1051-361-20101 Homework #4 Due 11/2/2010 (T)

You may hand in your solutions electronically, BUT as a complete document, with images, discussion, and your programs all in the same document. You also may submit directly, but as a single document (e.g., in Microsoft Word) that includes some discussion/explanation of the results.

1. Write a program to perform a convolution over a $3 \times 3$ neighborhood (you may implement a more general program over a neighborhood with a selectable size for extra credit). For a 2-D input image $f[n,m]$ where $1 \leq [n,m] \leq N$ and a $3 \times 3$ neighborhood kernel $h[k,\ell]$, where $-1 \leq [k,\ell] \leq 1$, the operation to be implemented is:

$$g[n,m] = \sum_{k=-1}^{+1} \sum_{\ell=-1}^{+1} f[n-k,m-\ell] \cdot h[k,\ell]$$

Submit your program.

2. Apply the program of #1 to an image of your choice of size at least $64 \times 64$ – you may use any of the images that were posted for the previous assignment if you choose. The ideal image would have some low-frequency content (large objects) and some high-frequency content (small details). In the calculation, you will have to consider how to deal with weights that appear “off the edge” of the image; you have several choices, so specify which you use.

(a) Apply a $3 \times 3$ identity operator to the image:

$$h_{1}[n,m] = \begin{bmatrix} 0 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Print out the result at a size that is sufficient to make the details visible.

(b) Apply a $3 \times 3$ uniform averager to the original image and print out at sufficient size:

$$h_{2}[n,m] = \frac{1}{9} \begin{bmatrix} +1 & +1 & +1 \\ +1 & +1 & +1 \\ +1 & +1 & +1 \end{bmatrix}$$

(c) To the result of part (b), independently apply $3 \times 3$ sharpening kernels derived from the Laplacian and print out the images.

$$h_{3a}[n,m] = \begin{bmatrix} 0 & -1 & 0 \\ -1 & +5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

$$h_{3b}[n,m] = \begin{bmatrix} -1 & -1 & -1 \\ -1 & +9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Submit your program.

3. Use the program in #1 to evaluate the “magnitude of the gradient” of the original image; print out the result at sufficient size.

4. (OPTIONAL BONUS) Implement a $3 \times 3$ median filter, i.e., replace the gray value of the pixel with the median of the gray values in the $3 \times 3$ neighborhood surrounding it. You will have to write (or find elsewhere – perfectly okay, but reference it) a sorting routine to implement this filter. Apply the median filter to the original image and compare the result (perhaps by subtraction) to the blurred image in #2b.