Wavelet Lab Instruction

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1 Expectation

1. Expect to learn basic matlab functions from on-line helpwin manuals.
2. Expect to learn to use the basics of the wavelet toolbox in Matlab.

2 Matlab Session

Try the following script:

```
>> x = 0 : 0.01 : 5;
>> y = sin(2 * x.^2);
>> plot(x, y)
>> y1 = sin(10 * x);
>> plot(x, y1)
>> fty = fft(y);
>> plot(abs(fty))
>> fty1 = fft(y1);
>> plot(abs(fty1))
```

You may put all matlab commands in a filename.m file. At the command line, simply typing filename, all the commands are executed.

For help, type helpwin to get the help window which is quite user friendly.

3 Using the Wavelet Toolbox

To start the wavelet toolbox, type
>> wavemenu

4 Project 1a

4.1 Topic 1: Comparison of wavelet decompositions with different wavelets

Open the wavelet toolbox by typing 'wavemenu'. Click on the button of [Wavelet 1-D]. Select [Demo Analysis] from the File pull-down menu, and select on [frequency breakdown]. Choose the number button next to [db], select a sequence of numbers (1, 2, 4, 6...), and then click on [Analyze].

1. Closely observe the details at each level, and the remainder $a5$. Make note on your observation. (Do the next step simultaneously). If you are to seek for a concise signal representation, which wavelet(s) would you willing to use? This would affect the compression result as well.
2. Compare the results while looking at the wavelets. Click on [Wavelet Display] on the main menu. Select [db] and [numbers], and click on [Display]. Make note on the shape and smoothness of the wavelets, and the correspondence between the wavelets (in terms of their smoothness etc) and the decomposition results.
3. Study the compression effect. The bottom is the [compress]. Observe and make notes on the reading from [Retained energy] and [Numbers of zeros]. Change the two numbers by left-clicking on (and hold) the dashed line and dragging it to the left or right. Observe and make notes on the energy and zero readings and the reconstruction results, the yellow curve plotted over the red original. Compare the readings and reconstruction results using several different 'db' wavelets. Note: you need to click on [Close] to go back to Wavelet 1-D window for choosing different wavelets.
4. What is your conclusion from the point of view of compression (in terms of the use of wavelets)? Is the smoothness important?
5. Try the above on a different demo signal. For example, the [Noisy Doppler]. Note the changes more on higher level of decompositions when changing the wavelets. The lower level(s) are similar? Why? Try both the [De-noise] function and [Compress] function, and compare the wavelets used. For the comparison purpose, always select 'db' wavelets for now.
6. Try other functions as well.

4.2 Topic 2: Study other possible construction of wavelet functions

Verify (before or after lab) that one can choose

$$G(\gamma) = e^{2\pi i N \gamma} \overline{H(\gamma + \frac{1}{2})}, \quad \forall \text{ odd } N.$$

Verify (before or after the lab session), the corresponding time sequence is

$$g(n) = (-1)^{N-n} \overline{h(N-n)}.$$

Ultimately, we will try to generate the wavelet ψ using the new g:

$$\psi(t) = \sqrt{2} \sum_n g(n) \phi(2t - n).$$

There are several things to get familiar with:

1. Learn to use the editing screen on matlab main screen.
2. Learn the functions of wavelet toolbox. In matlab, type 'helpwin' to learn functions 'wavefun', 'orthfilt', 'wfilters' etc. Try to use them to produce the ϕ and the ψ. Ex: [phi,psi,x]=wavefun('db5',10); returns the phi and psi functions at points of x. To see the x value, type 'x'. type 'figure (4)', then 'plot(phi)' and 'plot(psi)' to see the scaling function, and the wavelet function.

   Try out these functions. Eventually, you'll need to write a simple routine to generate new ψs.