Computer Vision I

SAMPLE EXAM I

October 19, 2018

Prob. 1		20 pts
Prob. 2		20 pts
Prob. 3		20 pts
Prob. 4		20 pts
TOTAL		80 pts

NAME:_____

Remember to:

- Read the whole test first.
- Stay in motion.
- Budget your time.
- Think partial credit.
- Show your work.
- Try to keep it legible.
- Check your answers if you have time at the end.

Computer Vision: EXAM I

1. (20 pts) Answer True (T) or False (F):

   (a) _____ Box filters smooth edges.

   (b) _____ Cascading filtering is a procedure where and image is filtered by progressively larger masks.

   (c) _____ To apply the median filter we must convolve the image with a mask.

   (d) _____ Lines that are perspective images of parallel 3D lines are also parallel.

   (e) _____ Salt and pepper noise is best cleaned when using a Gaussian filter.

   (f) _____ Applying the Hough transform to the Hough transform of an image will return the original image. (i.e. applying it twice, is the same as not applying it at all.)

   (g) _____ To find a curve using the Hough transform, it is not necessary to have a parametric equation of the curve being sought.

   (h) _____ Segmentation using image thresholding usually works poorly because histograms do not provide spatial information.

   (i) _____ The energy functional of a snake depends on the shape of the snake but it is independent of its location on the image.

   (j) _____ The Laplacian operator (second order derivative operator) is useful in calculating the direction of an edge.

2. (20 pts) Consider a room ($10m. \times 4m. \times 4m.$). An imaging system contains a camera located at the corner of the room as shown in Figure 1. The optical axis is at α degrees from the long wall, as shown in the figure, and the lens is in front of the center of projection. The focal length of the camera is 50mm. The x axis of the camera coordinate system is along the vertical direction as shown in the figure. The long wall of the room in front of the camera is made out of horizontal bricks. Each brick is $5cm. \times 20cm.$. The camera captures an image of the brick wall. A vanishing point for the images of the bricks is located at the point with camera coordinates $(0, 50\frac{\sqrt{3}}{3}, 50)$.

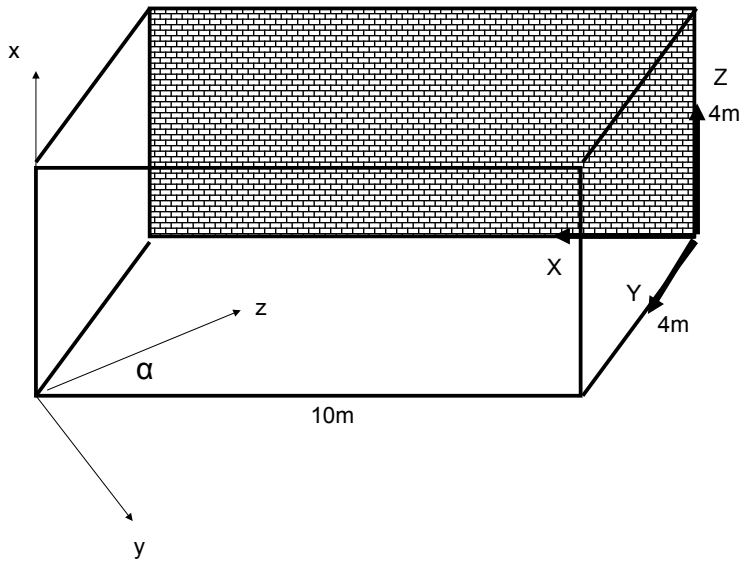

Figure 1: Room with brick wall.

(a) (10 pts) Find the angle α.

(b) (10 pts) Find a transformation matrix M (you can give it as a product of matrices) between the two coordinate systems such that:

$$\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = M \cdot \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

3. (20 pts) An 8×8 image $I(x, y)$ has gray level values given by the following equation:

$$I(x, y) = |x - y|$$

for $x, y = 0, 1, 2, \ldots, 7$.

(a) Find the output image obtained by applying a 1×3 horizontal median filter on the given image. (Leave the side–border pixels unchanged.)

(b) Suppose that the original image I is corrupted with salt noise (gray value 255) with probability 0.1. That is, each pixel has an independent probability of 0.1 of becoming 255. If the corrupted image is filtered with the median filter of part (a), what is the probability that a non-border pixel of the output has value 255?

(c) Suppose that the original image is corrupted with additive uncorrelated Gaussian noise with zero mean and variance σ^2. In order to clean the image, it is filtered with the following 1×5 filter

$\frac{1}{16}$	1	4	6	4	1

Find the variance of the noise of the output image. (Remember: $Var(n) = E[(n - E[n])^2]$)

4. (20 pts) Hough Transform and RANSAC.

   (a) The vertices of a square are $(0, 0)$, $(0, 1)$, $(1, 0)$ and $(1, 1)$. Consider the Hough transform using the line parametrization

   $$\rho = x \cos\theta + y \sin\theta$$

   with $-90 \leq \theta \leq 90$ and $-4 \leq \rho \leq 4$.

      i. Plot in parameter space the Hough transform of the vertices, the center and the diagonals of the square.

      ii. Find the Hough transform of the sides of the square after it is rotated 45 degrees clockwise around the origin.

   (b) Using a range sensor we have captured a 3D scene as a set of 3D points with (X, Y, Z) coordinates in the sensor coordinate system. Assume that the scene contains a single dominant plane (for example, the front of a building) at unknown orientation, plus smaller numbers of other scene points (for example, trees, light poles, a street) that are not in this plane.

      i. Define a Hough transform based algorithm for detecting the orientation of the dominant plane in the scene. Specify the dimensions of the Hough space, a procedure for mapping the data points to this space, and how the plane orientation would be determined.

      ii. Describe how the RANSAC algorithm could be used to detect the orientation of the plane in the scene from the data points.