CSE166 – Image Processing – Midterm

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`http://www-cse.ucsd.edu/classes/fa09/cse166`

11:00am-12:20pm Tuesday Nov. 3, 2009.

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. (5 pts) Consider the system $g(x) = \frac{1}{2} f(x) f(x-1)$.
   (a) Is this system linear? If it is linear, what is the impulse response?
   (b) Is this system shift invariant?
2. (10 pts) Let `W=dftmtx(8)`, as defined in Matlab.
   (a) Explain in words what each column of `W` represents.
   (b) Write down the result of the operation `(1/8)*W*W'`. What property of `W` does this illustrate?
   (c) What is the result of the operation `W*f` for an arbitrary column vector `f` of length 8?
   (d) How many multiplies and adds are required for the computation in part (c)? Briefly explain how this operation can be made more efficient.
3. (5 pts) Consider the kernel $h(x,y) = \nabla^2 g(x,y)$, where $g(x,y) = e^{-(x^2+y^2)/2\sigma^2}$.
   (a) What is the name of this kernel?
   (b) Which kind of filter is $h(x,y)$: lowpass, bandpass, or highpass?
   (c) What is the average value of any image convolved with $h(x,y)$?
   (d) What is the primary practical application of this kernel?
4. (10 pts) Let $h_i(k)$ and $h_j(k)$ denote two normalized histograms.
   (a) Write down the definition of the chi-squared distance $\chi^2(i,j)$ between $h_i(k)$ and $h_j(k)$.
   (b) What advantage does the chi-squared distance have over the squared Euclidean distance?
   (c) What is the chi-squared distance between two identical histograms? Show that $\chi^2(i,j)$ cannot be smaller than this value.
   (d) What is the largest possible chi-squared distance between two histograms? Show that $\chi^2(i,j)$ cannot exceed this value.