ECE 5273
Test 1

Monday, April 2, 2012
4:30 PM - 5:45 PM

Spring 2012 Name: SOLUTION

Dr. Havlicek Student Num:________

Directions: This is an open notes test. You may use the official course lecture notes and a calculator. Other materials are not allowed. You have 75 minutes to complete the test. All work must be your own.

SHOW ALL OF YOUR WORK for maximum partial credit!

GOOD LUCK!

SCORE:

1. (25) ________

2. (25) ________

3. (25) ________

4. (25) ________

TOTAL (100):

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this test.

Name:________ Date:________

1. **25 pts.** True or False. Mark *True* only if the statement is **always** true.

TRUE	FALSE	
	X	(a) **2 pts.** Imaging sonar is an example of absorption reflection imaging.
X		(b) **2 pts.** A binary median filter removes both gaps and peninsulas of insufficient size.
	X	(c) **2 pts.** The DFT of a real-valued digital image is real X and conjugate symmetric.
	X	(d) **2 pts.** A flat histogram usually indicates an overexposed image.
	X	(e) **2 pts.** Run-length coding always reduces the storage requirement for a digital image. See Notes Page 2.24
	X	(f) **2 pts.** To implement linear convolution of two 128×128 digital images by multiplying DFT's, it is generally necessary to zero pad the images to a size of 512×512. 256×256
X		(g) **2 pts.** The binary OPEN-CLOSE morphological filter tends to link neighboring holes together.
	X	(h) **2 pts.** The full-scale contrast stretch is an example of a geometric image operation.
X		(i) **2 pts.** For a typical digital image, logarithmic range compression is useful for displaying the DFT magnitude.
	X	(j) **2 pts.** Frame averaging differencing is a common technique for detecting motion in a video sequence.
X		(k) **2 pts.** Aliasing always occurs when an optical (continuous) Gaussian image is spatially sampled to make a digital image. Not band limited
	X	(l) **3 pts.** When electrical engineers say "Trans SP," they usually mean *IEEE Transactions on South Park.*

2. **25 pts.** Consider the 4×4 image $\mathbb{I}$ shown below, where the allowable range of gray levels is $0 \le I(i,j) \le 15$:

$\mathbb{I}$ =

10	**3**	**2**	**1**
4	**3**	**2**	**10**
3	**4**	**9**	**9**
2	**1**	**4**	**9**

Construct a new image $\mathbb{J}$ by applying the histogram flattening algorithm to $\mathbb{I}$. Show the new image $\mathbb{J}$ and its histogram $H_{\mathbb{J}}$ in the spaces provided below:

$\mathbb{J}$ =

15	8	5	2
10	8	5	15
8	10	13	13
5	2	10	13

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H_{\mathbb{J}}(k)$	0	0	2	0	0	3	0	0	3	0	3	0	0	3	0	2

$I(i,j)$	$J_1(i,j)$	$J(i,j) = \text{INT}[15 J_1(i,j) + 0.5]$
1	2/16	2
2	5/16	5
3	8/16	8
4	11/16	10
9	14/16	13
10	16/16	15

Work Space:

$\mathbb{J}_1$ =

16/16	8/16	5/16	2/16
11/16	8/16	5/16	16/16
8/16	11/16	14/16	14/16
5/16	2/16	11/16	14/16

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H(k)$	0	2	3	3	3	0	0	0	0	3	2	0	0	0	0	0
$p(k)$	0	2/16	3/16	3/16	3/16	0	0	0	0	3/16	2/16	0	0	0	0	0

$\sum_{i=0}^{k} p(i) \longrightarrow$ 0, 2/16, 5/16, 8/16, 11/16, 11/16, 11/16, 11/16, 11/16, 14/16, 16/16, 16/16, 16/16, 16/16, 16/16, 16/16

3. **25 pts.** A 3D scene consisting of a black square against a white background is imaged with a pinhole camera having a focal length of 35mm. The 3D space coordinates (X,Y,Z) of the four corners of the square in units of meters are

$$P_1 = (5.9994\text{ m}, -0.0349\text{ m}, 5.0605\text{ m}),$$
$$P_2 = (2.0698\text{ m}, 5.4638\text{ m}, 3.5364\text{ m}),$$
$$P_3 = (2.0698\text{ m}, 1.9997\text{ m}, 1.5364\text{ m}),\ \text{and}$$
$$P_4 = (2.0000\text{ m}, 0.0000\text{ m}, 5.0000\text{ m}).$$

Find the projections of the four corners in the image plane and carefully sketch the image that is obtained.

$f = 0.035\text{ m}$ $\quad (x,y) = \frac{f}{Z}(X,Y)$

$$P1: (x,y) = \frac{0.035}{5.0605}(5.9994, -0.0349) = (0.0415, -0.0002)$$

$$P2: (x,y) = \frac{0.035}{3.5364}(2.0698, 5.4638) = (0.0205, 0.0541)$$

$$P3: (x,y) = \frac{0.035}{1.5364}(2.0698, 1.9997) = (0.0472, 0.0456)$$

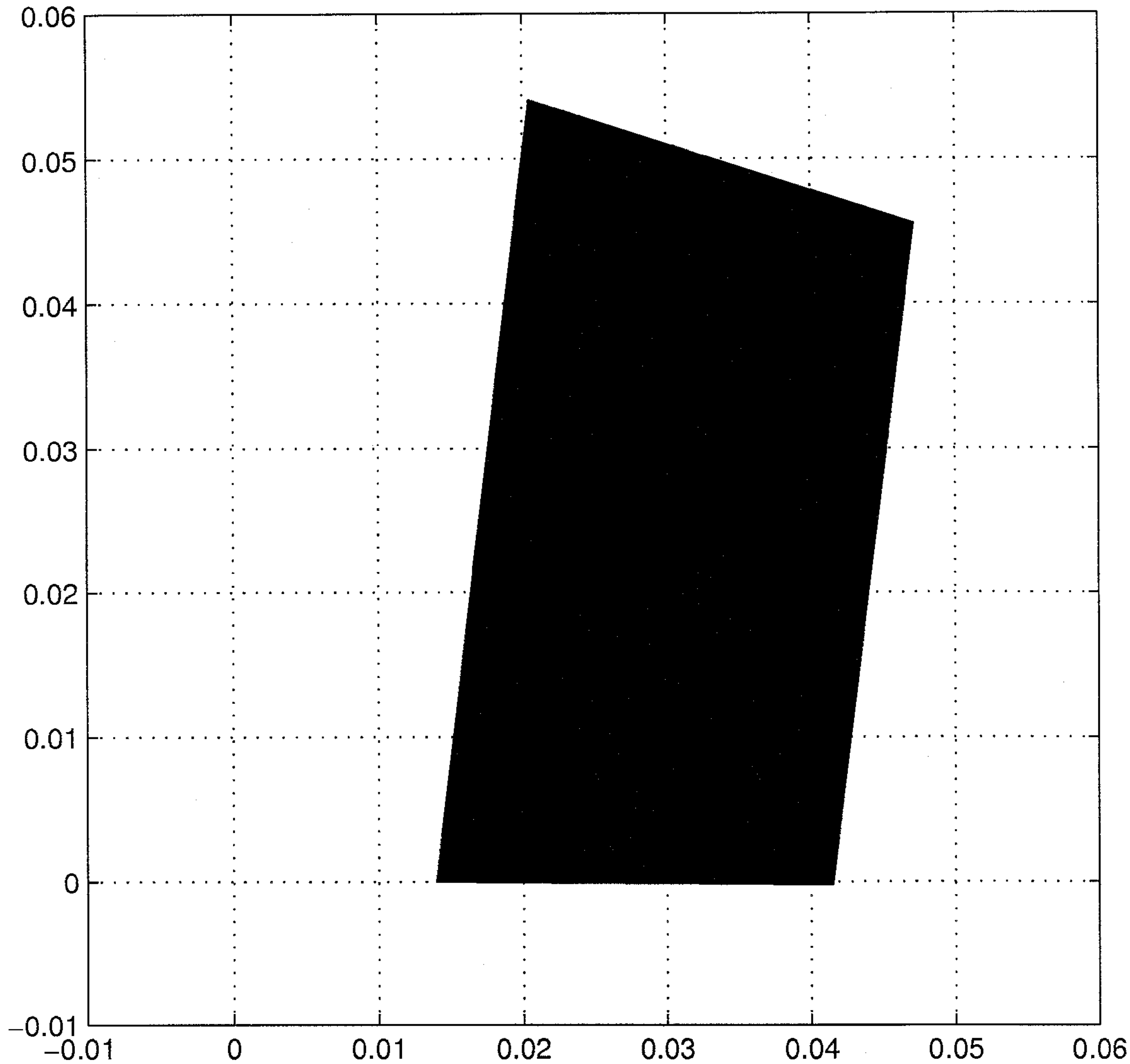
$$P4: (x,y) = \frac{0.035}{5.000}(2.0000, 0.0000) = (0.0140, 0)$$

The above are in <u>meters</u>.

In mm,

$$\left.\begin{aligned} P_1 &= (41.5, -0.2) \\ P_2 &= (20.5, 54.1) \\ P_3 &= (47.2, 45.6) \\ P_4 &= (14.0, 0) \end{aligned}\right\} \text{mm}$$

More Workspace for Problem 3...



$N=6$

4. **25 pts.** Consider a 6×6 digital image $\mathbb{I}$ given by

$$I(i,j) = 3 + 12\delta(i,j) + \cos\left[\frac{2\pi}{6}(i+2j)\right] + 2\cos\left[\frac{2\pi}{6}(2i-j)\right].$$

(a) **13 pts.** Find a closed form expression for the DFT $\widetilde{\mathbb{I}}$.

From the DFT pairs on Notes Pages 4.40 – 4.42, you can write down directly

$$\widetilde{I}(u,v) = 18\delta(u,v) + 2 + 3\left[\delta(u-1,v-2) + \delta(u+1,v+2)\right] + 6\left[\delta(u-2,v+1) + \delta(u+2,v-1)\right].$$

$-3 \le u,v \le 2$

(b) **12 pts.** Show the real and imaginary parts of the **centered** DFT array in the space provided below:

$\widetilde{\mathbb{I}} =$

v \ u	-3	-2	-1	0	1	2
-3	2	2	2	2	2	2
-2	2	2	5	2	2	2
-1	2	2	2	2	2	8
0	2	2	2	20	2	2
1	2	8	2	2	2	2
2	2	2	2	2	5	2

$+ \sqrt{-1} \times$

-3	-2	-1	0	1	2	u / v
0	0	0	0	0	0	-3
0	0	0	0	0	0	-2
0	0	0	0	0	0	-1
0	0	0	0	0	0	0
0	0	0	0	0	0	1
0	0	0	0	0	0	2