Final Examination: ESE 558 Digital Image Processing
Date: 5/9/95, Duration: 2 hrs. 30 mins., Max. Marks: 50
Spring 1995, SUNY at Stony Brook, Murali Subbarao

Instruction: You are allowed to use notes written on a sheet of paper no larger than 5.5 inches wide and 8.5 inches long (i.e. half of an A4 sheet).

1. *(6 points) Ch. 5, Image compression*
   Mention the relative advantages and disadvantages of the following transform compression methods for digital images: Karhunen-Louve (K-L) transform, DFT, DCT, and Hadamard transform. Consider compression rates and computational requirements.

2. *(5+5 points) JPEG paper, Image compression*
   (a) In image compression using JPEG, two consecutive blocks B1 and B2 after normalization and converting to one-dimensional sequence have the following form:

```
B1:        [   -35    5    -2    0    0    0   -4    EOB ]
B2:        [   -31   -3     0    0    0   -2    EOB ]
```

   Give the JPEG coding for block B2 (note: **B2**, not B1), i.e. give the binary pattern that codes B2. Show every step and explain what you are doing at every step to make clear that you have understood JPEG.

   (b) The JPEG coding of some image block is given below. Decode this block as much as possible to obtain a one-dimensional sequence as above and interpret the result. Once again, show every step and explain what you are doing at every step to make clear that you have understood JPEG.

```
B3:        [  0 0 0 0 1 1 0 0 0 1 0 1 1 0 0 1 1 0 1 0 ]
```

3. *(8 points) Ch. 6, Image enhancement*
   Briefly describe the following image smoothing filters and the circumstances under which each of them work well and work bad. Consider computational requirements, noise reducing power, and ability to preserve details like edges, corners, and thin lines. (i) 3x3 mean filter, (ii) 3x3 median filter, (iii) 3x3 K-nearest neighbor filter, and (iv) 5x5 Gaussian filter.

4. *(6 points) Ch. 6, Image enhancement*
   Prove that the *Laplacian* operator $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ is rotation invariant.

5. *(2+4 points) Ch 7 & Paper: Image Restoration*
   (a) Give expressions for the Weiner filter and the Spatial domain convolution/deconvolution transform (two non-zero terms for a circularly symmetric PSF). Explain them in the context of image restoration.

   (b) Compare the advantages and disadvantages of using the Spatial Domain Convolution/Deconvolution Transform vs the Weiner filter for restoring focused images from blurred images. Consider computational requirements, *a priori* information needed, and the quality of restoration. Answer this question in the context of the paper you have been assigned to read.

6. *(8 points) Ch 7 Image Restoration*
   Formulate the problem of restoring motion blurred images and derive an expression for the optical transfer function corresponding to motion blur as discussed in class.

7. *(4+2 points) Ch. 8 Image reconstruction*
   (b) State and prove the *Fourier Slice Theorem.*
   (c) Describe in about 5 sentences how the theorem can be used in *Computed Tomography* for parallel projection data. Provide illustrations where necessary for clarity.