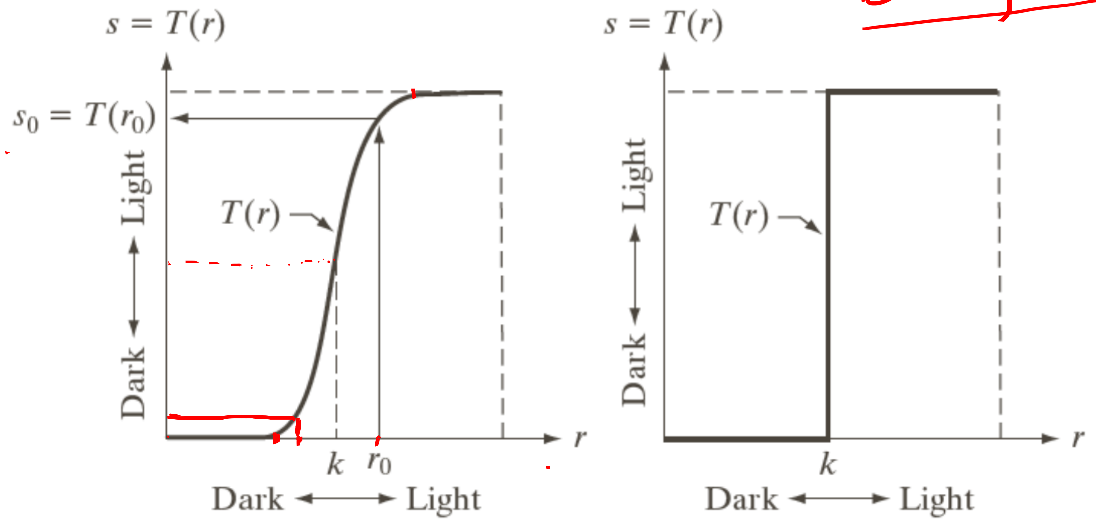
Intensity Transformations

- $g(x, y) = T[f(x, y)]$
- $s = T(r)$

output input

Binary image



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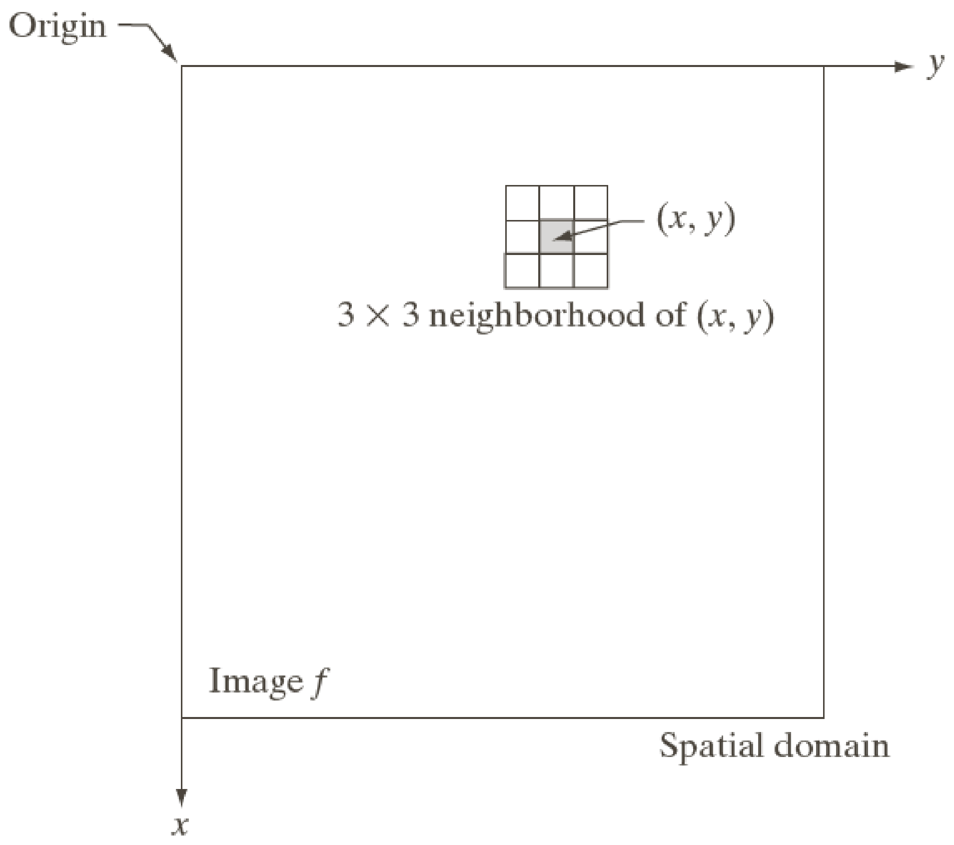


Basic Terms

- **Point Processing:** Approaches whose results depend only on the intensity at a point are called point processing.
- **Neighbourhood Processing:** Results depend not only on the target pixel but also on the neighbourhood.
- **Enhancement:** It is the process of manipulating an image so that the result is more suitable than the original for a specific application.

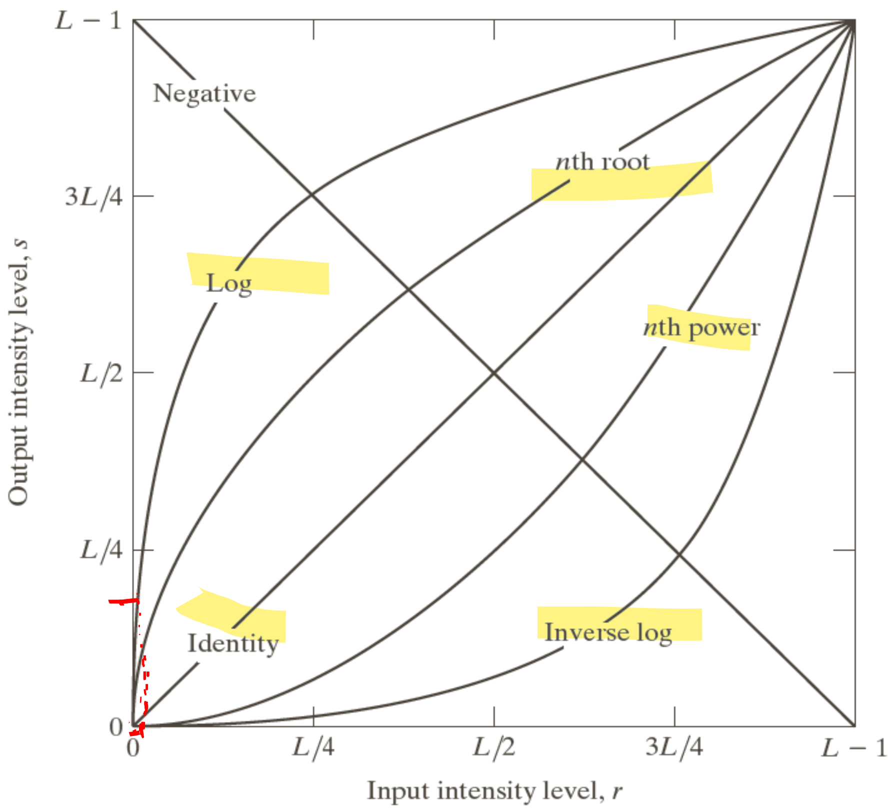
Contrast

- Contrast is the difference in luminance or color that makes an object (or its representation in an image or display) distinguishable.

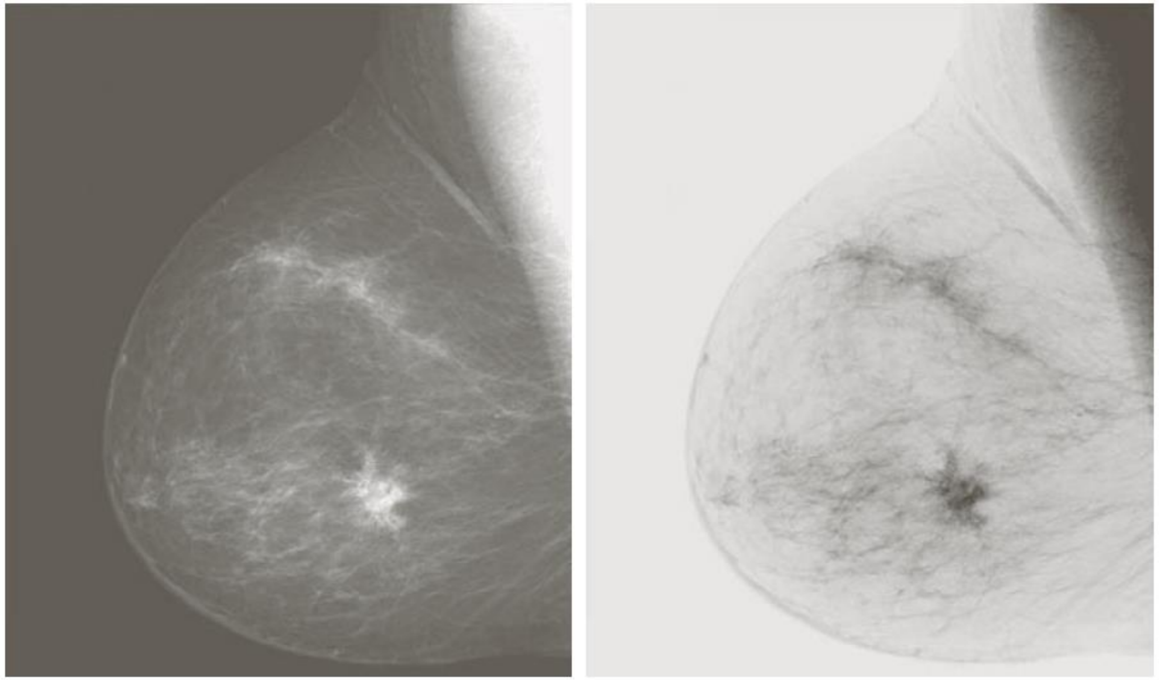
- Weber contrast: $\frac{I-I_b}{I_b}$ (where small features are present on a large uniform background)
- Michelson Contrast: $\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$ (used for patterns where both bright and dark features are equivalent and take up similar fractions of the area (e.g. sine-wave gratings))
- RMS Contrast: $\sqrt{\frac{1}{MN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left(I_{i,j}-\bar{I}\right)^2}$ (standard deviation of the pixel intensities)

Image Negative

- Enhancing white or grey detail embedded in a dark region.



$L = 2^K$

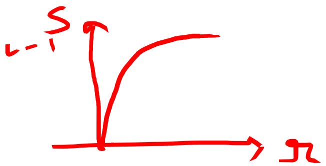


$s = L - 1 - r = 255 - r$

(8-bit)

Log Transformations

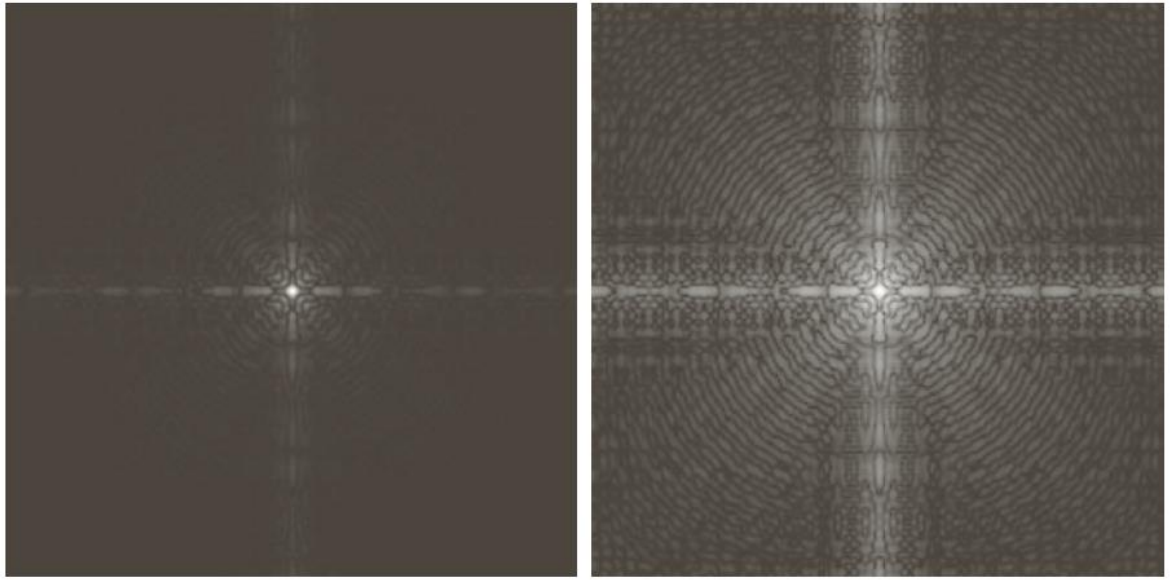
- $s = c\log(1 + r)$



- Maps a narrow range of low intensity values in the input into a wider range of output levels.
- Showing images, where pixel values have large dynamic range (e.g. Fourier spectrum).

Fourier Transformation

$0 - 10^6$



Power Law (Gamma) Transformations

$\gamma = 2.5$

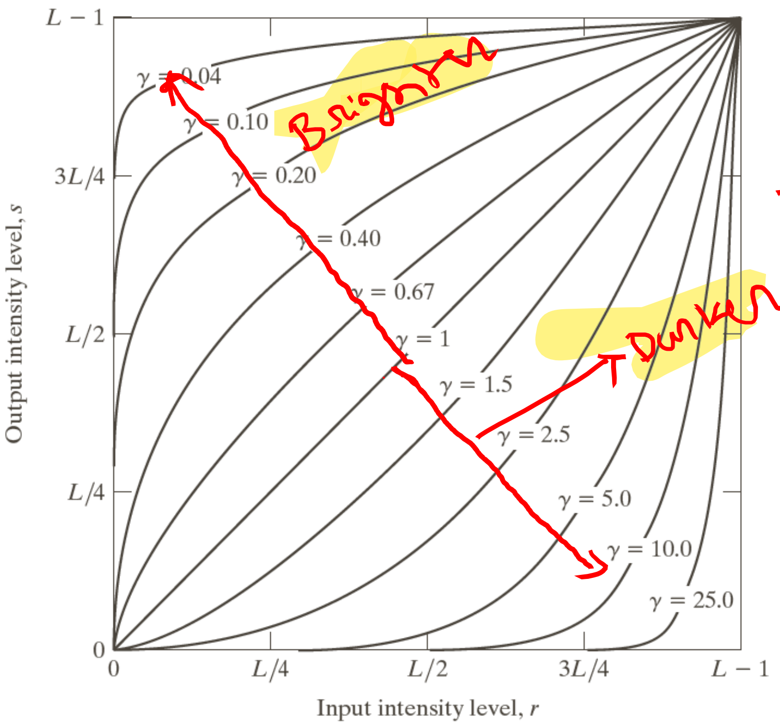
- $s = cr^{\gamma}$

$s = c(r+\varepsilon)^{\gamma}$

$c = 1, \ \gamma = 1$

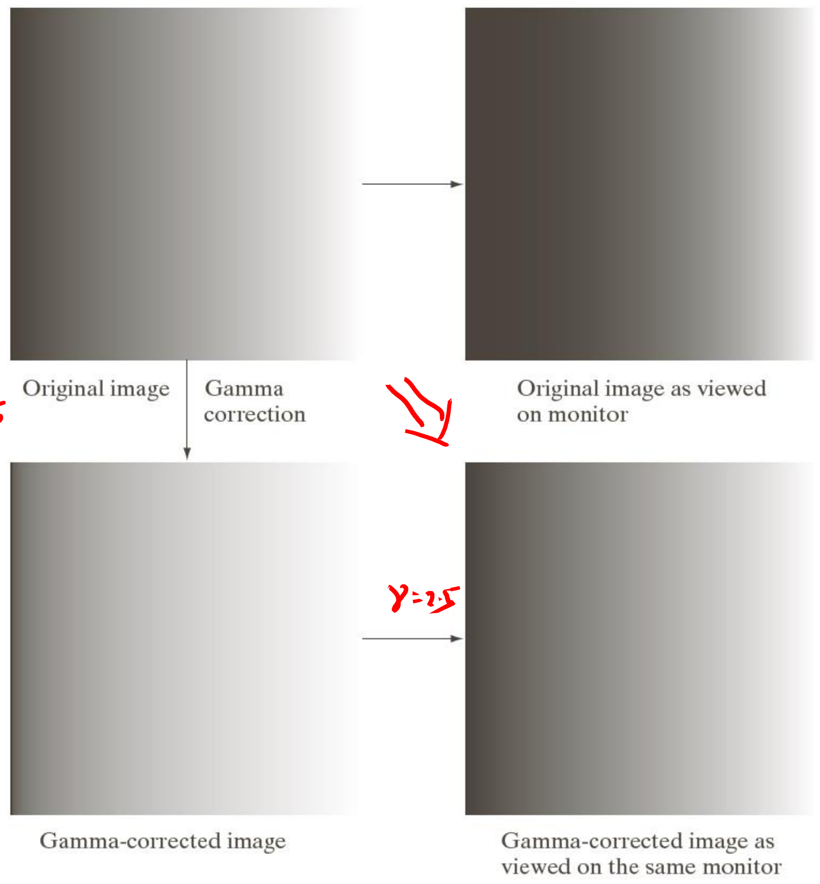
$c = 1, \ \gamma > 1$

$c = 1, \ \gamma < 1$



$\gamma = \frac{1}{2.5}$

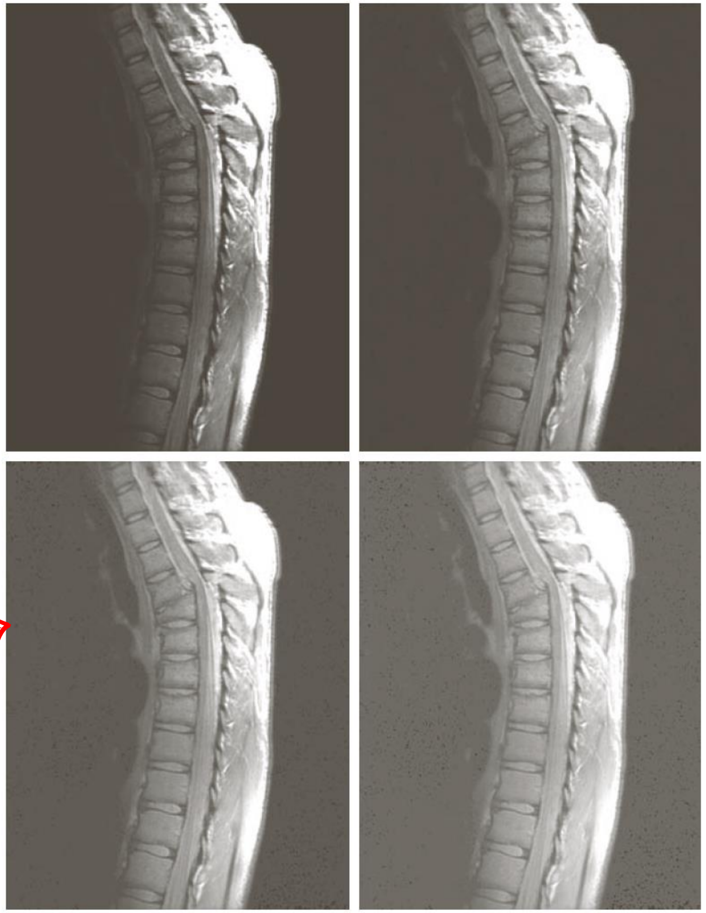
$s = r^{\frac{1}{2.5}}$



$s = \left(r^{\frac{1}{2.5}}\right)^{2.5} = r$

Results

$\gamma = 0.6$



$\gamma = 0.4 \rightarrow$

$\leftarrow \gamma = 0.3$

a b
c d

FIGURE 3.8 (a) Magnetic resonance image (MRI) 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 courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

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.)

Contrast Stretching

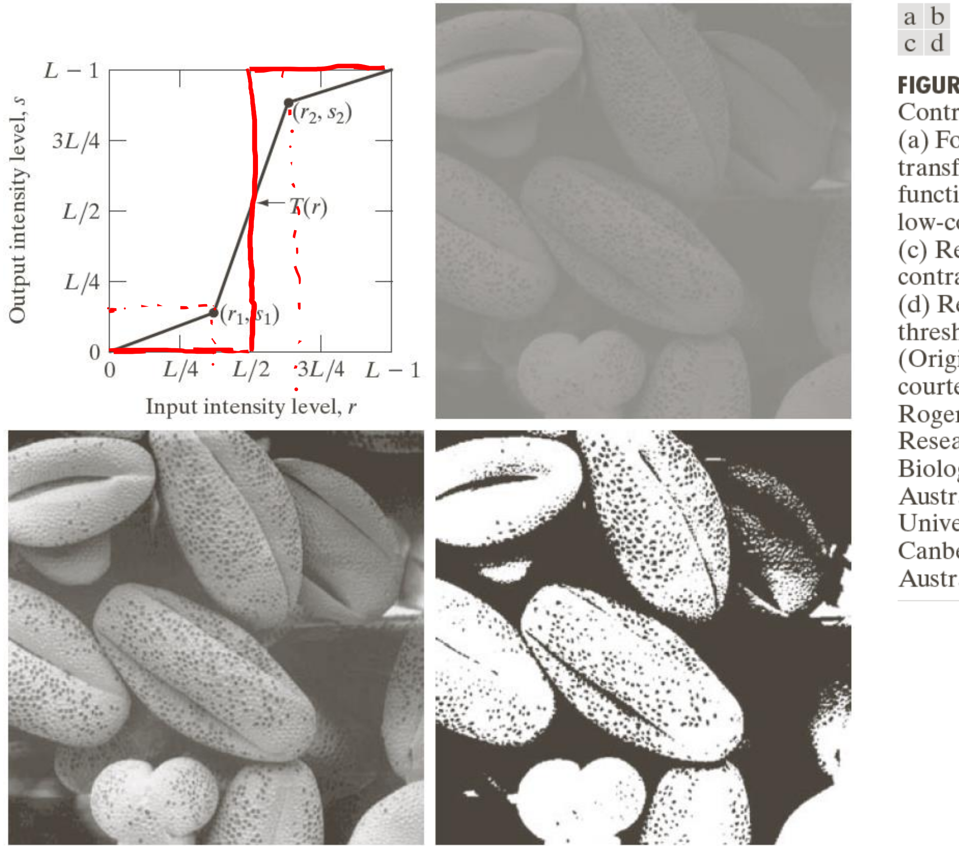
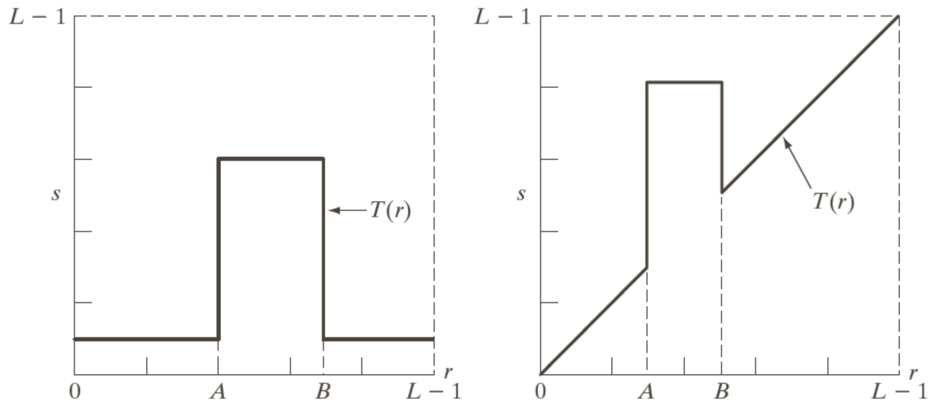


FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

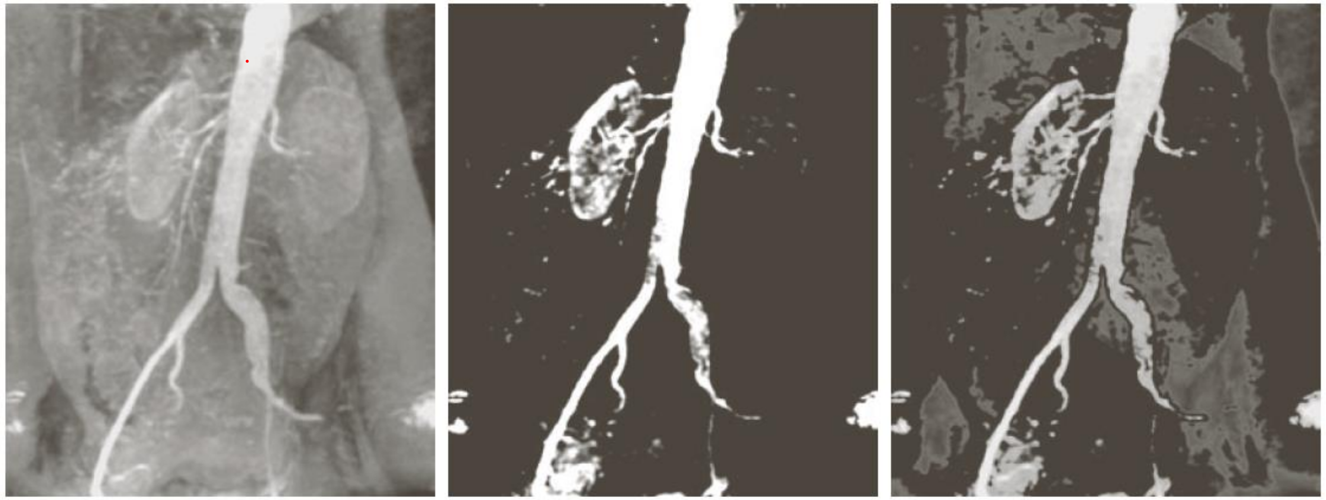
Intensity-Level Slicing

- Highlighting a specific range of intensities in an image.
- Enhancing certain feature (masses of water in satellite imagery, enhancing flaws in X-ray images).



a b

FIGURE 3.11 (a) This transformation highlights intensity range [A, B] and reduces all other intensities to a lower level. (b) This transformation highlights range [A, B] and preserves all other intensity levels.

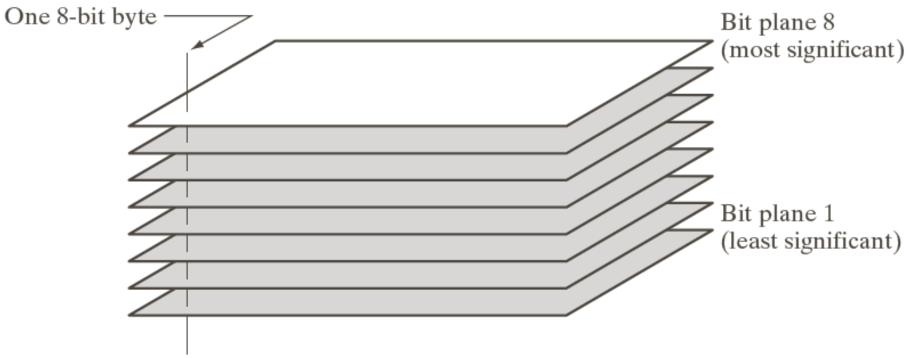


a b c

FIGURE 3.12 (a) Aortic angiogram. (b) Result of using a slicing transformation of the type illustrated in Fig. 3.11(a), with the range of intensities of interest selected in the upper end of the gray scale. (c) Result of using the transformation in Fig. 3.11(b), with the selected area set to black, so that grays in the area of the blood vessels and kidneys were preserved. (Original image courtesy of Dr. Thomas R. Gest, University of Michigan Medical School.)

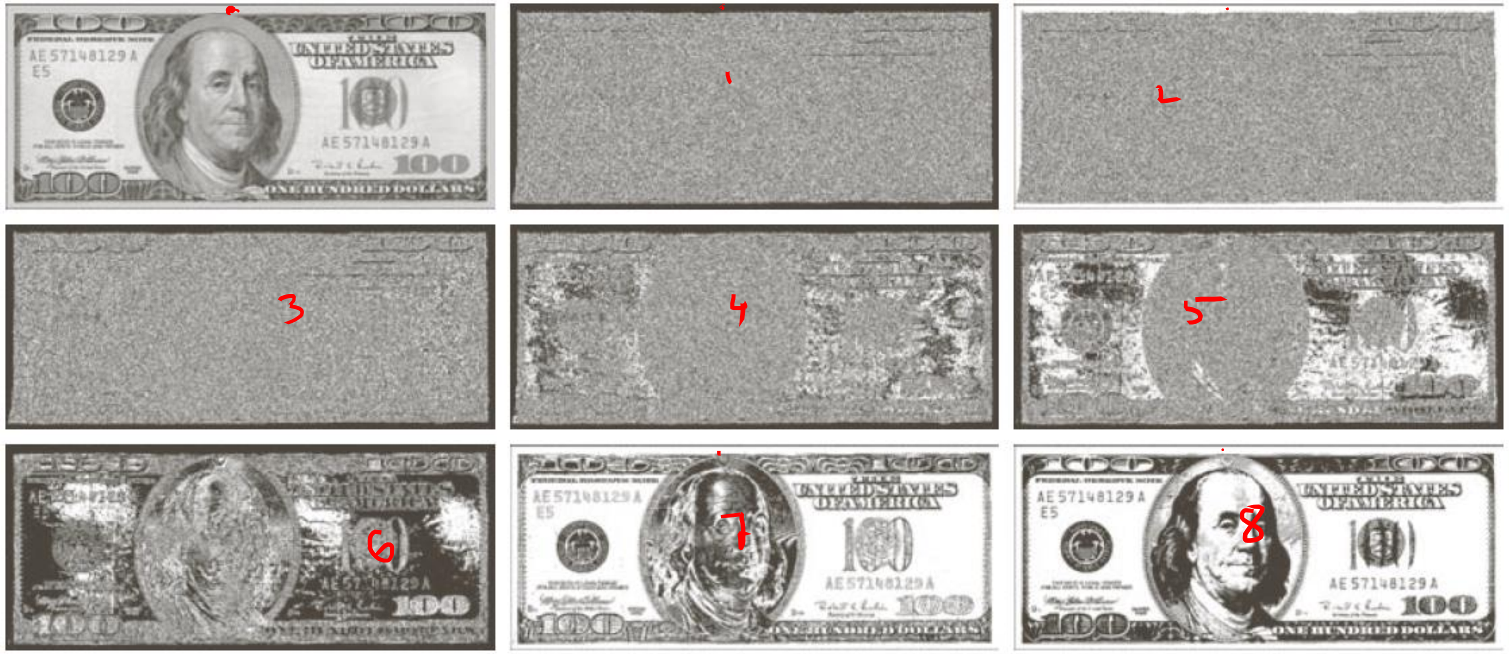
Bit-plane Slicing

- Pixels are digital numbers composed of bits.
- 256-level grey scale image is composed of 8 bits.



K-bit

8-bit



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11000010

a b c
d e f
g h i

$8_b \times 2^7 + 7_b \times 2^6 + 6_b \times 2^5 + ----$

FIGURE 3.14 (a) An 8-bit gray-scale image of size 500 × 1192 pixels. (b) through (i) Bit planes 1 through 8, with bit plane 1 corresponding to the least significant bit. Each bit plane is a binary image.

a b c

FIGURE 3.15 Images reconstructed using (a) bit planes 8 and 7; (b) bit planes 8, 7, and 6; and (c) bit planes 8, 7, 6, and 5. Compare (c) with Fig. 3.14(a).