CSE166 – Image Processing – Final

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`http://www-cse.ucsd.edu/classes/fa03/cse166`

3:00-6:00pm Tue. Dec. 9, 2003.

On this exam you are allowed to use a calculator and two 8.5" by 11" sheets of notes. The total number of points possible is 40. Good luck!

Part I: Fill in the Blank (1 pt. each).

1. The Fourier transform of a Gaussian is a(n) _____ .
2. If a function is wide in the spatial domain, then it is _____ in the frequency domain.
3. _____ in the spatial domain corresponds to multiplication in the frequency domain.
4. Laplacian of Gaussian and Gabor filters are _____ -pass filters.
5. The _____ of an image $I(x, y)$ is a vector field in which each vector points in the direction of greatest change from dark to light.
6. Given a function $f(x)$, the value of the DFT $F(u)$ at $u = 0$ is also known as the _____ -component.
7. The discrete approximation to the Gaussian formed from the rows of Pascal's triangle is known as the _____ kernel.
8. A odd-symmetric Gabor filter is formed by computing the product of a(n) _____ and a(n) _____ .
9. The minimum number of correspondences needed to solve for an affine transformation between two point sets is _____ .
10. We used the _____ transform to detect straight lines in images.
11. A neighborhood of an image where all the gradient vectors are equal to $(\pm 1, 0)$ is an example of a rank-_____ neighborhood.
12. We solved the equation $I_x u + I_y v + I_t = 0$ in small windows to estimate the _____ .
13. "Eigenfaces" are obtained by running _____ on a set of face images.
14. The convolution of an $M \times M$ image with an $N \times N$ kernel is of size _____ .
15. The image enhancement operation that makes the probability density function of pixel brightnesses approximately uniform is called _____ .
16. Given a set of vectors $\mathbf{x}_i, i = 1, \ldots, N$ with mean $\mathbf{m}_x$, the formula for the covariance matrix C_x is _____ .
17. The decision boundary of a minimum distance classifier between two classes in a 3D feature space is a(n) _____ .
18. _____ is an example of a lossless image compression method.
19. _____ is an example of a lossy image compression method.
20. The lower bound in lossless image compression is determined by the _____ of the source.

Part II: Written problems.

1. (3 pts.) Consider the system $g(x) = \sum_{k=x-2}^{x+2} f(k)$. Determine whether this system is LSI, and show your work. If it is LSI, what is the impulse response $h(x)$? If it is not LSI, provide an intuitive explanation of why it isn't.

2. (6 pts.) What are the three basic steps in Canny edge detection? Enumerate them and explain the purpose of each step.

3. (5 pts.) You are given an image $f(x, y)$ of size 256×256 and a kernel $h(x, y)$ of size 15×15. Explain the steps necessary to compute the convolution $g = f * h$ using frequency domain filtering, using zero padding to avoid aliasing. Your result should match what you would get by running the command `g=conv2(f,h)` in Matlab. Illustrate your answer with diagrams.

4. (6 pts.) Write down the steps of k-means clustering, including the initialization, the basic iteration, and the stopping criterion. Illustrate your answer with a 2D pointset example with $k = 2$.