# DAY 4
# Tuesday, July 25th, 2006

## I. Lecture:

### I.1. Orthogonal Wavelet Bases: (17/17 slides)

1. Connection to Orthogonal Filters
2. Orthogonality in the Frequency Domain
3. Biorthogonal Wavelet Bases

   Link:

   - http://ocw.mit.edu/NR/rdonlyres/Mathematics/18-327Wavelets--Filter-Banks-and-ApplicationsSpring2003/054BFCF8-AC71-4A82-8553-9777705B6229/0/Slides11.pdf

### I.2. Wavelet applications:

### I.3. Discussion:

## II. Exercise and Lab:

### II.1. Matlab:

1. Matlab Wavelet Toolbox:

   Link: http://web.mit.edu/1.130/WebDocs/wavelet_ug.pdf

2. 2-D signal analysis using Wavelets:

   - Load a test image: load woman2. The input image is in variable X and colormap is in variable map. Plot this image.
   - Use dwtmode to setsthe DWT mode to symmetric-padding (half-point). Then plot the structure of a two stage 9/7 filter bank.
   - Compute a 2-level decomposition of the image using the 9/7 filters using wavedec2.m.
   - Extract the level 1 coefficients by using appcoef2.m and detcoef2.m.
   - Extract the level 2 coefficients by using appcoef2.m and detcoef2.m.
   - Display the decomposition up to level 1 only using wcodemat.m and wkeep.m.
   - Display the entire decomposition upto level 2 using wcodemat.m and wkeep.m.

- Use wrcoef2.m to get the reconstructed average at level 2 and all of the reconstructed details then add all together to reconstruct the full reconstructed image.
- Use waverec2.m to find another way to reconstruct the original image.
- Use wdencmp.m to compress the image. Test with different thresholds allowed for different subbands.

3. FAWAVE:

   Link: http://www.uwec.edu/walkerjs/FAWAVE/index.htm

a) 1-D wavelet transform:

- Load a sound signal: File→New 1 Dim. Then right click on the graphpaper→Load→Sound. Choose sound file named "call back 1.wav" →Open.
- Play the sound file: Graph→Audio→Play. Test with bitrate 16 Bits or Sampling rate (Hz) 11025 or Volume level 2.5.
- Apply the 1-D Wavelet transform to the signal:
  - 1 level wavelet transform: Transform→Wavelet. Choose Graph 1, Level 1and Wavelet type Coif 6→Plot. Activate the new graph then play this file with suitable sampling rate.
  - 3 levels wavelet transform: plot the 3 levels wavelet coefficients of the audio signal, Wavelet type Coif 6 and play with suitable sampling rate.
  - Redo the 3 multi-level wavelet transform with different wavelet types.

b) 2-D wavelet transform:

- Load an image: File→New 2 Dim, right click on the first subgraph→Load→Image then open the image "barb.pgm".
- Apply the 1 level 1-D Wavelet transform to the signal:
  - 1 level 2-D wavelet transform with wavelet type Coif 6: Transform→Wavelet. Choose Level 1, Wavelet type Coif 6→Plot. To see full size of the image, right click on the interested subgraph→View larger size, then tick on the graph name to change to the other subgraphs in full size.
  - 1 level 2-D wavelet transform with wavelet type Daub 4: right click on the graph→View smaller graphs to see all subgraphs. Apply the same steps as in the previous 2-D wavelet transform but this time with wavelet type Daub 4.
  - 1 level 2-D wavelet transform with wavelet type Haar: Apply the same steps as in the previous 2-D wavelet transform but this time with wavelet type Haar.

- Switch among subgraphs in full size and give commends.
- Redo the above steps with different wavelet types.

➢ Apply the Multi-level wavelet transform:

- Load the image “mandrill.pgm”.
- Find the 2-D wavelet coefficient with 1, 2, 3 levels. Then get the commends.

c) Image compression:

➢ Format JPEG, TIFF, PNG:

- Open an image: File→New 2 Dim, then right click on the top left subgraph→Load→Image. Choose the image named “boat.pgm”.
- Compress the image in format JPEG: File→Save options (images), in the JPEG subblock, choose Quality factor 30 (high quality factor lead to low bit per pixel and low quality compressed image). Then click Apply. Right on the first subgraph→Save Graph→Image, then save the image with name “boat.jpeg” →OK. Right click on the second subgraph→Load→Image→load the image “boat.jpeg”.
- Compress the image in format TIFF: Redo the same step as the previous part, but in the TIFF subblock, tick on the option Interlaced, then save the compressed image under the name “boat.png”. Load this image to the 3rd subgraph.
- Compress the image in format PNG: Redo the same step as the previous part, but in the PNG subblock, tick on the option JPEG, then save the compressed image under the name “boat.tiff”. Load this image to the 4th subgraph.
- See four compressed images in full size. Compare their quality and sizes.

➢ Format WC2 (compression using wavelet):

- Open the image “fingerprint 1.pgm”.
- Compress the image using wavelet transform with different levels: File→Save options (images). In the subblock wavelet compression (.WC2 files), choose Levels 7, Wavelet type Daub 9/7→Apply. Right click on the original image→Save graph→Image. Then save the compressed image under the name “fingerprint7.wc2”. Then load this image to the second subgraph. Repeat wavelet compression with levels 2 and 5 then save these images under the name “fingerprint2.wc2” and “fingerprint5.wc2”. Load these images to the 3rd and 4th subgraph. Compare the quality and size of the 3 compressed image with the original image.
- Compress the image using wavelet transform with different wavelet types: repeat the previous part with the same Levels 4 but with different

wavelet types: Daub 9/7, DD (2+2,2) integer, DD 5/3 integer. Compare their quality and sizes.