

CEG4311

Computer Experiment (Lab) #1

Plotting & Spatial Filtering of Images

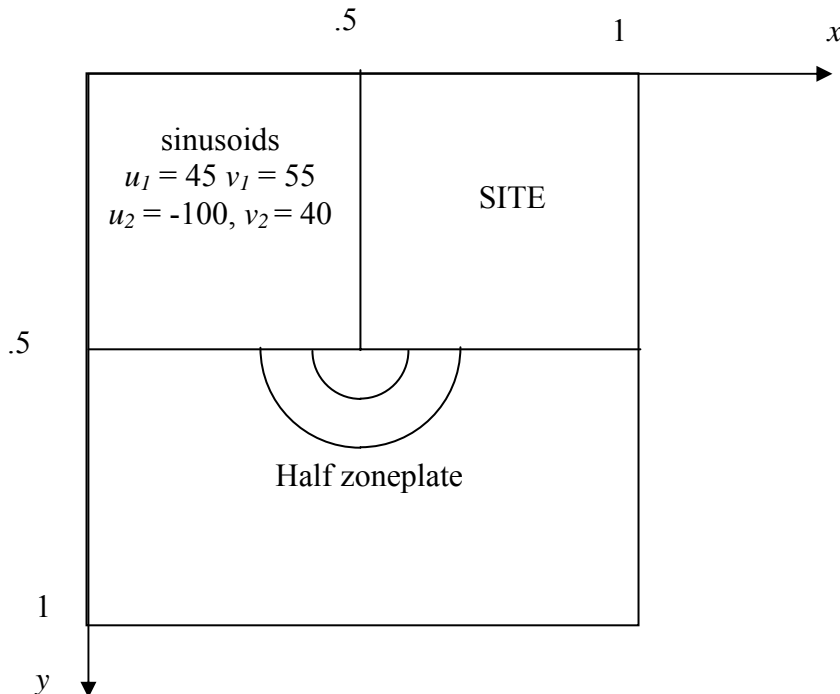
Due date: Your report is due by *midnight October 14, 2007*, submitted electronically (details to follow). Results will be demonstrated to the TA during the lab periods on September 26, October 3 and October 10 as you complete different parts. Attendance is mandatory and will be recorded.

Objectives:

1. Read, write and display images in MATLAB
2. Compute and display the frequency response of 2D filters
3. Filter images with various FIR filters and observe the effects.

Procedure:

A. Create and display a square image (1 ph by 1 ph) consisting of 512 by 512 samples as follows.



This image can be defined mathematically in continuous space as below. This is simply *notation* and *cannot* be used in MATLAB! You should create three images A, B, C and mosaic them as $Z = [A \ B; \ C]$.

$$f_1(x, y) = (0.5 + 0.4 \cos(\pi(x^2 + y^2)/r^2)) \text{rect}(x, 2y - 0.5), \quad r^2 = 1/450$$

$$f_2(x, y) = \text{SITE}(2x, 2y)$$

$$f_3(x, y) = (0.5 + 0.2 \cos(2\pi(45x + 55y))) + 0.2 \cos(2\pi(-100x + 40y)) \text{rect}(2x - 0.5, 2y - 0.5)$$

$$\vec{f} = T_{(.5,.5)} \vec{f}_1 + T_{(.5,0)} \vec{f}_2 + \vec{f}_3$$

where T is the shift operator. The original continuous space SITE image is non-zero for $0 \leq x, y \leq 1.0$. You are given a 256×256 version on the web page that you can *use as is* (B above).

Save the test image as a TIFF file, and make sure you can display the saved image. Note: It may be necessary to set the monitor resolution to 1024 x 768 using the Display Properties control panel, Settings tab in Windows to get a suitable rendition of the zone plate without spurious stripes that may appear at higher display resolution.

B. For each of the 2D finite-impulse-response (FIR) filters in the following list, compute and display the *frequency response* using the MATLAB function `freqz2`. Generate both perspective (mesh) plots and contour plots, where contours are spaced by 0.1 (unless you think some other spacing is more informative). Label the frequency axes in cycles per picture height (c/ph) with the v -axis pointing down. Assume a square lattice with $X = (1/512)\text{ph}$. **Only include in your report those plots and images that are explicitly requested, and answer any specific questions.** However, in your report, give a *qualitative* description of *each* frequency response and comment on any distinctive features. Be prepared to show *any* frequency response in the lab demos. Filter the test image of part A with each filter described below and relate the changes you see in the filtered image to the form of the filter's frequency response. Use the 2D convolution function `conv2` in MATLAB to convolve the image with each of the filter unit sample responses, to create a new 512×512 image, using the option 'same'. Note that some filters remove the DC component and you have to add an offset (say 0.5) to be able to view the image correctly.

1. Moving average filter: $h[n_1X, n_2X] = 1/25, -2 \leq n_1, n_2 \leq 2; 0$ otherwise.

2. Separable filters: Let

$$h_1 = [1 \ 10 \ 45 \ 120 \ 210 \ 252 \ 210 \ 120 \ 45 \ 10 \ 1]/1024 \quad \text{and}$$

$$h_2 = [-3 \ 0 \ 25 \ 0 \ -150 \ 256 \ -150 \ 0 \ 25 \ 0 \ -3]/512$$

be two 1D filters defined for $-5 \leq n \leq 5$. Consider the four separable filters $h_1[n_1X]h_1[n_2X]$, $h_1[n_1X]h_2[n_2X]$, $h_2[n_1X]h_1[n_2X]$ and $h_2[n_1X]h_2[n_2X]$. For this question, generate the 11×11 two-dimensional unit-sample response, and then ignore separability in the filtering (but see 5. below). Include the contour and mesh plots of $h_1[n_1X]h_1[n_2X]$ and $h_2[n_1X]h_1[n_2X]$, and the filtered images in your report.

3. Gaussian filters: $h[n_1X, n_2X] = c_i \exp(-(n_1^2 + n_2^2)/2r_i^2)$, $-9 \leq n_1, n_2 \leq 9$, for the values $r_1 = 1.25$ and $r_2 = 3.75$. For each value of r_i , determine the value of c_i that gives a DC gain of $H(0, 0) = 1.0$. Include the contour and mesh plots of the second Gaussian filter with $r_2 = 3.75$ in your report.

4. Gabor filter: $h[n_1X, n_2X] = \delta[n_1, n_2] - 2c_2 \exp(-(n_1^2 + n_2^2)/2r_2^2) \cos(2\pi(u_2n_1 + v_2n_2)/512)$

where $u_2 = -100$ c/ph and $v_2 = 40$ c/ph, and r_2 and c_2 are as in item 3. Also, filter the corrupted image `SITEPlusNoise` from the course web page and explain what happens. Include a contour plot of the filter response in your report, as well as the original and filtered `SITEPlusNoise` images.

5. For the first separable Gaussian filter of item 3, see if it is any faster to first filter with the horizontal filter and then the vertical filter, by using `conv2` twice. Also try the separable mode of `conv2`. Use MATLAB's timing functions `tic` and `toc` to check.

For the lab demos, you will be asked to demonstrate the above eight filters by showing the frequency response plots, as well as the original and filtered image. Show these to the TA as soon as you are satisfied with the result.

Your report should be submitted electronically using a method to be described on the course web page. It should be prepared using a good text processing system and submitted in PDF or MSWord format. Pay attention to the quality of the images pasted in the report.

For more information, read sections in the MATLAB Image Processing Toolbox User's Guide on image formats, reading and writing images and on image filtering (Chapter 2, 3, 8) and associated function descriptions in Chapter 16, or equivalent info from the `html` version.

Some of the MATLAB functions that you *may* require or that *may* be useful: `imread`, `imwrite`, `imshow`, `imfinfo`, `im2double`, `uint8`, `ones`, `freqz2`, `conv2`, `tic`, `toc`, `input`.