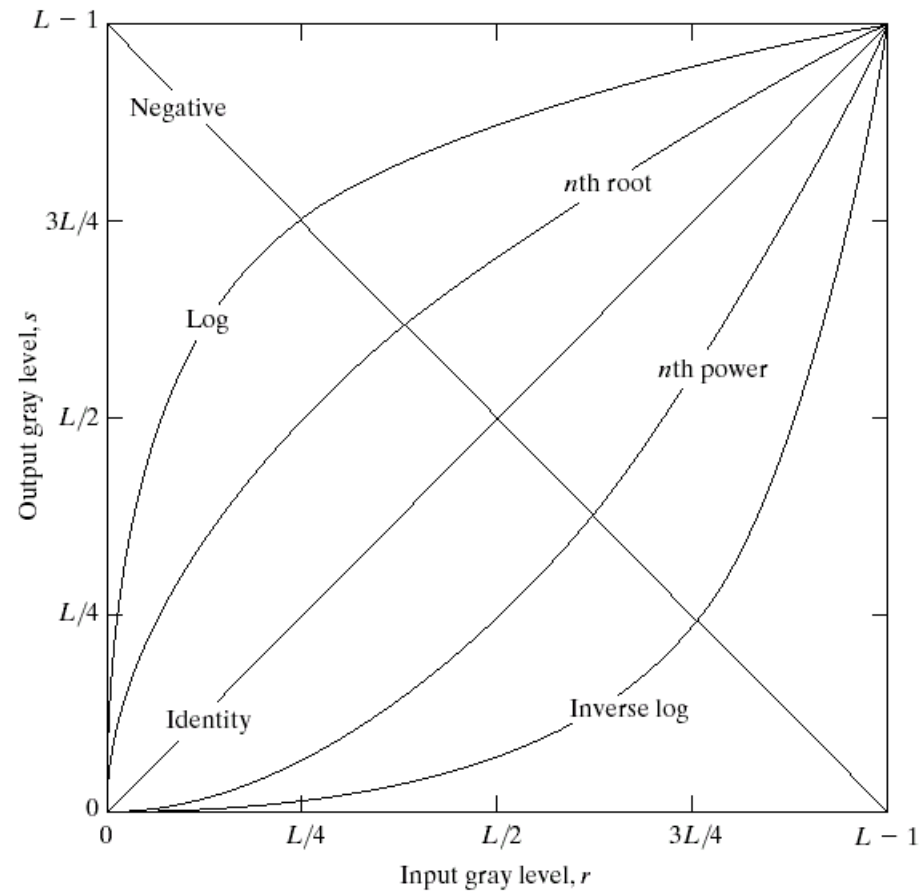


a b

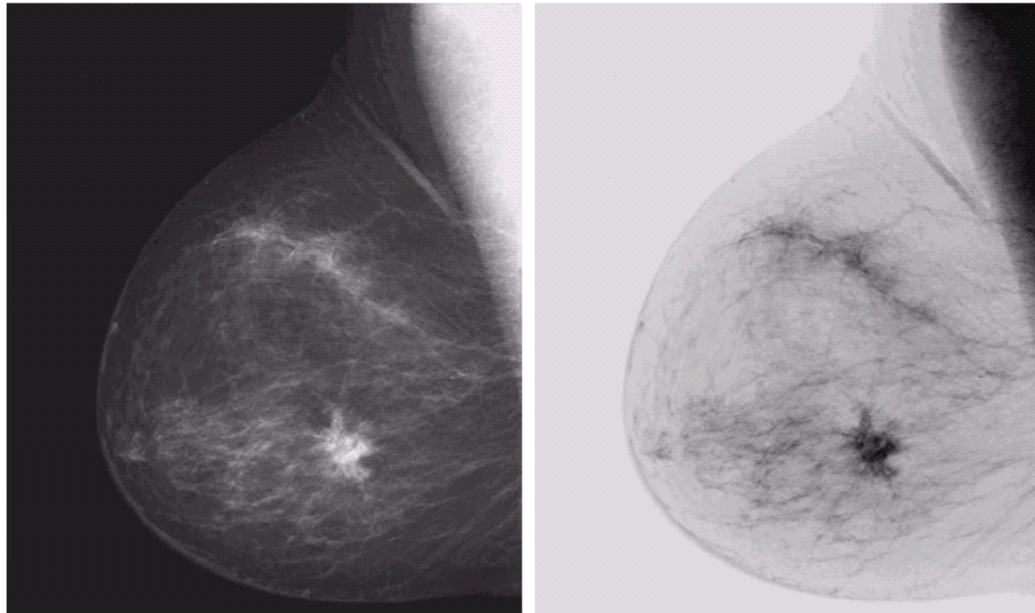
FIGURE 3.2 Gray-level transformation functions for contrast enhancement.

Funciones de transformación básicas

FIGURE 3.3 Some basic gray-level transformation functions used for image enhancement.



Transformación a negativo



a b

FIGURE 3.4

(a) Original digital mammogram.
(b) Negative image obtained using the negative transformation in Eq. (3.2-1).
(Courtesy of G.E. Medical Systems.)

Transformación logarítmica

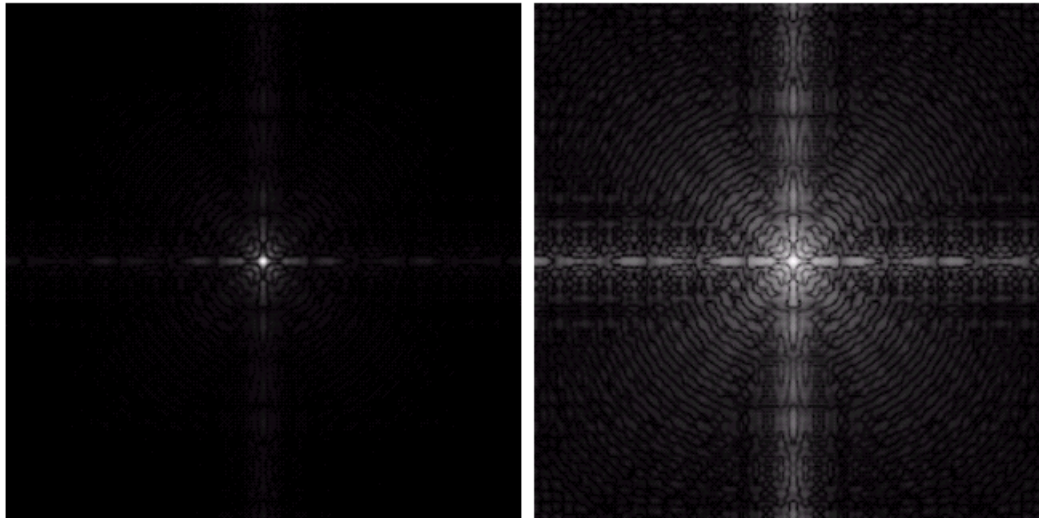


a b

FIGURE 3.5

(a) Fourier spectrum.

(b) Result of applying the log transformation given in Eq. (3.2-2) with $c = 1$.



Transformación por potenciación

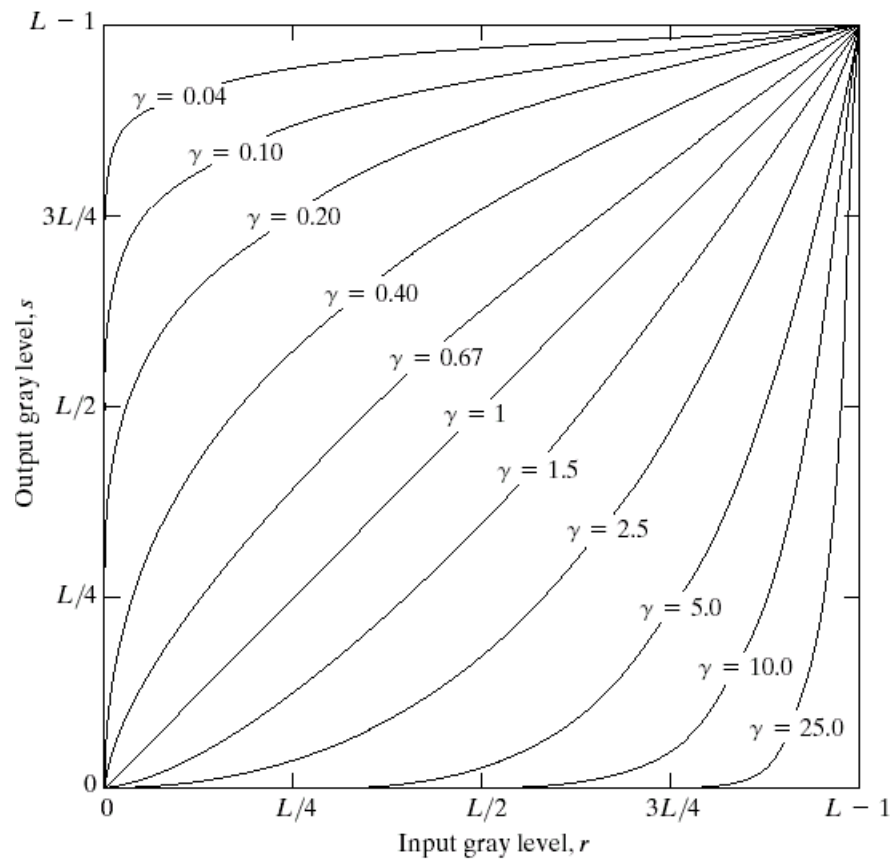


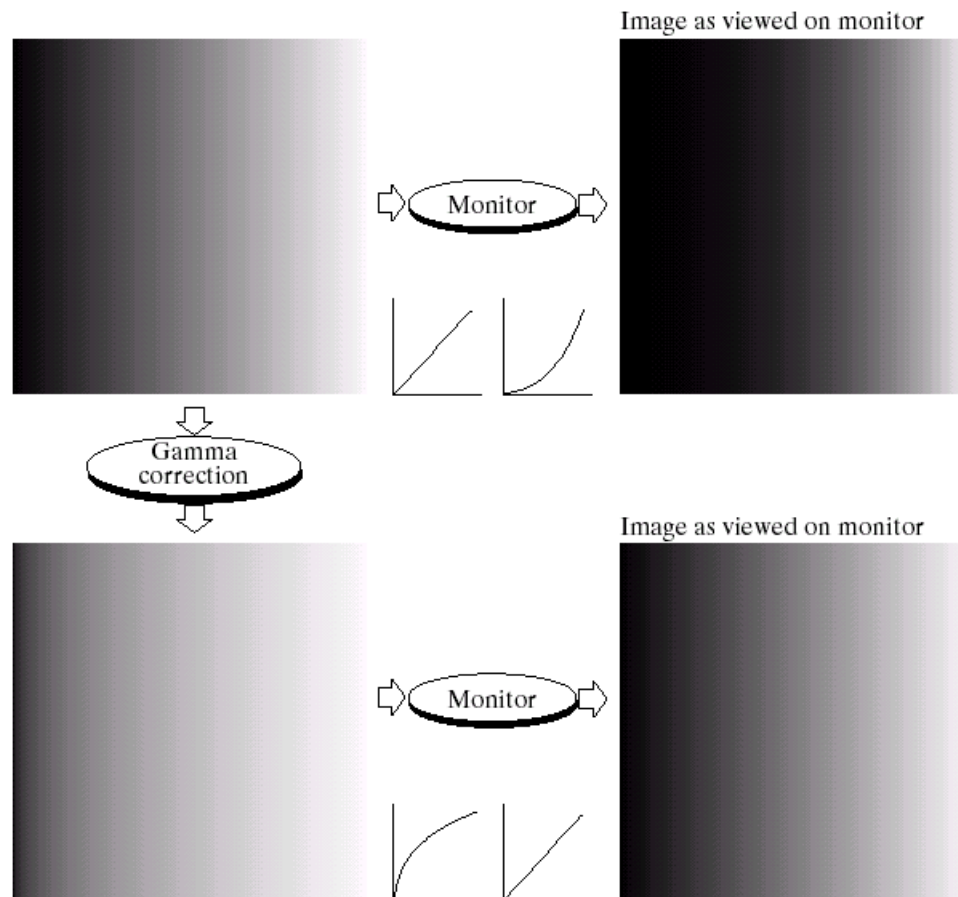
FIGURE 3.6 Plots of the equation $s = cr^\gamma$ for various values of γ ($c = 1$ in all cases).

Corrección de gama

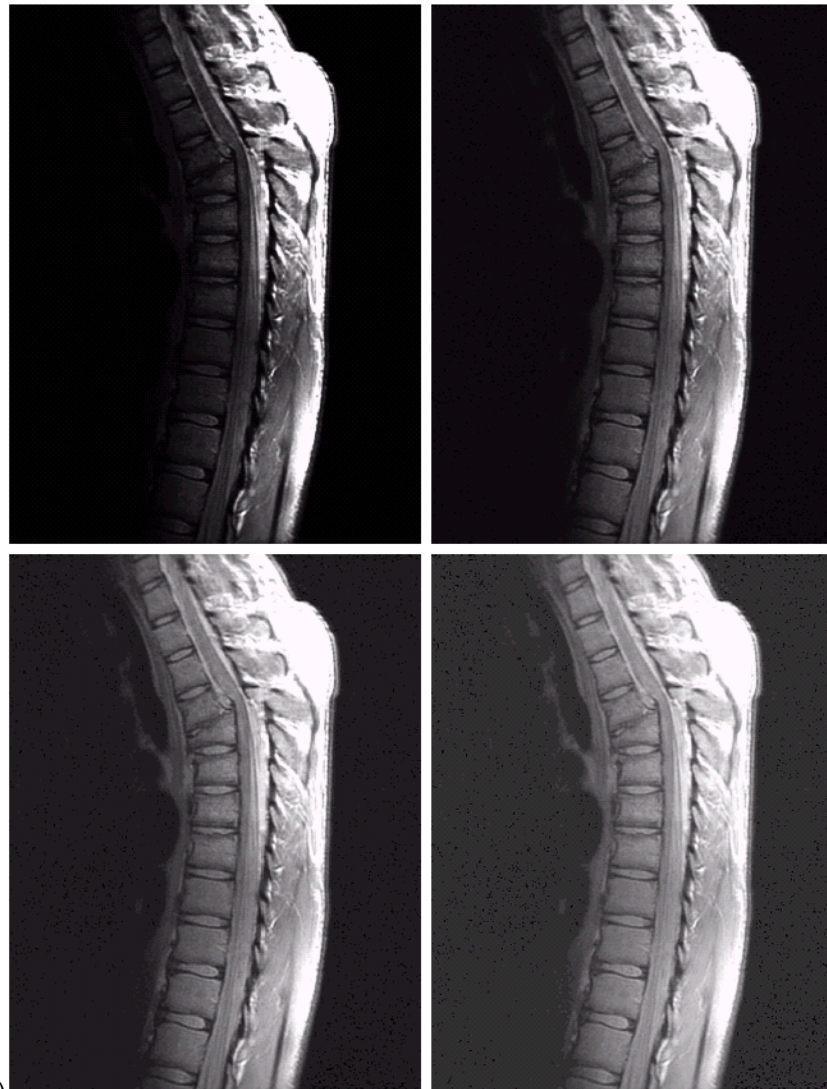
a b
c d

FIGURE 3.7

(a) Linear-wedge gray-scale image.
(b) Response of monitor to linear wedge.
(c) Gamma-corrected wedge.
(d) Output of monitor.



Transformación por función de potencia



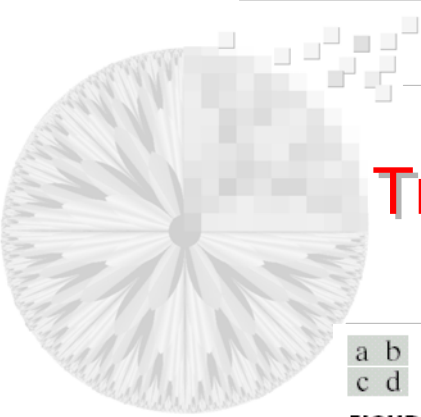
a	b
c	d

FIGURE 3.8

(a) Magnetic resonance (MR) image of a fractured human spine.

(b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 0.6, 0.4,$ and 0.3 , respectively. (Original image for this example courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

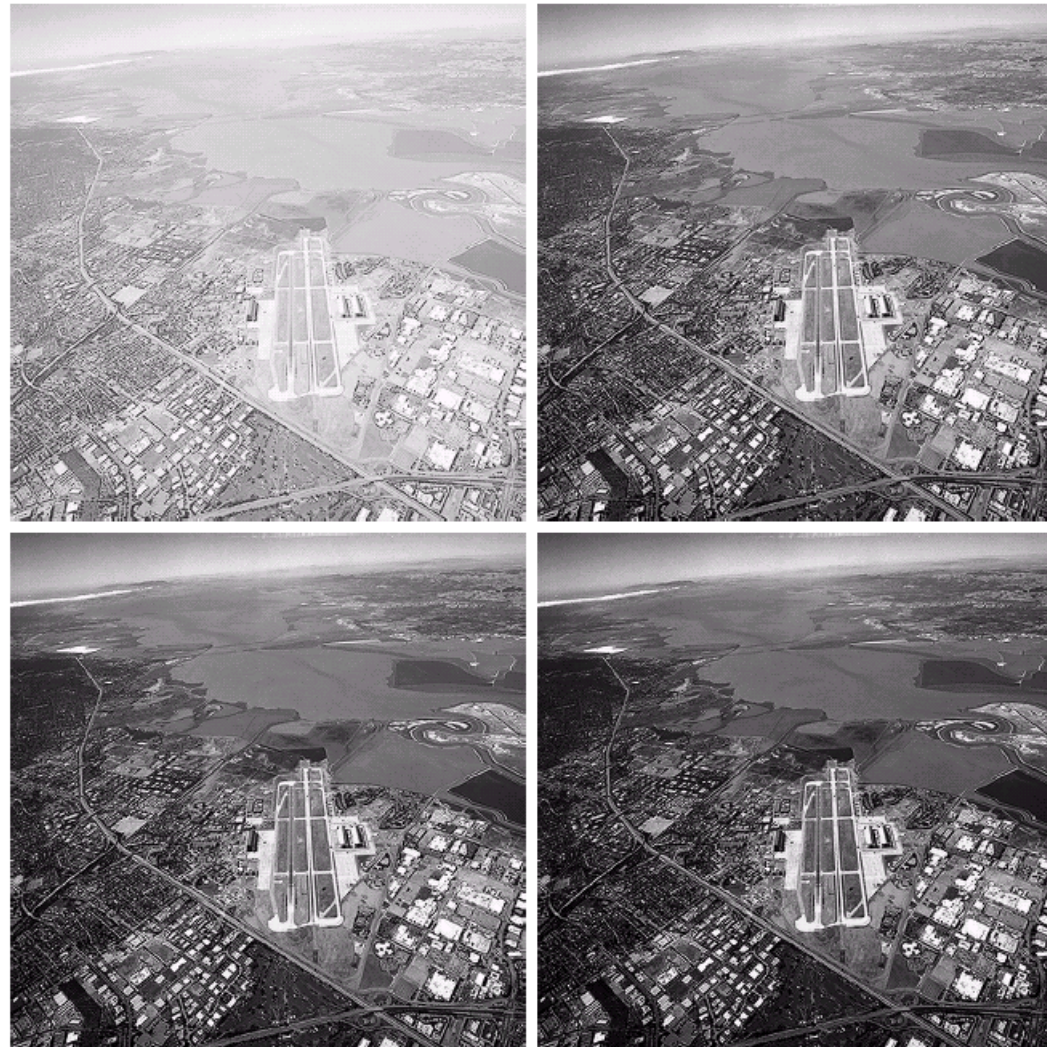
Transformación por función de potencia



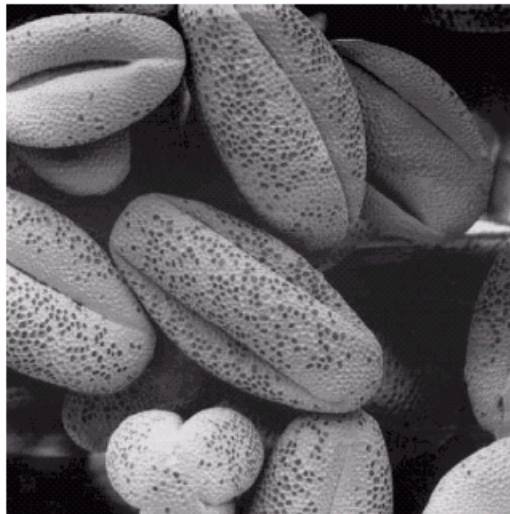
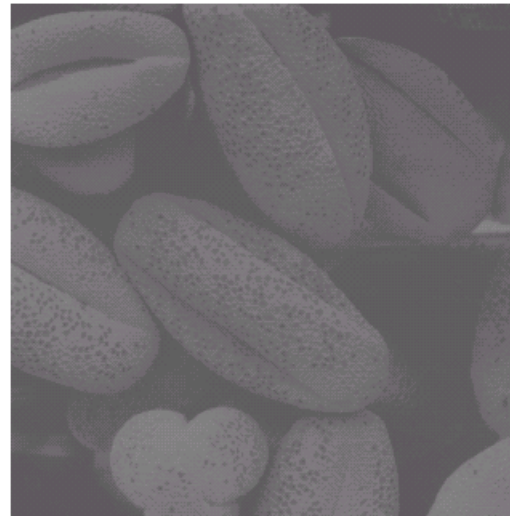
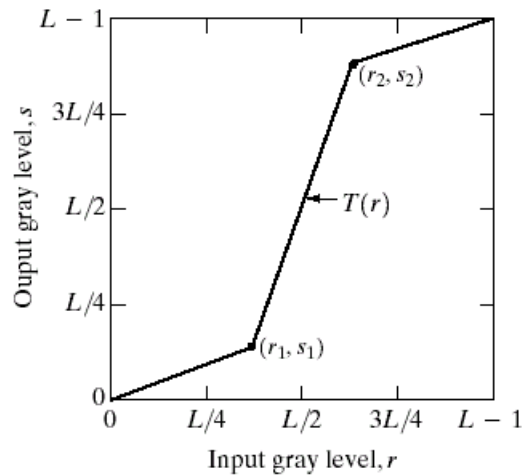
a	b
c	d

FIGURE 3.9

(a) Aerial image.
(b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0, 4.0,$ and 5.0 , respectively. (Original image for this example courtesy of NASA.)



Compresión del nivel de gris (ajuste del contraste)

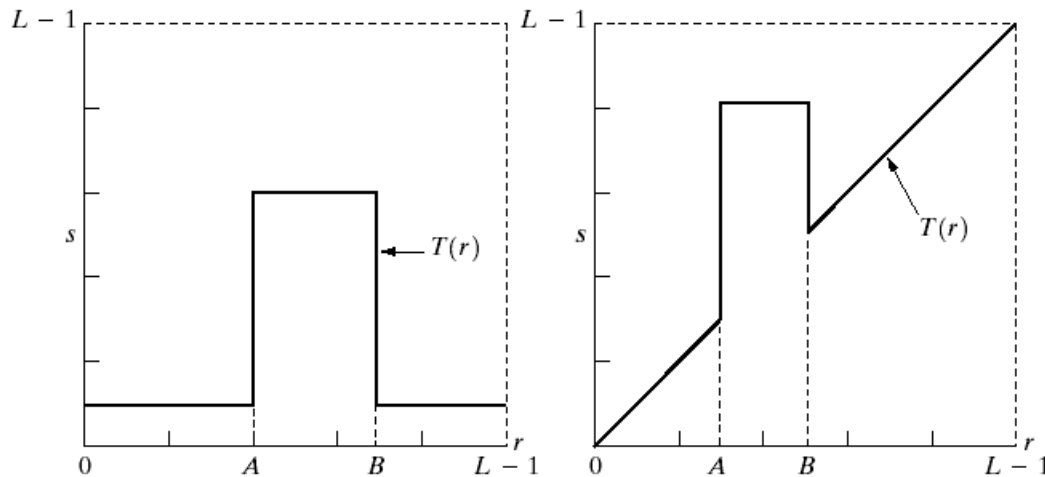
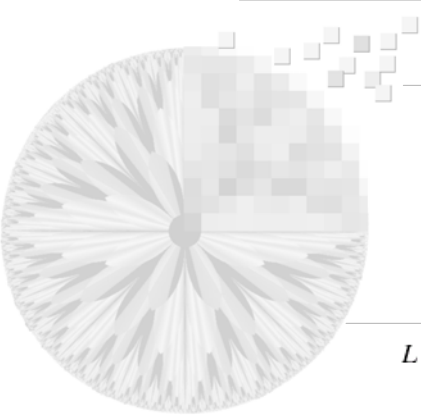


a b
c d

FIGURE 3.10

Contrast stretching.
(a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Fraccionamiento del nivel de gris



a	b
c	d

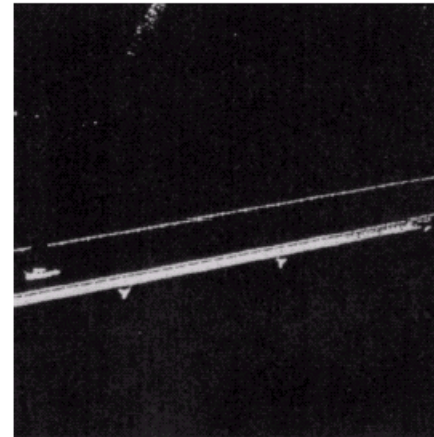
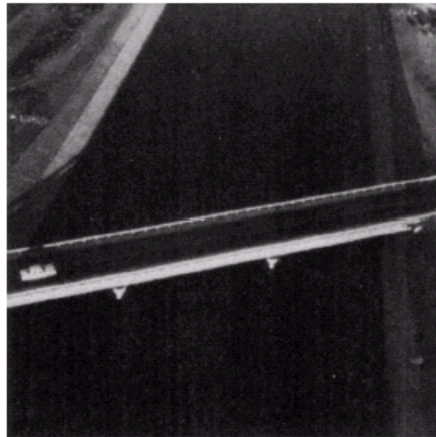
FIGURE 3.11

(a) This transformation highlights range $[A, B]$ of gray levels and reduces all others to a constant level.

(b) This transformation highlights range $[A, B]$ but preserves all other levels.

(c) An image.

(d) Result of using the transformation in (a).



Fraccionamiento por planos de bits

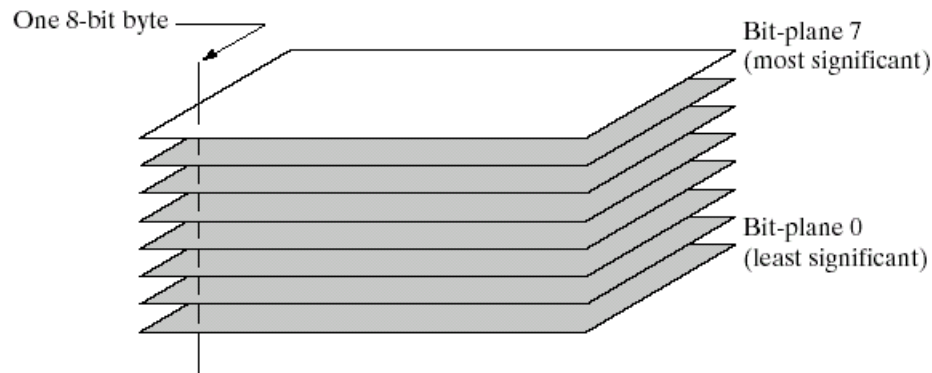


FIGURE 3.12
Bit-plane
representation of
an 8-bit image.



Imagen fractal de 8 bits

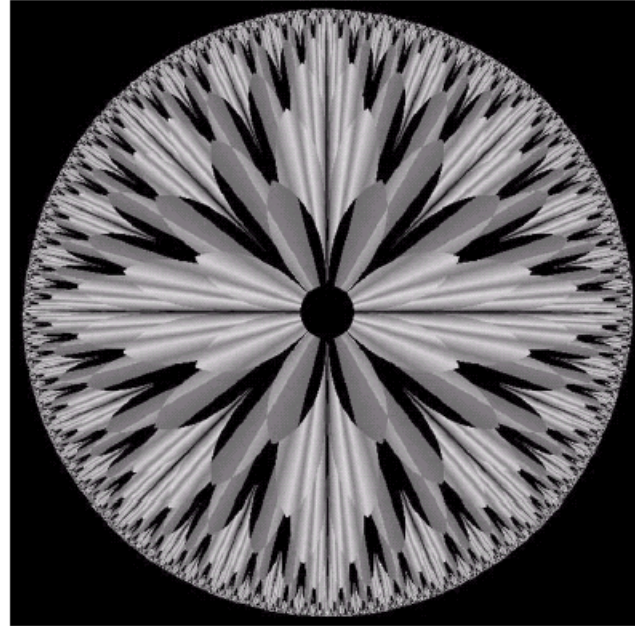


FIGURE 3.13 An 8-bit fractal image. (A fractal is an image generated from mathematical expressions). (Courtesy of Ms. Melissa D. Binde, Swarthmore College, Swarthmore, PA.)

Fraccionamiento del nivel de gris

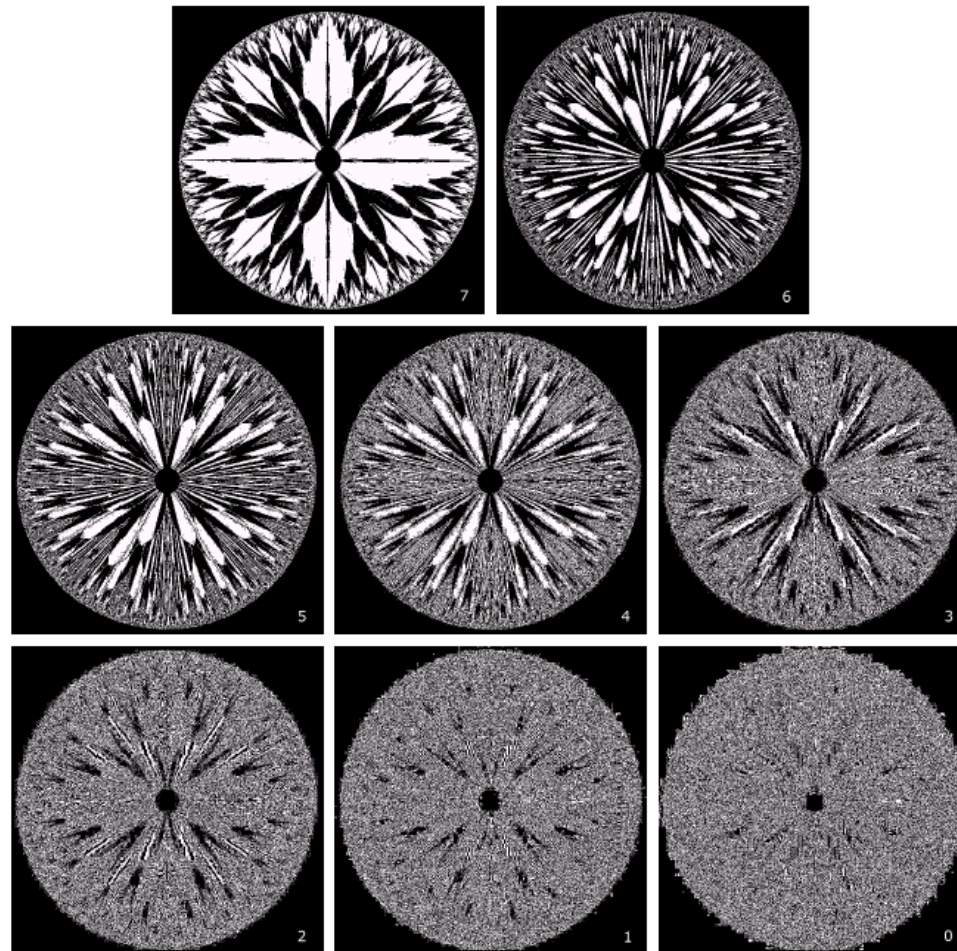
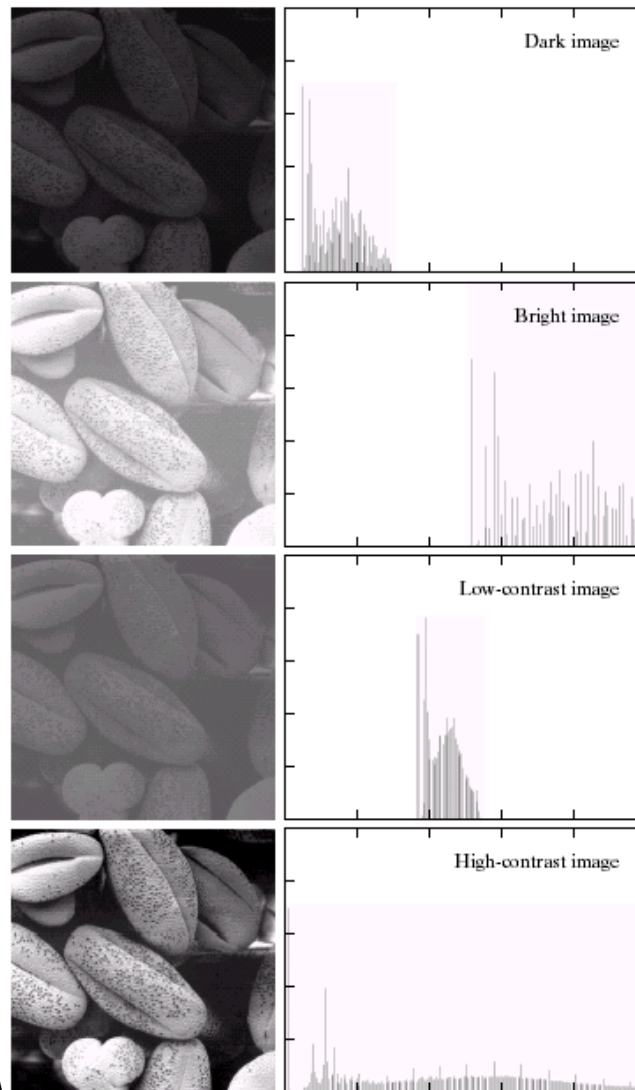


FIGURE 3.14 The eight bit planes of the image in Fig. 3.13. The number at the bottom, right of each image identifies the bit plane.



Histogramas



a b

FIGURE 3.15 Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)



Función de transformación del nivel de gris Valor sencillo e incremento monótono

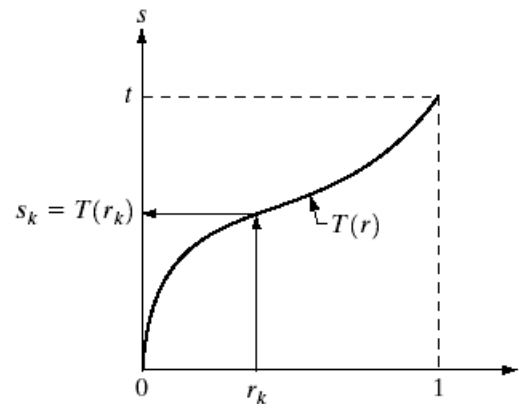
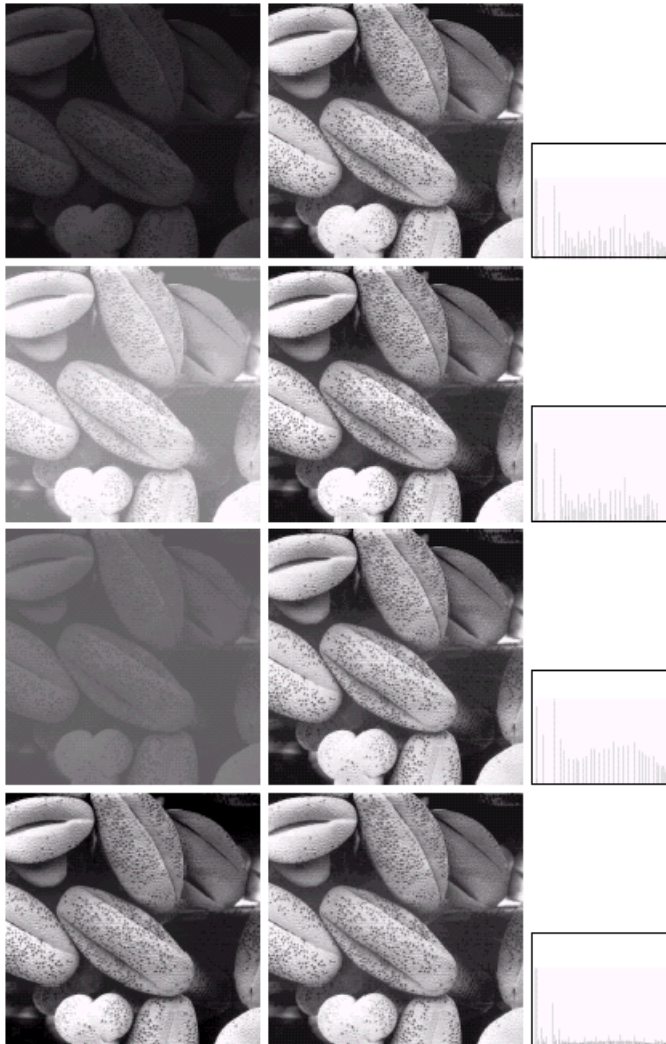


FIGURE 3.16 A gray-level transformation function that is both single valued and monotonically increasing.

Ecualización del histograma

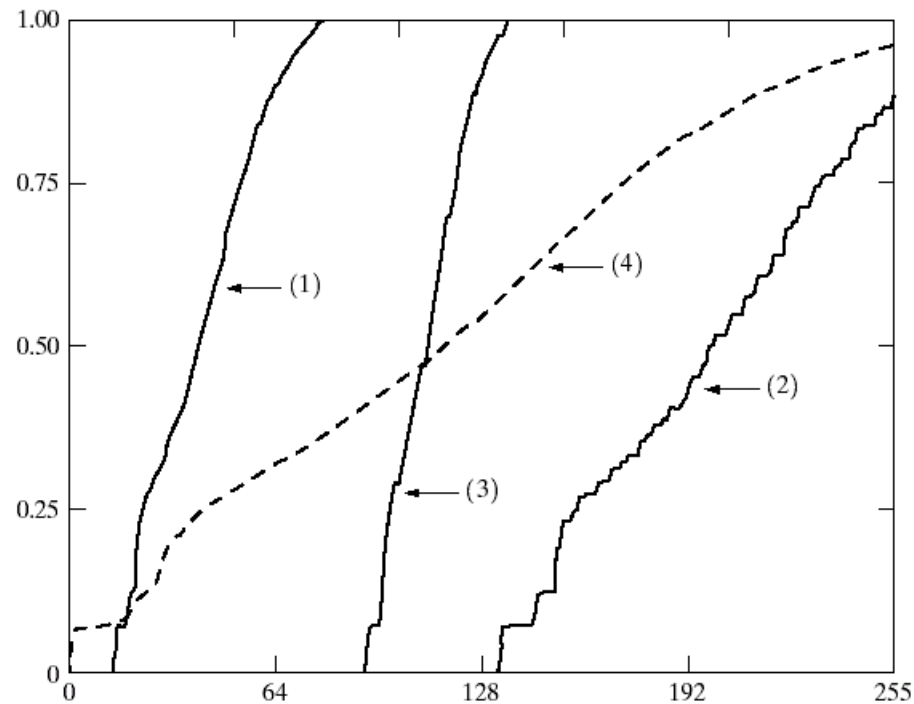


a b c

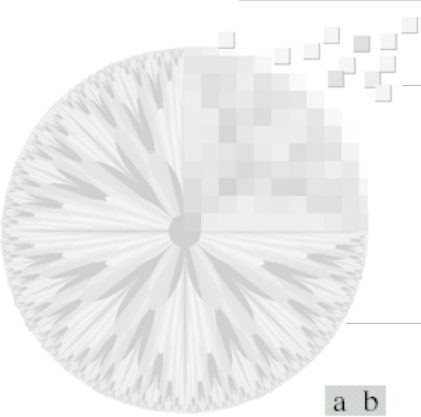
FIGURE 3.17 (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.

Usos del histograma

FIGURE 3.18
Transformation functions (1) through (4) were obtained from the histograms of the images in Fig.3.17(a), using Eq. (3.3-8).



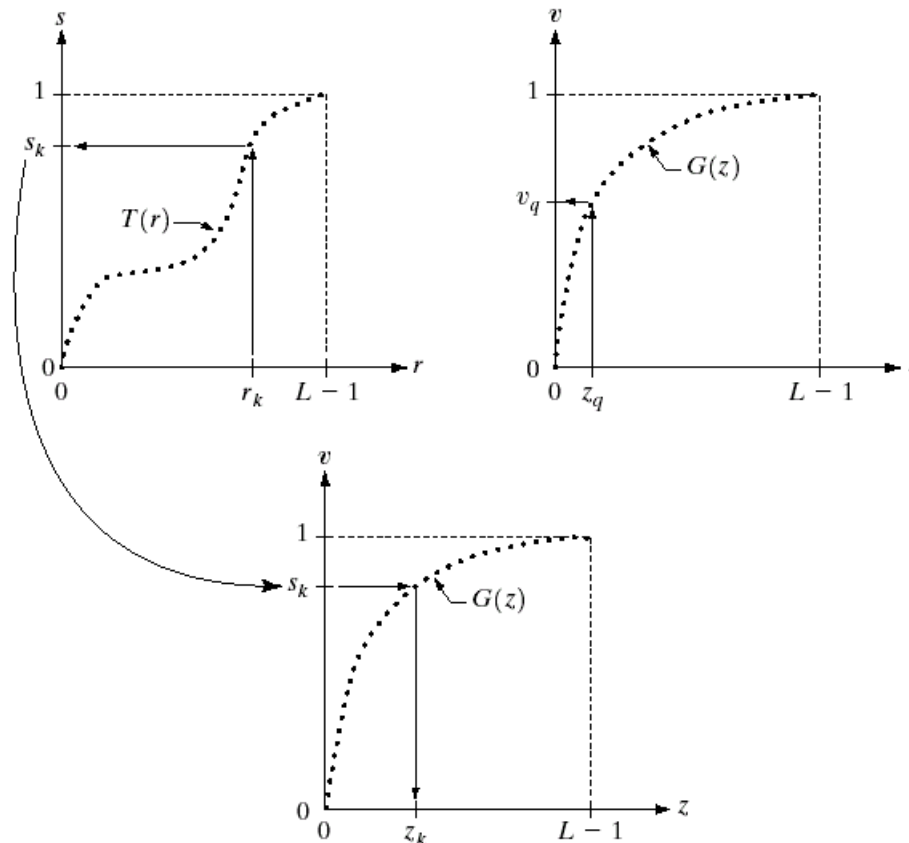
Interpretación y uso del histograma



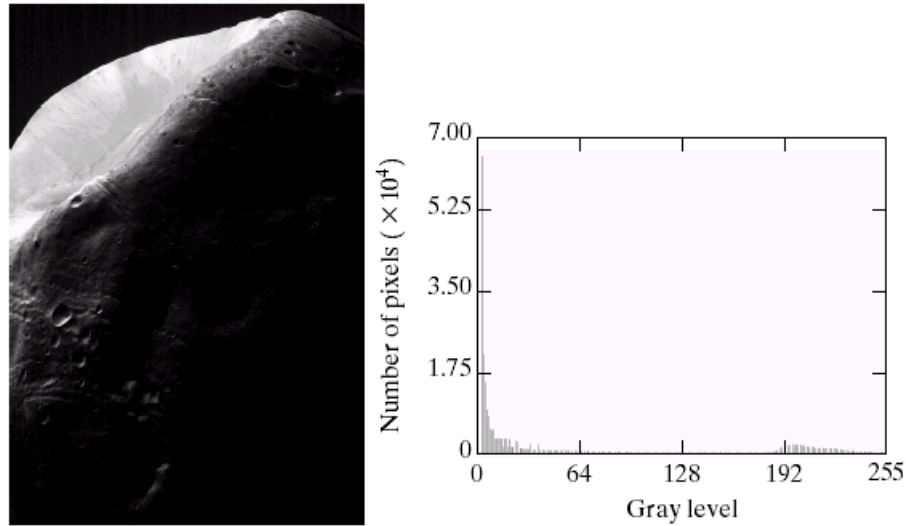
a b
c

FIGURE 3.19

(a) Graphical interpretation of mapping from r_k to s_k via $T(r)$.
(b) Mapping of z_q to its corresponding value v_q via $G(z)$.
(c) Inverse mapping from s_k to its corresponding value of z_k .



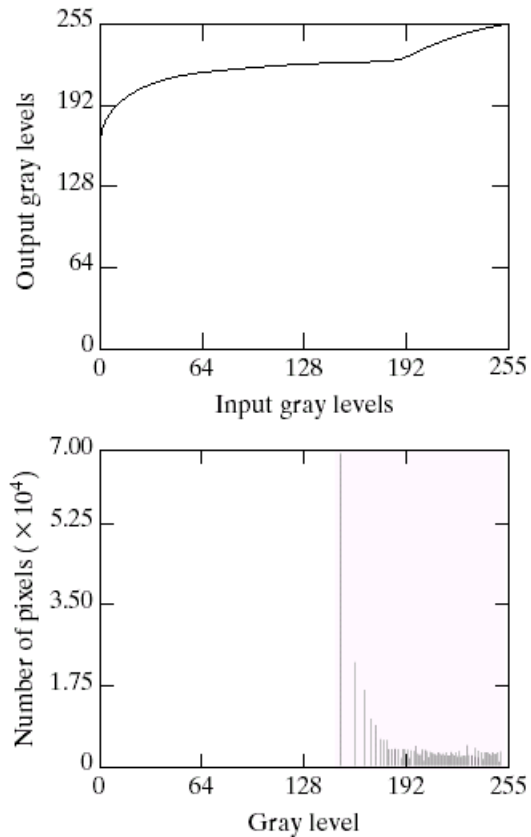
Uso de histograma



a b

FIGURE 3.20 (a) Image of the Mars moon Phobos taken by NASA's *Mars Global Surveyor*. (b) Histogram. (Original image courtesy of NASA.)

Uso del histograma



a b
c

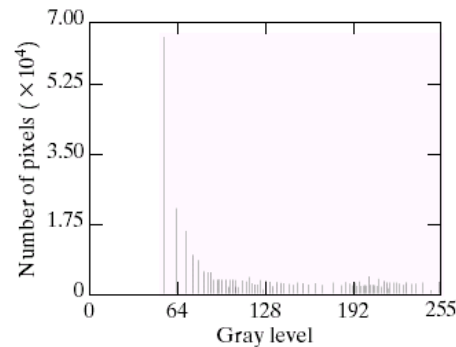
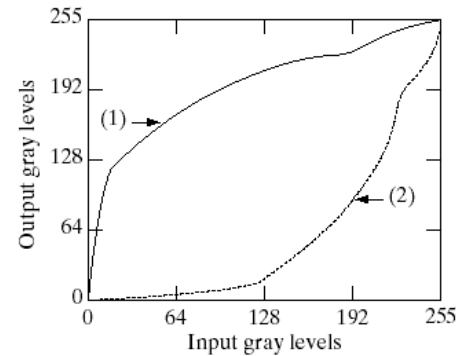
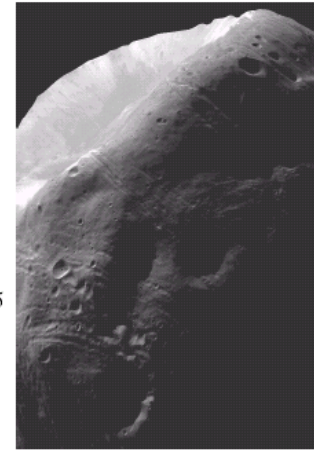
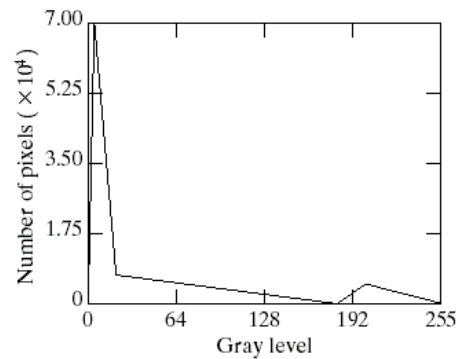
FIGURE 3.21
(a) Transformation function for histogram equalization.
(b) Histogram-equalized image (note the washed-out appearance).
(c) Histogram of (b).

Especificación del histograma

a
b
c
d

FIGURE 3.22

(a) Specified histogram.
(b) Curve (1) is from Eq. (3.3-14), using the histogram in (a); curve (2) was obtained using the iterative procedure in Eq. (3.3-17).
(c) Enhanced image using mappings from curve (2).
(d) Histogram of (c).



Ecualización local Del histograma

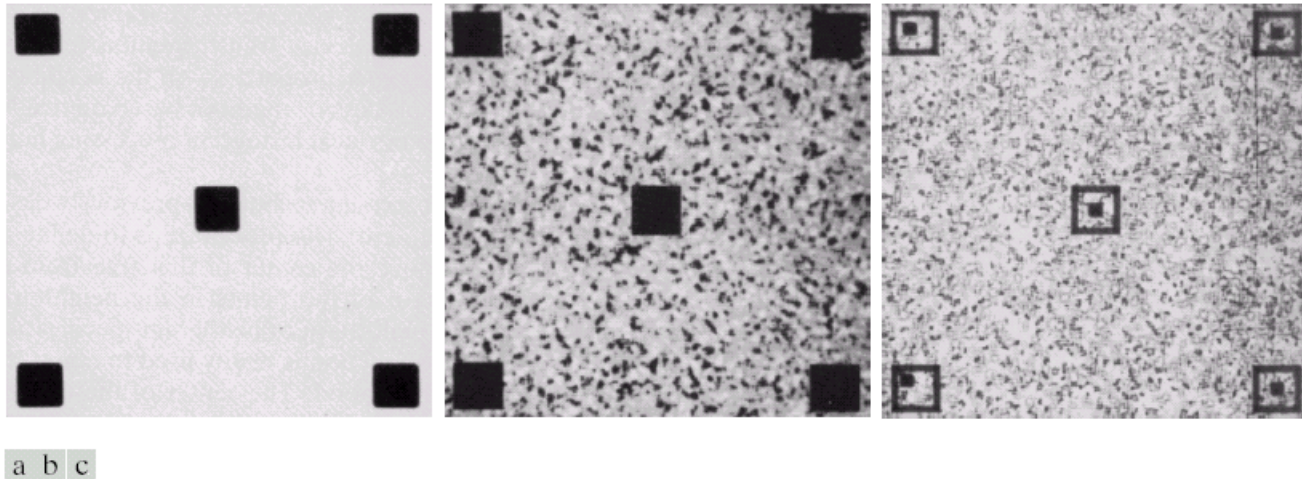


FIGURE 3.23 (a) Original image. (b) Result of global histogram equalization. (c) Result of local histogram equalization using a 7×7 neighborhood about each pixel.

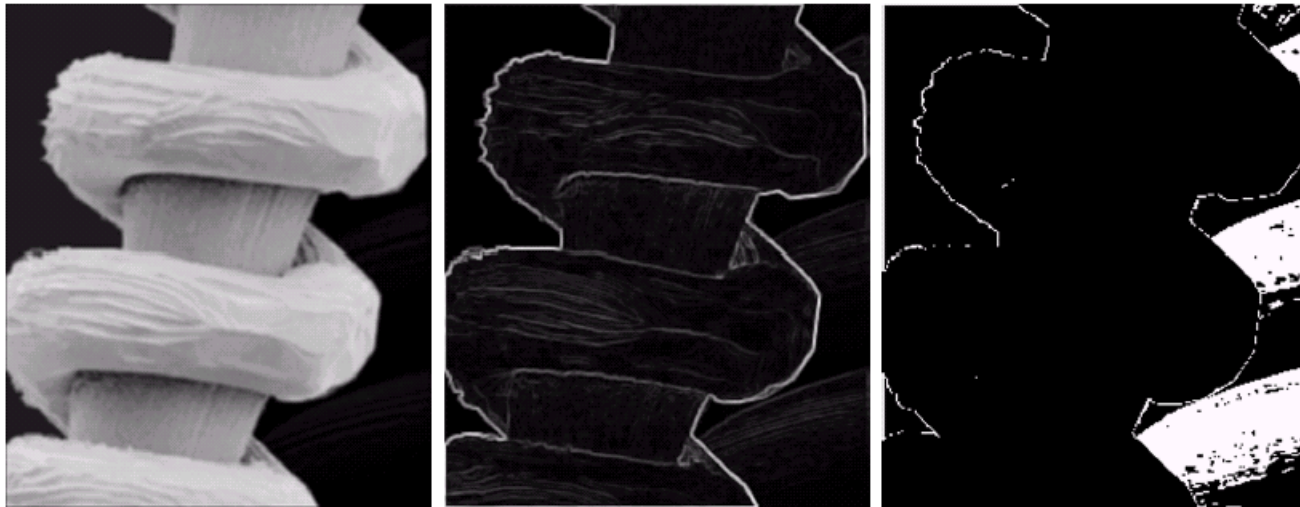
Imagen original



FIGURE 3.24 SEM image of a tungsten filament and support, magnified approximately 130 $\times$. (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene).



Media, desviación estándar



a b c

FIGURE 3.25 (a) Image formed from all local means obtained from Fig. 3.24 using Eq. (3.3-21). (b) Image formed from all local standard deviations obtained from Fig. 3.24 using Eq. (3.3-22). (c) Image formed from all multiplication constants used to produce the enhanced image shown in Fig. 3.26.

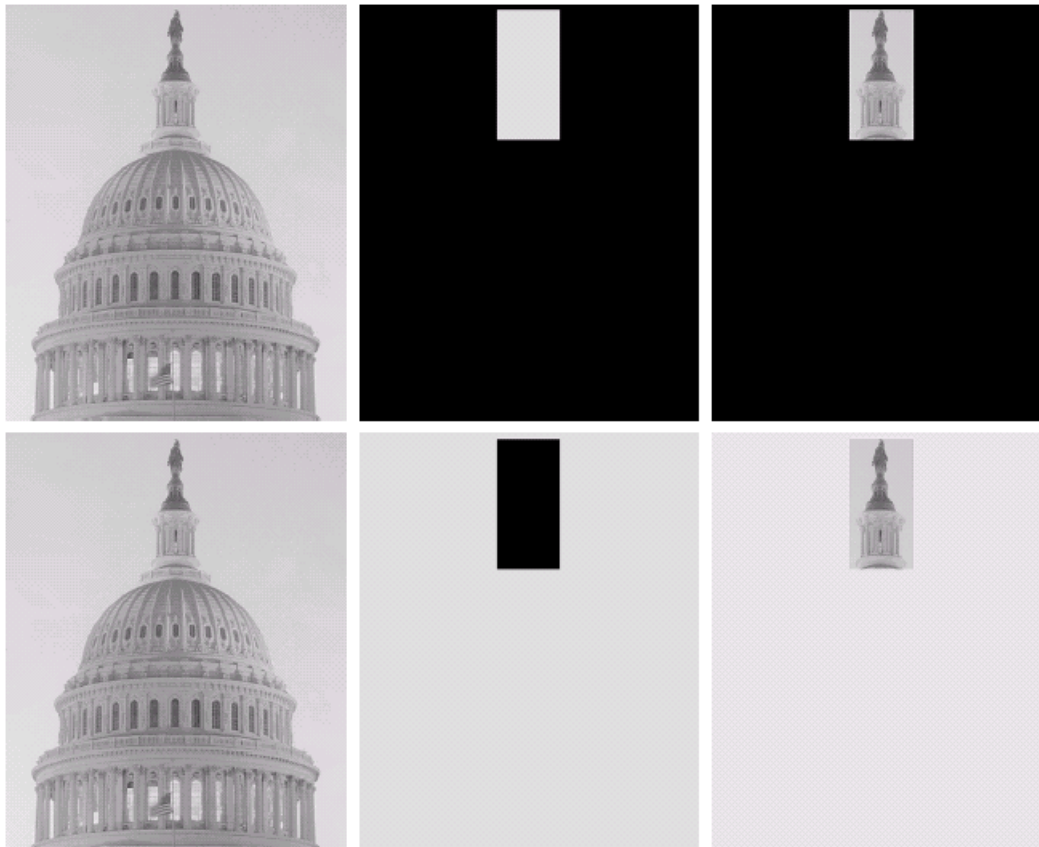


Imagen mejorada



FIGURE 3.26
Enhanced SEM
image. Compare
with Fig. 3.24. Note
in particular the
enhanced area on
the right side of
the image.

Máscaras AND y OR

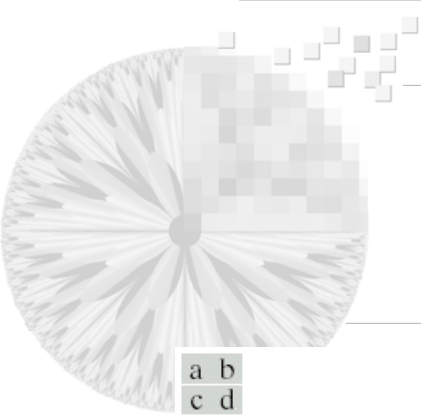


a	b	c
d	e	f

FIGURE 3.27

(a) Original image. (b) AND image mask. (c) Result of the AND operation on images (a) and (b). (d) Original image. (e) OR image mask. (f) Result of operation OR on images (d) and (e).

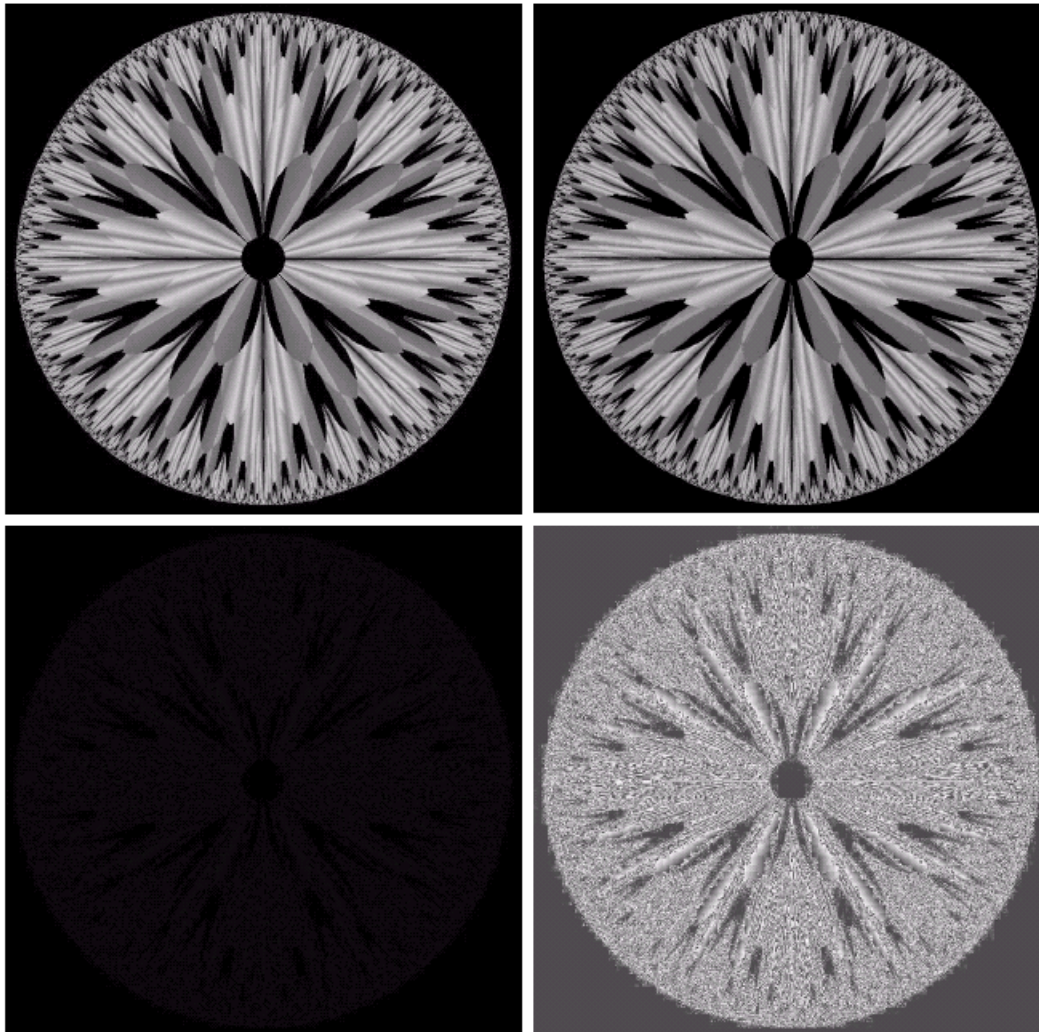
Operaciones aritméticas



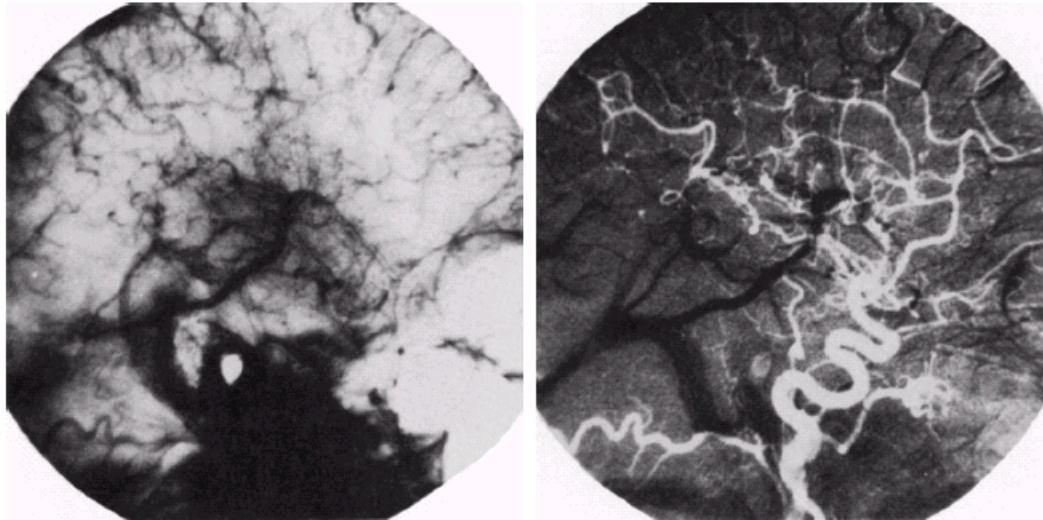
a b
c d

FIGURE 3.28

(a) Original fractal image.
(b) Result of setting the four lower-order bit planes to zero.
(c) Difference between (a) and (b).
(d) Histogram-equalized difference image. (Original image courtesy of Ms. Melissa D. Binde, Swarthmore College, Swarthmore, PA).



Operaciones aritméticas

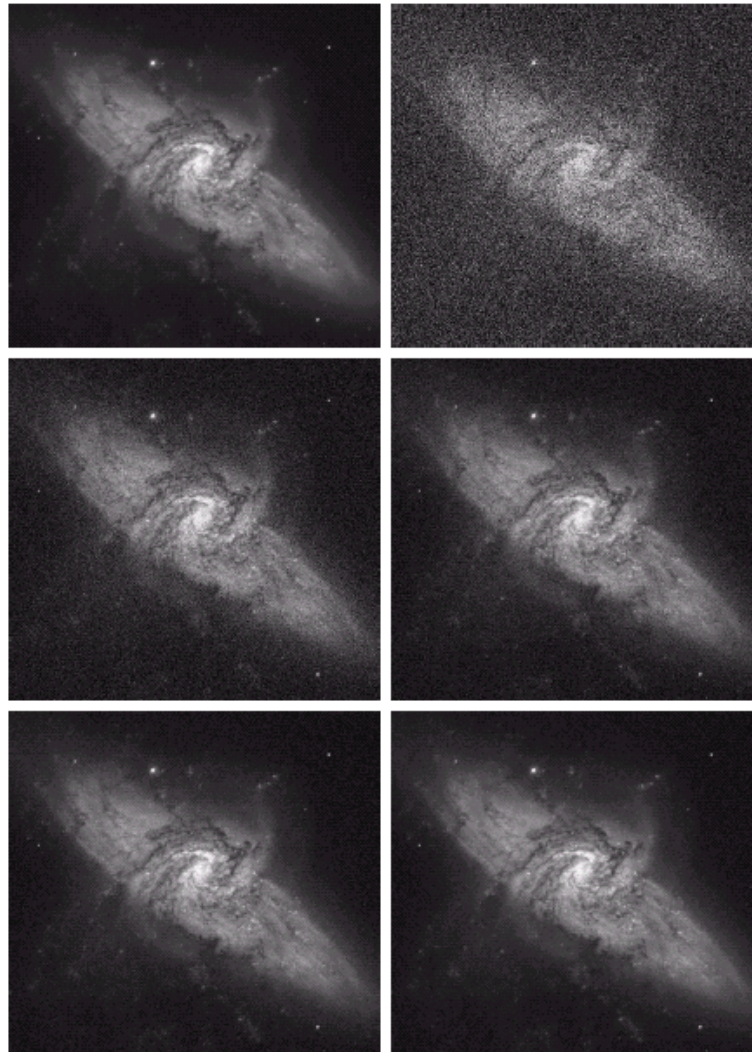
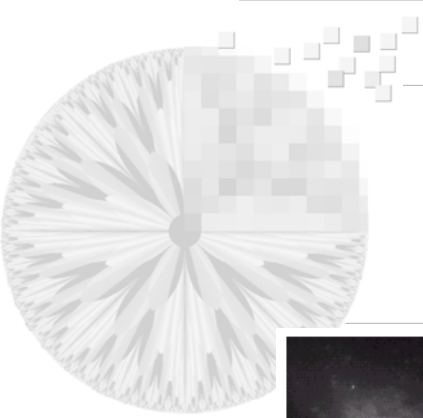


a b

FIGURE 3.29

Enhancement by image subtraction. (a) Mask image. (b) An image (taken after injection of a contrast medium into the bloodstream) with mask subtracted out.

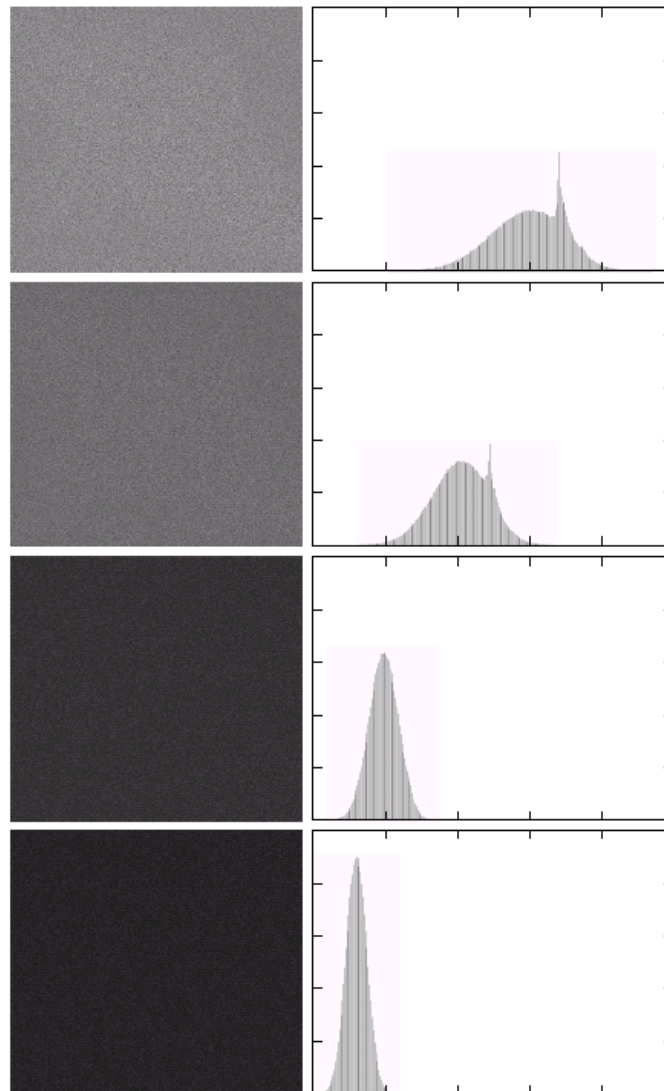
Filtros



a b
c d
e f

FIGURE 3.30 (a) Image of Galaxy Pair NGC 3314. (b) Image corrupted by additive Gaussian noise with zero mean and a standard deviation of 64 gray levels. (c)–(f) Results of averaging $K = 8, 16, 64$, and 128 noisy images. (Original image courtesy of NASA.)

Histogramas e imágenes Diferencia de ruido



a b

FIGURE 3.31

(a) From top to bottom: Difference images between Fig. 3.30(a) and the four images in Figs. 3.30(c) through (f), respectively. (b) Corresponding histograms.

Filtros espaciales

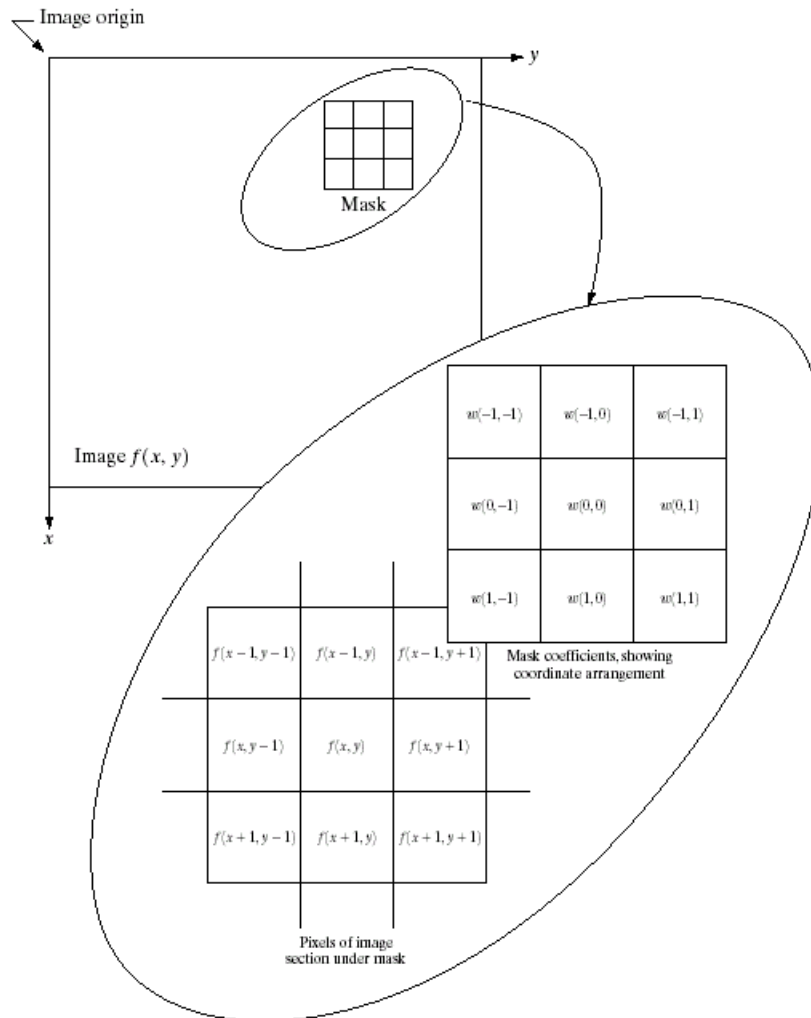


FIGURE 3.32 The mechanics of spatial filtering. The magnified drawing shows a 3×3 mask and the image section directly under it; the image section is shown displaced out from under the mask for ease of readability.



Máscara 3 x 3

FIGURE 3.33

Another representation of a general 3×3 spatial filter mask.

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

Máscaras suavizantes



$\frac{1}{9} \times$	1	1	1
	1	1	1
	1	1	1

$\frac{1}{16} \times$	1	2	1
	2	4	2
	1	2	1

a b

FIGURE 3.34 Two 3×3 smoothing (averaging) filter masks. The constant multiplier in front of each mask is equal to the sum of the values of its coefficients, as is required to compute an average.

Máscaras suavizantes

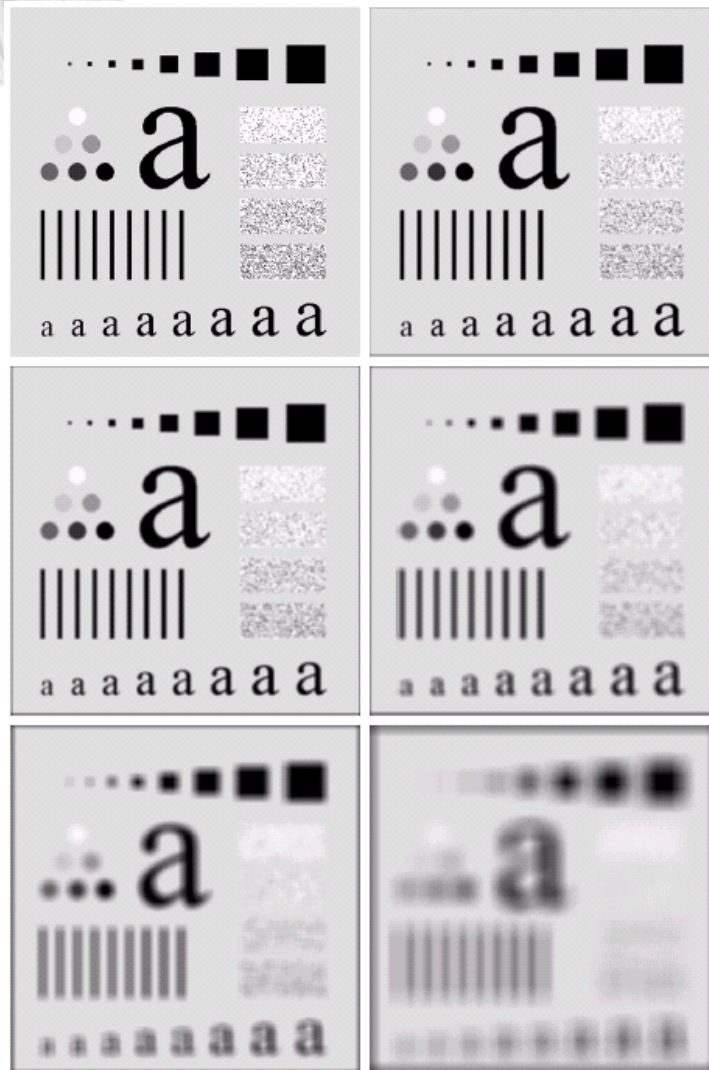
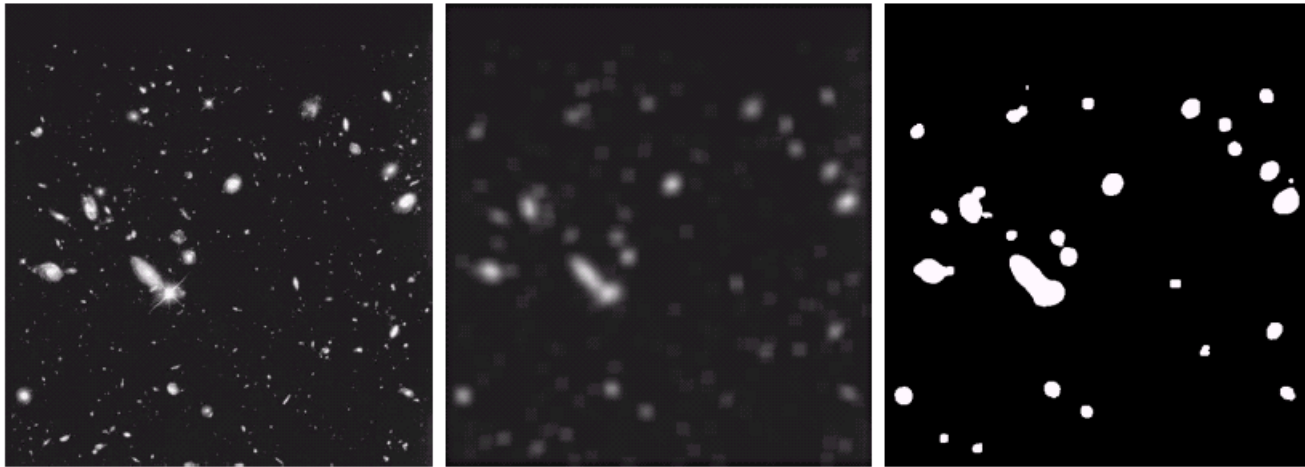


FIGURE 3.35 (a) Original image, of size 500×500 pixels. (b)–(f) Results of smoothing with square averaging filter masks of sizes $n = 3, 5, 9, 15,$ and 35 , respectively. The black squares at the top are of sizes 3, 5, 9, 15, 25, 35, 45, and 55 pixels, respectively; their borders are 25 pixels apart. The letters at the bottom range in size from 10 to 24 points, in increments of 2 points; the large letter at the top is 60 points. The vertical bars are 5 pixels wide and 100 pixels high; their separation is 20 pixels. The diameter of the circles is 25 pixels, and their borders are 15 pixels apart; their gray levels range from 0% to 100% black in increments of 20%. The background of the image is 10% black. The noisy rectangles are of size 50×120 pixels.



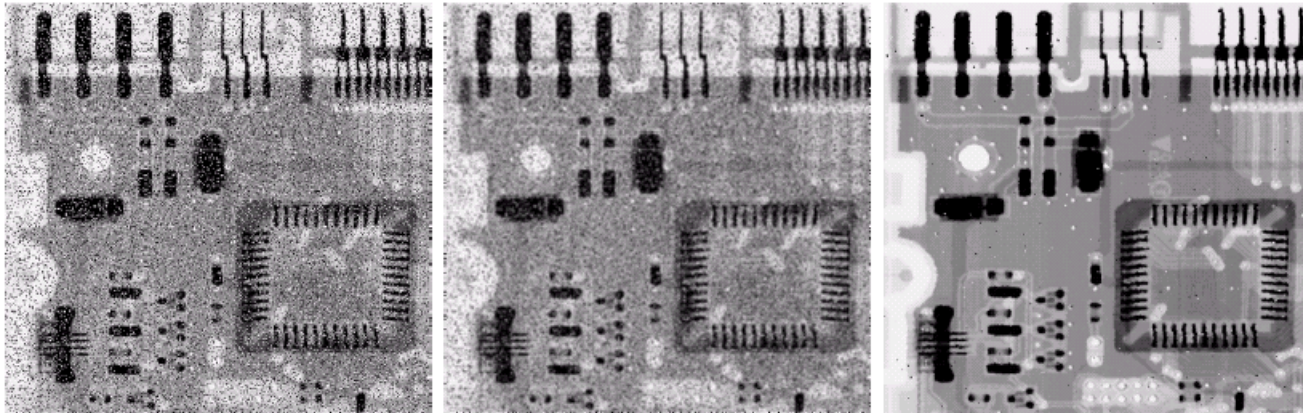
Máscara de promediado



a b c

FIGURE 3.36 (a) Image from the Hubble Space Telescope. (b) Image processed by a 15×15 averaging mask. (c) Result of thresholding (b). (Original image courtesy of NASA.)

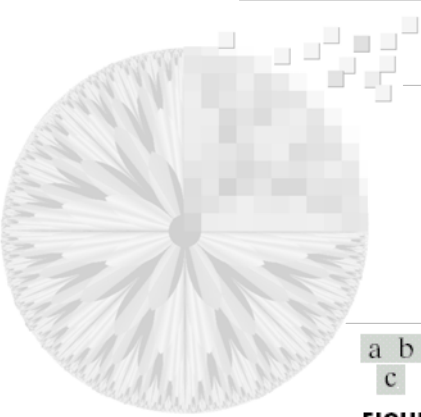
Máscara de promediado y De mediana



a b c

FIGURE 3.37 (a) X-ray image of circuit board corrupted by salt-and-pepper noise. (b) Noise reduction with a 3×3 averaging mask. (c) Noise reduction with a 3×3 median filter. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)

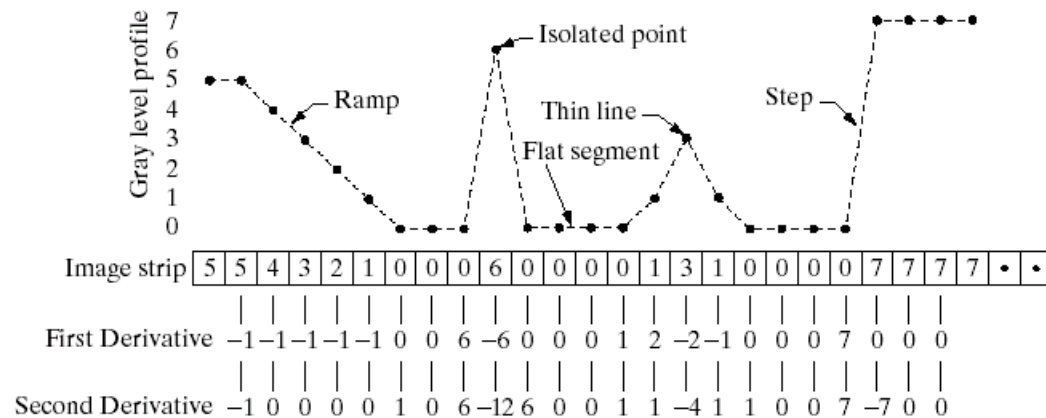
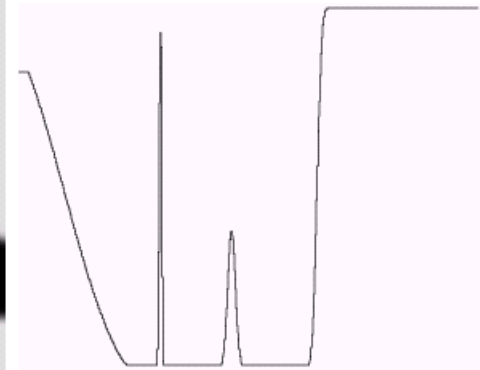
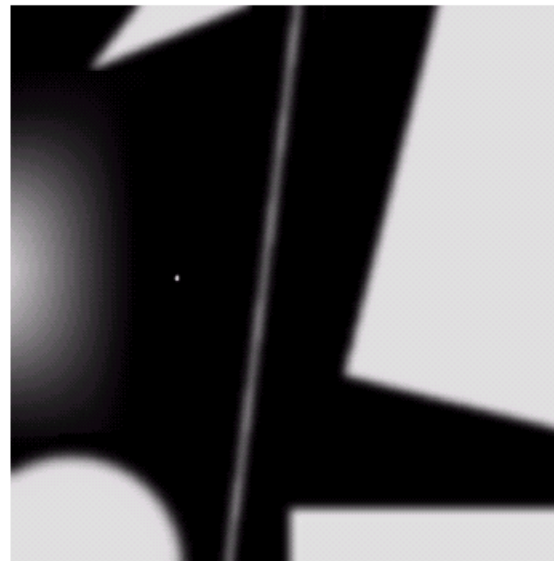
Imagen original y su perfil a lo largo del centro



a b
c

FIGURE 3.38

(a) A simple image. (b) 1-D horizontal gray-level profile along the center of the image and including the isolated noise point. (c) Simplified profile (the points are joined by dashed lines to simplify interpretation).



Laplaciano digital



0	1	0	1	1	1
1	-4	1	1	-8	1
0	1	0	1	1	1

0	-1	0	-1	-1	-1
-1	4	-1	-1	8	-1
0	-1	0	-1	-1	-1

a	b
c	d

FIGURE 3.39

(a) Filter mask used to implement the digital Laplacian, as defined in Eq. (3.7-4). (b) Mask used to implement an extension of this equation that includes the diagonal neighbors. (c) and (d) Two other implementations of the Laplacian.



Filtro laplaciano

a b
c d

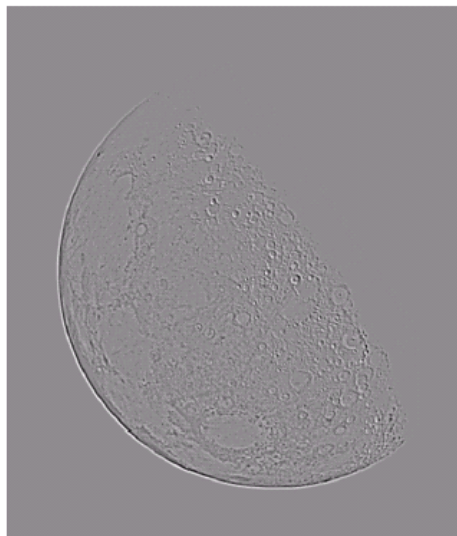
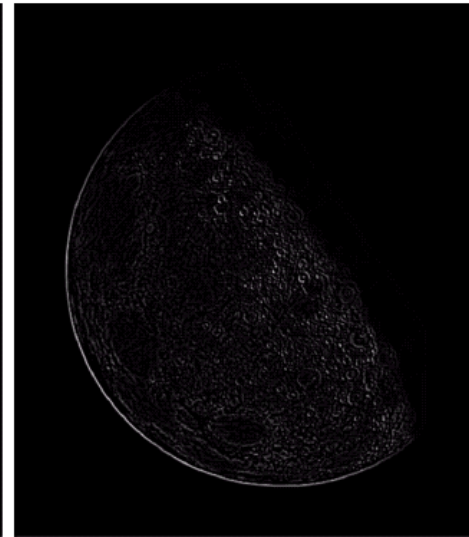
FIGURE 3.40

(a) Image of the North Pole of the moon.

(b) Laplacian-filtered image.

(c) Laplacian image scaled for display purposes.

(d) Image enhanced by using Eq. (3.7-5). (Original image courtesy of NASA.)

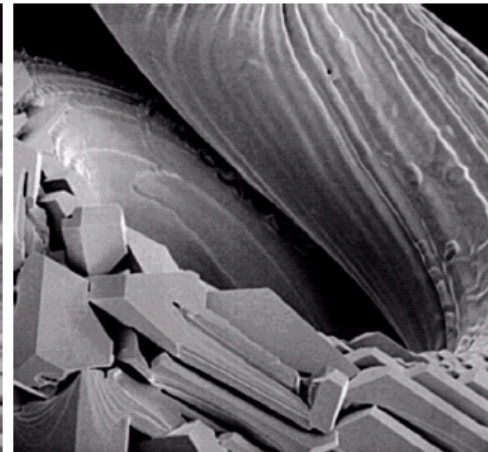
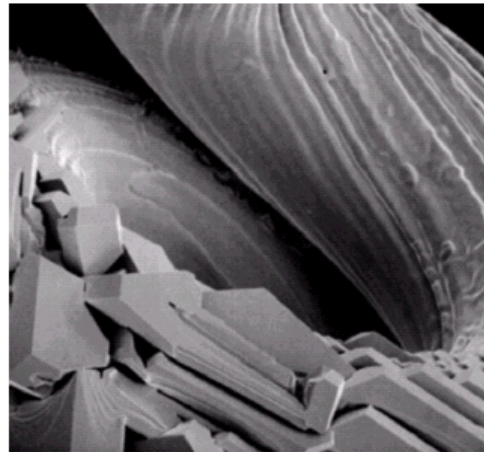
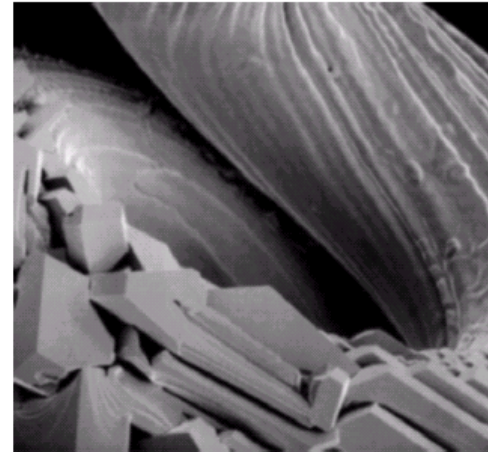


Variaciones de filtros laplacianos



0	-1	0
-1	5	-1
0	-1	0

-1	-1	-1
-1	9	-1
-1	-1	-1



a b c
d e

FIGURE 3.41 (a) Composite Laplacian mask. (b) A second composite mask. (c) Scanning electron microscope image. (d) and (e) Results of filtering with the masks in (a) and (b), respectively. Note how much sharper (e) is than (d). (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)



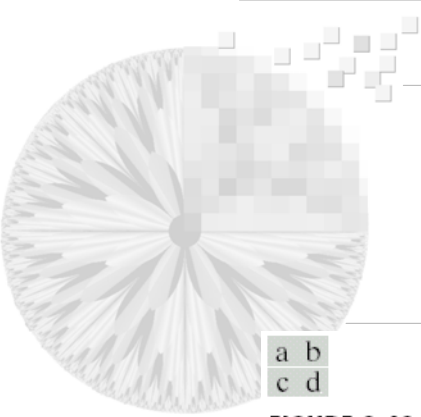
Filtro High-boost

0	-1	0	-1	-1	-1
-1	$A + 4$	-1	-1	$A + 8$	-1
0	-1	0	-1	-1	-1

a b

FIGURE 3.42 The high-boost filtering technique can be implemented with either one of these masks, with $A \geq 1$.

Comparación entre el Laplaciano y el high-boost



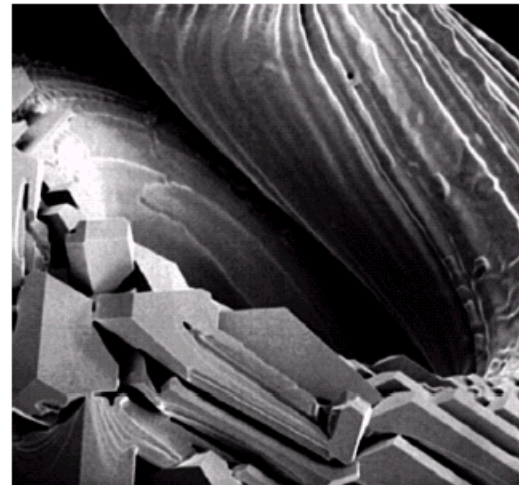
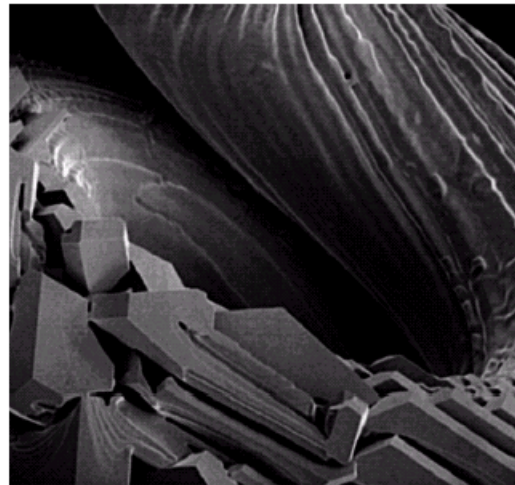
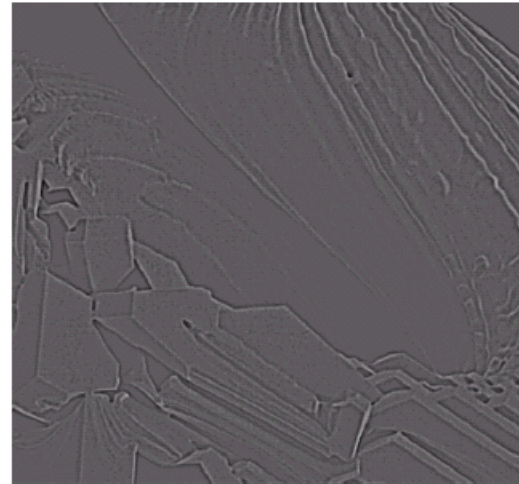
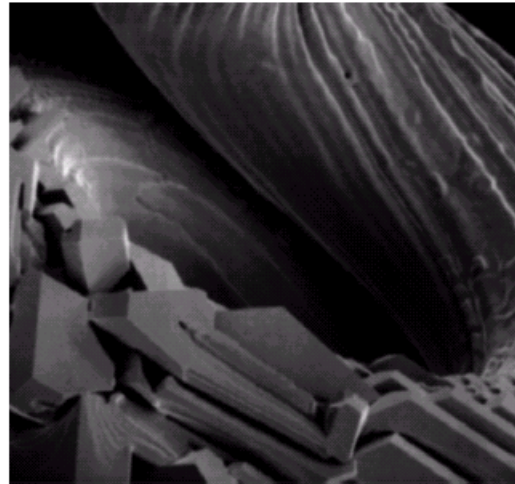
a	b
c	d

FIGURE 3.43

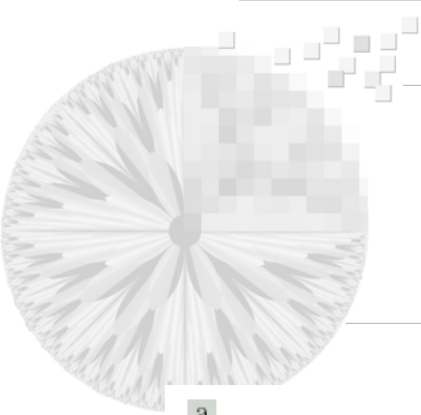
(a) Same as Fig. 3.41(c), but darker.

(a) Laplacian of (a) computed with the mask in Fig. 3.42(b) using $A = 0$.

(c) Laplacian enhanced image using the mask in Fig. 3.42(b) with $A = 1$. (d) Same as (c), but using $A = 1.7$.



Filtros de gradiente



a
b c
d e

FIGURE 3.44

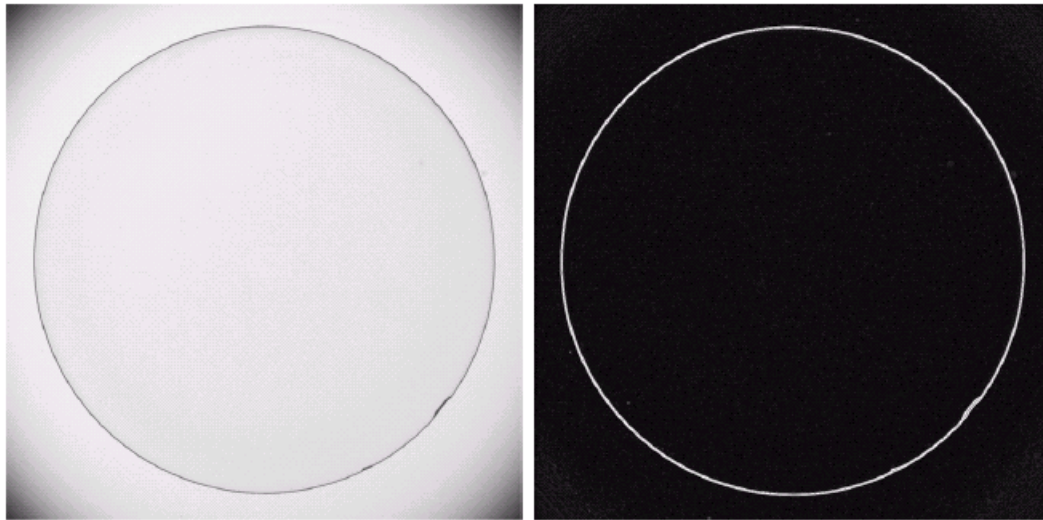
A 3×3 region of an image (the z 's are gray-level values) and masks used to compute the gradient at point labeled z_5 . All masks coefficients sum to zero, as expected of a derivative operator.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

-1	0	0	-1
0	1	1	0

-1	-2	-1	-1	0	1
0	0	0	-2	0	2
1	2	1	-1	0	1

Imagen original y su gradiente de sobel



a b

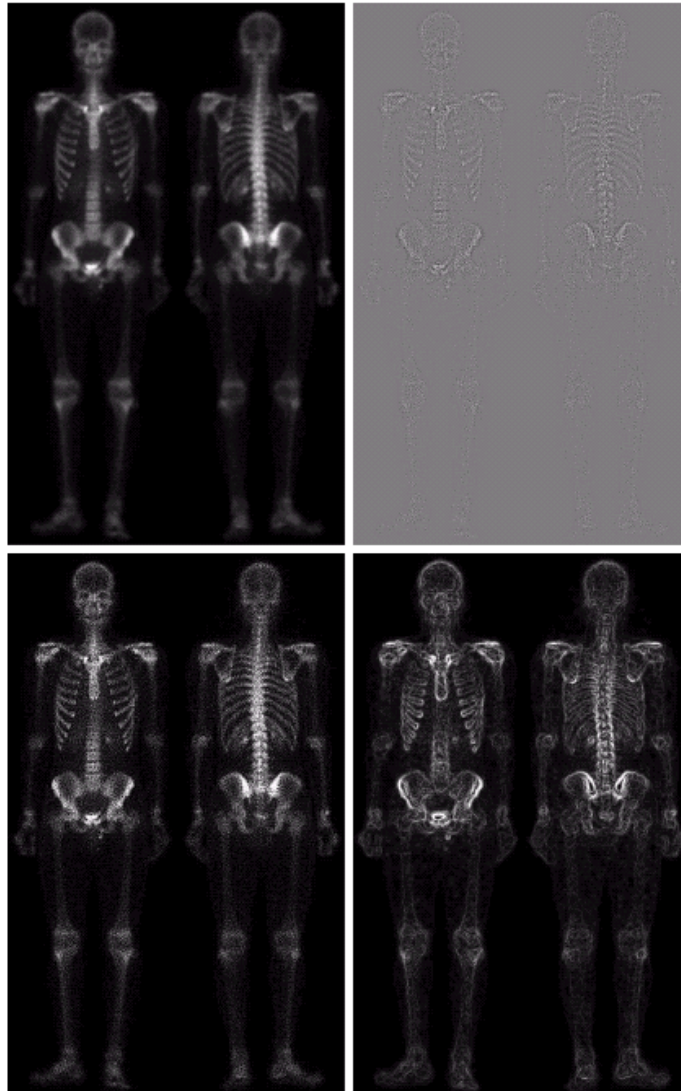
FIGURE 3.45

Optical image of contact lens (note defects on the boundary at 4 and 5 o'clock).

(b) Sobel gradient.

(Original image courtesy of Mr. Pete Sites, Perceptics Corporation.)

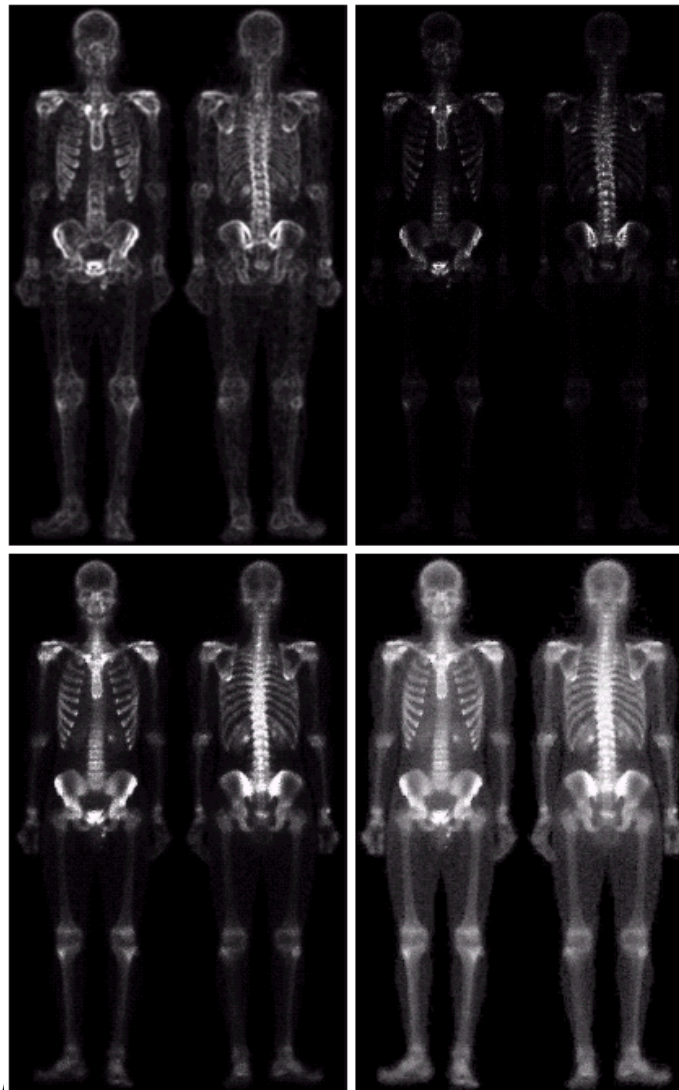
Laplaciano y Sobel



a	b
c	d

FIGURE 3.46
(a) Image of whole body bone scan.
(b) Laplacian of (a). (c) Sharpened image obtained by adding (a) and (b). (d) Sobel of (a).

Combinación de filtros



e	f
g	h

FIGURE 3.46
(Continued)

(e) Sobel image smoothed with a 5×5 averaging filter. (f) Mask image formed by the product of (c) and (e). (g) Sharpened image obtained by the sum of (a) and (f). (h) Final result obtained by applying a power-law transformation to (g). Compare (g) and (h) with (a). (Original image courtesy of G.E. Medical Systems.)