Assignments/Announcements

- Lab #2 due today by 11:59 pm through CatCourses.
- HW #3 due Mon. Oct. 15 by 11:59 pm through CatCourses.
- Lab #3 assigned, due Mon. Oct. 22 by 11:59 pm through CatCourses.
- Midterm exam will be on Wed. Nov. 7 during lecture.
  - More details closer to the time.
- Xueqing will not have office hours tomorrow, Tues. Oct. 9.
Questions?
Today

• Chap. 3: Intensity Filtering and Spatial Filtering
  – Some basic intensity transformation functions
  – Histogram processing
CSE107
Chapter 3: Intensity Transformations and Spatial Filtering
Chap 3: Intensity transformations and spatial filtering

- Two principle categories of spatial domain processing
  1. Intensity transformations
     - Operate on a single pixel
     - Usually for contrast manipulation and thresholding
  2. Spatial filtering
     - Operates in a neighborhood of every pixel
     - Image sharpening, smoothing, edge enhancement
Chap 3: Intensity transformations and spatial filtering

• Spatial domain processing

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

where \( f(x,y) \) is the input image, \( g(x,y) \) is the output image and \( T \) is an operator on \( f \) defined over a neighborhood of point \((x,y)\)

• Neighborhood can be any shape but is typically rectangular and much smaller than the image
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• Spatial domain processing

\[ g(x, y) = T[f(x, y)] \]
Chap 3: Intensity transformations and spatial filtering

• Spatial filtering
• Neighborhood operation is called
  – Spatial filter
  – Spatial mask
  – Kernel
  – Template
  – Window
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• We will first deal with case when neighborhood is a single pixel = intensity transformation
  – Image negative
  – Thresholding
  – Log transformations
  – Piecewise-linear transformations
    • Contrast stretching
    • Intensity-level slicing
    • Bit-plane slicing
  – Histogram processing
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- Intensity transformation
- Drop \((x,y): s = T(r)\)
- Examples
Chap 3: Intensity transformations and spatial filtering

- Can utilize different families of functions for intensity transformations

**FIGURE 3.3** Some basic intensity transformation functions. All curves were scaled to fit in the range shown.
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• Image negative: \[ s = L - 1 - r \]

• Useful for enhancing (for visualization) white or gray detail embedded in dark regions of an image especially when the black areas are dominant in size

**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.)
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- Log transformations: $s = c \log(1 + r)$
- Maps a narrow range of low intensity values in the input to a wider range of output levels
- Expands the values of dark pixels in an image while compressing the higher-level values
- Useful when range of pixel values is large (example $\sim 10^6$) but most values are small
  - Such an image would be mostly dark—wouldn’t be able to see detail in dark areas
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• Log transformations: \( s = c \log(1 + r) \)
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• Piecewise linear transformation functions

• Advantages
  – Unlike log, inverse log, etc., can be arbitrarily complex

• Disadvantage
  – Require more user input (for parameter selection)
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- Piecewise linear transformation functions
- Contrast stretching
- Let

\[(r_1, s_1) = (r_{\text{min}}, 0) \text{ and } (r_2, s_2) = (r_{\text{max}}, L-1)\]

where \(r_{\text{min}}\) and \(r_{\text{max}}\) denote the minimum and maximum intensity in the image

- Stretches the levels linearly from their original range to the full range \([0, L-1]\)
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• Contrast stretching example

• $r_{min} = 84$ and $r_{max} = 152$
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- Histogram processing
- The **histogram** of a digital image with intensity levels in the range \([0, L-1]\) is a discrete function

\[
h(r_k) = n_k
\]

where \(r_k\) is the \(k\)th intensity value and \(n_k\) is the number of pixel values in the image with intensity \(r_k\).
• Usually normalize a histogram by dividing each of its components by the number of pixels in the image, $MN$

• A normalized histogram is thus given by

$$p(r_k) = \frac{n_k}{MN} \quad \text{for } k = 0, 1, \ldots, L-1$$

• Loosely speaking, $p(r_k)$ is an estimate of the probability of occurrence of intensity level $r_k$ in an image
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• Histogram based analysis is good for
  – Enhancement
  – Compression
  – Segmentation

• Histograms are simple to calculate in software and lend themselves to economic hardware implementations, thus making them a popular tool for real-time image processing

• Let’s look at some examples
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