# Lecture 4 : Image & Processing

- Lecture 4 : Image & Processing
  - Point Operations
    - Contrast Change: Linear Stretching
    - Contrast Enhancement: Power Law Function
    - Contrast Enhancement: Look up tables (LUT)
    - Contrast Enhancement: Histogram Equalisation
  - Neighbourhood Operation
    - Convolution
    - Noise
      - Noise Reduction: Low Pass Filter (1st principles)
      - Noise Reduction: Low Pass Filter
      - Noise Reduction: Median Filter
    - Filter Operations

Point Operations

- A function is applied to **every pixel**: *Transfer function* $O = T(I)$.

- Operates only on the pixel's **current value**.
  - Thresholding
  - Color correction
  - Change Contrast: through the look up tables

Contrast Change: Linear Stretching
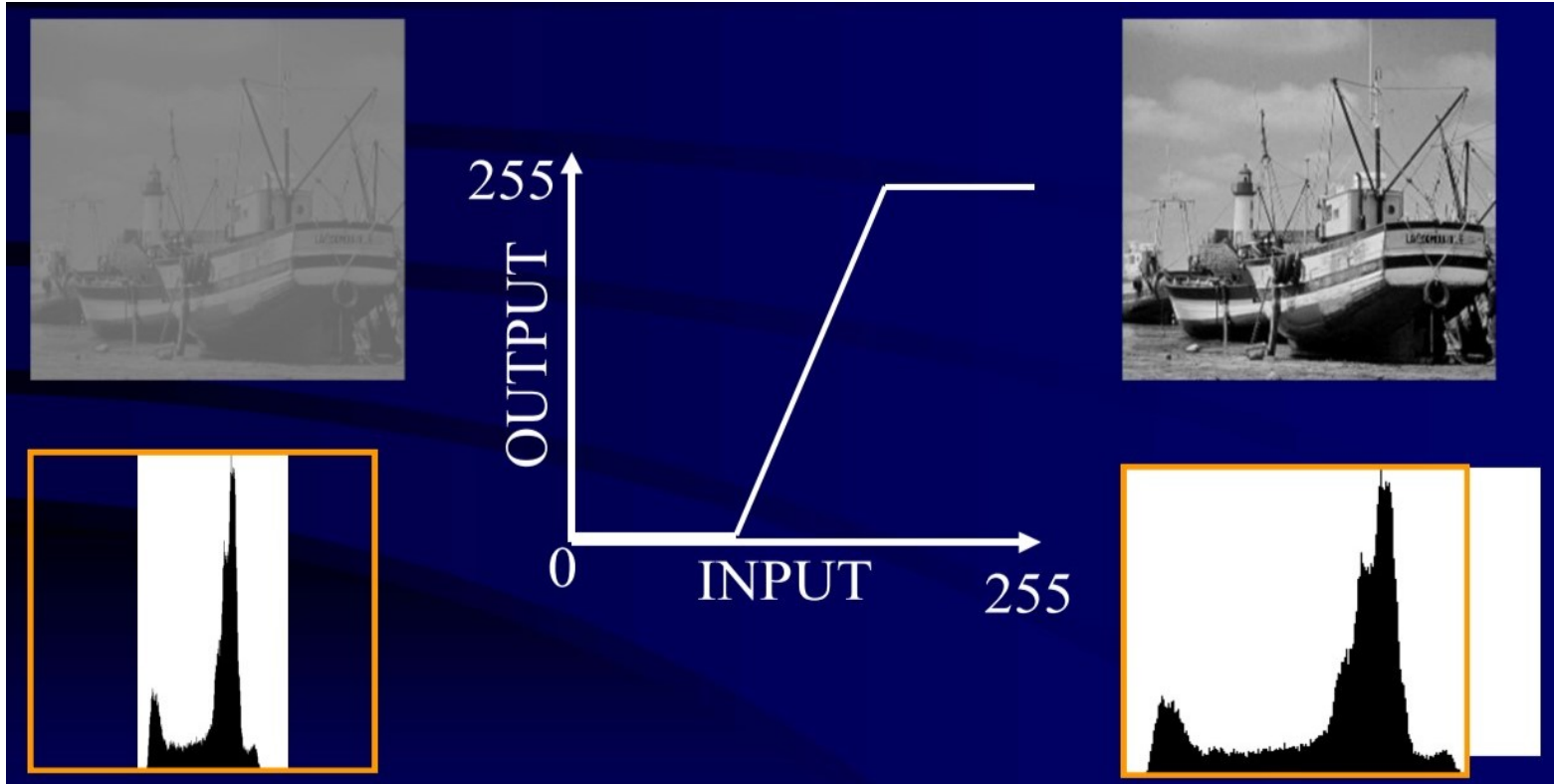
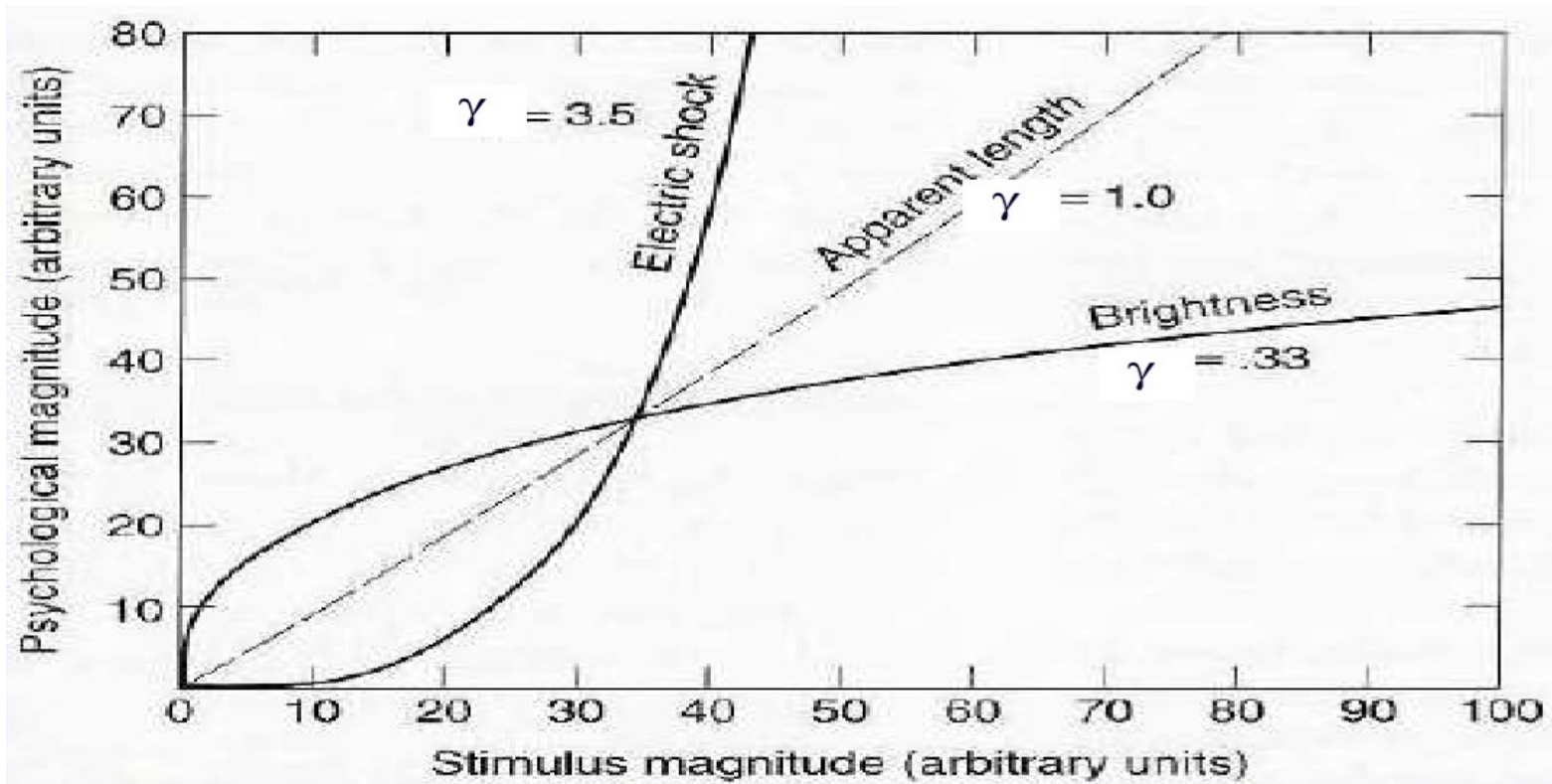# Contrast Enhancement: Power Law Function

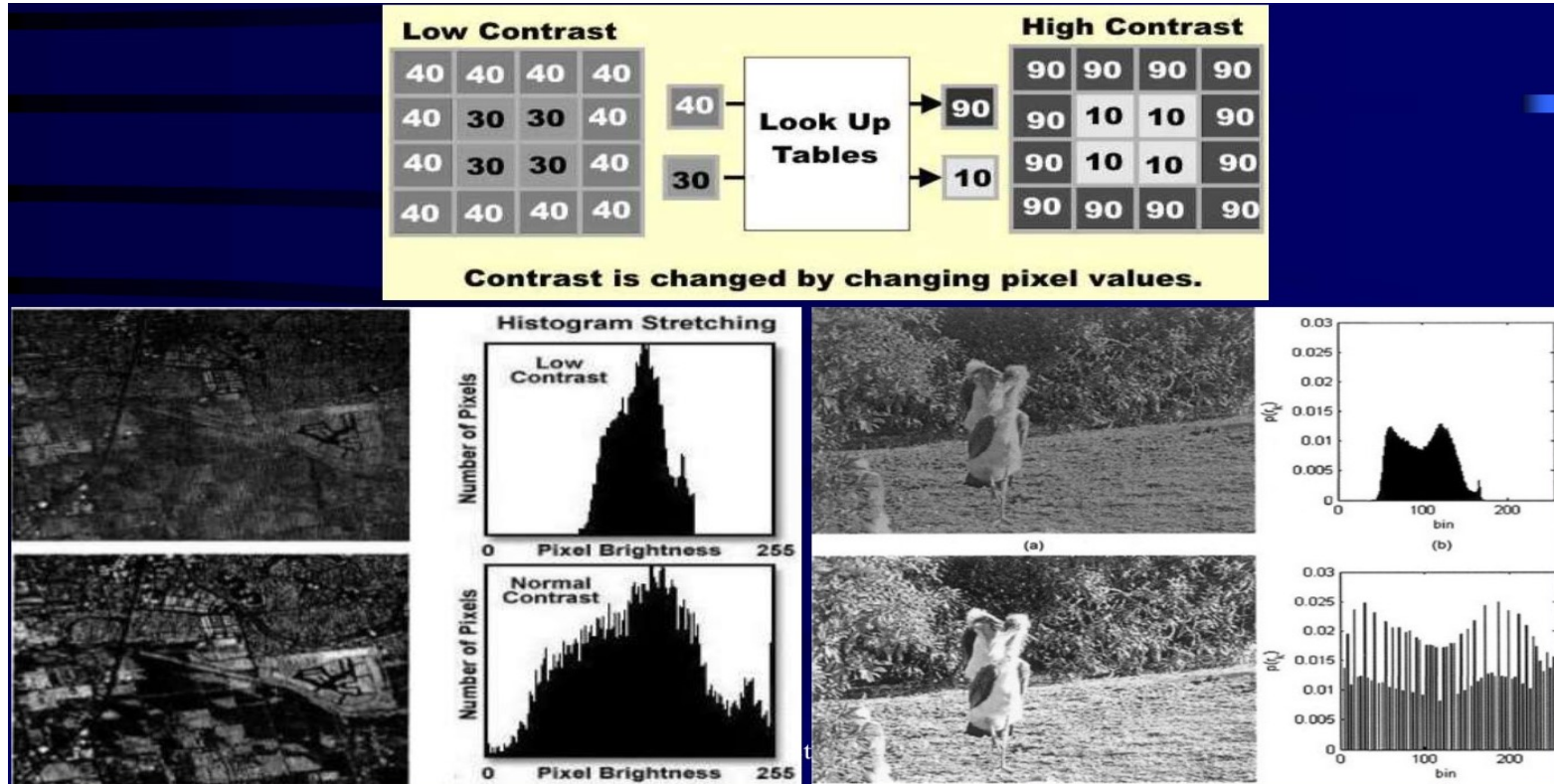$$O = I^\gamma$$

$\gamma < 1$: enhance **contrast** in the **dark** regions.

$\gamma > 1$: enhance **contrast** in the **bright** regions.
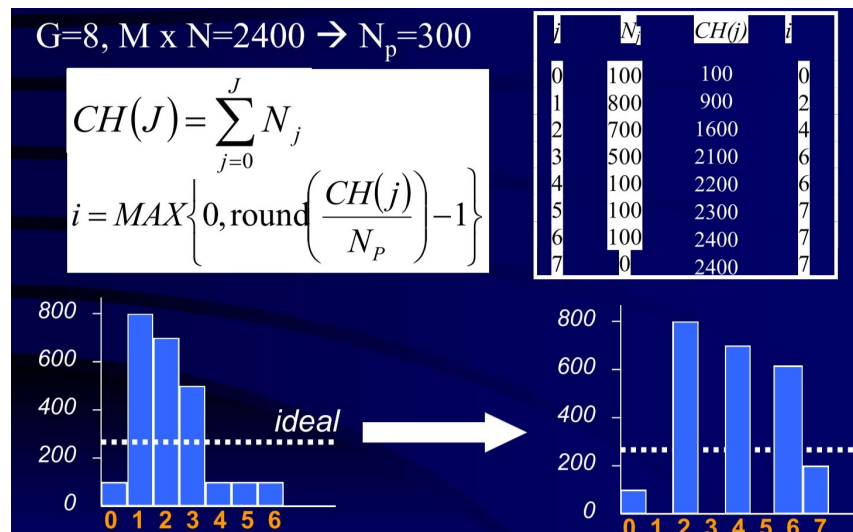
Contrast Enhancement: Look up tables (LUT)

Contrast Enhancement: Histogram Equalisation

- Expand Peak

- Squeeze Plain

- Objective: Flat histogram

$$N_P = \frac{M \times N}{G} \; (M \times N: \text{no. of all pixels; } G: \text{no. of gray levels})$$

$$CH(J) = \sum_{j=0}^{J} N_j$$

$$i = \max\left(0, round(\frac{CH(j)}{N_P} - 1)\right) \; (CH: \text{acommulated } N)$$

Neighbourhood Operation

- Relationships between neighbours determin image features

Convolution

- Mask: every pixel is a weight.
- Weights modify relationships between pixels.
- Convolution size = $(M_1 - M_2 + 1) \ times (N_1 - N_2 + 1)$

Noise

Plot: image brightness.

Noise Reduction: Low Pass Filter (1st principles)

$$C_{i+1} = \frac{A_i + A_{i+1} + A_{i+2}}{3}$$

Noise Reduction: Low Pass Filter

Averaging: Smooth an image

With a convolution:

E.g.

$$\frac{1}{9} \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

Problem: *blurs* the edge.

Noise Reduction: Median Filter

$$C_i = median{A_{i-1} \times B_1, A_i \times B_2, A_{i+1} \times B_3}$$

Filter Operations

1. Low-Pass Filter: smooth an image.

$$\frac{1}{9} \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

Note: the sum = 1.

2. High-Pass Filter: sharpen an image.

$$\begin{pmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{pmatrix}$$

Note: the sum > 0.

3. Sobel Edge Enhancement: Edge extraction (vertical mask & horizontal mask)

$$\begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix}$$

Note: the sum is 0.

4. Laplacian Edge Enhancement: Get all edges.

$$\begin{pmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{pmatrix}$$

Note: the sum is 0.