

Mid-Term Examination: ESE 558 Digital Image Processing

Date: 3/27/2001, Duration: 2 hour 30 mins, Spring 2001
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This test is open-text books. No other reference materials are allowed. Note: RK and GW respectively denote the text books by Rosenfeld & Kak and Gonzalez & Woods. In answering the following questions write down all the important steps to get full credit.

1. (5 points, RK, Ch. 2, Mathematical Preliminaries)

The Fourier transform of $f(x, y)$ is given to be $F(u, v)$. Starting from the definition of the continuous Fourier transform, derive the Fourier transform of $f(a(x - b), c(y - d))$ in terms of $F(u, v)$ where a, b, c, d are scalar constants.

2. 5 points, GW, Ch. 2, Connected component labelling

A binary image $b[m][n]$ of size 100×100 is given where $b[i][j]=0$ for background and $b[i][j]=1$ for object pixels. There are a maximum of 10 objects and none of them touch the border of the image. Assuming that the image has already been read into a two-dimensional integer array $b[100][100]$, give a step-by-step computational algorithm for connected component labeling using 4-connectedness definition. You can present the algorithm as a procedure/function in a high-level programming language (e.g. C, FORTRAN) or as psuedo-code in English. You can skip the implementation of Equation 2.4-1 on page 45 in GW book (as it is already given there), but you must describe how the array B is assigned values initially. You must also give the algorithm or code for reassigning a unique label to pixels with equivalent labels.

3. (5 points GW Ch. 2, Imaging geometry)

Excercise 2.17 on page 79 in GW text book.

4. (5 points, RK, Ch. 4, Digitization and Aliasing)

An image is specified by $f(\mathbf{r}) = \cos 2\pi(\mathbf{w}_0 \cdot \mathbf{r})$ where $\mathbf{r} = (x, y)$ and $\mathbf{w}_0 = (0.2, 0.7)$. The image is sampled on a lattice $\mathbf{r}_{mn} = m\mathbf{r}_1 + n\mathbf{r}_2$ where $\mathbf{r}_1 = (1, 0)$, and $\mathbf{r}_2 = (0, 1)$ for $m, n = 0, \pm 1, \pm 2, \pm 3, \dots$

(i) Find the reciprocal lattice $\mathbf{w}_{mn} = m\mathbf{w}_1 + n\mathbf{w}_2$ (i.e. find \mathbf{w}_1 and \mathbf{w}_2).

(ii) If $G(\mathbf{w}) = \text{rect}(\mathbf{w})$ is the Fourier transform of the interpolation filter $g(\mathbf{r})$ used in reconstructing the image from its samples, find an explicit expression for the reconstructed image $f'(\mathbf{r})$.

5. (5 points, RK, Ch. 4, Optimal quantization)

The probability density function of an image signal z is $p(z) = 0.75(1 - z^2)$ for $|z| \leq 1$ and $p(z) = 0$ for $|z| > 1$. We need to optimally quantize the signal to two distinct levels q_1, q_2 with a decision level z_2 . Guess a solution for z_2 using common sense and then solve for q_1, q_2 .