CSE166 – Image Processing – Homework #3
Instructor: Prof. Serge Belongie
`http://www-cse.ucsd.edu/~sjb/classes/fa02/cse166`
Due (in class) 3:00pm Wed. Oct. 23, 2002.

Reading

- GW 4.3-4.4, 4.6.

Written exercises

1. GW, Problem 4.2.
2. GW, Problem 4.7.
3. GW, Problem 4.8.
4. GW, Problem 4.10.
5. GW, Problem 4.15.
6. GW, Problem 4.18.

Matlab exercises

1. Filtered Noise

   (a) Consider the filter with Fourier transform

   $$H(u, v) = \frac{1}{u^2 + v^2}$$

   on the interval $[-127, 128] \times [-127, 128]$. This is known as a $1/f^2$ transfer function. Since it blows up at the origin, replace that value with zero. Apply this filter to a 256×256 image of normally distributed random noise (use `randn`). For practical reasons, it is best to perform this operation in the frequency domain. Hint: you will need to use `meshgrid`, `fft2`, `ifft2`, and `fftshift`. Also, due to numerical error, you will need to use `real` to look at the real part of the filtered image in the spatial domain.

   (b) Display the filtered image along with the original noise image. Quite remarkably, the filtered image should look like a "natural" texture, such as clouds or terrain. What does this suggest about the statistics of natural images vs. that of images of manmade objects (e.g. skyscrapers)?

   Things to turn in:

   - Code listing for part 1a.
   - Printout and written answer for part 1b.

2. Filtering in the Frequency Domain

   Before doing this exercise, review GW Sections 4.6.3 and 4.6.4 to learn about frequency domain filtering, zero-padding, and the relationship between correlation and convolution.

   (a) Write an m-file to reproduce Figure 4.41(a-f) using Frequency domain filtering. Note: the Matlab command for the complex conjugate is `conj`.

   (b) Repeat the previous step using operations in the spatial domain and show that the results are the same. Hint: use `conv2` and `rot90`.

Things to turn in:

- Code listing for parts 2a and 2b.
- Printouts of program output for parts 2a and 2b.

3. Properties of the DFT Matrix

   Before starting this problem, study the function `dftmtx` and how it can be used (albeit inefficiently) to compute the DFT.

   Note: a circulant matrix is an $n \times n$ matrix whose rows (or columns) are cyclically shifted copies of a fixed length n vector.

   (a) Create an 8×8 circulant matrix of your choice, e.g. `c=[1:8]` and `C=gallery('circul',c)'`. Demonstrate that the DFT matrix diagonalizes this matrix by computing and inspecting `L=W*C*W'`, where `W=dftmtx(8)`.

   (b) Explain the significance of the entries on the diagonal of `(1/8)*L` with respect to the entries in `c`. Hint: appeal to the shifting/modulation properties of the DFT.

   Things to turn in:

   - Code listing and program output for part 3a.
   - Written answer for part 3b.