CS 376A
Digital Image Processing

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Today's Topics

- Questions / Comments?
- Color image processing
  - Finish discussion of Fixing tonal problem
  - Histograms

Color Image Processing

- Tonal problems
  - Image can be overexposed (too light)
  - Image can be underexposed (too dark)
  - Image can be flat
  - Let's see examples of these kinds of images and corrected versions and the mapping functions from color channel in original image to color channel in output image
  - The same mapping function will be applied to each channel (R, G and B)

Color Image Processing

- 0-1 (decimal) range to 0-255 (integer)
  - notice some examples:
    - $0 \rightarrow 0$
    - $0.25 \rightarrow 63$
    - $0.5 \rightarrow 127$
    - $1 \rightarrow 255$
- 0-255 (integer) range to 0-1 (decimal)
    - $0 \rightarrow 0$
    - $63 \rightarrow 0.25$
    - $127 \rightarrow 0.5$
    - $255 \rightarrow 1$

Color Image Processing

- Image manipulation programs (like gimp) have an interactive window to allow you to change the curve and see the results.
- Let's bring up one of those dark images and one of the too light images and experiment a bit with the curves and results (Colors → Curves...)

Color Image Processing

- What would the mappings for slicing look like?
  - Intensity slicing → pseudocolor
  - Example we did with keeping green ...

Color Image Processing

- Notice that the mappings that we just discussed were independent of the specific image data. That is, those mappings were defined, independent of any specific image.
- Suppose we wanted to have a mapping be based on the content of an image
  - mapping would be tailored to the content of an image instead of some standard mapping
- Has anyone heard of a histogram? What's a histogram?

Color Image Processing

- A histogram contains discrete bins across the x-axis and a frequency (or proportion of total frequencies) for each bin on y-axis
- In the case of images
  - bins are individual (or ranges of) intensity values, or ranges of color values
  - and the frequencies are how many pixels (or proportion of all pixels) correspond to that bin

Color Image Processing

- Histograms are a way to describe the global intensity (or color) content of an image.
- Note well --- a histogram ignores where pixels are in the image
  - very different images can have same histogram
  - Let's consider some images that might be different looking but have same histogram
- Let's look at an image in gimp and do (Colors → Info → Histogram) to examine histograms of each color channel and the intensity histogram.

Histograms

- The histograms we just looked at all had 1 intensity per bin.
- We could create a histogram of say 4 bins for a grayscale image
  - if we wanted each bin to be the same "width" the bins would group the following intensities together:
    - 0-63
    - 64-127
    - 128-191
    - 192-255
  - notice each of the four bins represent a different range of 64 intensities
  - what would be stored in each of those bins?
  - For example what would the height of histogram for the first bin represent?

Histograms

- For contrast enhancement via histogram equalization
  - we want to stretch the intensities to use a wider range (ideally all) of available intensities
  - should have approx. the same number of pixels per intensity (approx. a uniform distribution)
- Create a mapping from input intensity to output intensity based on the histogram (which tells us how frequent each intensity occurred in the input image).
- So, first we'll create a histogram of intensities (1 intensity per bin)

Histograms

- For our output, since we should have approx. the same number of pixels per intensity and we want the range of intensities to be as large as possible, then we'd like to roughly have the same number of pixels in each output intensity.
- But this will not be perfect because all pixels that have the same input intensity must be mapped to the same output intensity
  - some input intensities will have more than #pixels / 256 in their histogram bin

Histograms

- Histogram equalization
  - compute histogram, h, of image intensities
  - from that histogram h, create a cumulative histogram, ch, defined to be
    - ch[i] = sum $_{j=0 \text{ to } i}$ of all h[j]'s
  - ch_{min} = lowest non-zero ch[i]
  - then mapping from input intensities (in) to output intensities is:

$$out(in) = 255 * (ch[in] - ch_{min}) / (numberOfpixels - 1)$$