CS 482 Exam: Computer Vision (due Tuesday April 12, 6pm)

HONOR SYSTEM: This examination is strictly individual. You are not allowed to talk, discuss, exchange solutions, etc., with other fellow students. Furthermore, you are only allowed to use the book and your class notes. If you use other materials please you should make a note of it. You may only ask questions to the class instructor. Any violation of the honor system, or any of the ethic regulations, will be immediately reported according to George Mason University honor court.

1. (10) You are given a simple 10×10 image that has eleven distinct gray levels $i = 25k, k = 0, \ldots, 10$. Their relative frequencies are $h(0) = \frac{1}{100}, h(25) = \frac{5}{100}, h(50) = \frac{10}{100}, h(75) = \frac{5}{100}, h(100) = h(125) = \frac{2}{100}, h(150) = \frac{5}{100}, h(175) = \frac{10}{100}, h(200) = \frac{30}{100}, h(225) = \frac{25}{100}, h(250) = \frac{5}{100}$. Describe and use the peak and valley method to choose a threshold for this image.

2. (10) Another important parameter of the imaging system is the *field of view* (FOV). Field of view is twice the angle between the optical axis (z-axis) and the end of the retinal plane (CCD array). Imagine that you have a camera system with focal length 16mm, and retinal plane (CCD array) is $(16mm \times 12mm)$ and that you digitizer samples your imaging surface 500×500 pixels in each direction.

   a) Compute the FOV.

   b) Write down the relationship between the image coordinate and a point in 3D world expressed in the camera coordinate system.

   d) Describe how is the size of FOV related to the focal length and how it affects the resolution in the image.

3. (a) (20) Show the resulting image obtained after convolution of the original with the following approximation of the derivative filter $[-1, 0, 1]$ in the horizontal direction.

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

   (b) Compute gradient magnitude of the above image at all points.

   (c) Compute gradient direction at all points.

   (d) Show the image after applying non-maximum suppression step on the gradient magnitude image.

4. (5) Why is it important to smooth the image before taking the derivatives ?

5. (5) What is a difference between Gaussian smoothing and median filtering? How would you decide to use one vs. another ?

6. (15) A pair of cameras with parallel optical axis are observing a square in front of a flat wall. How would you design a *random dot stereogram* of the scene if the camera and the scene have following parameters:: focal lengths of the cameras are $f = 20mm$ (256 pixels), the baseline $b = 0.1m$, the distance of the wall from the camera is $z_0 = 1m$, and the distance of the surface of the square from the camera is $z_1 = 0.9m$. Choose the position and the size of the square to fill the central portion of the image. What are the disparities of the points on the square ? What are the disparities of the points on the wall ?

7. (20) You are given the following binary image. Assume that the coordinate system x-axis is pointing right and y-axis is pointing up, with the origin in the left bottom corner.

0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	0	0
0	0	0	1	1	1	0	0	0
0	0	0	1	1	1	0	0	0
0	0	0	1	1	1	0	0	0
0	0	1	1	1	1	1	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Compute following parameters:

- area
- perimeter
- center of mass
- second order moments M_{11}, M_{20}, M_{02}
- central moments $\mu_{11}, \mu_{12}, \mu_{02}$

8. (15) Straight line in 3D world is projected in to a straight line in the image. The projections of two parallel line intersect in the image at so called *vanishing point*.

   a) Show (mathematically) that projections of parallel lines in the image intersect in a point.

   b) Compute for a certain family of parallel lines where in the image will the vanishing point be.

   c) When does the vanishing point of the lines in the image lie at infinity (i.e. they do not intersect)?