영상처리
- Intensity Transformations and Spatial Filtering -

Background

The Basics of Intensity Transformations and Spatial Filtering (밝기값 변환과 공간 필터링의 기초)

- Spatial domain vs Frequency domain

- 이번 chapter 에서는 spatial domain technique을 다룸
  - Image 자체에 가하는 processing
- Frequency domain → Fourier transform image에 processing

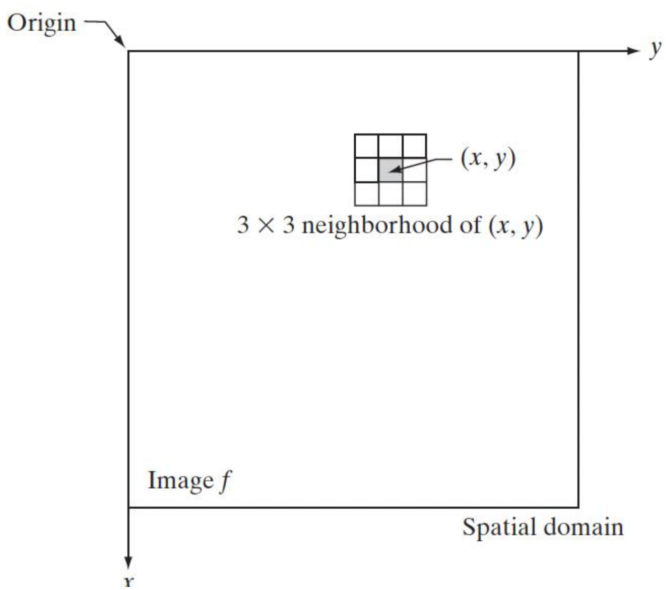
Background

The Basics of Intensity Transformations and Spatial Filtering

- Spatial domain processes (공간도메인처리)

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

- g : processed image, f : input image, T : operator defined over a neighborhood of point (x, y)

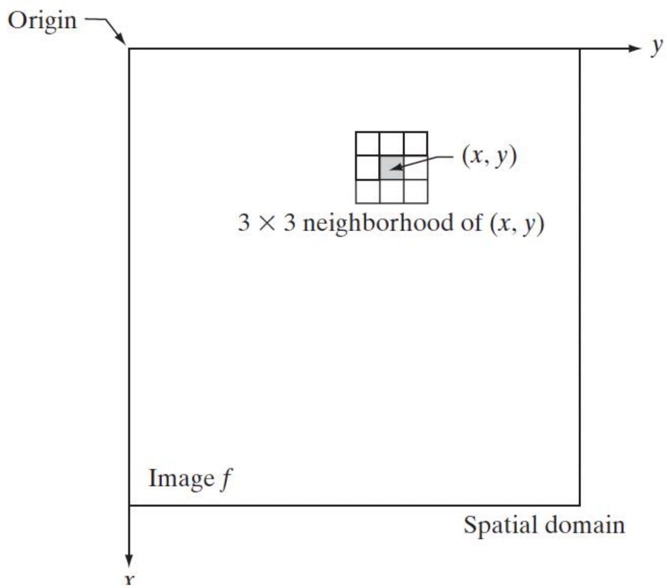


3x3 mask를 사용할 때 spatial domain operation (filtering)의 예시
→ x, y의 intensity를 얻기 위해 주면 3x3의 값을 이용

Background

The Basics of Intensity Transformations and Spatial Filtering

- Top left → bottom right (행렬)
- 경계는?



Background

The Basics of Intensity Transformations and Spatial Filtering

- Smallest possible neighborhood: 1x1
  - 이때, 결과 g 는 단일 점 (x, y) 에 있는 밝기값(intensity)과 변환 T에만 영향을 받음

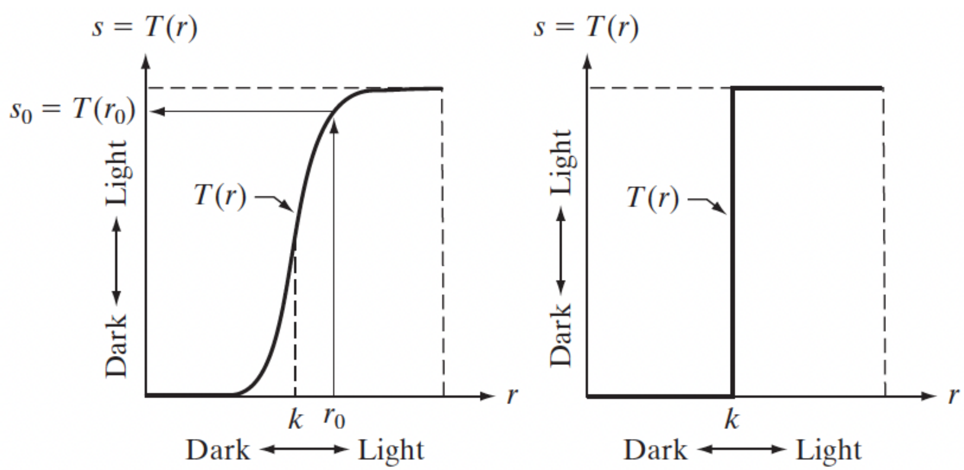
$$s = T(r)$$

  - s: intensity of g(x,y), r: intensity of f(x,y)
  - ***intensity transformation function*** *(also called gray-level or mapping function)*

The Basics of Intensity Transformations and Spatial Filtering

- Smallest possible neighborhood: 1x1

$$s = T(r)$$

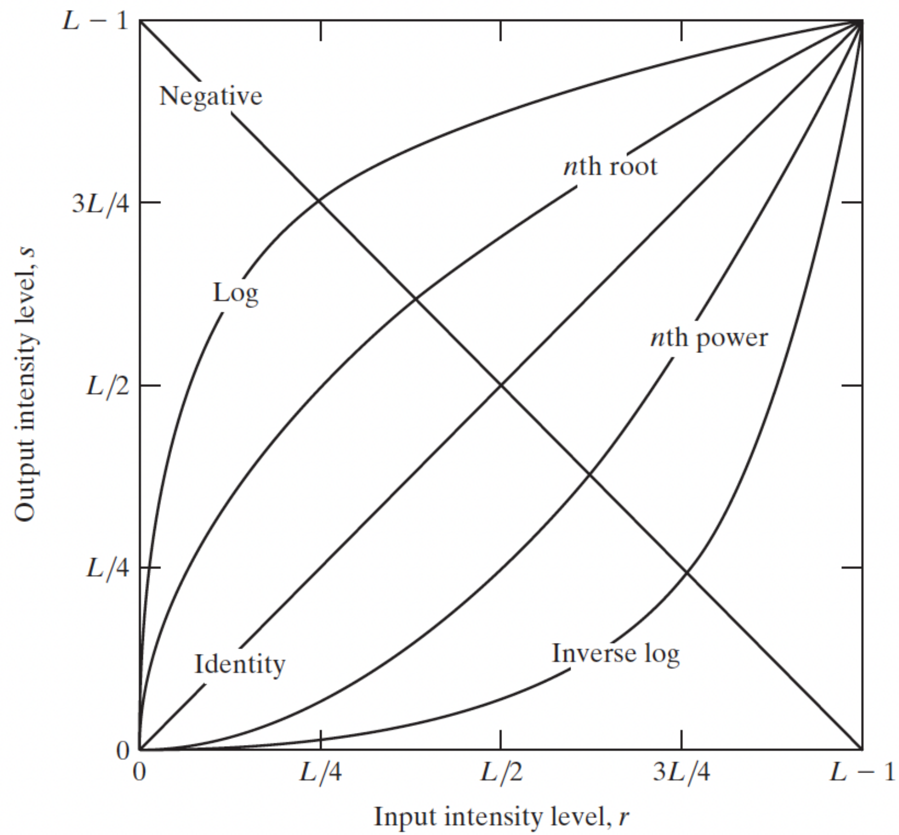


a b

FIGURE 3.2 Intensity transformation functions. (a) Contrast-stretching function. (b) Thresholding function.

Some Basic Intensity Transformation Functions

FIGURE 3.3 Some basic intensity transformation functions. All curves were scaled to fit in the range shown.



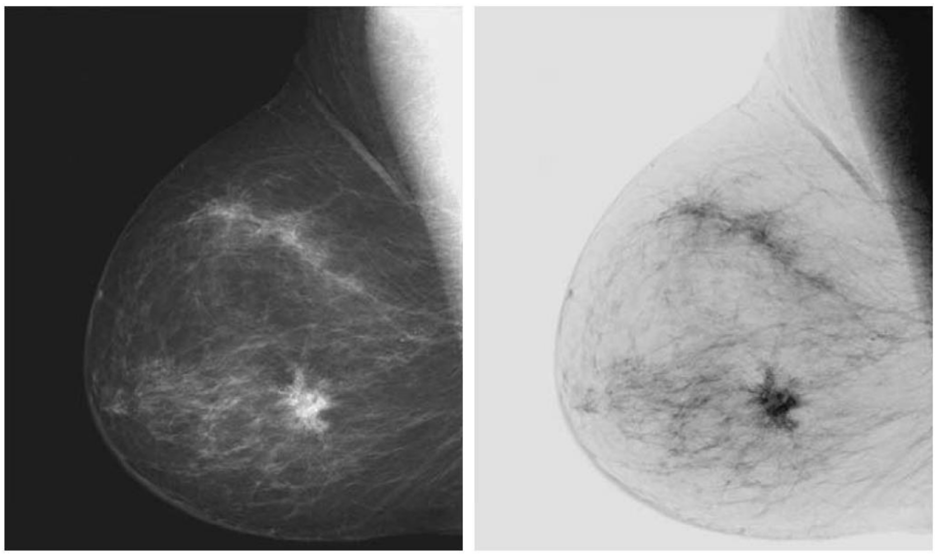
Lookup table
X-axis: input
Y-axis: output

Some Basic Intensity Transformation Functions

Image negatives

- Image with intensity levels in the range [0, L – 1]

$$s = L - 1 - r$$



a b

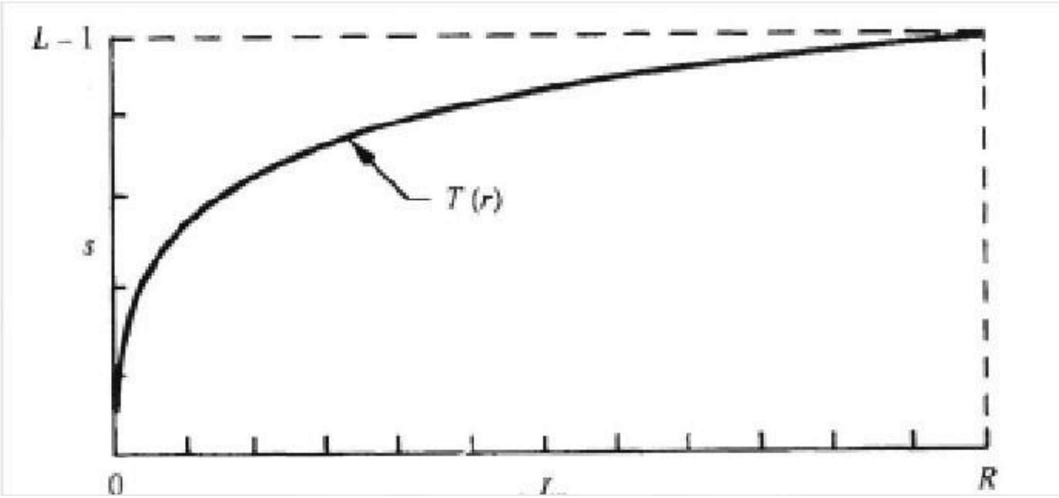
FIGURE 3.4
(a) Original digital mammogram.
(b) Negative image obtained using the negative transformation in Eq. (3.2-1).
(Courtesy of G.E. Medical Systems.)

black area is dominant in size

- Suitable for enhancing white or gray detail embedded in dark regions

Log transformations

- When the dynamic range of the input gray values is very large (ex: Fourier transform magnitude), compared to that of the display,
  - we need to compress the Gray value range
  - **Compression of Dynamic Range**
    - Typically, we use a log scale.



Low range -> expanded
High range -> compressed

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

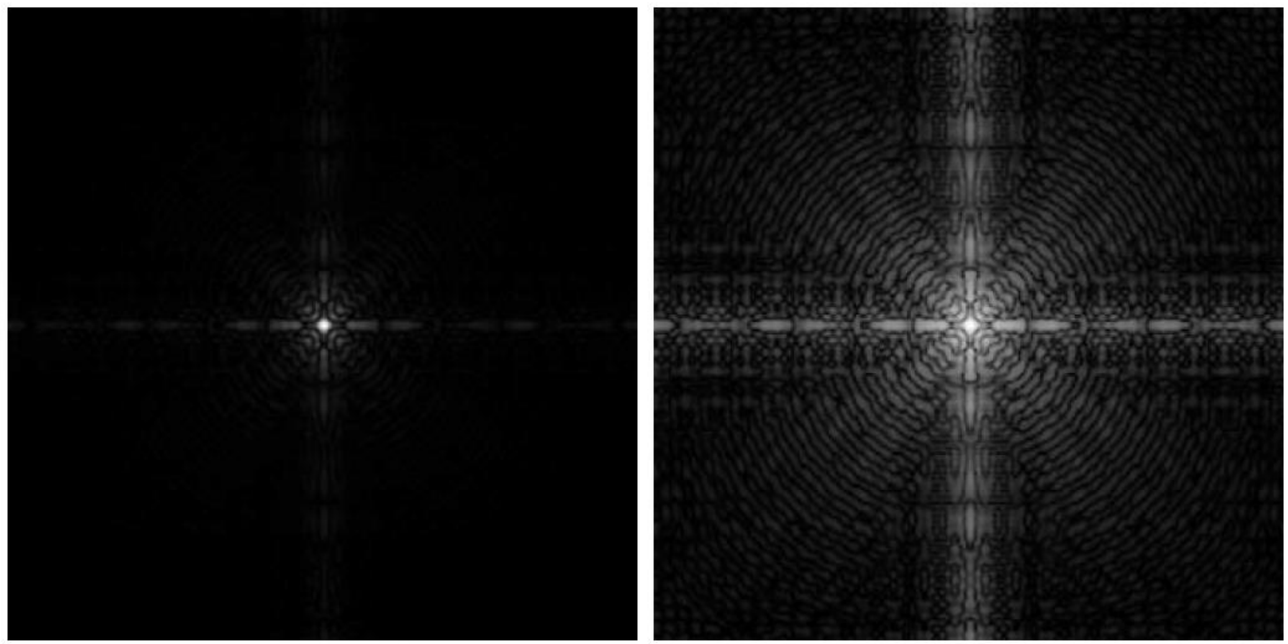
Some Basic Intensity Transformation Functions

Log transformations

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

a b

FIGURE 3.5 (a) Fourier spectrum. (b) Result of applying the log transformation in Eq. (3.2-2) with $c = 1$.



$0 \sim 10^6$

$\Rightarrow$ *linearly scale down to* 256 *levels*

$0 \sim 6$(taking logarithm)

$\Rightarrow$ *scale up to* 256 *levels*

Some Basic Intensity Transformation Functions

Power-Law (Gamma) Transformations

$$s = cr^{\gamma} \ (\gamma > 0)$$

밝게 만듦

expansion of gray levels when an image is dark

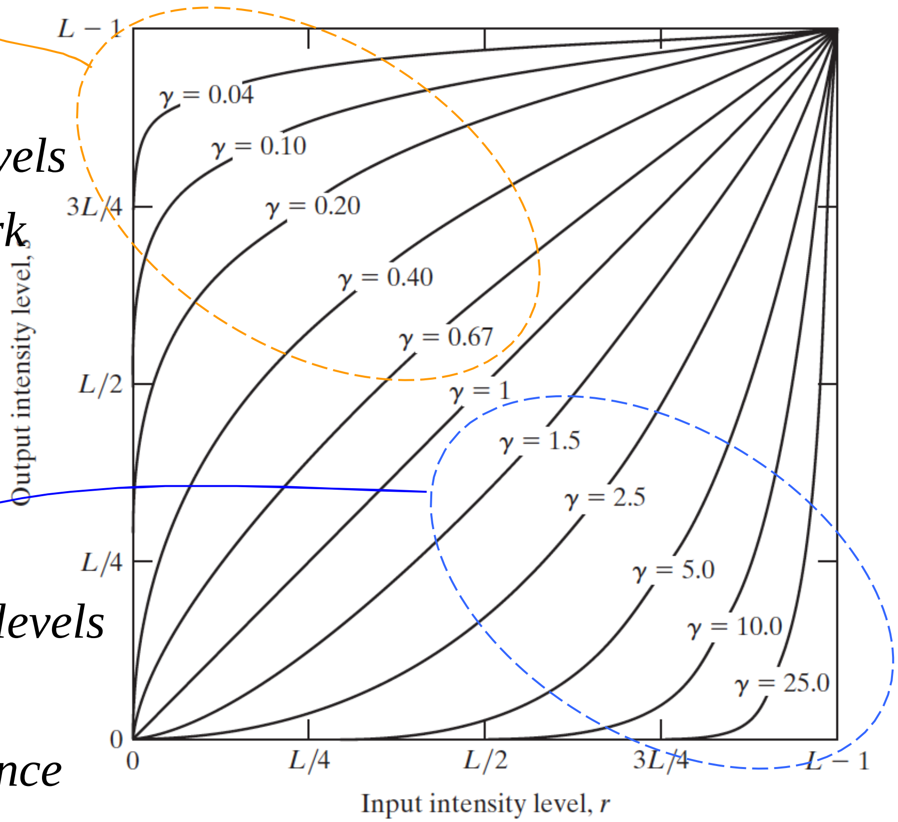


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases). All curves were scaled to fit in the range shown.

compression of gray levels when an image has washed – out appearance

어둡게 만듦

narrow range of dark input values $\Rightarrow$ *wider range of output value*

expansion

Some Basic Intensity Transformation Functions

Power-Law (Gamma) Transformations

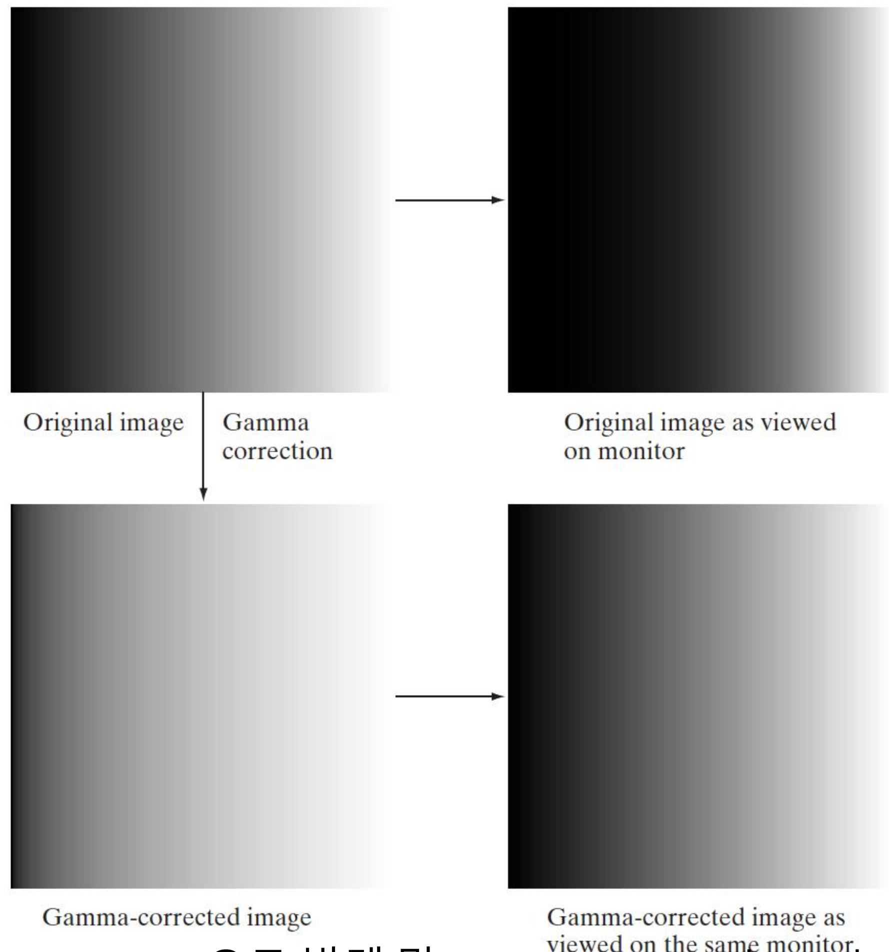
Example 1)

Original image

Gamma 2.5를 가진 모니터에서 보이는 이미지

a b
c d

FIGURE 3.7 (a) Intensity ramp image. (b) Image as viewed on a simulated monitor with a gamma of 2.5. (c) Gamma-corrected image. (d) Corrected image as viewed on the same monitor. Compare (d) and (a).



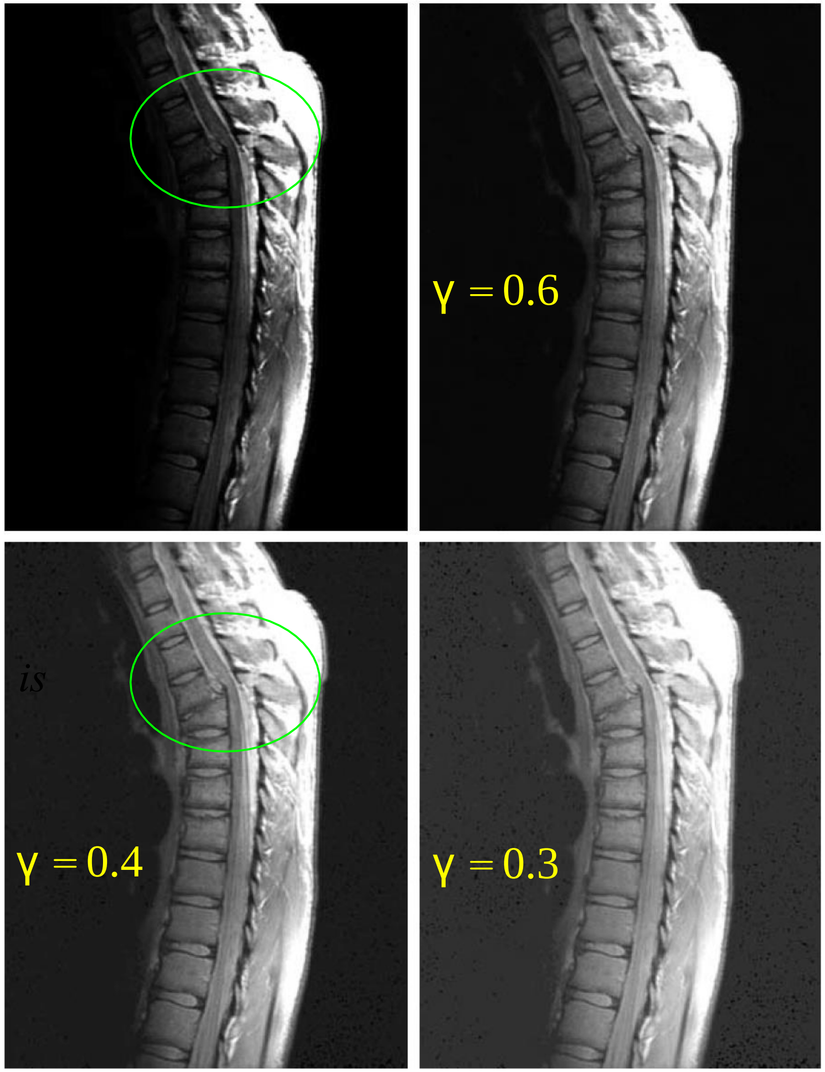
Gamma correction으로 밝게 만든 이미지

Correction 후 모니터에 보이는 이미지

Some Basic Intensity Transformation Functions

Power-Law (Gamma) Transformations

Example 2) Spine MRI



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.)

the best enhancement in terms of *contrast and discernable detail is achieved with* $\gamma = 0.4$

Some Basic Intensity Transformation Functions

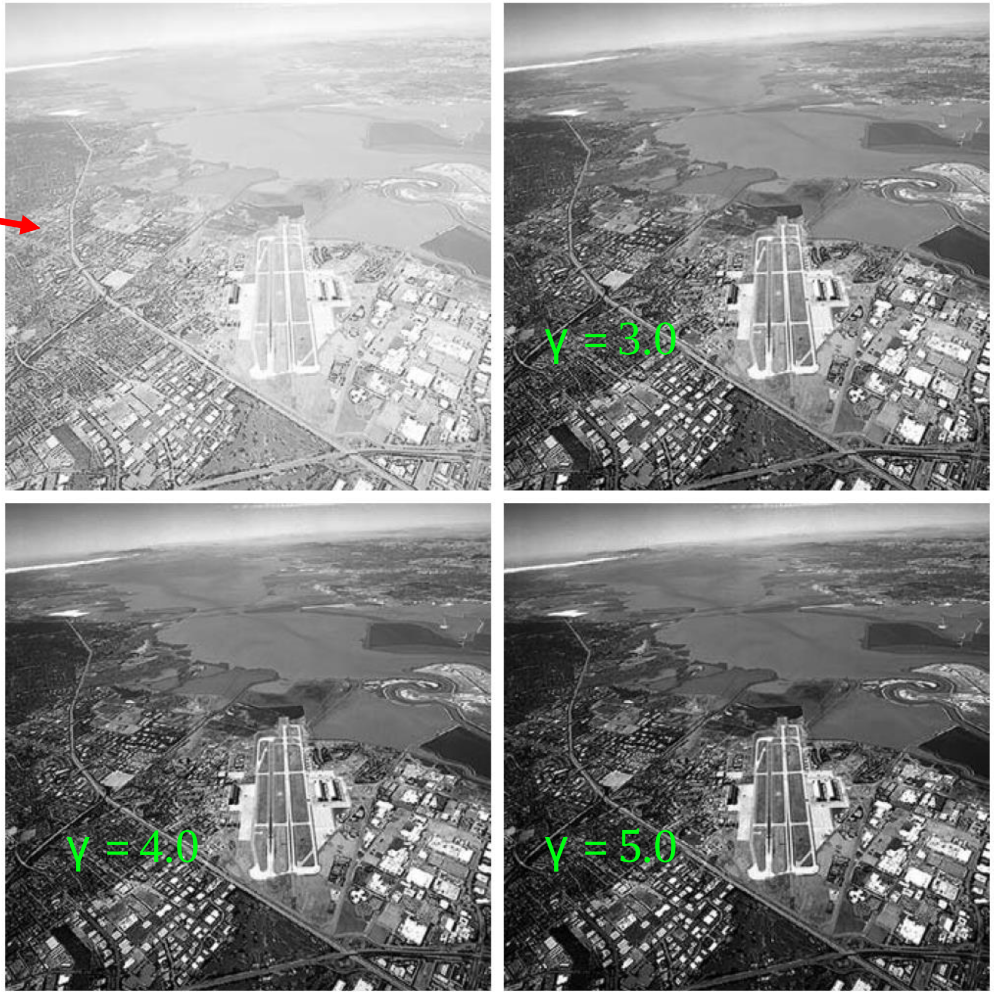
Power-Law (Gamma) Transformations

Example 3) Aerial image

Washed-out, so the compression of gray levels is required

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.)



the best enhancemenet with $\gamma = 4$

Too dark

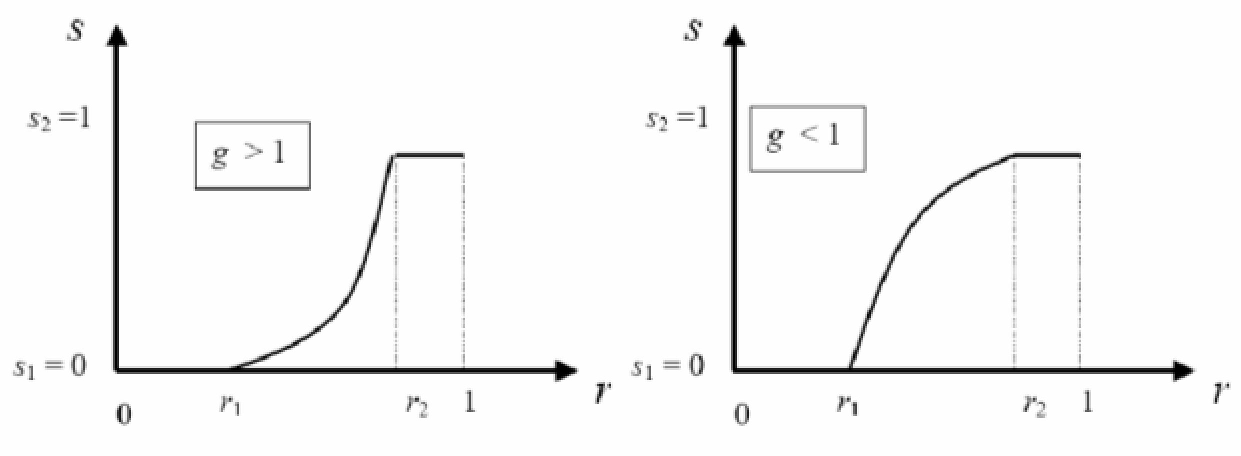
Some Basic Intensity Transformation Functions

Power-Law (Gamma) Transformations

- General form

$s_1 = 0, s_2 = 1, and$

$$T(r) = \begin{cases} 0, & r < r_1 \\ \left(\dfrac{r - r_1}{r_2 - r_1}\right)^{\gamma} & r_1 \le r \le r_2 \\ 1, & r > r_2 \end{cases}$$



Output Image is “darker” Output Image is “brighter”

Some Basic Intensity Transformation Functions

실습

DLIP_practice1.IntensityTransformation.ipynb

Some Basic Intensity Transformation Functions

Piecewise-Linear Transformation Functions

- Intensity 구간별로 서로 다른 linear transformation function 적용
  - Advantage: The form of functions can be arbitrary complex
  - Disadvantage: Specification requires considerably more user input

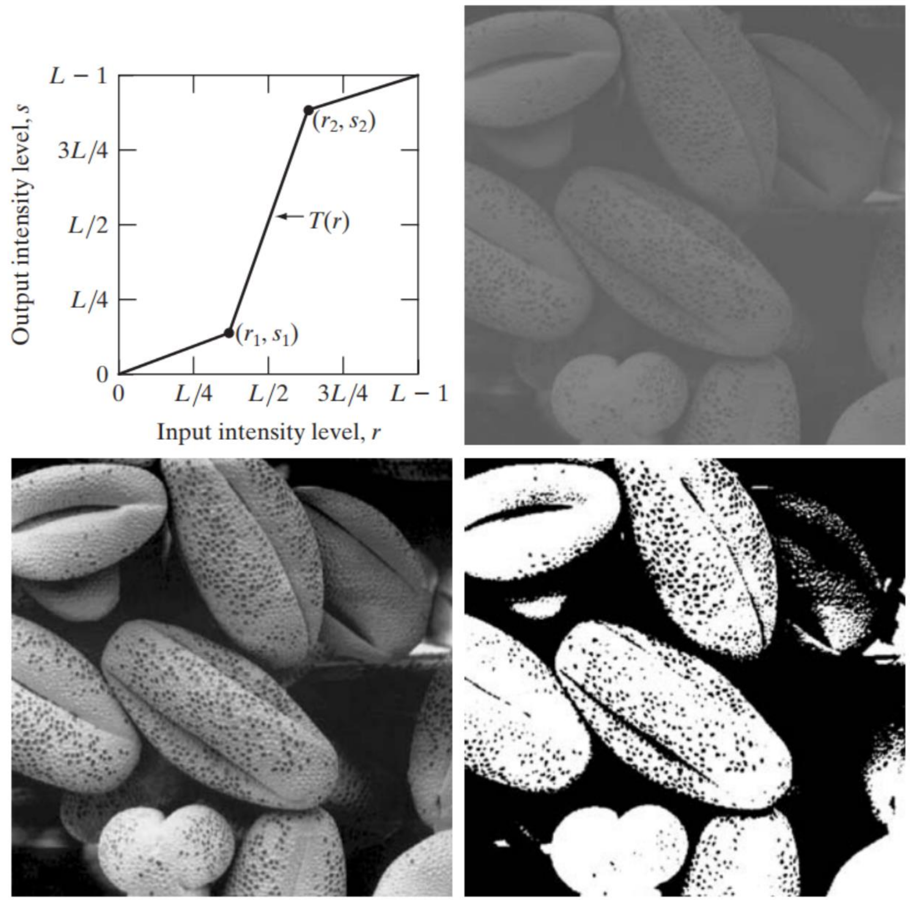
Some Basic Intensity Transformation Functions

Piecewise-Linear Transformation Functions

- **Contrast stretching**
  - process that expands the range of intensity levels in an image so that it spans the full intensity range of the recording medium or display device

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.)



Low-contrast
= lack of dynamic range

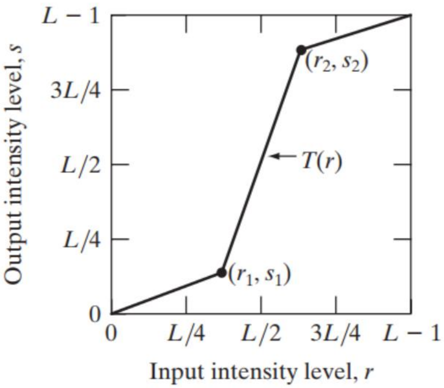
Full range linear stretching

Thresholding

Some Basic Intensity Transformation Functions

Piecewise-Linear Transformation Functions

- **Contrast stretching**
  - Increase the dynamic range of gray values in the input image.
  - Suppose you are interested in stretching the input intensity values in the interval [r1, r2]:

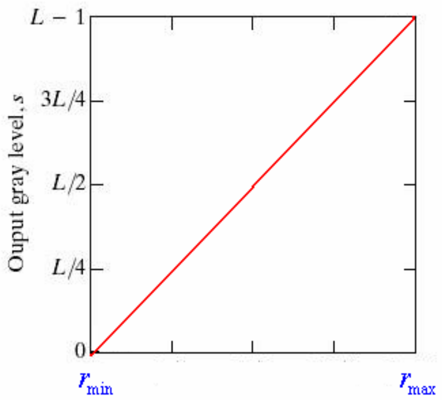


  - Note that (r1- r2) < (s1- s2).
  - The gray values in the range [r1, r2] is stretched into the range [s1, s2].

Piecewise-Linear Transformation Functions

- **Contrast stretching**

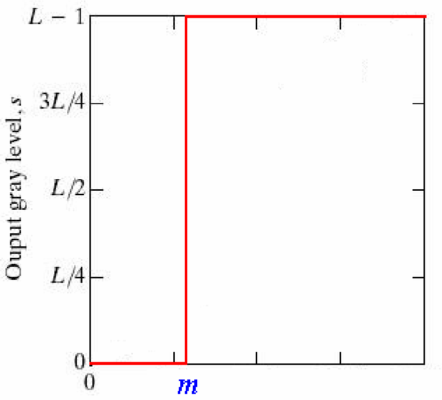
full range linear stretching



r_{min} : minimum *gray level in the image*

r_{max} : maximum *gray level in the image*

Thresholding function

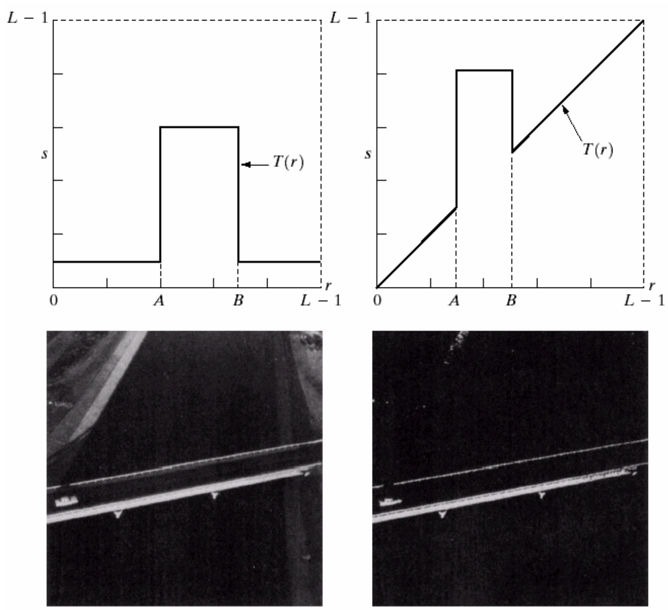


$m = mean[gray\ level\ in\ the\ image]$

Some Basic Intensity Transformation Functions

Piecewise-Linear Transformation Functions

- **Intensity-level slicing**
  - Highlighting a specific range of gray levels



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).

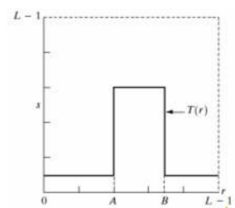
Some Basic Intensity Transformation Functions

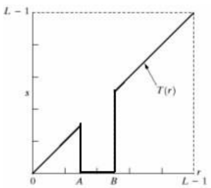
Piecewise-Linear Transformation Functions

- **Intensity-level slicing**

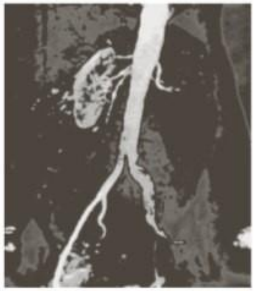
How can we preserve kidney and blood vessel?

X-ray image





aortic
angiogram

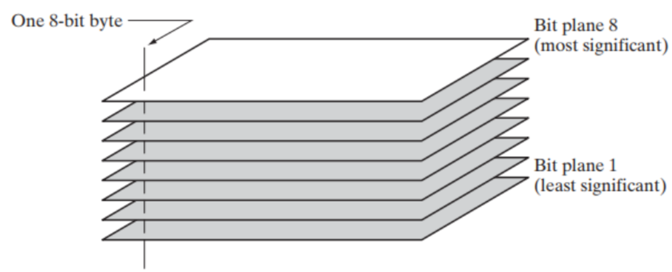


B /W representation

Piecewise-Linear Transformation Functions

- Bit-Plane slicing
  - mainly used for data compression and progressive transmission
  - highlight the contribution made to total image appearance by specific bits

FIGURE 3.13 Bit-plane representation of an 8-bit image.



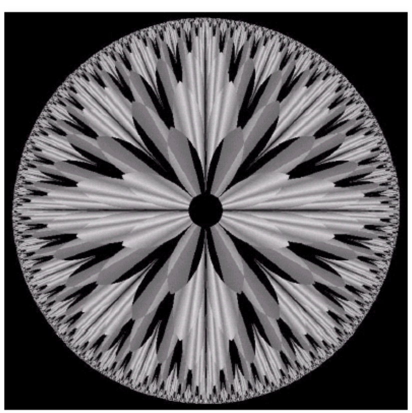


FIGURE 3.13 An 8-bit fractal image. (A fractal is an image generated from mathematical expressions). (Courtesy of Ms. Melissa D. Binde, Swarthmore College, Swarthmore, PA.)

Pixels most significant bit = 1

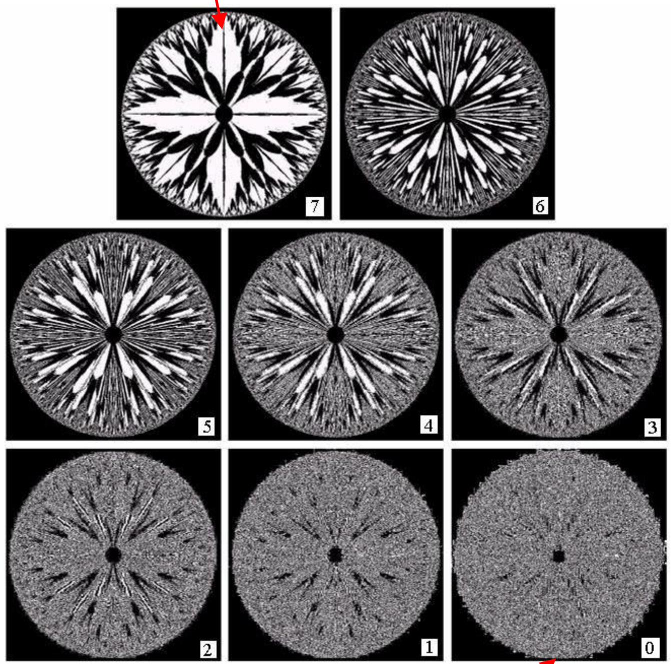


FIGURE 3.14 The eight bit planes of the image in Fig. 3.13. The number at the bottom, right of each image identifies the bit plane.

Pixels least significant bit = 1
(detail or noise?)

Some Basic Intensity Transformation Functions

Piecewise-Linear Transformation Functions

- Bit-Plane slicing
  - mainly used for data compression and progressive transmission

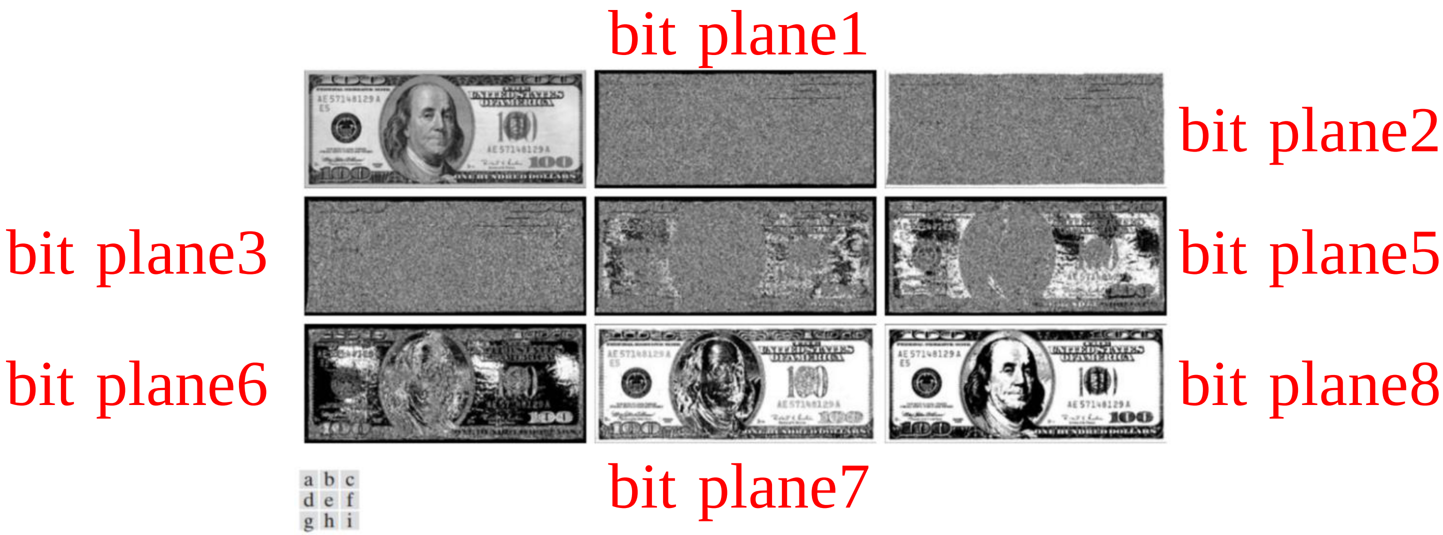


FIGURE 3.14 (a) An 8-bit gray-scale image of size 500 × 1192 pixels. (b) through (i) Bit planes 1 through 8, with bit plane 1 corresponding to the least significant bit. Each bit plane is a binary image.

Piecewise-Linear Transformation Functions

- Bit-Plane slicing
  - mainly used for data compression and progressive transmission

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).

Some Basic Intensity Transformation Functions

실습

DLIP_practice2.IntensityTransformation.ipynb