

Lecture 3 – Spatial Filtering (空间滤波)

This lecture will cover:

- Spatial domain (空间域)
- Intensity Transformation (灰度变换)
- Histogram (直方图)
- Spatial Filtering (空间滤波器)
 - ✓ Smoothing (平滑)
 - ✓ Sharpening (锐化)

Lecture 3 – Spatial Filtering (空间滤波)

This lecture will cover:

- **Spatial domain (空间域)**
 - Intensity Transformation (灰度变换)
 - Histogram (直方图)
 - Spatial Filtering (空间滤波器)
 - ✓ Smoothing (平滑)
 - ✓ Sharpening (锐化)

Spatial Domain

➤ Spatial Domain (空间域)

- Refer to Image plane
- Direct manipulation of pixels
- Computation efficient

➤ Transform Domain (变换域) / Frequency Domain (频率域)

- Transform and inverse transform
- By applying small spatial mask
- By using approximations based on mathematical or statistical criteria

Spatial Domain

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

➤ Intensity Transformation (灰度变换)

- Operate on single pixels of an image – point processing
- Contrast manipulation and image thresholding (对比度和阈值处理)

➤ Spatial Filtering (空间滤波器)

- Operate on a neighborhood of pixels of an image – neighborhood processing
- Deal with performing operations, for example sharpening and smoothing (锐化和平滑)

➤ Enhancement and segmentation (增强和分割)

Image Enhancement

Goal - More suitable for specific application

- Problem oriented
- Specific
- Subjective
 - For visual interpretation : viewer is the judge
 - For machine perception : easy to quantify

Lecture 3 – Spatial Filtering (空间滤波)

This lecture will cover:

- Spatial domain (空间域)
- **Intensity Transform (灰度变换)**
- Histogram (直方图)
- Spatial Filtering (空间滤波器)
 - ✓ Smoothing (平滑)
 - ✓ Sharpening (锐化)

Intensity Transformation

➤ Simplest image processing techniques

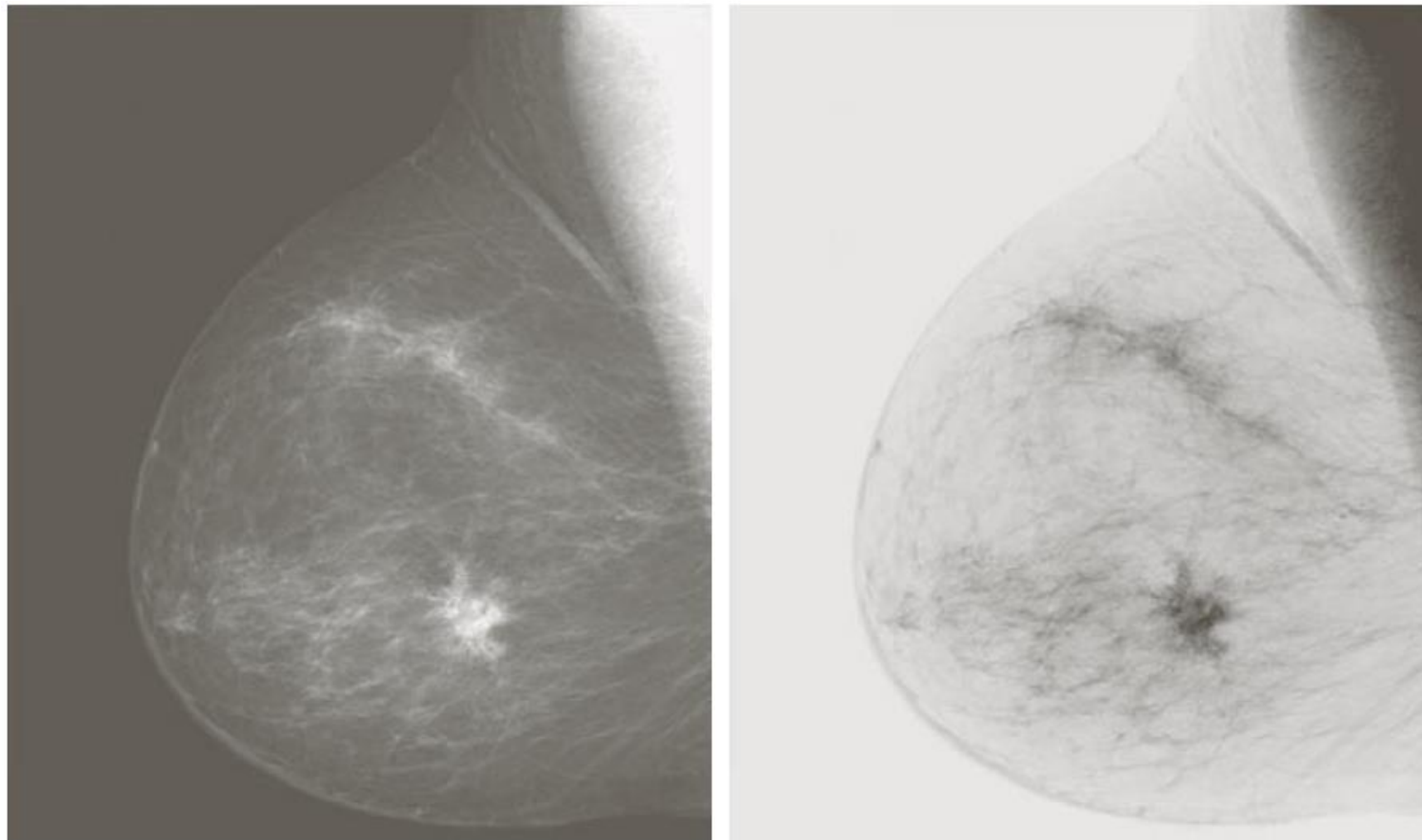
$$s = T(r)$$

➤ Types of Intensity Transformation

- Image Negatives (图像反转)
- Log Transformation (对数变换)
- Power-law (gamma) Transformation (幂律/伽马变换)
- Piecewise-Linear Transformation (分段线性变换)

Image Negatives

$$s = L - 1 - r$$



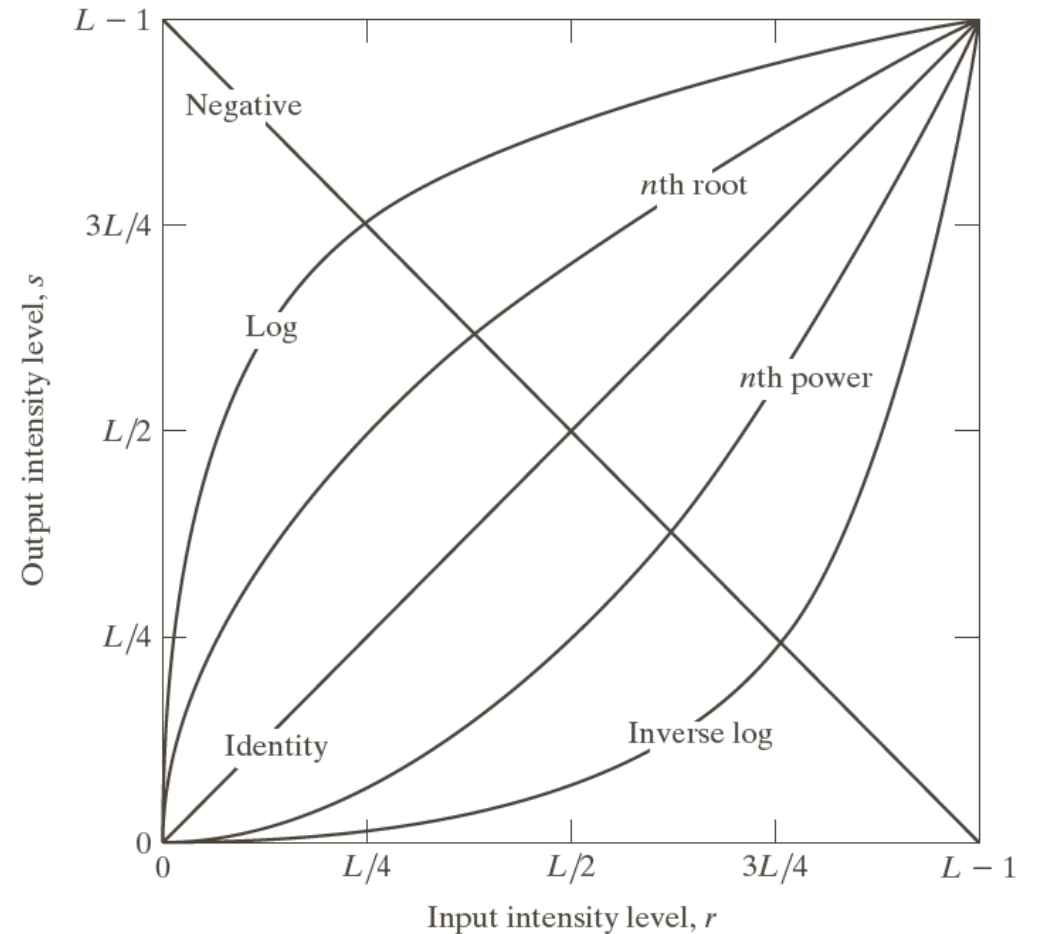
Log Transformation

➤ Log Transformation (对数变换)

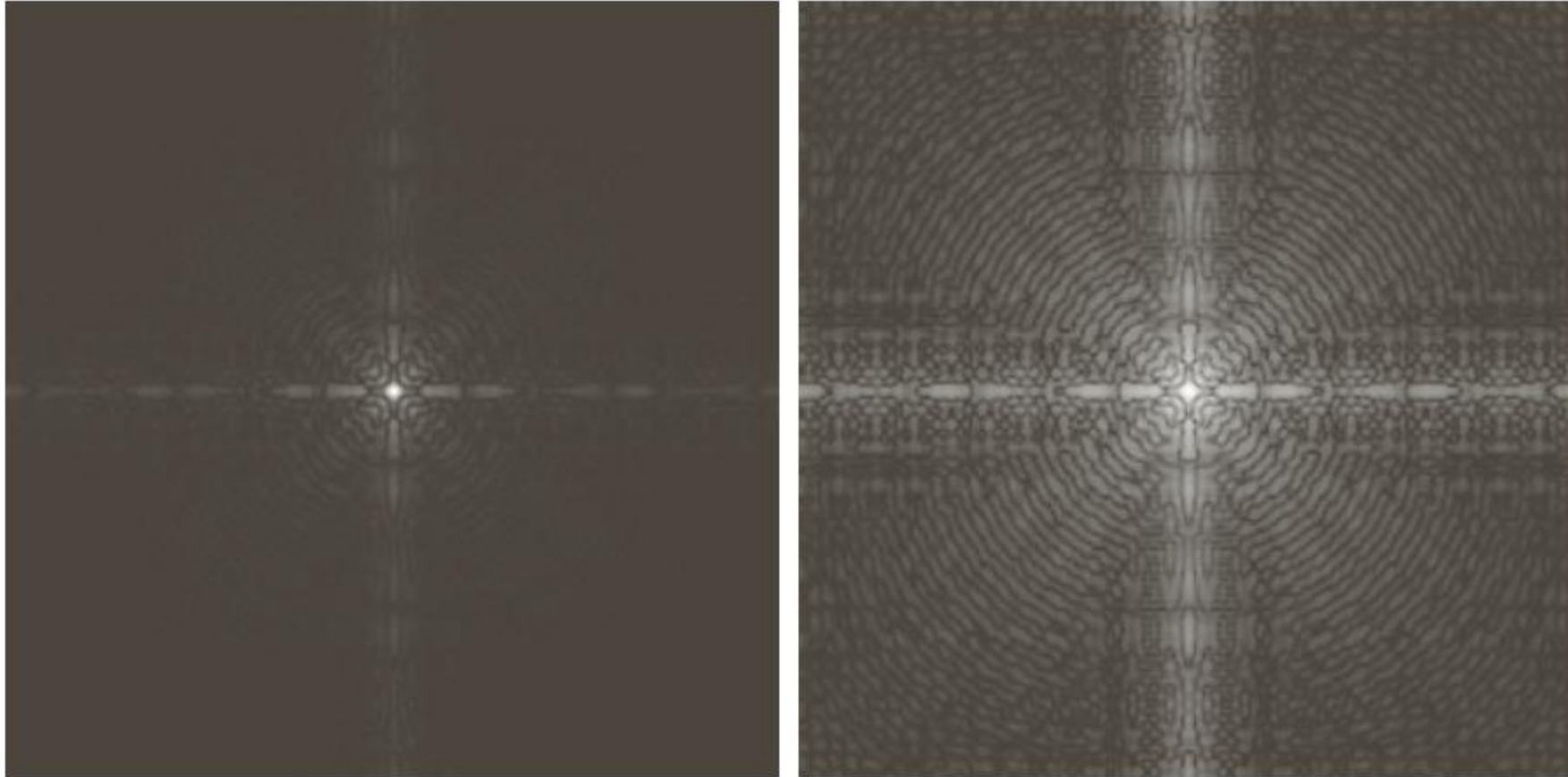
$$s = c \log(1 + r)$$

➤ Inverse Log Transformation (反对数变换)

$$s = c \cdot 2^r - 1$$



Fourier Spectrum



Gray Level Range



Original Picture



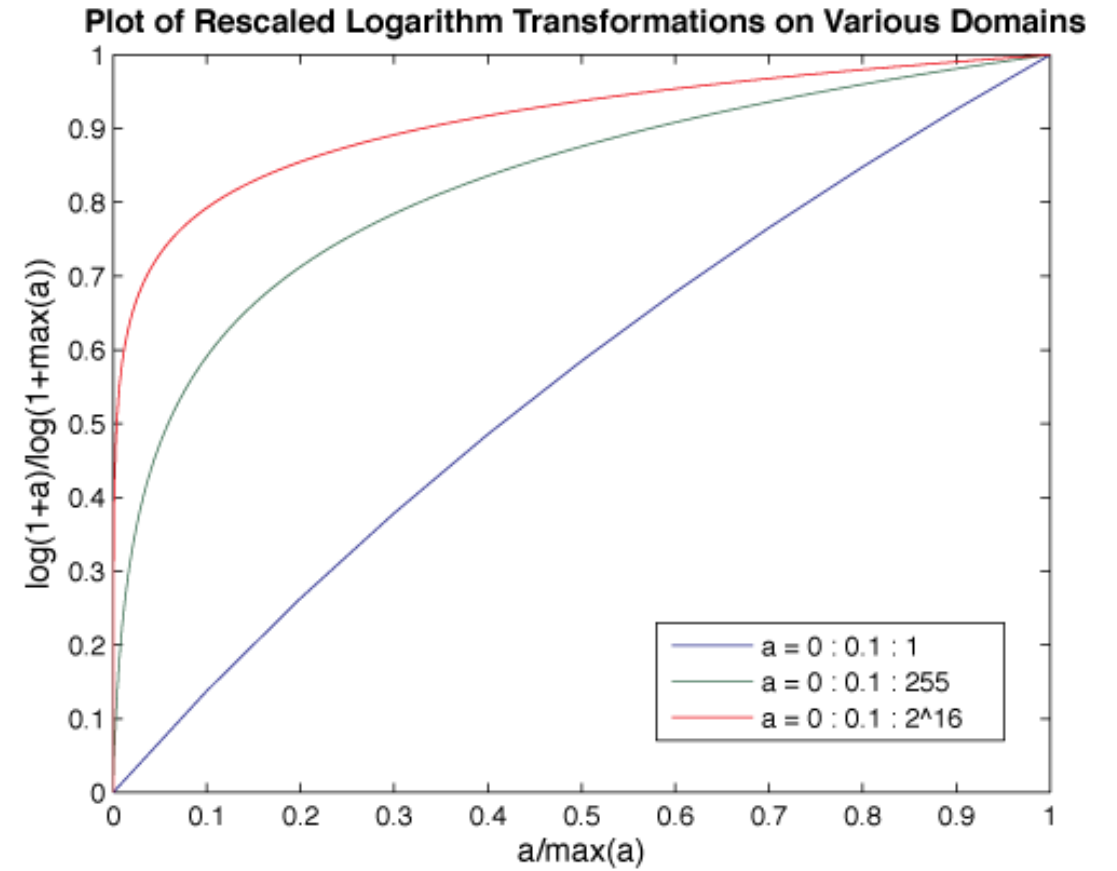
log on domain [0, 1]



log on domain [0, 255]

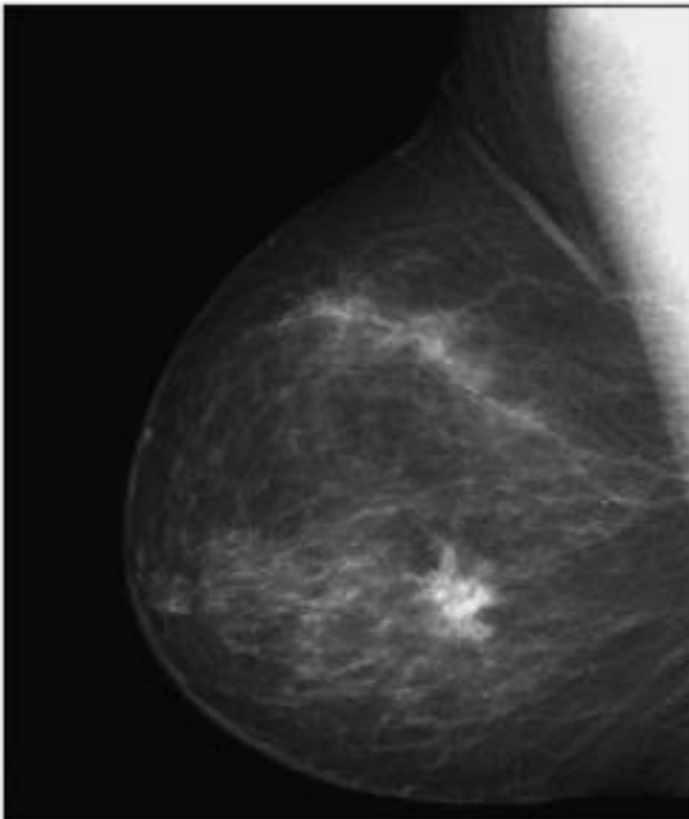


log on domain [0, 65535]

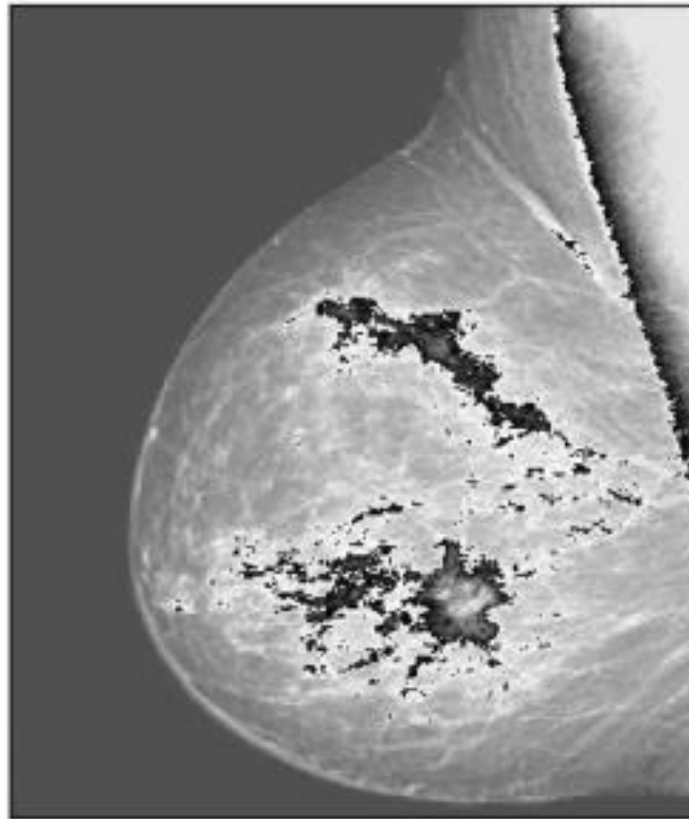


Log Transformation

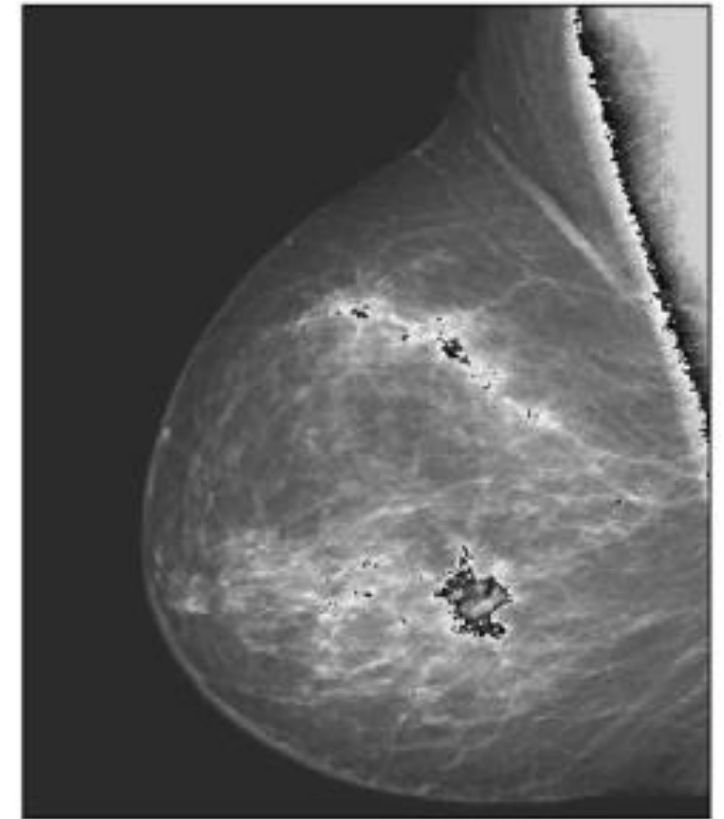
Original Image



Log Transform



Inverse Log transform



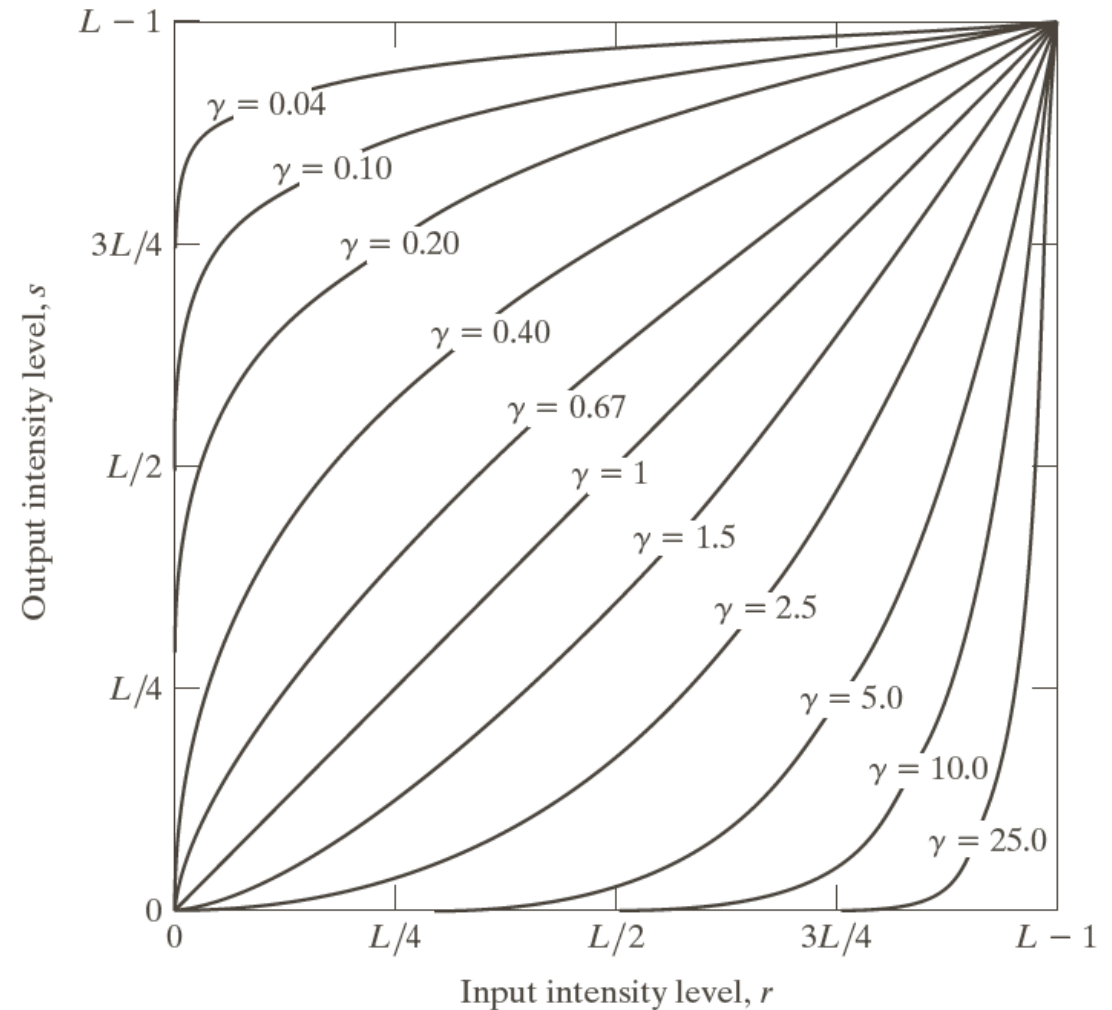
Gamma Transformation

➤ Gamma Transformation (伽马变换)

$$s = c \cdot r^\gamma$$

or

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



Gamma Transformation



Fractured spine



$\gamma = 0.6$



$\gamma = 0.4$



$\gamma = 0.3$

Gamma Transformation



Aerial image



$\gamma = 3.0$

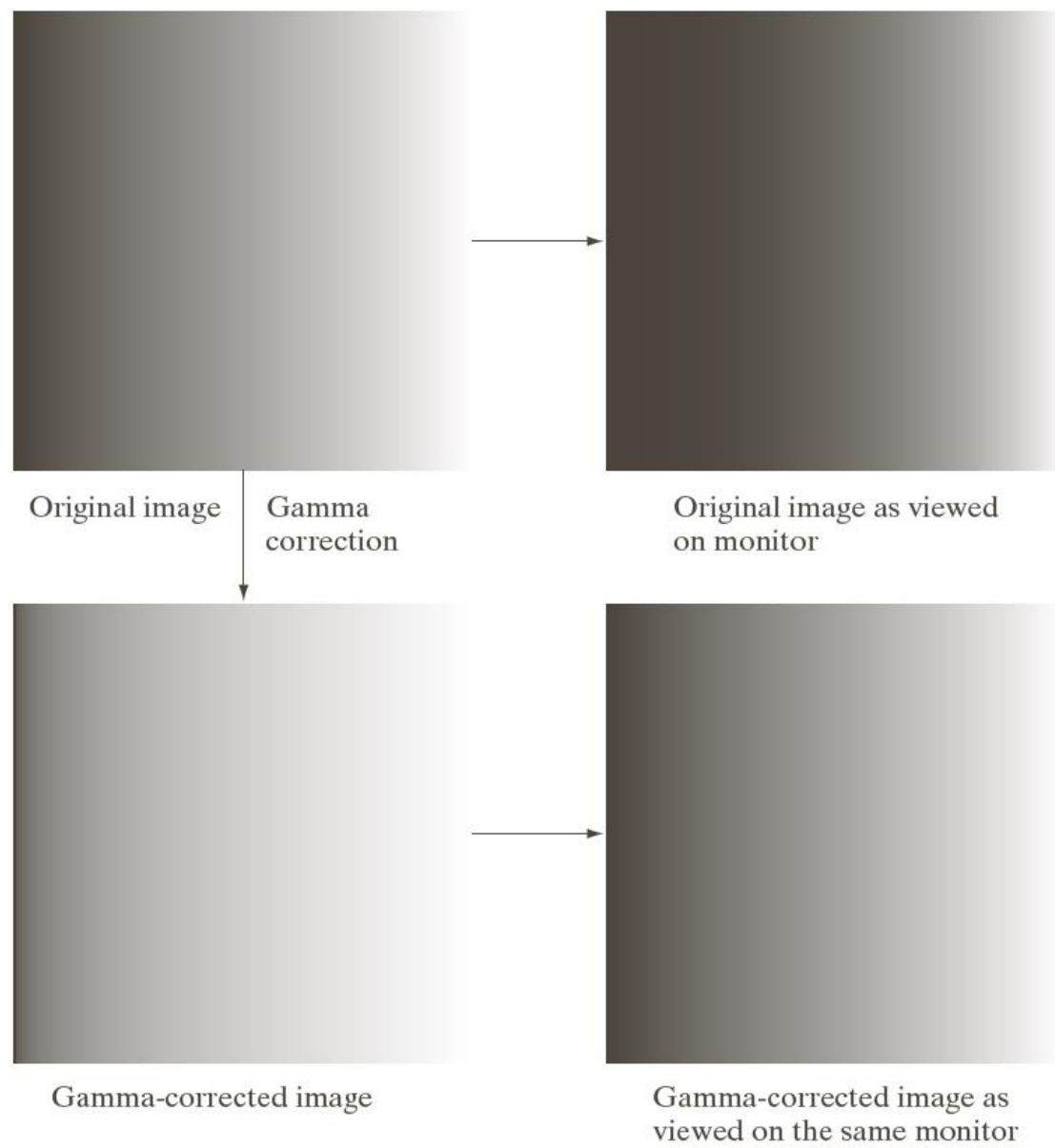


$\gamma = 4.0$



$\gamma = 5.0$

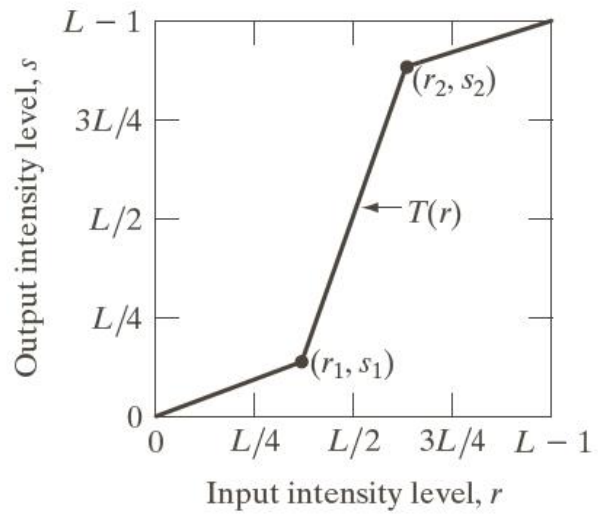
Gamma Correction (伽马校正)



Piecewise-Linear Transformation

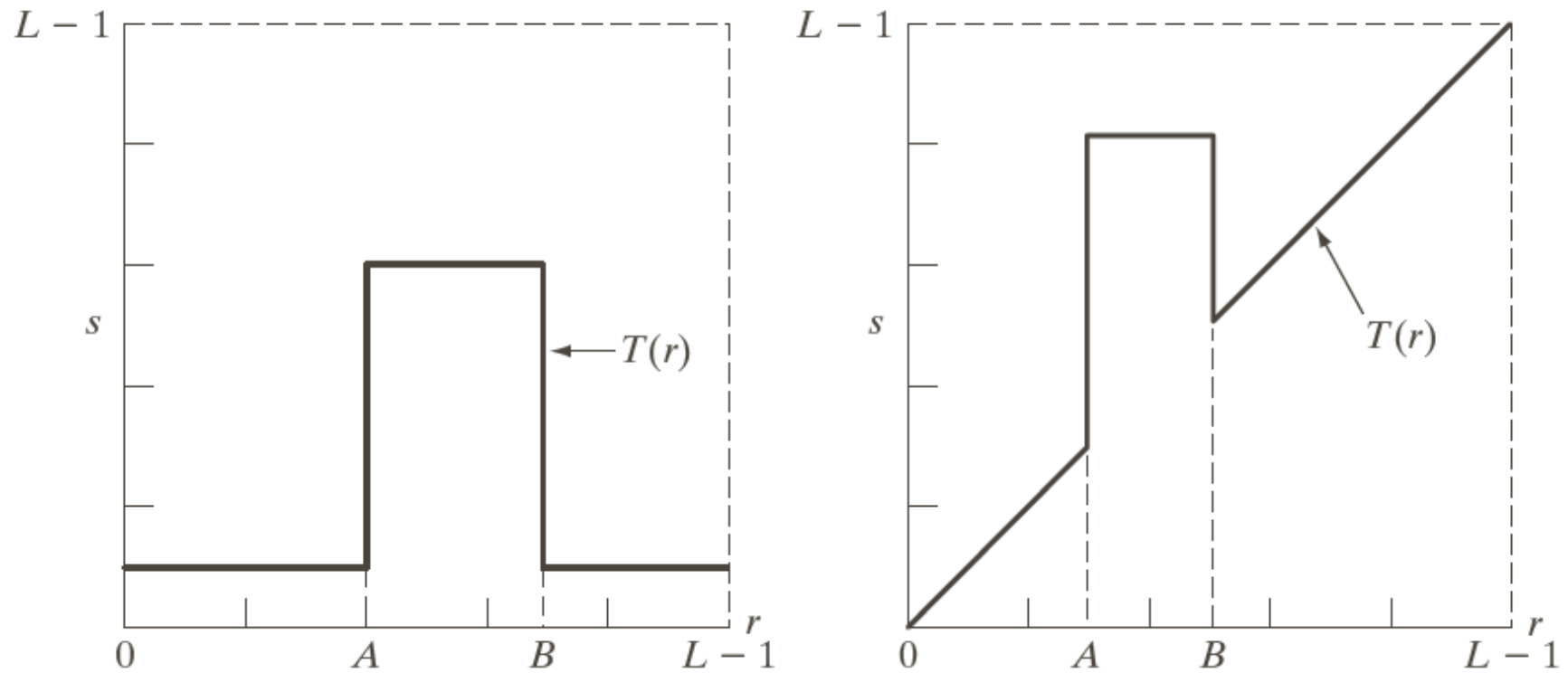
- **Arbitrarily complex**
- **User defined**
- **Commonly used methods**
 - Contrast Stretching (对比度拉伸)
 - Intensity-level slicing (灰度级分层)
 - Bit-plane slicing (比特平面分层)

Contrast Stretching

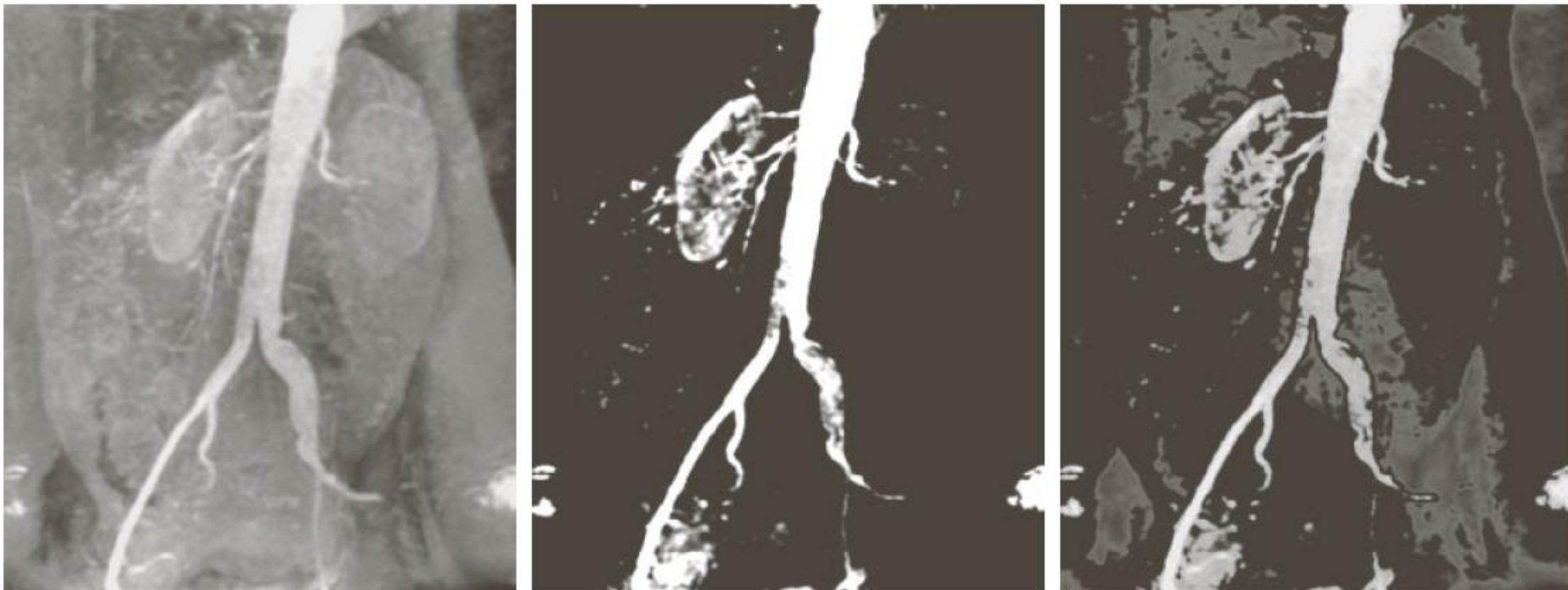


$$r_1 = r_2, s_1 = 0, s_2 = L-1$$

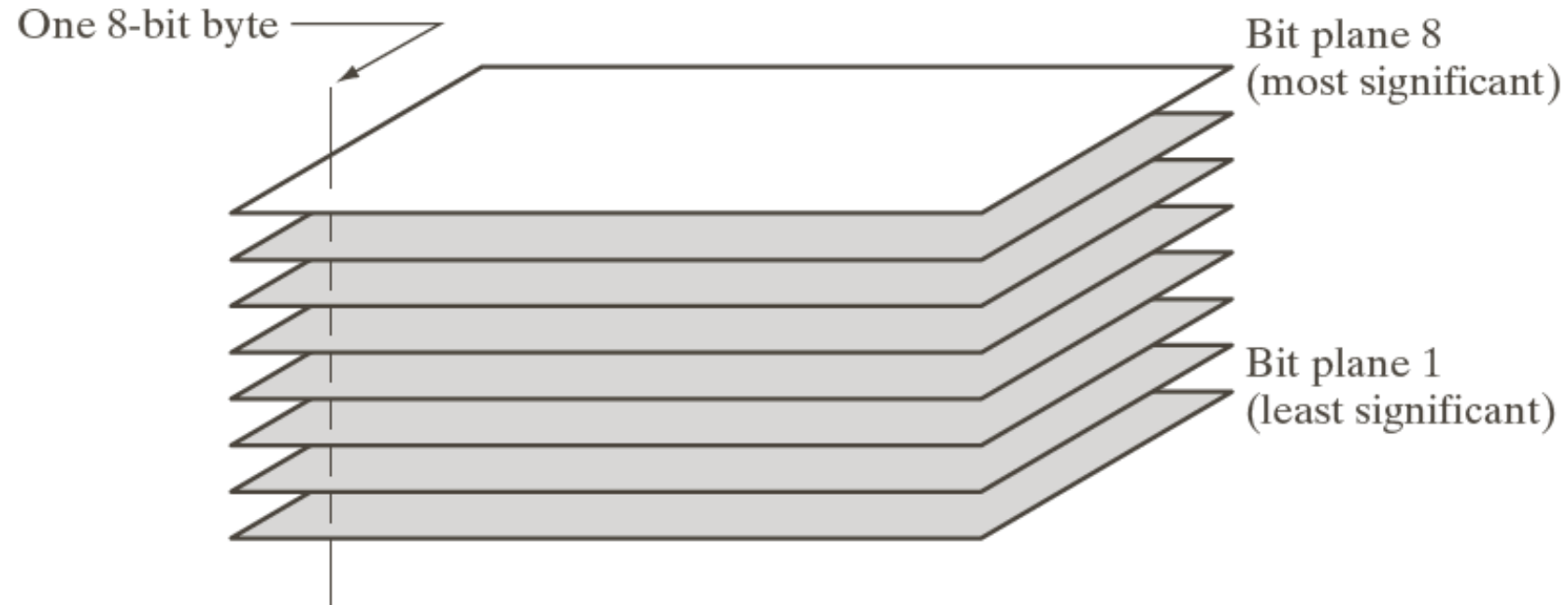
Intensity-level slicing



Intensity-level slicing



Bit-plane slicing



Bit-plane slicing



Bit-plane slicing

