Mid-Term Test 1: ESE 558 Digital Image Processing

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This complete test is open text book. Show all steps to demonstrate your understanding and to get full credit.

1. (8.5 pts) A 3 bits/pixel image of size 5x5 is given here. At the center pixel (2,2), find the following:

IMAGE

y	x=	0	1	2	3	4
0		3	7	6	2	0
1		2	4	6	1	1
2		4	7	2	5	4
3		3	0	6	2	1
4		5	7	5	1	2

Laplacian

0	1	0
1	-4	1
0	1	0

Low-pass filter

0.01	0.10	0.01
0.10	0.56	0.10
0.01	0.10	0.01

(a)(0.5 pt) The output of a 3x3 mean filter at (2,2).
(b) (0.5 pt) The output of a 3x3 median filter at (2,2).
(c) (0.5 pt) The output of the 3x3 Laplacian filter shown above at (2,2).
(d) (0.5 pt) The output of the 3x3 Low-pass filter shown above at (2,2).
(e) (0.5 pt) City-block distance (D4) from (2,2) to (4,3).
(f) (0.5 pt) The Euclidean distance from (2,2) to (4,3).
(g) (1 pt) Gradient magnitude at (2,2).
(h) (1 pt) The result of unsharp-masking at (2,2) (assume suitable parameters if needed). Show your steps.
(i)(1 pt) The historgram of the whole image.
(j)(2 pts) The result of histogram equalization at the point (2,2). Show steps in obtaining your solution.
(k)(0.5 pt) The result of Gamma correction at (2,2) for displaying on a computer monitor where output = (input)**Gamma, with Gamma=2.5.

2. (0.5 pt) A camera records image frames with electronic noise having a standard deviation of 1.0 gray level. The noise at a pixel for different image frames can be modeled as zero-mean Gaussian independent identically distributed random variables. Four image frames of the same object are averaged to obtain an output image with reduced noise. What is the noise standard deviation, mean, and distribution in the output image?

3. (a) (2 points) A digital camera has focal length f mm and pixel size p mm. Derive an expression for the spatial resolution (lines/mm) of the camera as a function of object distance z. Assume that the distance between the lens and the CCD image plane is a constant equal to the focal length f.
   (b) (1 point) If $f = 50$ mm and $p = 0.005$ mm for a camera, what is its spatial resolution at a distance of 1 meter?

4. (a) (2 pts) For median filtering in 7×7 neighborhoods, propose a technique for updating the median as the center of the neighborhood is moved from a pixel to its right neighbor.
   (b) (1 pt) Estimate the computational speed up of your scheme compared to the regular scheme of recomputing the median at each point. Assume the image size to be very large and ignore the computation at border pixels.

5. (2 pts) Compare the advantages and disadvantages of global versus local histogram equalizations for image enhancements.

6. (1 pt) (a)Give an espression for the discrete convolution a digital image f[m][n] of size 128x128 with a filter h[m][n] of size 5x5.
   (b) (4 pts) If the filter h[m][n] is separable as h[m][n] = h1[m] * h2[n], write a computationally efficient C/C++ function to implement the discrete convolution of the image f with the filter h to obtain the output image g (i.e. g[m][n] = h[m][n] ** f[m][n]). You need not compute g[m][n] at border pixels that are less than 3 pixels away from the outer boundary of g[m][n]. Assume that array memories f[128][128], h1[5], h2[5], and g[128][128], have all been allocated, and f[128][128], h1[5], and h2[5], have all been initialized. You just need to compute g[128][128]. There is no need to read or write any data.