TEL 519E – Homework 2

Due 26.11.2010

1. Using the windowing method, design a bandpass filter h with passband defined as

$$0.2\pi < \sqrt{\omega_1^2 + \omega_2^2} < 0.4\pi. \tag{1}$$

   Use a circularly symmetric Hamming window. Experiment with different sizes. Apply the filter on the 'Barbara' and 'Boat' images.

2. Design a highpass filter using the frequency sampling method. Experiment with different filter sizes. Apply the filter on images of your own choosing.

3. (From Lim's book) Recall

$$\cos(A+B) = \cos(A)\,\cos(B) - \sin(A)\,\sin(B)$$
$$\sin(A+B) = \sin(A)\,\cos(B) + \cos(A)\,\sin(B)$$

   Using these trigonometric identities,

   (a) Show that $\cos(2\omega) = 2\cos(\omega)\,\cos(\omega) - 1$.

   (b) Show that $\cos(3\omega) = 2\cos(\omega)\,\cos(2\omega) - \cos(\omega)$.

   (c) More generally, show that for $n \geq 2$,

$$\cos(\omega n) = 2\cos(\omega)\,\cos(\omega(n-1)) - \cos(\omega(n-2)). \tag{2}$$

   The last result allows us to express $\cos(\omega\, n)$ as

$$\cos(\omega\, n) = \sum_{k=0}^{n} q(k)\,(\cos\omega)^k \tag{3}$$

   for some $q(k)$.

4. Design a zero-phase lowpass filter with characteristics as discussed in the slides, using the McClellan transformation. For the design of the 1D filter, you may use `firpm` command of MATLAB.

5. Apply the filter from the previous exercise on 'Barbara' and downsample (in both horizontal and vertical directions) by 4. Compare with downsampling without filtering. What happens when you downsample without filtering? Perform similar experiments using other images of your own choosing.