GEOS 622 – Digital image processing in the geosciences

Bonus Homework problem 4 (total number of points that can be earned: 5; grade on this homework will replace lowest grade of previous three homeworks, if grade is higher), due December 14

Transforms in the spectral domain of sand dune imagery

You'll find the image that you'll be working with for this problem set on ftp.gi.alaska.edu in the directory /pub/eicken/GEOS622/HW4.
As part of this homework problem, you will have to generate 2 resulting images and some text. Please transfer these to me by e-mail or by ftp (copying them on the GI anonymous ftp server into the directory /pub/eicken/incoming). If that doesn't work, printouts on paper are also OK.
Note that for this exercise, using Scion Image (or ImageJ) works best. In Scion, you should go into the "Special" "Load Macros" menu and load the "FFT" macro from within the Scion Directory (in the Subdirectory "Macros").

1. Load the image:
Dune1.TIFF
This image is an aerial photograph (scanned from a print reproduction!) that measures approximately 7 km across, showing dune fields in the Saudi-Arabian Rub al-Khali (also known as the Empty Quarter, but the validation of this name with remote-sensing data is the topic of another homework exercise…; if you want to learn more about dunes in general, visit: http://exploration.nasa.gov/articles/06dec_dunes_lite.html). The scene has been spatially calibrated (i.e., 36.57 pixels/km) so that you should be able to obtain cycle lengths and other parameters.

1.1. Compute the Fast Fourier Transform and consider the displayed amplitude spectrum. What is the origin of the four peaks in the spectrum at approximately 0.1 km/cycle? Remove the signal that is associated with this spatial frequency from the image, e.g., by bandpass filtering or some other method of choice and explain briefly what you have done. Save the resulting image (after backtransformation into the spatial domain). (1.5 points)
1.2. The present image has a volume of 64 kByte. Explain briefly how you could reduce the amount of storage space required to represent this image by modifying the scene in the spectral domain. (0.5 points)

2.1. What is the prevailing directional orientation of the dunes? Give an azimuthal orientation (North, i.e. 0°, is up; you can obtain this from the length of lines that you specify in the Zoom or Image Window using the Measurement Tool under "Tools"; note also that you may have to perform a histogram transform on the Power Spectrum to enhance visibility of peaks). (0.5 points)
2.2. What is the prevailing spatial wavelength of the dunes in the image? (0.5 points)

2.3. How could you identify and delineate boundaries between coherent dune patterns in the image based on transforms in the spectral domain? The aim would be to identify individual regions in which the orientation, wavelength or phase of the large dunes does not vary significantly. In places where such coherent regions border against one another, one should be able to identify a shift in phase, orientation or wavelength of the large, low-wavenumber dunes. Outline briefly how this could be done and generate an image (based on transformations in the spectral domain) that illustrates your point. (1.5 points)

3. There are several ways of low-pass filtering an image such as the one shown here. Briefly identify two of them. (0.5 points)