Lab 7: Data acquisition, Aliasing Fast Fourier Transform (FFT) and the Optical Fourier Transform

Objective:

This lab explores the techniques of data acquisition with a USB data acquisition system, aliasing (in the time domain), aliasing (in the spatial domain), the Fast Fourier Transform (time domain), and the optical Fourier transform (spatial domain).

PreLab Questions:

[PL1] What is the harmonic spectrum of a triangle wave?

[PL2] Make sure to have a picture (digitally) that you already have performed a 2D FFT on. This does not need to be answered in your notebook, but shown to the TA to verify.

[PL3] Make sure to bring at least one laptop for your lab group to work in Matlab on. This does not need to be answered in your notebook, but shown to the TA to verify.

Lab Exercises:

A. Function Generated Sampling (1hr estimated amount of time)

1. USB DATA ACQUISITION

1. Hook up the LabJack to the USB port and watch it set itself up. Refer to *LabJack_U12_Users_Guide.PDF* and use the Function Generator as the input. Make connections between analog input A0 and GND.

2. Run the included program ***LJscope***. Observe the real-time oscilloscope display and the real-time FFT (power spectrum) of your input signal.

2. ALIASING IN THE TIME DOMAIN

- **(Q1)** Demonstrate aliasing, using a sine wave. Report your results in graphical form. Clearly label the frequencies that were aliased. What was the sampling frequency? What was the input frequency at which aliasing began to occur?

- **(Q2)** What is the FFT of a square wave? (low-frequency, not aliased). Report graphically.

- **(Q3)** What is the FFT of a triangle wave? (low-frequency, not aliased). Report graphically.

B. Aliasing in the Spatial Domain (2hr estimated amount of time)

For this section, you will be using Matlab to perform filtering of your pre-lab image. Be sure to come to lab prepared with at least one laptop between your lab group. The entirety of this section will be performed in Matlab. In your lab notebook be sure to paste copies of your images. This includes your original image, a low pass filtered image, down-sampled image, filtered down-sampled image, up-sampled image, and filtered up-sampled image. For note taking in this lab, be sure to explain what you were doing in Matlab to get the resultant images that you pasted in. You do not need to put in your Matlab code.

In OPTI-330 you learned about the concepts of sampling and aliasing. For this section of the lab, you will use different interpolation strategies to demonstrate the effects of aliasing, and use filtering to limit these effects. From the Pre-Lab, begin with an image of your choosing. The image can be a real-world image from your camera or the web, or can be a synthesized image that you put together to demonstrate aliasing. Begin with a high resolution image. Perform a down-sampling on the image directly.

- **(Q4)** Can you see any aliasing? Can you quantify the aliasing? Make sure to show the TA your results in the lab.

Now create a low-pass filter that operates on the original image and prevents the aliasing from occurring when you down-sample.

- **(Q5)** How does the resulting imagery compare to what you saw before the low-pass filtering? Make comparisons in both the spatial and the spatial frequency domain.

Now up-sample (interpolate) your images back to the original resolution using a method of your choosing (Matlab has the interp and interp2 functions, or you can use your own).

- **(Q6)** How do these images compare to the original image you started with? Make comparisons in both the spatial and the spatial frequency domain.