University of California, Berkeley
College of Engineering
Department of Electrical Engineering and Computer Sciences

Prof. A. Zakhor Spring 2008

EE225b – Digital Image Processing
Assignment #4 – 2D-FIR filter design

J. S. Lim, Two-Dimensional Signal and Image Processing
Problem 4.12, 4.14, 4.15, 4.16, 4.17, 4.20

Overview:

The filter which appears in problem 4.14, is an ideal directional fan filter. In this assignment, you will design a practical 2D-FIR filter which implements the ideal fan filter using the transformation method.

Assignment specifics:

To implement the ideal fan filter using an FIR filter, we first need to define some specifications $\boldsymbol{\omega}_p$, $\boldsymbol{\omega}_s$, $\delta_p = 0.1$, $\delta_s = 0.1$.

$$\boldsymbol{\omega}_p = (\omega_1 \geq 0, \omega_2 \geq 0) \text{ or } (\omega_1 \leq 0, \omega_2 \leq 0)$$

$$\boldsymbol{\omega}_s = (-0.8\pi \leq \omega_1 \leq -0.2\pi, 0.2\pi \leq \omega_2 \leq 0.8\pi) \text{ or } (0.2\pi \leq \omega_1 \leq 0.8\pi, -0.8\pi \leq \omega_2 \leq -0.2\pi)$$

Design a 2D-FIR filter which meets or exceeds these requirements. Problem 4.14 covers the design of $t(n_1,n_2)$. Plot the pass band and stop band contours, as well as the constant value contours of $T(\omega_1,\omega_2)$. Translate the specifications given here to the specifications of a 1D filter. Compute the Parks-McClellan optimal filter design to create a 1D Type I filter (odd, symmetric) $h(n)$ which meets these specifications. Use the transformation method to compute the 2D-FIR filter which implements the ideal fan filter. How large is the resulting filter? Make a 3D plot of the frequency response. Apply it to the image `Turtle.bmp` available from the class website. Save the resulting image as `Result.bmp`. What does this filter do?

Using the window method (Hamming window), design a 2D-FIR filter which also implements the ideal fan filter, with the same support as the filter you obtained previously. Make a 3D-plot of the frequency response and compare it to response of the transformation-method filter. Are the specifications met? If not, how large a filter do you need before the specifications are met? Make a few statements about the effectiveness of this approach.

Using the frequency sampling method, design a 2D-FIR filter which also implements the ideal fan filter, with the same support as the other two filters. Make a 3D-plot of the frequency response and compare it to the response of the other two filters. Are the specifications met? If not, how large a filter do you need before the specifications are met? Make a few statements about the effectiveness of this approach.

Please submit a written lab writeup, including the 3D-plots, on the due date. Also please submit all your `.m` files and `Result.bmp` via email to zhanghao8301@gmail.com. Email submissions must be received before class on the due date. There should be an executable Matlab script `Lab6.m` which will generate all your results.

Here are some helpful Matlab commands:

`remez`	Parks-McClellan algorithm
`remezord`	Parks-McClellan optimal FIR filter order estimation
`ftrans2`	2D-filter design using transformation method
`fwind1`	2D-filter design using the window method
`fsamp2`	2D-filter design using the frequency sampling method
`freqz2`	Computes the frequency response of a filter (equivalent to padding + circshift + fft2), can be used to make 3D plots of the frequency response
`freqspace`	Creates a mesh of frequency values f1, f2
`contour`	Contour plots
`colorbar`	Color bar to illustrate contour plots
`clabel`	Labels the constant value contours in the plot