(Assigned on 2/15, due on 2/22)

4.4 Consider the continuous function f(t)=sin(2πnt).
(a) What is the period of f(t)?
(b) What is the frequency of f(t)?
The Fourier transform, F(μ), of f(t) is purely imaginary (Problem 4.3), and the transform of the sampled data will also be purely imaginary. Draw a diagram similar to Fig. 4.6, and answer the following questions based on your diagram (assume that the sampling starts at t=0).
(c) What would the sampled function and its Fourier transform look like in general if f(t) is sampled at a rate higher than the Nyquist rate?
(d) What would the sampled function looks like in general if f(t) is sampled at a rate lower than the Nyquist rate?
(e) What would the sampled function looks like in general if f(t) is sampled at the Nyquist rate with samples taken at t=0, Δt,2ΔT,…?

4.12 Consider a checkerboard image in which each square is 1 × 1mm. Assuming that the image extends infinitely in both coordinate directions, what is the minimum sampling rate (in samples/mm) required to avoid aliasing?

4.22 The two Fourier spectra shown are of the same image. The spectrum on the left corresponds to the original image, and the spectrum on the right was obtained after the image was padded with zeros. Explain the significant increase in signal strength along the vertical and horizontal axes of the spectrum shown on the right. Also, use a computer with GPUmat software installed (or any other software that uses a GPU with MATLAB or IDL) and measure the speed up gained when computing FFTs of 256×256, 512×512, and 1024×1024 image sizes. Speedup is defined as

$$S_p=T_1/T_p$$

Where T_1 is the execution time of the sequential algorithm, and T_p is the executing time of the parallel algorithm. Explain the results.

4.29 Find the equivalent filter, H(u,v), that implements in the frequency domain the spatial operation performed by the Laplacian mask in Fig. 3.37(a).

4.43 A skilled medical technician is assigned the job of inspecting a certain class of images generated by an electron microscope. In order to simplify the inspection task, the technician decides to use digital image enhancement and, to this end, examines a set of representative images and finds the following problems: (1) bright, isolated dots that are of no interest; (2) lack of sharpness; (3) not enough contrast in some images; and (4) shifts in the average intensity, when this value should be V to perform correctly certain intensity measurements. The technician wants to correct these problems and then display in white all intensities in a band between I1 and I2, while keeping normal tonality in the remaining intensities. Propose a sequence of processing steps that the technician can follow to achieve the desired goal. You may use techniques from both Chapters 3 and 4.