**ECE 439 Sample Test #2 KEY NAME\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Answer all questions in space provided. Use back of the pages for extra work. Note that each question is not weighted equally. You should have 6 pages. You have 75 minutes.

#1) a) List the three basic steps in image sharpening. b) Give an example operation for each step.

a) STEP 1. extract high frequency/detail/edge information with, for example, highpass spatial masks, highpass frequency domain filtering, or edge detection masks. Highpass or edge detection spatial masks typically have alternating positive and negative coefficients – this approximates the mathematical derivative. STEP 2. Combine the results form step 1 with the original image; for example, by adding, multiplying OR’ing. Often the high frequency information is scaled by a constant less than 1. STEP3. Apply contrast enhancement, such as histogram equalization or histogram stretch. Histogram specification may also be used.

b) see (a).

#2) Find the Huffman code for a 2-bit per pixel image with the following histogram:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Gray Level** | 0 | 1 | 2 | 3 |
| **Number of Pixels** | 400 | 200 | 300 | 100 |

gray level 0 = 12, gray level 1 = 0102, gray level 2 = 002, gray level 3 = 0112

What is the average word length ? \_\_\_1.9\_\_\_

What is the entropy ? \_1.846\_\_\_

#3) What is the best frequency domain restoration filter to use in the absence of noise ? Using our restoration model, derive the equation for this filter.

The inverse filter,1/H. In the frequency domain: D = HI + N.

Assume N = 0, then we have : D = HI, so I = D/H and 1/H is our inverse filter to restore the degraded image, D, to the original image I.

#4) a) What do *OTF* and *MTF* stand for and what do they mean? b) What does it mean for an image to be stationary? c) Are images typically stationary? Explain.

a) Optical Transfer Function and Modulation Transfer Function; the OTF usually refers to the response of the optics in an imaging system, and the MTF refers to the response of the entire imaging system, including the optics. Some authors will use these terms interchangeably. These both refer to the response in the frequency domain, and represent the Fourier transform of the PSF, H(u,v). b) Images are typically NOT stationary. The stationary attribute is a mathematical property of the frequency content of a signal. A stationary signal has frequency content that does not change in space (or time). For an image this means the frequency content is reasonably the same throughout the image. This is not true; for example, at object edges there is much more high frequency energy than in areas of constant color (or gray level). Finely textured areas have much more high frequency energy than coarse textures.

#5) a) One way to correct for geometric distortion involves using tiepoints. What is a tiepoint?

b) What can be done if the mapping equations return non-integer values? Explain how.

c) List three methods to perform gray level interpolation, along with an advantage and disadvantage of each.

a) Tiepoints are points with matching spatial locations in the both the original and in the distorted image

b) Gray level interpolation needs to be performed based on the surrounding pixels in the distorted image. The estimated (r,c) coordinates from the mapping equations are applied to the distorted image, and the four closest surrounding pixels are used to estimate the gray level value.

c) 1) zero-order hold: fast, but blocky output, 2)neighborhoood averaging: smooth but slower than zero-order, also result blurry, 3) bilinear interpolation: best visual results, but slow – higher computational burden.

#6) Apply the following filters to the 3x3 (window size is 3x3) subimages below, and find the output for each. a) median, b) minimum, c) midpoint, d) alpha-trimmed mean with T = 2.



a) 119, 99, b) 111,0 c) 183, 50, d) 118, 98.4

#7) ) Given an image with 3-bits per pixel, with the following histogram, a) find the histogram mapping table, and b) the resulting histogram after histogram equalization.

|  |  |
| --- | --- |
| Gray Level | Number of Pixels |
| 0 | 5 |
| 1 | 5 |
| 2 | 10 |
| 3 | 20 |
| 4 | 5 |
| 5 | 5 |
| 6 | 0 |
| 7 | 0 |

a) b)

|  |  |  |  |
| --- | --- | --- | --- |
| Original  Gray Level | HistEqValues | Gray Level | Number of Pixels |
| 0 | (round)(5/50)x7; 1 | 0 | 0 |
| 1 | (round)(10/50)x7; 1 | 1 | 10 |
| 2 | (round)(20/50)x7; 3 | 2 | 0 |
| 3 | (round)(40/50)x7; 6 | 3 | 10 |
| 4 | (round)(45/50)x7; 6 | 4 | 0 |
| 5 | (round)(50/50)x7; 7 | 5 | 0 |
| 6 | (round)(50/50)x7; 7 | 6 | 25 |
| 7 | (round)(50/50)x7; 7 | 7 | 5 |

#8) Mark T for true and F for false.

\_F\_\_ Quantization is a reversible process

\_\_F\_ In the presence of gamma noise, a Wiener filter reduces to an inverse filter.

\_F\_\_ Unsharp masking gives images a “softer” look

\_F\_\_ In image coding, the mapping process is not reversible

\_T\_\_ Order filters are nonlinear filters

\_F\_\_ When measuring image quality with a subjective test, the best type is an impairment test.

\_F\_\_ Image enhancement methods utilize a mathematical model of the image formation process

\_T\_\_ Homomorphic filtering assumes low frequencies are primarily from the lighting

\_F\_\_ PSF stands for “Point Space Feature”

\_F\_\_ A Huffman code is uniform length code

\_T\_\_ In unsharp masking the amount of sharpening is controlled by a histogram shrink

\_T\_\_ Using a gray code in preprocessing can improve RLC results

\_T\_\_ JPEG2000 uses the wavelet transform

\_F\_\_ Objective image quality measures are useful for all applications.

\_T\_\_ Notch filters are useful for removing periodic noise caused by engine vibration

\_F\_\_ Most real images can be considered to be stationary signals

#9) a) Sketch the histogram of an image with high entropy. b) Sketch the histogram of an image with medium entropy. c) Sketch the histogram of an image with zero entropy

* Sketch histograms so that higher entropy-> more spread out. Zero entropy is a impulse histogram

#10) a) Describe the image model used in homomorphic filtering. b) List the assumptions that underlie application of this filter for image improvement. c) Describe an example where the assumptions are not valid.

a) I(r,c) = L(r,c)R(r,c). A multiplicative model where L is form the lighting and R is from the \reflectance properties of the objects in the image.

b) The underlying assumptions are that the lighting component, L, causes the low spatial frequency information in the image, and the reflectance functions of the objects are responsible for the middle and high frequencies.

c) The assumptions are not valid if we have harsh shadows, or HF from the lights, or smooth changing reflectance function, such as a constant smooth, but curved surface.

#11) a) Given the following image, list a sequence of steps that could be used to make the image look better. b) Is the order of operations important? Why or why not?



a) 1. Notch filter to remove the horizontal sinusoid interference, 2. adaptive median to remove S&P noise, but retain image detail. 3. Maybe unsharp masking to sharpen, 4. Histogram equalization to improve contrast

b) Yes, order is important. The contrast enhancement should be performed last, or we may enhance the noise.

#12) a) What is the power spectrum ratio and how is it related to the signal-to-noise ratio? b) Sketch the filter response of the Wiener and the inverse filter and explain why the Wiener works better in the presence of noise. c) Why use a constant in place of the power spectrum ratio in the Wiener filter?

a) Sn/Si = power spectrum ratio, it is the inverse of signal/noise ratio-> SiSn

b)

Spatial Frequency

N/2

−N/2

0

Wiener Filter

Response

Inverse Filter Response

At high frequencies most energy is noise and should be cut, but inverse filter boosts it

c) Because in practice the original image is not available

#13) a) Briefly describe a method for estimating a noise model for an image. b) Briefly describe a method for estimating the degradation function of an image acquisition system.

a) Find an area in an image that looks like it should be constant, or known. Crop it out and examine the histogram. Subtract the known histogram and what is left is the noise model, compare to existing models and estimate noise. (Also, you can aim at a blank wall to estimate noise in an image acquisition system)

b) Aim at a point light source, the resultant image is the point spread function, PSF, h(r,c), for the system. A more reliable method is to use sinusoidal inputs at various frequencies to estimate the modulation transfer function, MTF, H(u,v). Given images from the system, but not the system itself apply 1) Image analysis: find a known point or line and estimate the blur or degradation, 2) Experimentation (as above), or 3) mathematical modeling: for example motion or atmospheric blurring