Review of the Discrete Fourier Transform GPGN 411/511

LAB 3

October 8, 2015

Lab Due: Oct 15, 2015

1 Objective

Understanding the Fourier transform of 2D data maps through the fast Fourier transform (FFT).

2 Background

It is standard practice to use the discrete Fourier transform to approximate the Fourier integrals used in potential-field analysis. This practice requires that the data in the space domain are sampled at equal intervals and we computationally implement the discrete Fourier transform by using the fast Fourier transform (FFT) algorithm. As a result, FFT is almost synonymous with the continuous Fourier transform at this point (but we know better, right?). This is true to first order, but there are also differences–this lab exercise will focus on the behavior of the FFT and aims to establish some intuitive understanding by applying the FFT to different data sets.

2.1 Concepts

- 1D and 2D Fourier transform
- Power spectrum (square of modulus of Fourier transform of a function)
- Fast Fourier transform (fft)

3 Characteristics of Fourier Transform of different functions

We will use Matlab to explore some of the properties important in the wavenumber-domain processing of potential-field maps, and to gain intuitive understanding of the transform results.
Provided for this exercise are two Matlab codes (and associated functions) for performing and displaying the Fourier transform of real data (non-complex) and a group of simplistic data files with special features[1].

3.1 Codes Provided

· ft1d.m performs a 1D FFT and displays the result
· ft2d.m performs a 2D FFT and displays the result

[1] Note that these codes were almost entirely developed by Yaoguo Li for GPGN-411/511 and he has been kind enough to allow me to use them. Keep these codes in your back pocket. They may be useful in other classes or your professional life.

3.2 Tasks

- Run ft1d on *even_1d.dat* and *odd_1d.dat* to observe the difference in the corresponding power spectra, and real and imaginary components in the Fourier domain for 1D functions. The *dat* files contain even and odd functions, respectively.
- Run ft2d on *even.dat*, *odd.dat*, and *off.dat* to observe the differences in the corresponding power spectra, and real and imaginary components for 2D functions.
- Run ft2d on *sml.dat* and *lrg.dat* to study the difference in wavenumber content and band with in anomalies with different widths.
- Run ft2d on *nn.dat*, *ne.dat*, *nw.dat*, and *ee.dat* to explore the Fourier spectrum of elongated features.
- Run ft2d on *even.dat* and *noisy.dat* to examine the power spectra of accurate and noisy data.

For the next part you will use the gradient tensor and total field data you generated in the previous labs. If this is not already completed, you will need to output your generated datamaps as a text file with the following format:

nx ny

x_n y_n d_n

The easiest way to generate this file is to create a double for-loop which first loops over X (using ii or some other index), then Y in the inner loop (jj), such that it prints out:

X(ii,jj) Y(ii,jj) d(ii,jj) assuming X and Y represent meshgrids (your notation may differ). You are of course free to generate this however you see fit. You can use the attached *dat* files as an example.

Once the data from the previous labs are output as text files,

- Run ft2d on two components of the gravity gradient tensor data you generated previously. Observe the outputs.
- Run ft2d on the total-field magnetic anomaly previously generated. Observe the outputs.

3.3 Useful observations to make

- The relative magnitude of the real and imaginary parts (especially with even and odd functions)
- Relationship between the width of the box-car anomaly and the 'width' of it's Fourier transform
- Directions of elongation in the wavenumber domain relative to that in the spatial domain. This is the most important observation to make–try to understand why the transform has that shape.

4 Deliverables

Submit a formal report with a simple description of the observations you made in the lab exercise (including relevant figures).