Intensity Transformations

Image Processing
CSE 166
Lecture 3
Announcements

• Assignment 1 is due Apr 8, 11:59 PM
• Assignment 2 will be released Apr 8
  – Due Apr 15, 11:59 PM
• Reading
  – Chapter 3: Intensity Transformations and Spatial Filtering
Intensity transformations

Contrast stretching function

Thresholding function
Intensity transformations

Some basic transformation functions
Negative transformation

![Image of mammograms](image.png)

*FIGURE 3.4*

(a) A digital mammogram.
(b) Negative image obtained using Eq. (3-3).
(Image (a) Courtesy of General Electric Medical Systems.)
Gamma transformation

Figure 3.6
Plots of the gamma equation $s = cr^\gamma$ for various values of $\gamma$ ($c = 1$ in all cases). Each curve was scaled independently so that all curves would fit in the same graph. Our interest here is on the shapes of the curves, not on their relative values.
Gamma transformation

Dark image

$\gamma < 1$
Gamma transformation

Light image

$\gamma > 1$

FIGURE 3.9
(a) Aerial image. (b)–(d) Results of applying the transformation in Eq. (3-5) with $\gamma = 3.0, 4.0, \text{ and } 5.0, \text{ respectively.}$
(c = 1 in all cases.) (Original image courtesy of NASA.)
Piecewise-linear transformations

• Contrast stretching
• Intensity-level slicing
• Bit-plane slicing
Contrast stretching

![Graph and images showing contrast stretching](image)

**Figure 3.10**
Contrast stretching.
(a) Piecewise linear transformation function. (b) A low-contrast electron microscope image of pollen, magnified 700 times. (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.)
Intensity-level slicing

**FIGURE 3.11**
(a) This transformation function highlights range \([A, B]\) and reduces all other intensities to a lower level.
(b) This function highlights range \([A, B]\) and leaves other intensities unchanged.

**FIGURE 3.12**
(a) Aortic angiogram. (b) Result of using a slicing transformation of the type illustrated in Fig. 3.11(a), with the range of intensities of interest selected in the upper end of the gray scale. (c) Result of using the transformation in Fig. 3.11(b), with the selected range set near black, so that the grays in the area of the blood vessels and kidneys were preserved. (Original image courtesy of Dr. Thomas R. Gest, University of Michigan Medical School.)
Bit-plane slicing

**FIGURE 3.13**
Bit-planes of an 8-bit image.

**FIGURE 3.14**
(a) An 8-bit grayscale image of size 837 × 988 pixels.
(b) through (i) Bit planes 8 through 1, respectively, where plane 1 contains the least significant bit. Each bit plane is a binary image. Figure (a) is an SEM image of a trophozoite that causes a disease called *giardiasis*. (Courtesy of Dr. Stan Erlandsen, U.S. Center for Disease Control and Prevention.)
Bit-plane slicing

**Figure 3.15**
Image reconstructed from bit planes:
(a) 8 and 7;
(b) 8, 7, and 6;
(c) 8, 7, 6, and 5.

**Figure 3.14**
(a) An 8-bit grayscale image of size $837 \times 988$ pixels.
(b) through (i) Bit planes 8 through 1, respectively, where plane 1 contains the least significant bit. Each bit plane is a binary image. Figure (a) is an SEM image of a trophozoite that causes a disease called *giardiasis.* (Courtesy of Dr. Stan Erlandsen, U.S. Center for Disease Control and Prevention.)
Histogram

FIGURE 3.16 Four image types and their corresponding histograms. (a) dark; (b) light; (c) low contrast; (d) high contrast. The horizontal axis of the histograms are values of $r_k$ and the vertical axis are values of $p(r_k)$.

Similar to probability density function (pdf)
Histogram equalization

FIGURE 3.18 (a) An arbitrary PDF. (b) Result of applying Eq. (3-11) to the input PDF. The resulting PDF is always uniform, independently of the shape of the input.
Histogram equalization

\[ s_k = T(r_k) = (L - 1) \sum_{j=0}^{k} p_r(r_j) \quad k = 0, 1, 2, \ldots, L - 1 \]

**FIGURE 3.20** Left column: Images from Fig. 3.16. Center column: Corresponding histogram-equalized images. Right column: histograms of the images in the center column (compare with the histograms in Fig. 3.16).
Histogram equalization

FIGURE 3.22
(a) Image from Phoenix Lander.
(b) Result of histogram equalization.
(c) Histogram of image (a).
(d) Histogram of image (b).
(Original image courtesy of NASA.)
Histogram matching

FIGURE 3.26
Histogram specification.
(a) Specified histogram.
(b) Transformation \( G(z_q) \), labeled (1), and \( G^{-1}(s_k) \), labeled (2).
(c) Result of histogram specification.
(d) Histogram of image (c).
Local histogram equalization

FIGURE 3.32
(a) Original image. (b) Result of global histogram equalization.
(c) Result of local histogram equalization.
Next Lecture

• Spatial filtering
• Reading
  – Chapter 3: Intensity Transformations and Spatial Filtering