Point Processing

CS194: Image Manipulation, Comp. Vision, and Comp. Photo
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Image Formation

\[ f(x,y) = \text{reflectance}(x,y) \times \text{illumination}(x,y) \]

Reflectance in [0,1], illumination in [0,inf]
Problem: Dynamic Range

The real world is High dynamic range
Long Exposure

Real world

10^{-6} \quad \text{High dynamic range} \quad 10^6

Picture

10^{-6} \quad 0 \text{ to } 255 \quad 10^6
Short Exposure

Real world

0 to 255

High dynamic range

Picture

0 to 255
Image Acquisition Pipeline

- Scene radiance ($\text{W} / \text{sr} / \text{m}^2$)
- Sensor irradiance
- Sensor exposure ($\Delta t$)
- Analog voltages
- Digital values
- Pixel values

Lens | Shutter
--- | ---
Sensor irradiance | Sensor exposure

CCD | ADC | Remapping
--- | --- | ---
analog voltages | digital values | pixel values
Simple Point Processing: Enhancement

**FIGURE 3.9**
(a) Aerial image.
(b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0, 4.0, \text{ and } 5.0$, respectively. (Original image for this example courtesy of NASA.)
Power-law transformations

\[ s = cr^\gamma \]
Basic Point Processing

**FIGURE 3.3** Some basic gray-level transformation functions used for image enhancement.
Negative

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

- Dark image
- Bright image
- Low-contrast image
- High-contrast image

Cumulative Histograms

\[ s = T(r) \]

**FIGURE 3.15** Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)
Histogram Equalization

Figure 3.17: (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.
Color Transfer [Reinhard, et al, 2001]

Limitations of Point Processing

Q: What happens if I reshuffle all pixels within the image?

A: It’s histogram won’t change. No point processing will be affected...