Image Enhancement

Reading:
Chapter 3 (Spatial domain)
Chapter 4 (Frequency domain)
Image Enhancement

- Basic gray level transformations
- Histogram Modification
- Average and Median Filtering
- Frequency domain operations
- Homomorphic Filtering
- Edge enhancement
Image Enhancement

Input image → Enhancement technique → “Better” image

- Application specific
- No general theory

Spatial domain
- Manipulate pixel intensity directly

Frequency domain
- Modify the Fourier transform
Spatial domain techniques

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

**Simplest case:** Neighbourhood is \((x,y)\)

\[ g(.) \text{ depends only on the value of } f \text{ at } (x,y) \]
Contrast Stretching

Example:

\[ s = T(r) \]

Thresholding

Example of contrast stretching.

There are all point operations hence referred to as point processing.

s, r : Gray levels
Figure 3.3

Some basic gray-level transformation functions used for image enhancement.
**Frequency domain techniques**

\[ g(x,y) = h(x,y) \ast f(x,y) \]

\[ G(u,v) = H(u,v) \cdot F(u,v) \]

\[ g(x,y) = F^{-1} \{ H(u,v) \cdot F(u,v) \} \]

\( h(x,y) \rightarrow \text{Spatial convolution mask} \)

**Convolution Masks** vs **Spatial masks**

- **Convolution Masks**: Involves flipping about origin
- **Spatial masks**: No flipping
Gray level transformations

(a) Negative image: 
Example: \( g(x,y) = 255 - f(x,y) \)
Contrast Stretching

( b ) Contrast stretching

\[ T(r) = \begin{cases} 
    r - r_1 & \text{if } r_1 \leq r \leq r_2 \\
    s_2 - (r - r_2) & \text{if } r_2 < r \leq L-1
\end{cases} \]

- **no change**
  - \( r_1 = s_1 \)
  - \( r_2 = s_2 \)

- **Thresholding at \( r_1 \)**
  - \( r_1 = r_2 \)
  - \( s_1 = 0 \)
  - \( s_2 = L-1 \)
(c) Compressing dynamic range

\[ s = c \log (1 + |r|) \]

\( c \rightarrow \) Scaling factor

Example: Displaying the Fourier Spectrum
Power-Law Transformations

\[ S = cr^\gamma \]

C and \( \gamma \) are positive constants.

Often referred to as “gamma correction”.

CRT –intensity-to-voltage response follows a power function (typical value of gamma in the range 1.5-2.5.)
Gamma correction

\[ \gamma = 1, 0.7, 0.4, 0.1 \]
Gamma correction (cont.)

\( \gamma = 1, 2, 5. \)
Figure 3.6

The figure illustrates the plots of the equation $s = cr^\gamma$ for various values of $\gamma$ ($c = 1$ in all cases). The plots show the relationship between the input gray level $r$ and the output gray level $s$ for different values of $\gamma$. Each curve represents a specific value of $\gamma$, and as $\gamma$ increases, the curve becomes steeper, indicating a greater nonlinear effect on the output.
In Matlab

• Checkout the imadjust function.
  – Adjust image intensity values or colormap

Syntax

J = imadjust(I,[low_in high_in],[low_out high_out],gamma)
newmap = imadjust(map,[low_in high_in],[low_out high_out],gamma)
RGB2 = imadjust(RGB1,...)
Point Processing (contd.)

(d) Gray level slicing (Intensity level slicing)

Highlights only the range \([ A - B ]\)

Preserves other intensities
(e) Bit plane slicing

Highlights contributions made by specific bits
MSB plane: an example

Threshold at 128
Figure 3.13: bit plane slicing

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.)
Figure 3.14: bit planes

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.