**ECE 439 Sample Test #1 NAME\_\_\_\_\_\_\_\_KEY\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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

#1) An inventor wants to build a weather radar instrument for private aircraft. Rather than using a traditional radial sweep display, the system electronically warps spatial information so that it can be displayed in the form of a 8" x 8" raster pattern (square grid). What spatial resolution would you suggest (a power of 2, for digital display reasons) if the pilot's eyes are about 24" from the screen?



#2) For the following row of an image, find the Fourier transform:

[3 3 0 5]

Answer = ¼[11 3+2j -5 3-2j] = [2.75 0.75+0.5j -1.25 0.75-0.5j]

#3) a) Given the following 2-D data distribution, show (graphically) how the PCT would modify the data. b) After applying the PCT, what is it that is maximum along the principal component axis? c) How is the PCT applied to color images? (answer in one sentence, with no equations!) d) Why is the PCT useful in image processing?



b) variance c) applied to RGB data d) to decorrelate data between spectral bands, useful for compression

#4) Sketch the following gray level mapping equations, assume 8-bit data. a) digital negative, b) To enhance gray levels from 50-100, and leave others the same. c) Stretch the range 100 to 200 over the entire range, with clipping at both ends

a) b) c)

255

255

255

255

50

100

255

255

100

200

#5) Let the rows of the following matrix represent basis vectors.

a) Are they in sequency order? Why or why not?

b) Are they orthogonal? Why or why not?

c) Are they orthonormal? Why or why not?

$$\left\{\begin{matrix}\begin{matrix}+1&+1\\+1&-1\end{matrix}&\begin{matrix}+1&+ 1\\-1&+1\end{matrix}\\\begin{matrix}+1&-1\\ +1&+1\end{matrix}&\begin{matrix}+1&-1\\-1&-1\end{matrix}\end{matrix}\right\}$$

a) no, they are in the following order: 0,2,3,1 ; not increasing sequency

b) yes, vector inner product = 0

c) no, not normalized, need to find vector magnitude ,

#6) a) Given this convolution mask, i) what type of filter is it? ii) How will it affect the image?

 

i) Lowpass, mean or average

ii) it will blur the image, retain average brightness along the horizontal and vertical, increase overall brightness (which may or may not matter when it is remapped)

b) Given this convolution mask, i) what type of filter is it? ii) How will it affect the image?

 

i) highpass, sharpening, enhancement

ii) enhance horizontal edges (vertical lines), remove average (DC) brightness

#7) Answer T for true and F for false.

\_T\_\_ The results of an 8th-order Butterworth filter are similar to those of an ideal filter

\_T\_\_ Using too few bits per pixel results in false contours in images

\_\_T\_ The convolution theorem allows us to perform filtering in the spatial domain

\_F\_\_ We typically log remap a spectrum image so that the lizards stop squeaking, oh so loudly

\_T\_\_ In CVIPtools, the Transform tab is in the Analysis window

\_T\_\_ Computer vision and image processing both use image analysis methods.

\_T\_\_ Image analysis can be performed in both the spatial and spectral domains

\_\_F\_ Convolution masks whose terms add up to zero tend to retain the original average brightness

\_T\_\_ The Human Visual System's (HVS) spatial cutoff frequency for bright images is at about 50 cycles per degree

\_T\_\_ Gamma correction is used to compensate for the fact that imaging equipment reacts according to a power –law equation

\_\_F\_ The rods in the human eye have high spatial resolution capability due to the fact that each sensor is tied to an individual nerve.

\_T\_ The *approximate* bandwidth of the HVS, in terms of wavelength, is from 400 to 700 nm.

\_T\_\_ The FFT basis functions more closely resemble natural images than do the WHT basis functions

\_F\_\_ In a *range* image, the brightness values correspond to the amount of energy in the infrared

\_F\_\_ The phase of a Fourier spectrum contains most of the information about image contrast

\_T\_\_ Optical illusions are created when the brain completes missing spatial information

\_T\_\_ About one-half of the FFT coefficients are redundant

#8) a) Given the following matrix where the rows are the one-dimensional basis vectors, find the basis image corresponding to (u,v) = (1,3). b) Do you think these basis vectors form a good set of basis vectors? Why or why not?

 

$\left\{\begin{matrix}\begin{matrix} 1&1\\-1&2\end{matrix}&\begin{matrix} 1& 1\\ 2& -1\end{matrix}\\\begin{matrix} 3& 3\\ 0& 0\end{matrix}&\begin{matrix}-3&-3\\ 5&-5\end{matrix}\end{matrix}\right\}$ a)  b) no, they are not all orthogonal or orthonormal

#9) Given the following four basis images:

 v→ 0 1

u

↓

0

1 

and I(r,c) = 

a) Find: T(u,v)

b) Are these basis images orthonormal? Why or why not?

a)  b) no, magnitude not equal to 1, 

#10) Describe or sketch the image that results from the convolution of the following two images:

Image #1: a horizontal sine wave of frequency 4; Image #2: a vertical sine wave of frequency 16

SHOW ALL YOUR WORK ! EXPLAIN YOUR RESULTS!

Apply convolution theorem:

F1

F2

F2xF2

DC Term only

F-1[F1xF2] = Constant image

The Fourier transform of Image1 and Image2 are DC terms in the center and the corresponding frequencies along the axis. When these are multiplied together, we get only DC. The inverse Fourier transform of this is a constant, or gray level, image.

#11) a) even, b) cosine is faster, it only requires real arithmetic while the Fourier requires complex arithmetic c) 2Nx2N, d) rectangular, e) Walsh-Hadamard because it only require adding or subtracting since all the basis function coefficients are +1 or -1, and the cosine requires multiplication with floating point numbers

#12) a) Name the two properties of the Fourier transform that are used to shift the DC term to the center. b) Applying these two properties in the spatial domain gives the equation to implement this, what is it?

a) periodicity and modulation

b) 