CSE166 – Image Processing – Midterm

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`http://www-cse.ucsd.edu/classes/fa06/cse166`

11:00am-12:20pm Tuesday Oct. 31, 2006.

On this exam you are allowed to use a calculator and one 8.5" by 11" sheet of notes. The total number of points possible is 30. In order to get full credit you must **show all your work**. Good luck!

1. (7 pts) Consider the 1D continuous kernel $h(x) = e^{-x^2/2\sigma^2}$.
   (a) Give the name of this kernel.
   (b) What type of filter is $h(x)$: lowpass, bandpass, or highpass?
   (c) Sketch $h(x)$ and its Fourier transform $H(u)$ for $\sigma = 0.5$. Repeat for $\sigma = 2$. Label the axes in each of your four plots.
   (d) Suppose we want to convert this filter into a real, even-symmetric bandpass filter with a passband centered around $u = \pm u_o$. What would we multiply $h(x)$ by in the spatial domain to achieve this effect? What is the name of the resulting filter?

2. (7 pts) Suppose you are given an image $f(x, y)$ and you produce a new image $g(x, y)$ by subtracting $f(x, y)$ from a copy of itself shifted two pixels to the right.
   (a) Is this operation on f linear? Is it shift invariant?
   (b) Writing this operation in the form $g = f * h$, what choice of h will produce the desired g?
   (c) Let f represent an image of a white disk on a black background. Sketch f and $\|g\|$.

3. (8 pts) Let `W=dftmtx(4)`.
   (a) Explain in words what each column of `W` represents.
   (b) Write down the result of the operation `(1/4)*W*W'`. What property of `W` does this illustrate?

4. (8 pts) Recall that the chi-squared distance between a pair of K-bin histograms $h_i(k)$ and $h_j(k)$ is given by:
$$\chi^2(i, j) = \frac{1}{2} \sum_{k=1}^{K} \frac{[h_i(k) - h_j(k)]^2}{h_i(k) + h_j(k)}$$
   (a) For the use of this distance to be valid, what two conditions must each histogram satisfy?
   (b) What is the chi-squared distance between two identical histograms? Show that $\chi^2(i, j)$ cannot be smaller than this value.
   (c) What is the largest possible chi-squared distance between two histograms? Show that $\chi^2(i, j)$ cannot exceed this value.