

CSE166 – Image Processing – Midterm

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<http://www-cse.ucsd.edu/classes/fa11/cse166-a>

12:00-12:50pm Friday Oct. 28, 2011.

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!

- (10 pts) In this problem, $b_N(x)$ denotes the 1D binomial kernel of length N .
 - Write down a one-line Matlab command to calculate $b_N(x)$ for arbitrary N .
 - What is $b_5(x)$?
 - Suppose you want to filter a 2D image with a 9×9 binomial kernel, but the only kernel you have available is $b_5(x)$. Explain how to do this. Use sketches and/or pseudocode to illustrate your answer.
 - What continuous function $h_\sigma(x)$ does $b_N(x)$ approach as $N \rightarrow \infty$? Give the relationship between N and σ .
- (4 pts) Consider the 3-tap filtering operation $g(x) = \frac{1}{4}[f(x-1) - 2f(x) + f(x+1)]$.
 - Expressing this as a convolution $g(x) = f(x) * h(x)$, what are the coefficients of $h(x)$?
 - What is the special name for this filtering operation?
 - You can achieve the same result via iterated convolution with a 2-tap filter. What is that filter?
- (6 pts) Consider the $M \times N$ image $f(x, y) = (-1)^x$ for $x = 0, \dots, N-1$ and $y = 0, \dots, M-1$.
 - Describe what $f(x, y)$ looks like as an image.
 - Put $f(x, y)$ into the form $e^{j2\pi \mathbf{u}_o \cdot \mathbf{x}}$, where $\mathbf{x} = (x, y)^\top$ and $\mathbf{u}_o = (u_o, v_o)^\top$.
 - What is the Fourier transform $F(u, v)$? Write it down for the case of $M = N = 4$.
- (10 pts) Consider the 1D continuous kernel $h(x) = e^{-x^2/2\sigma^2}$.
 - Give the name of this kernel and write the expression for its Fourier transform $H(u)$.
 - Sketch $h(x)$ and $H(u)$ for two cases: large σ and small σ .
 - Calculate $g(x) = \frac{dh(x)}{dx}$ and its Fourier transform $G(u)$.
 - Sketch $g(x)$ and $G(u)$ for two cases: large σ and small σ .