

Digital Image Processing

Image Enhancement in the Spatial Domain

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Objective

The principal objective of enhancement is to process an images so that the result is more suitable than the original image for a **SPECIFIC** application

Category of image enhancement

- Spatial domain
- Frequency domain

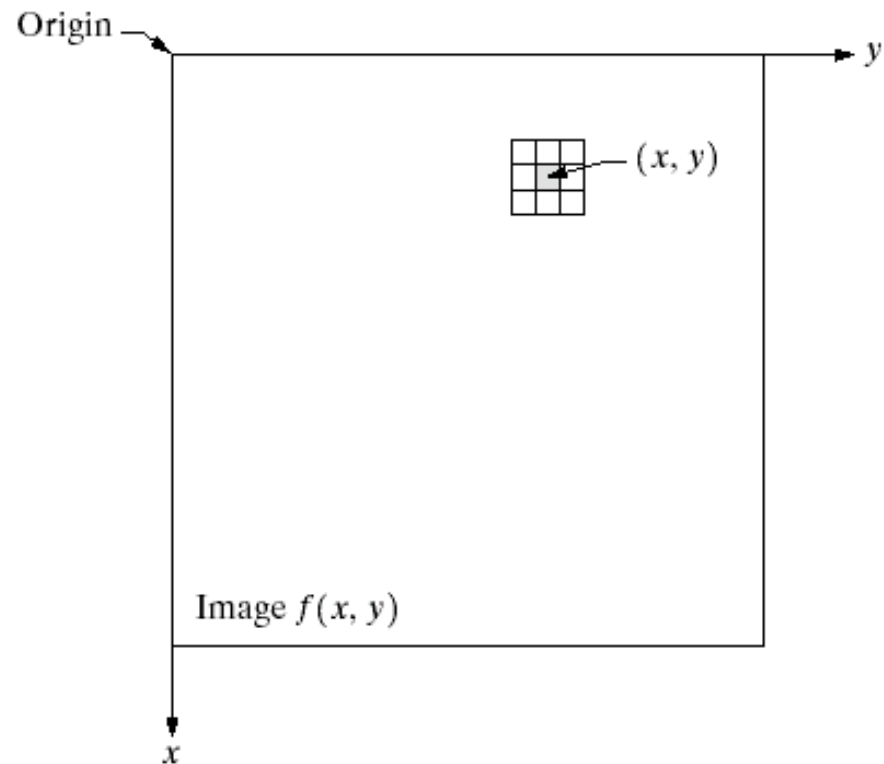
Need for Image Enhancement

- Highlighting interesting details in the images.
- Removing noise from the images.
- Making images more visually appealing.
- Enhance hidden information.
- Filter important image features.
- Discard unimportant image features.

Background

The spatial domain process can be denoted as
$$g(x,y) = T [f(x,y)]$$

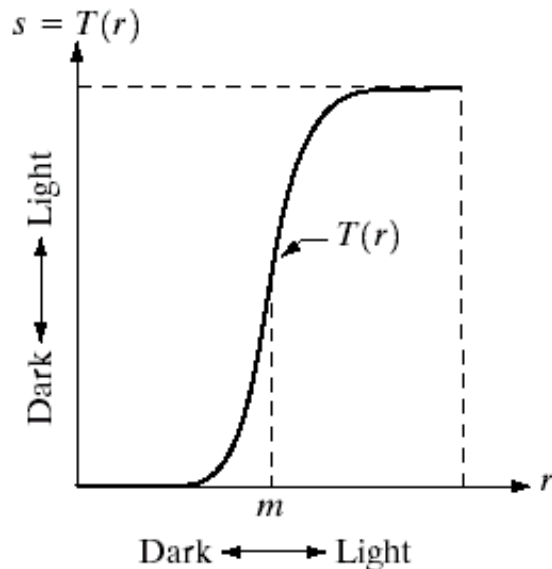
FIGURE 3.1 A
 3×3
neighborhood
about a point
 (x, y) in an image.



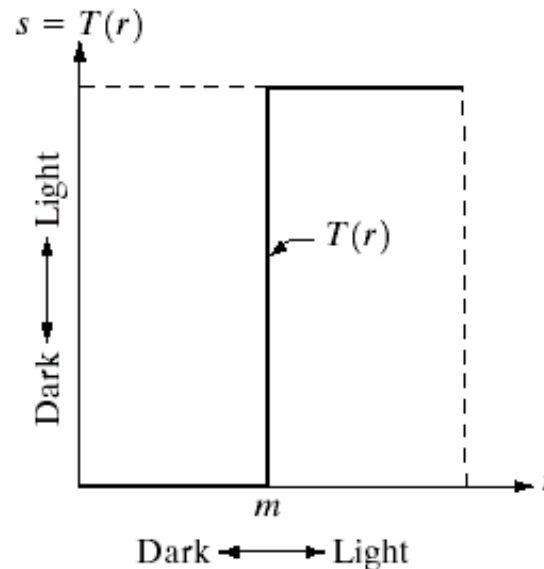
Point Processing, Gray-Level Transformation Function

$$s = T(r)$$

**Contrast
stretching**



Thresholding



a b

FIGURE 3.2 Gray-level transformation functions for contrast enhancement.

Basic Gray Level Transformation

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

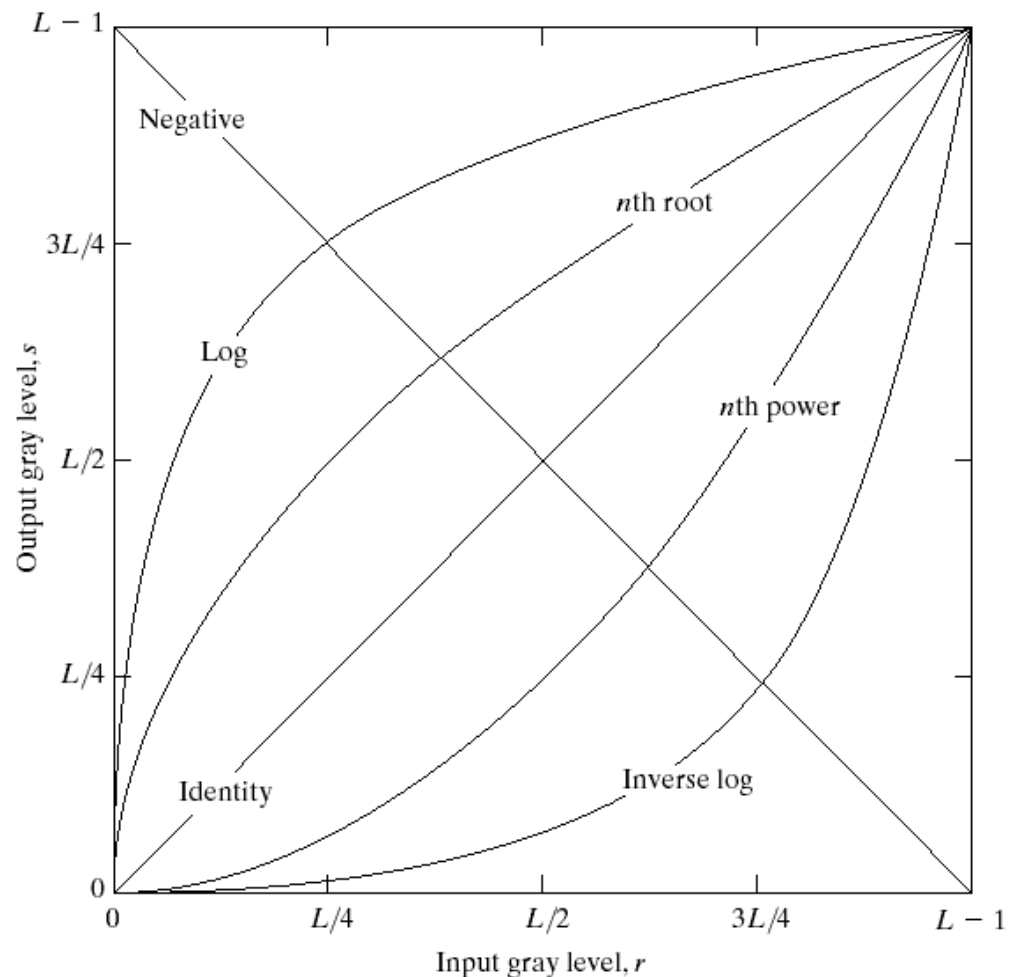
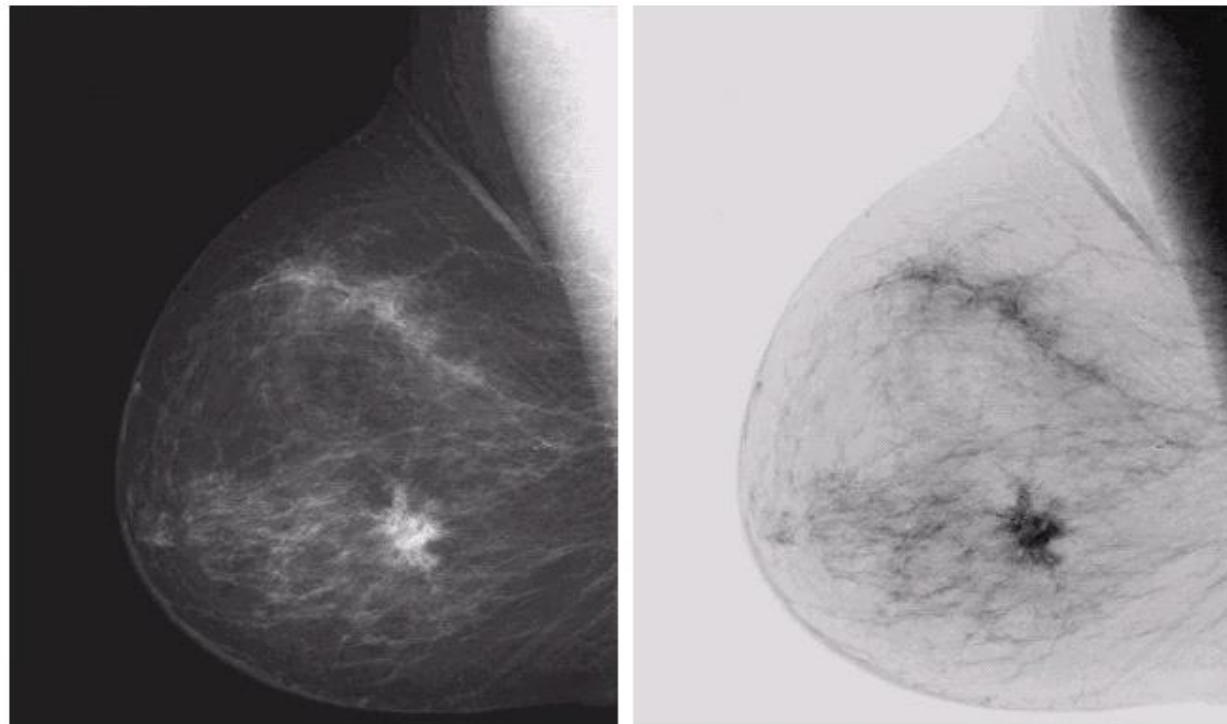


Image Negative

$$s = L - 1 - r$$

It results in getting photograph negative.

It is useful when for enhancing white details embedded in dark regions of the image.



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.)

Log Transformations

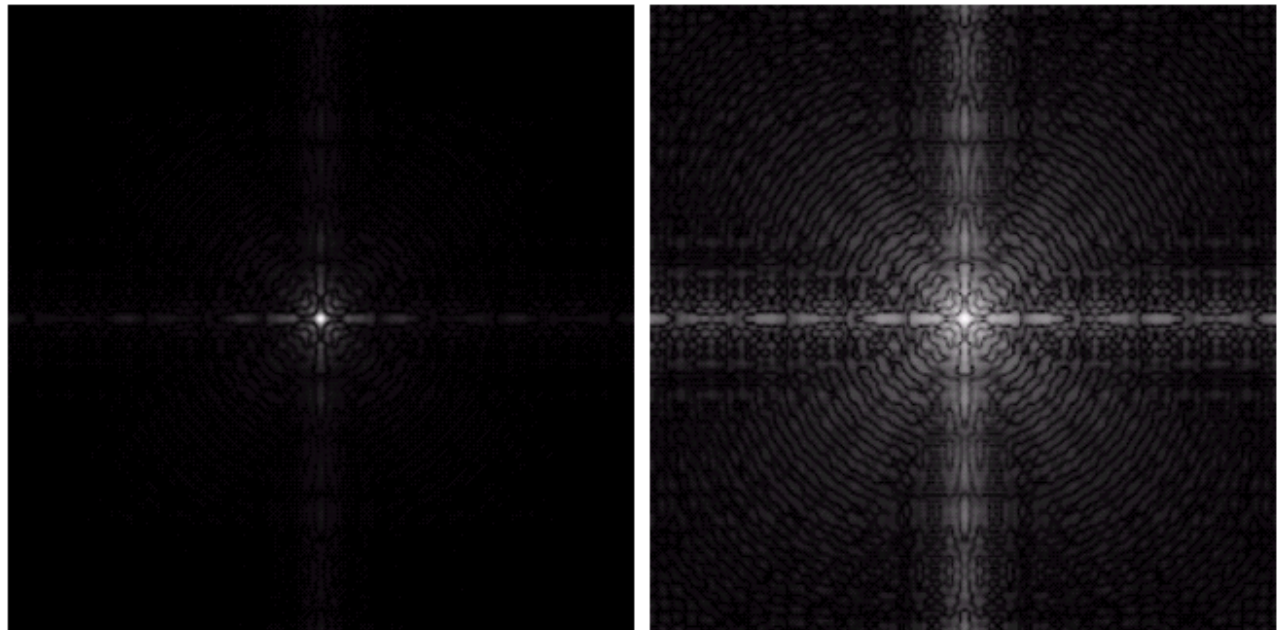
$$s = c \log(1+r)$$

a b

FIGURE 3.5

(a) Fourier spectrum.

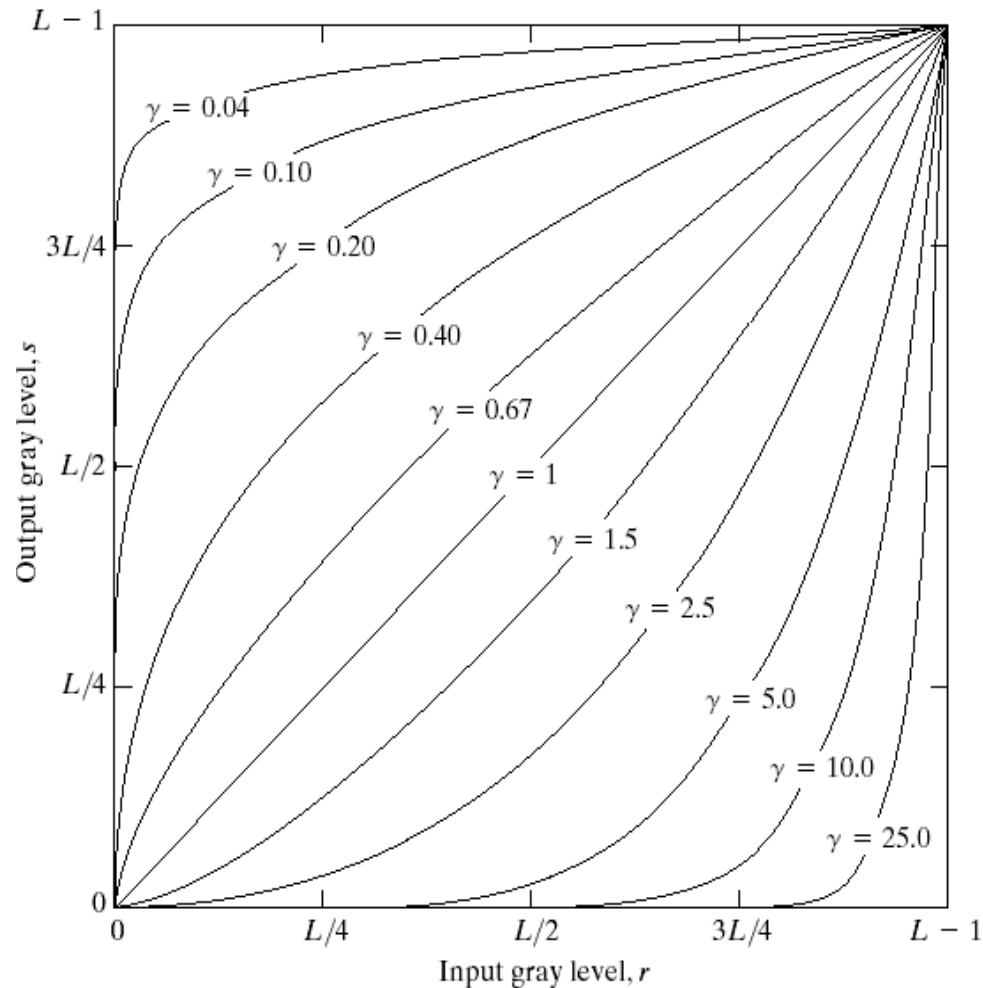
(b) Result of applying the log transformation given in Eq. (3.2-2) with $c = 1$.



Expands the details of darker regions in an image while compressing the brighter pixels.

Power-Law Transformations

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



$$s = cr^\gamma$$

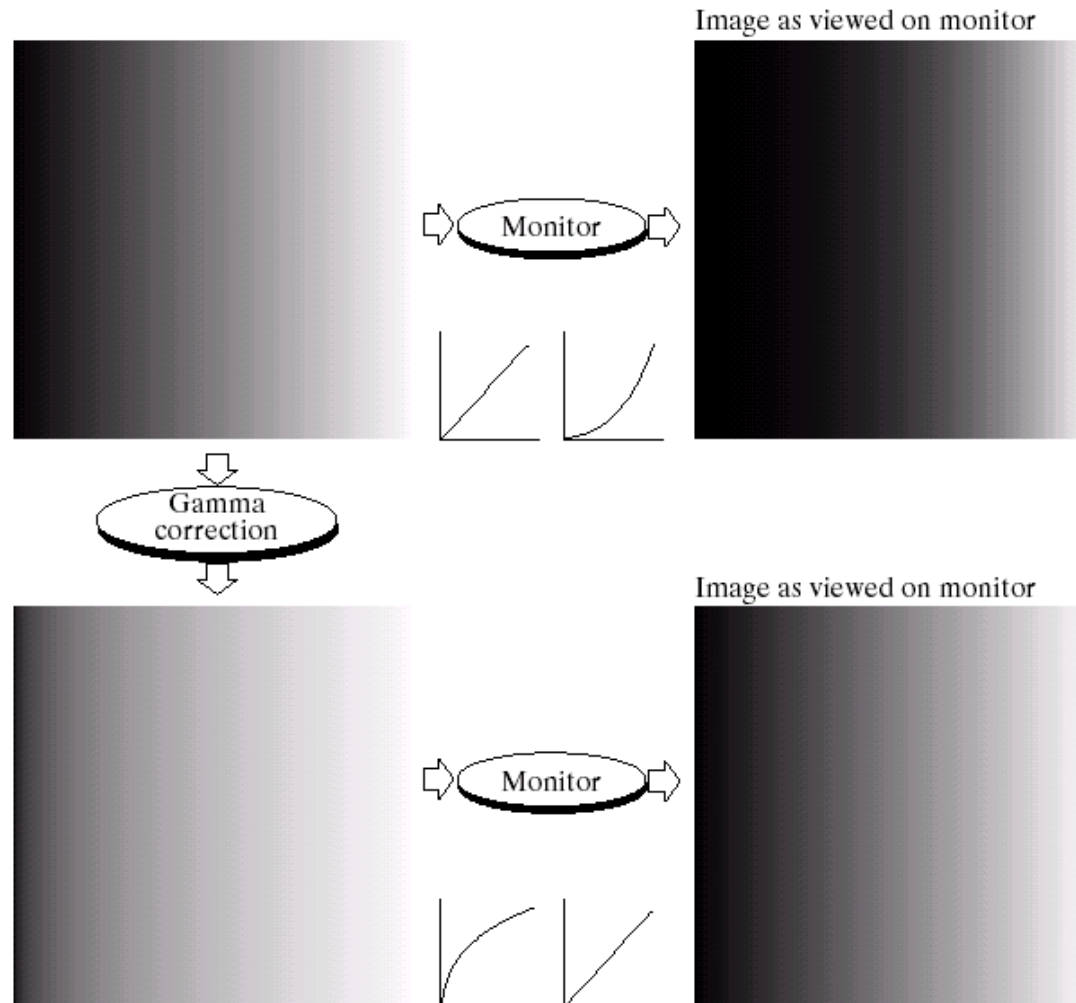
$$s = c \cdot 255 \left[\frac{r}{255} \right]^{\frac{1}{\gamma}}$$

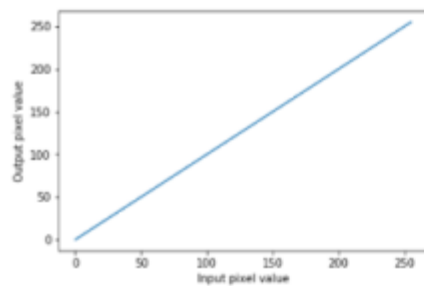
Power-Law Transformations - Gamma Correction

a	b
c	d

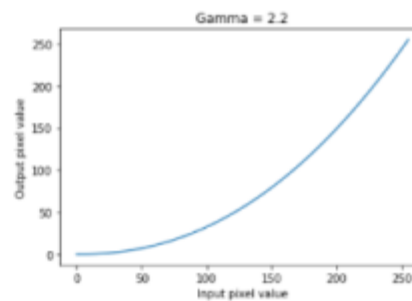
FIGURE 3.7

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

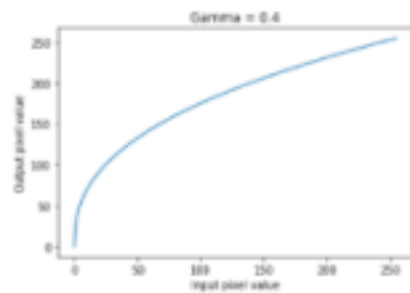




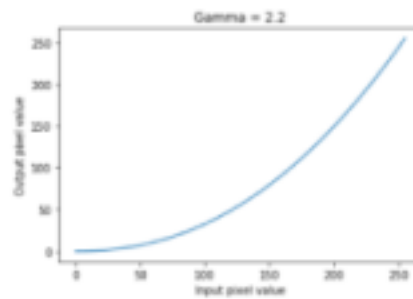
Input Signal



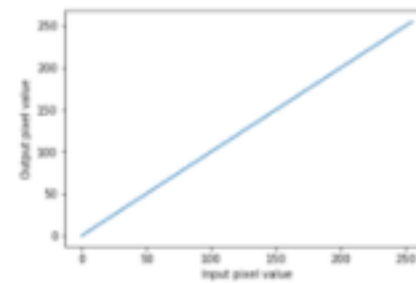
Transformed Output from Display



**gamma corrected
input signal**



Transformed Output from Display



Final Output

Power-Law Transformations

$$c=1$$
$$\gamma = 0.4$$



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.)

$$c=1$$
$$\gamma = 0.6$$



$$c=1$$
$$\gamma = 0.3$$

Power-Law Transformations

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.)



$c=1$
 $\gamma=3$



$c=1$
 $\gamma=4$



$c=1$
 $\gamma=5$

Piecewise-Linear Transformation Functions

- Advantage
 - Arbitrarily complex
- Disadvantage
 - More user input
- Type of Transformations
 - Contrast stretching
 - Gray-level slicing
 - Bit-plane slicing

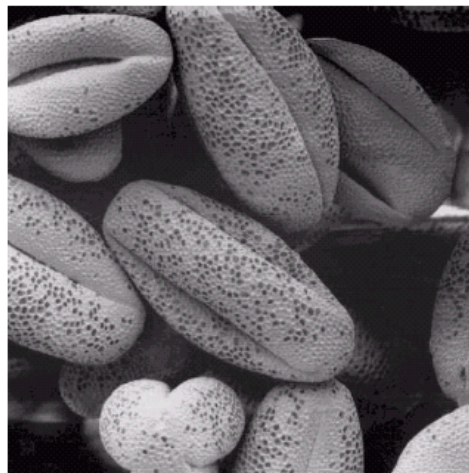
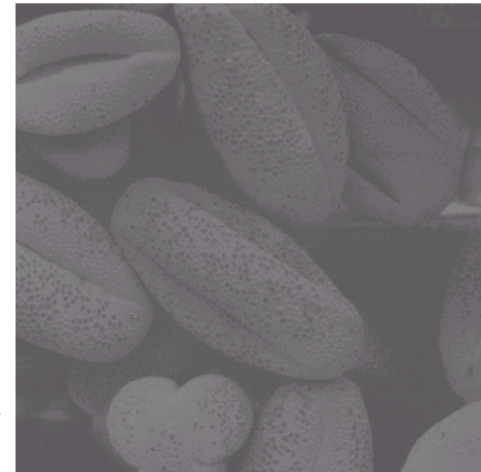
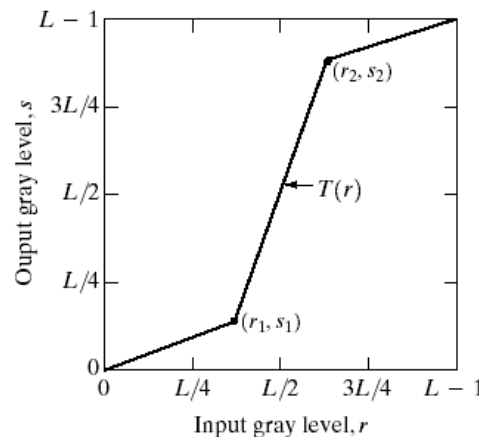
Contrast Stretching

Objective: Increase the dynamic range of the gray levels in the image

Causes for poor image

- Poor illumination
- Wrong lens aperture
- Wrong shutter speed
- Lack of dynamic range in the imaging sensor

$$s = (r - r_1) \left[\frac{s_2 - s_1}{r_2 - r_1} \right] + s_1$$



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.)

piecewise Linear transformation functions.

Exercise on Contrast stretching and thresholding

Exercise:

the following matrix represents the pixels values of a 8-bit image (r) , apply thresholding transform assuming that the threshold $m=95$, find the resulting image pixel values.

solution:

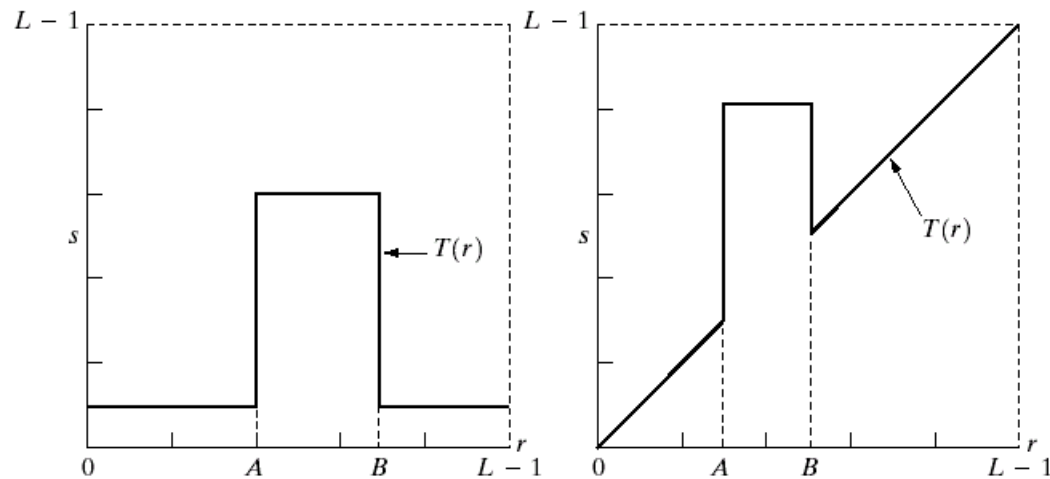
Image (s)

Image (r)

110	120	90	130
91	94	98	200
90	91	99	100
82	96	85	90

Gray-Level Slicing

Objective: Highlighting a specific range of gray levels in an image.



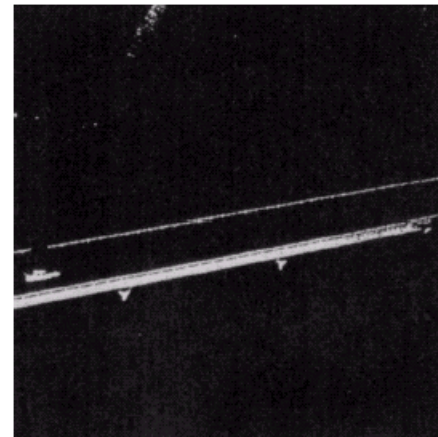
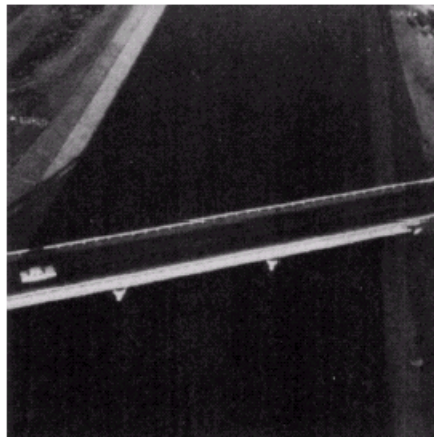
a	b
c	d

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).



Bit-Plane Slicing

255 138 30
65 12 201
180 111 85

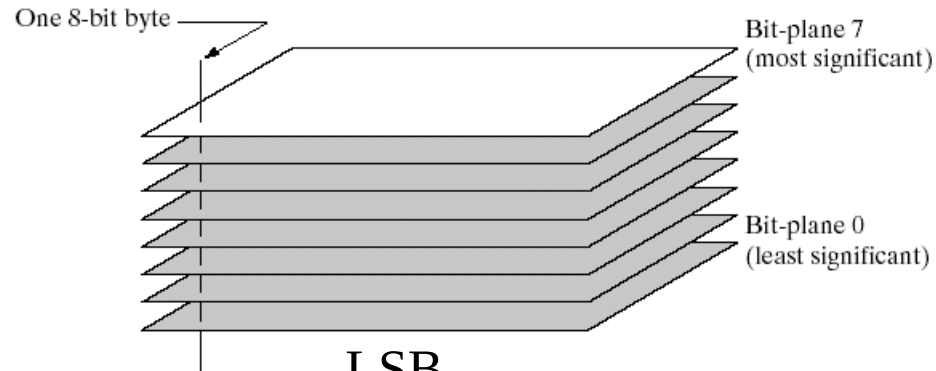
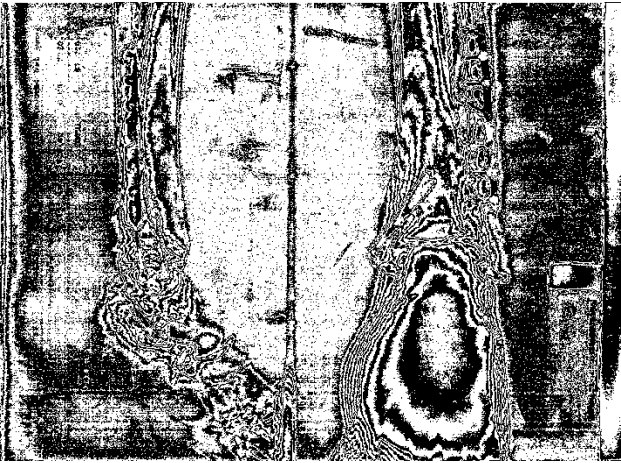
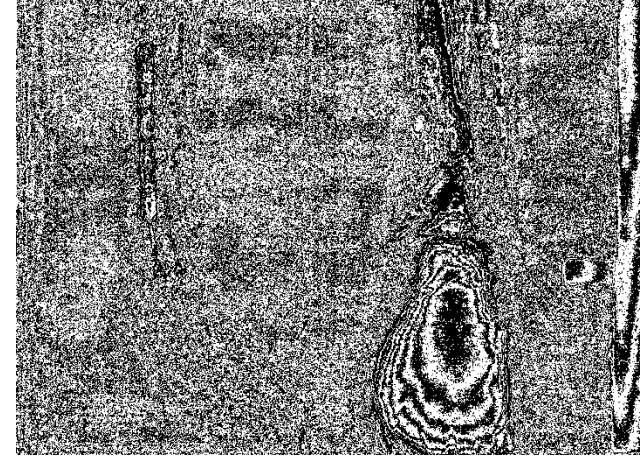
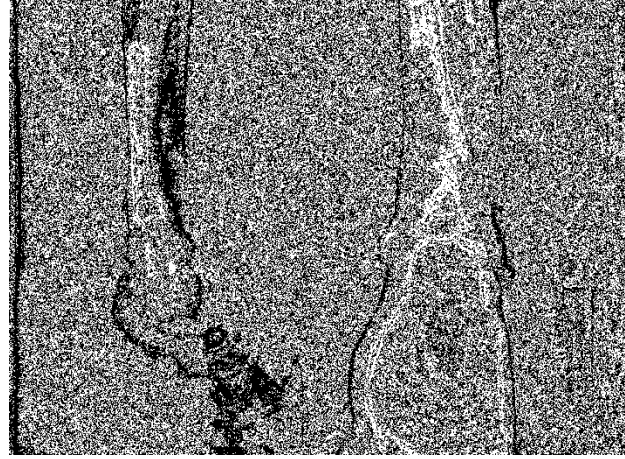


FIGURE 3.12
Bit-plane
representation of
an 8-bit image.

		LSB								MSB
MSB plane	255	1	1	1	1	1	1	1	1	1
1 1 0	138	0	1	0	1	0	0	0	0	1
0 0 1	30	1	1	1	1	1	0	0	0	0
1 0 0	65	1	0	0	0	0	0	1	0	0
	12	0	0	1	1	0	0	0	0	0
LSB plane	201	1	0	0	1	0	0	1	1	1
1 0 1	183	1	1	1	0	1	1	0	0	1
1 0 1	111	1	1	1	1	0	1	1	1	0
1 1 1	85	1	0	1	0	1	0	1	1	0



Bit-Plane Slicing

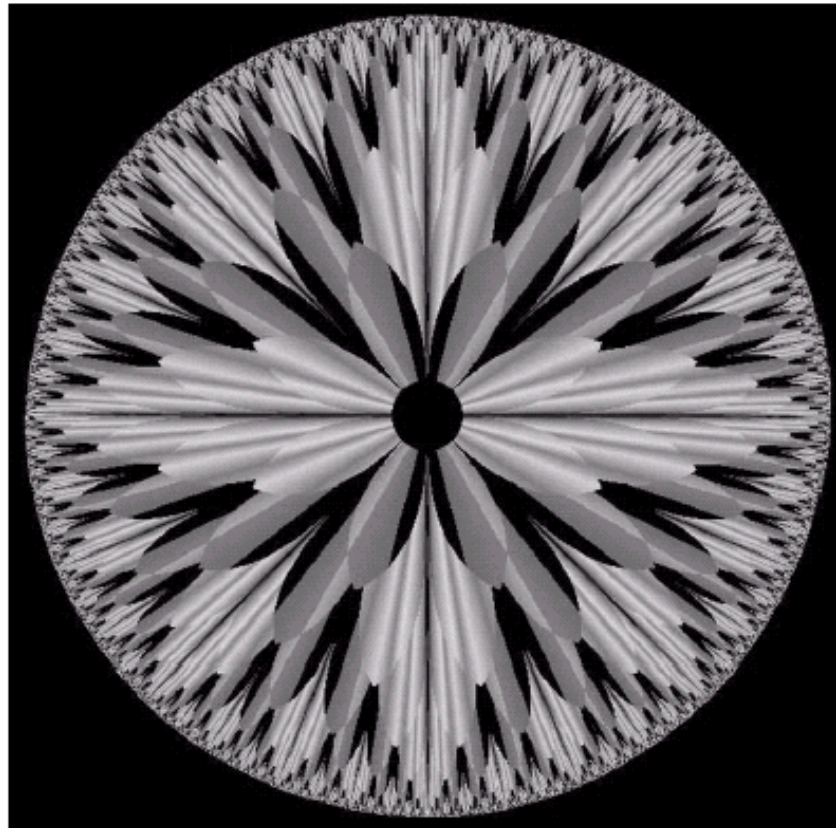


FIGURE 3.13 An 8-bit fractal image. (A fractal is an image generated from mathematical expressions). (Courtesy of Ms. Melissa D. Binde, Swarthmore College, Swarthmore, PA.)

Bit-Plane Slicing

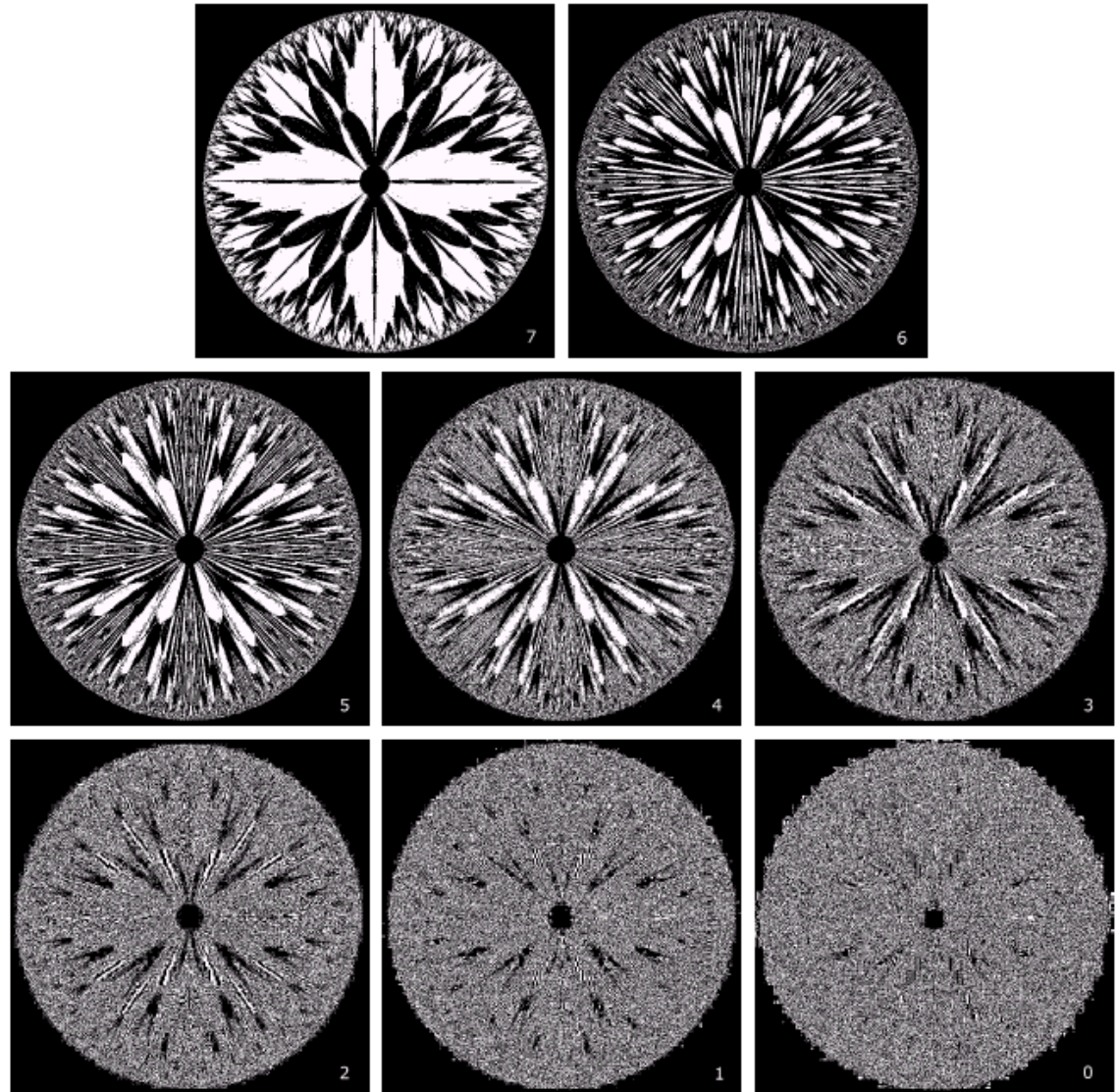


FIGURE 3.14 The eight bit planes of the image in Fig. 3.13. The number at the bottom, right of each image identifies the bit plane.