Bioengineering 599 - Biomedical Imaging Systems

Matlab project: Fast Fourier Transforms

The Fourier transform is often a useful tool to smooth and/or filter a time series or image data set. In this case, a user usually designs a filter function in the Fourier domain, (also called the frequency-domain). The original dataset represented in the Fourier domain is then multiplied with the designed filter function element-by-element, or pixel-by-pixel, which is finally inverse Fourier transformed into the original time or image domain.

For discrete calculations with computers, we have to use the Discrete Fourier Transform (DFT), which is efficiently calculated with the fast Fourier transform (FFT).

Remember that

1. The DFT assumes the signal is periodic, so to use zero-padding to approximate a non-periodic signal
2. FFTs work best with powers of 2
3. When computing the FFT, the origin needs to be offset by N/2 before and after, where N is the array or vector size.
4. It can be helpful to look at the phase to determine if you have made an errors in the offset.

In this project you can use the Matlab fft() and fft2() routines for 1-D and 2D fast Fourier transforms (FFTs). If you need a refresher, the Matlab help facility is useful as well as some notes at : http://www.mathworks.com/help/techdoc/math/brentm1-1.html

Part 1: 1-D Fourier Transforms

A) Known object: Start with a rect(*x*) (i.e. rectangle) function:

```
x = -1:0.01:1;
y = ((-0.5 <= x).*(x < 0.5));
```

a) Plot this function (this is often called time-domain or object-domain signal).

b) Compute and plot the Fourier Transformation of this function;

c) Smooth this function (signal) with a Gaussian filter.

Here, in smoothing your dataset, please have an option to choose the width of the smoothing function (number of cells/pixels). Please plot both the original signal and the smoothed signal in the time domain.

B) Unknown object: Load in the data from the Matlab MAT file " one D data.mat" in the BE599 Biomedical Imaging / Project1 folder or the Computer lab server

a) Plot this dataset;

b) Compute and plot both the real and imaginary parts of the Inverse Fourier

Transformation of this dataset.

Part 2: 2-D Fourier Transforms

A) Known 2D data: Start with a 2D rect(x,y) function:

```
x=-9.99:0.01:10;
y = ((-0.5 <= x).*(x < 0.5));
rects=zeros(2000,2000);
for i=1:2000
rects(i,:)=y;
```

a) Plot this 2D rect(x,y) dataset;

b) Compute and display the real and imaginary parts of the 2D Fourier Transformation of this dataset;

c) Smooth the data with a 2D Gaussian filter. Please plot/display both the original 2D dataset and the filtered 2D dataset in time domain. Try to use myfilter = fspecial('gaussian',[3 3], 0.5);

B) Unknown object: Load in the data from the Matlab MAT file " two D data.mat" in the BE599 Biomedical Imaging / Project1 folder or the Computer lab server

a) Plot/display this dataset;

b) Compute and plot/display the Inverse Fourier Transformation of this dataset.

Bonus questions:

A) Add noise to 1D or 2D (try to use data+rand(1,k) (k is the length of noise and “1” means the amplitude of this noise is from 0-1) and imnoise(rects,'gaussian',0,0.01) (rects is the original data, Gaussian is the noise type)) and plot the data;

B) Try different widths of the Gaussian kernel to smooth the noisy data and explain how the results vary and why.