SNS COLLEGE OF TECHNOLOGY
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Department of Biomedical Engineering

Course Name: 19BMB304 & Biomedical Image Processing

III Year : VI Semester

Unit II –IMAGE ENHANCEMENT

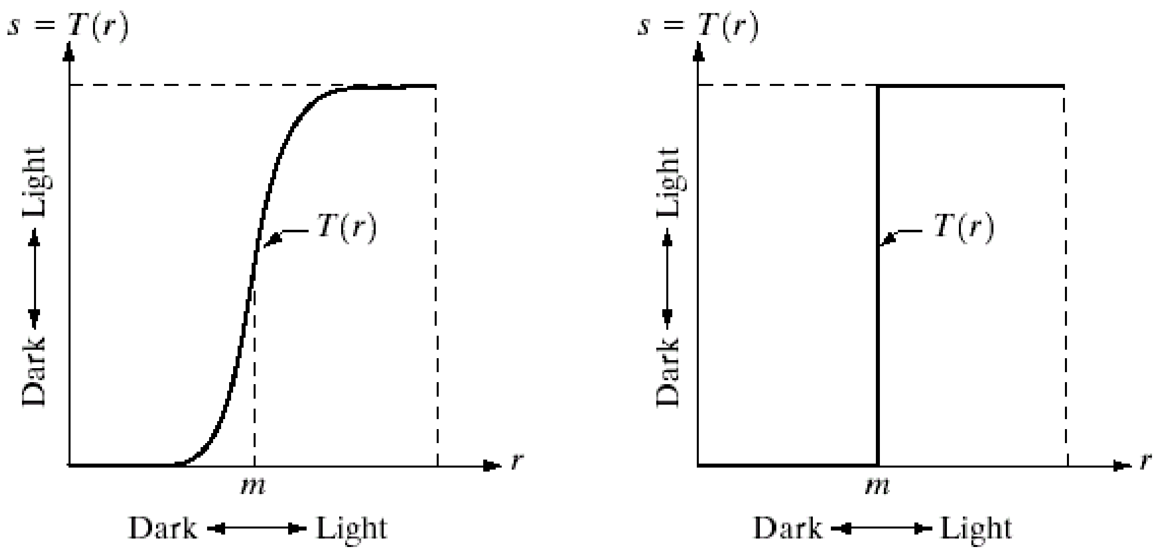
Topic : Histogram Processing

Image Enhancement

- The objective of image enhancement is to process an image so that the result is more *suitable* than the original image for a specific application.
- There are two main approaches:
  - Image enhancement in spatial domain: Direct manipulation of pixels in an image
    - Point processing: Change pixel intensities
    - Spatial filtering
  - Image enhancement in frequency domain: Modifying the Fourier transform of an image

Image Enhancement by Point Processing

- Intensity Transformation



a b

FIGURE 3.2 Gray-level transformation functions for contrast enhancement.

Image Enhancement by Point Processing

Contrast Stretching

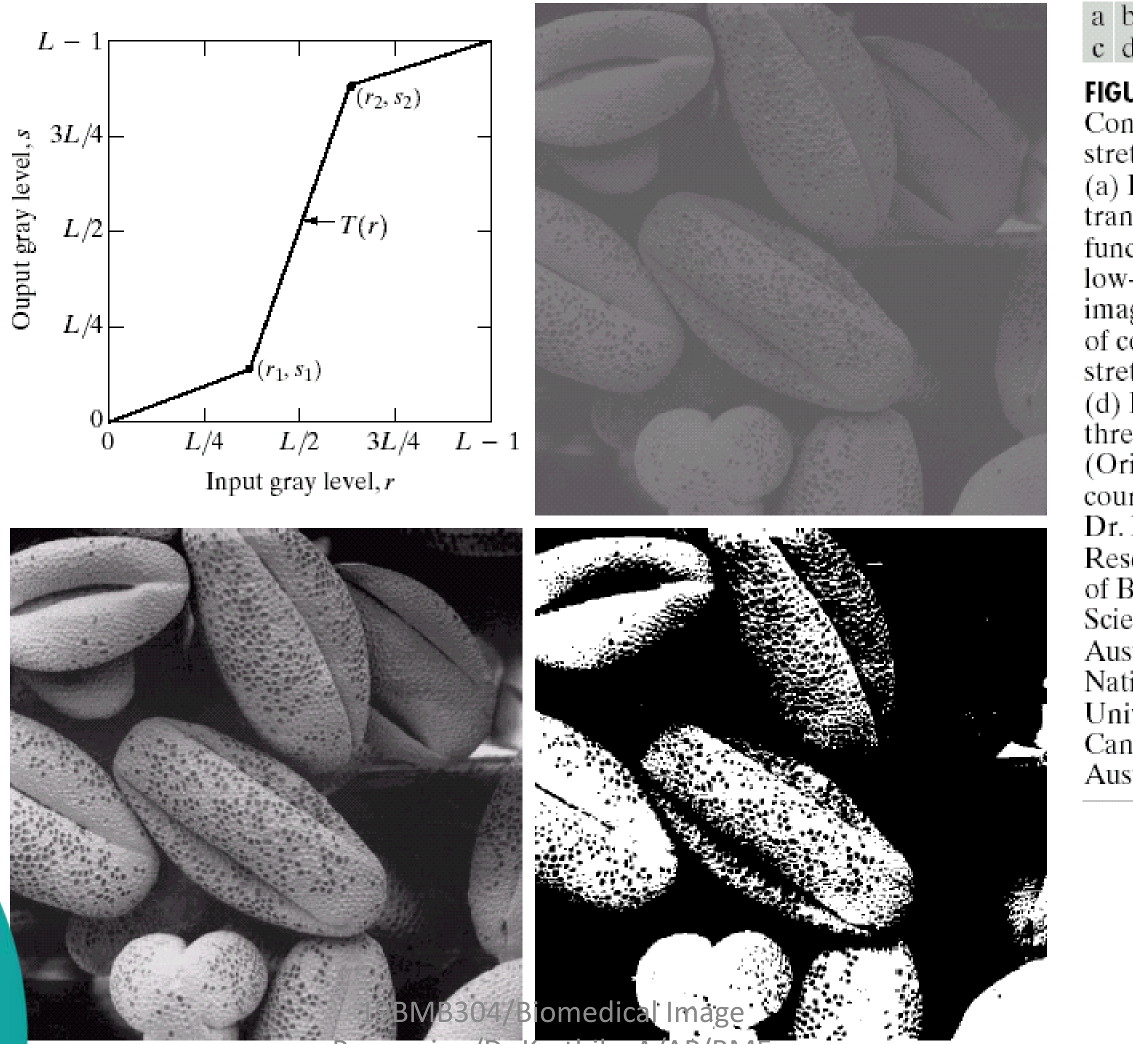


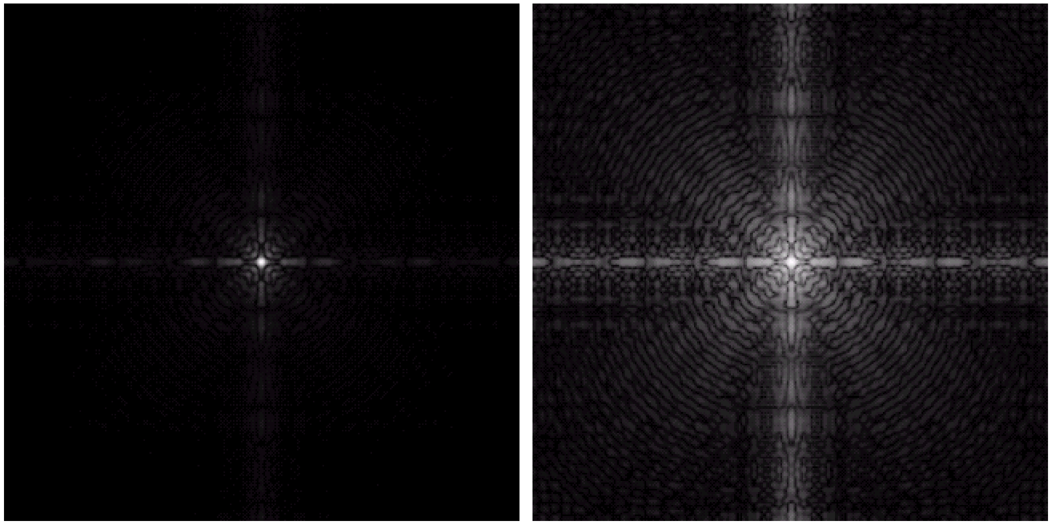
FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

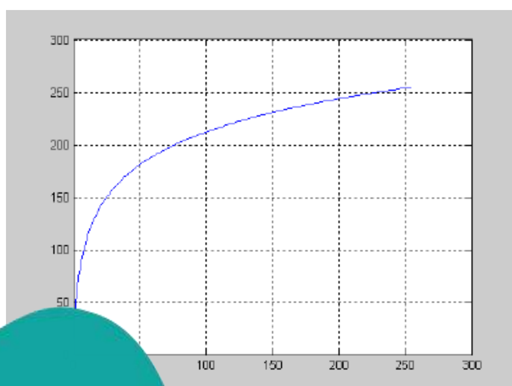
Image Enhancement by Point Processing

Contrast Stretching

a b

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





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

Image Enhancement by Point Processing

- Intensity Transformation

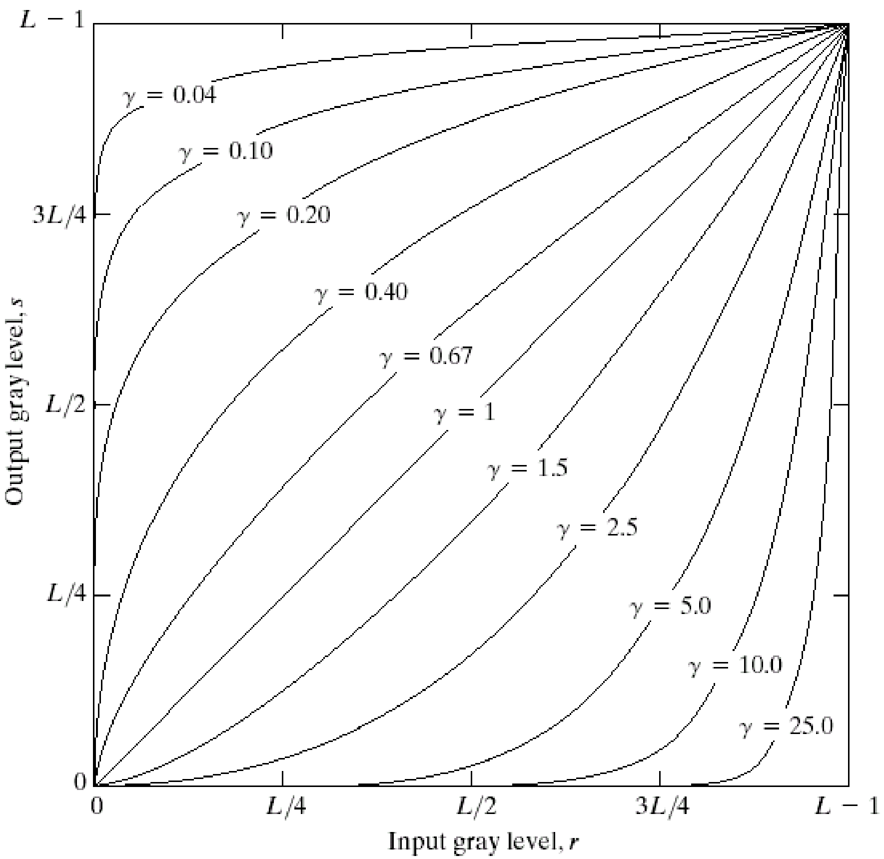
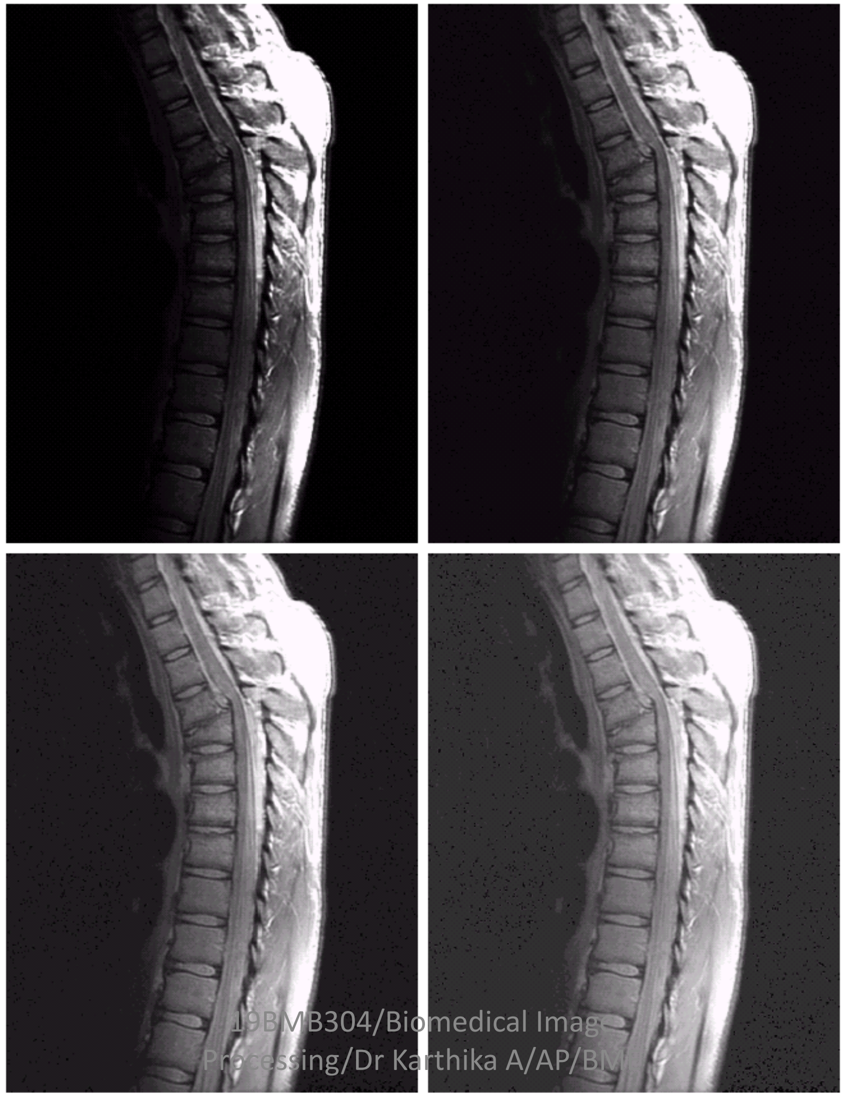


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases).

Image Enhancement by Point Processing

Intensity Transformation



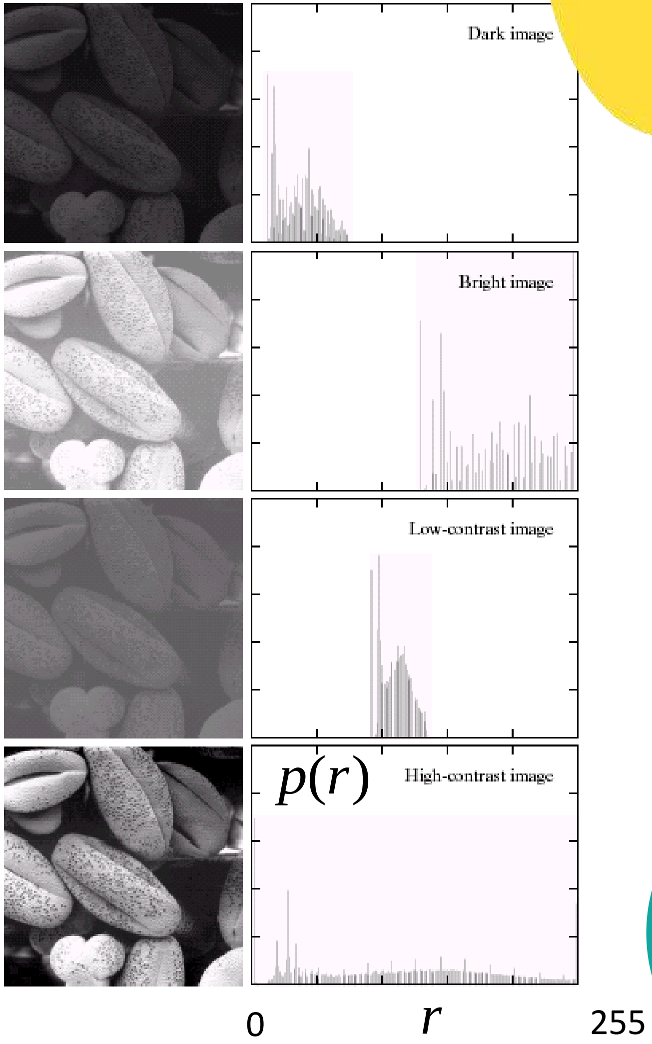
a b
c d

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.)

Image Enhancement by Point Processing

- Histogram

$$p(r) = \left(\frac{\text{Number of pixels with intensity } r}{\text{Total number of pixels}} \right)$$



Histogram Specification

- Intensity mapping

$$s = T(r)$$

- Assume
  - *T(r)* is single-valued and monotonically increasing.
  - $0 \le T(r) \le 1 \text{ and } 0 \le r \le 1$

- The original and transformed intensities can be characterized by their probability density functions (PDFs)

$$p_r(r)$$

$$p_s(s)$$

Histogram Specification

- The relationship between the PDFs is

$$\int p_s(s)ds = \int p_r(r)dr = 1 \qquad p_s(s) = \left[p_r(r)\frac{dr}{ds} \right]_{r=T^{-1}(s)}$$

- Consider the mapping

$$s = T(r) = \int_{w=0}^{r} p_r(w)dw$$ → Cumulative distribution function of *r*

$$\Rightarrow \frac{ds}{dr} = \frac{d}{dr}\int_{w=0}^{r} p_r(w)dw = p_r(r)$$

$$\Rightarrow p_s(s) = \left[p_r(r)\frac{1}{p_r(r)} \right]_{r=T^{-1}(s)} = 1, \qquad 0 \le s \le 1$$ → Histogram equaliz

Image Enhancement by Point Processing

- Histogram Equalization

$$T(r) = round\left(255\frac{\text{Number of pixels with intensity } i \le r}{\text{Total number of pixels}}\right)$$

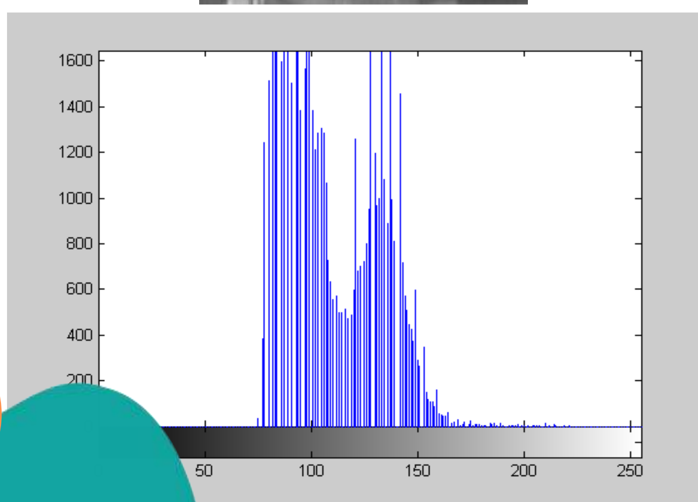
$$= round\left(255\sum_{i=0}^{r}\frac{\text{Number of pixels with intensity } i}{\text{Total number of pixels}}\right)$$

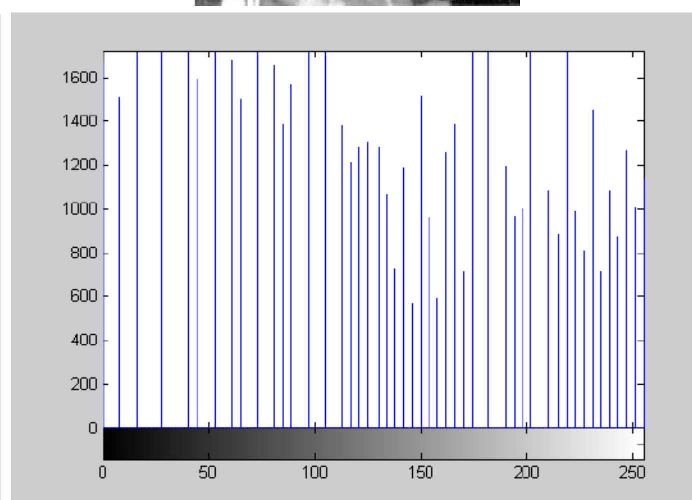
$$= round\left(255\sum_{i=0}^{r} p(i)\right)$$

$$0 \le r \le 255$$

Image Enhancement by Point Processing

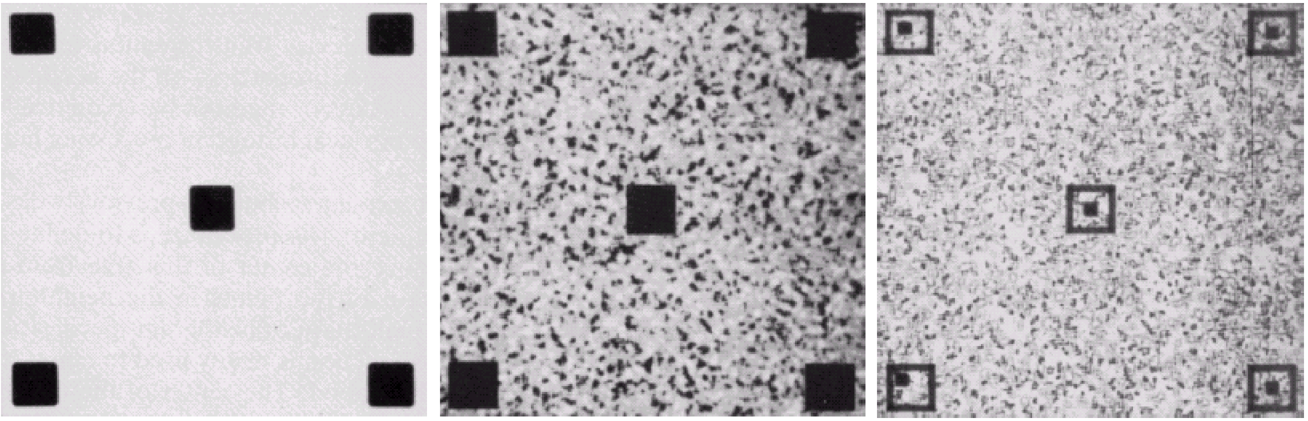
- Histogram Equalization





Local Histogram Processing

- Histogram processing can be applied locally.



a b c

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.

Thank You