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

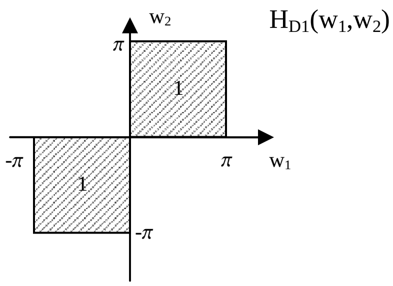
Prof. A. Zakhor Spring 2006

# EE225b – Digital Image Processing
## Assignment #6 – 2D-FIR Fan Filters Design

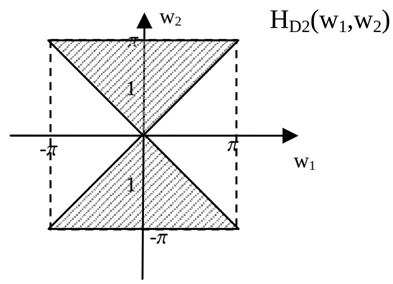
Overview:

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

Assignment specifics:




(1)




(2)

To implement the ideal fan filters (1) and (2) using FIR filters, we first need to define some specifications $\boldsymbol{\omega}_p$, $\boldsymbol{\omega}_s$, $\delta_p = 0.1$, $\delta_s = 0.1$.

For (1)

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

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

For (2)

$$\boldsymbol{\omega}_p = (|\omega_2| \geq |\omega_1|)$$

$$\boldsymbol{\omega}_s = (|\omega_2| - |\omega_1| \leq -0.35\pi)$$

Design two 2D-FIR filters which meet or exceed these requirements for (1) and (2) respectively. Problem 4.14 covers the design of $t_1(n_1, n_2)$ for (1). Plot the pass band and stop band contours, as well as the constant value contours of $T_1(\omega_1, \omega_2)$ and $T_2(\omega_1, \omega_2)$. Translate the specifications given here to the specifications of two 1D filters. Compute the Parks-McClellan optimal filter design to create two 1D Type I filters (odd, symmetric) $h_1(n)$ and $h_2(n)$ which meet these specifications for (1) and (2) respectively. Use the transformation method to compute the 2D-FIR filters which implement the ideal fan filters. Make 3D plots of the frequency response $H_1(w_1,w_2)$ and $H_2(w_1,w_2)$. Apply them to the image `Turtle.bmp` available from the class website. Save the resulting image of filter (1) and filter (2) as `Result1.bmp` and `Result2.bmp` respectively. What do these filters do?

Using the window method (Hamming window), design two 2D-FIR filters which also implement those ideal fan filters, with the same support as the filters you obtained previously. Make 3D-plots of the frequency response and compare them to the response of the transformation-method 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.

Using the frequency sampling method, design 2D-FIR filters which also implement the ideal fan filters, with the same support as the other two methods. Make 3D-plots 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 write-up, including the 3D-plots, on the due date. Also please submit all your `.m` files, `Result1.bmp`, and `Result2.bmp` via email to hsil@eecs.berkeley.edu. 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 (firpm)` | Parks-McClellan algorithm |
| `remezord (firpmord)` | Parks-McClellan optimal FIR filter order estimation |
| `ftrans2` | 2D-filter design using transformation method |
| `fwind1` | 2D-filter design using the window 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 |