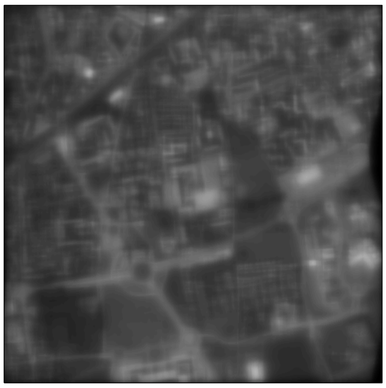
ELEC 431
Digital Signal Processing
Homework 7

Due Friday, February 14, 2003

Note: Homework, tests and solutions from previous offerings of this course are off limits, under the honor code.

This problem investigates image deblurring. An ideal sattelite image is depicted below (This is an image of Nimes, France, copyright CNES). A blurred version is shown next to it. The blurring could be caused by a number of factors including atmospheric distortions. Typically the blur is not this significant, but in adverse conditions it can be quite severe. Both images can be downloaded from `www.ece.rice.edu/~nowak/elec431`. The file containing the ideal image is called `nimes.mat` and the blurred image is in `nimes_b.mat`.

ideal image



blurred image

The point spread function (PSF) $h[m, n]$ of the blurring operator is known in this case, and is contained in the file `blur.mat`. The inverse PSF can be derived from $h[m, n]$. The inverse PSF is in the file `blurinv.mat`. Both PSF files can also be downloaded from `www.ece.rice.edu/~nowak/elec431`.

a. Verify that the inverse PSF is indeed the inverse of the blurring PSF $h[m, n]$ by convolving the two together.

b. Using the function for image convolution you developed in the last homework problem, apply the inverse PSF to the blurred image. Determine the number of required floating point operations required using the Matlab `flops` command.

c. Apply the inverse PSF to the blurred image in the DFT domain using the 2D fft (Matlab command `fft2`). Compare the number of flops required in this case with the flop count for direction convolution above.

d. In order to obtain the regular convolution from the FFT-based procedure, we must zero pad the original image. What amount of zero-padding is required? How significant is the "wrap-around" effect of circular convolution if zero-padding is not performed?

e. Another blurred version of the Nimes image is contained in the file `nimes_bn.mat`. A small amount of noise was added to this image, which could be due to instrumentation noise, atmospheric effects, and quantization. The noise is imperceptible to the eye, but has a dramatic effect on the deblurring process. Apply your FFT-based deblurring process to this image. Comment on the result. Can you come up with an improved deblurring process that deals the noise more effectively?