CS296.1 Final Exam Sample

This sample final exam gives you an indication of the flavor of the questions asked. Topics covered may be somewhat different in the actual exam. Also, topics covered in the last lectures after this sample is handed out will be included in the final exam as well.
This exam is open-book, open-notes. Please write your name on this page *now*.

1. Under perspective projection, a square in the world projects to a quadrilateral in the image. Given the quadrilateral, how can you find the image projection of the center of the square?

2. When is the focal distance of a camera equal to the focal length of it lens?

3. What axis is the following rotation about, by how many degrees, and in what direction (clockwise or counterclockwise)?

$$R = \begin{bmatrix} \sqrt{3}/2 & -1/2 & 0 \\ 1/2 & \sqrt{3}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

[Hint: Unless you can tell by inspection, find a vector that is not changed by R. That is the axis. Then pick a simple vector orthogonal to the axis, and see by how much it is rotated.]

4. What is the Rodrigues vector for the rotation in the previous question?

5. Write the result of convolving the finite, discrete signals

$$\begin{bmatrix} 1 & 2 & 4 \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} 1 & 3 & 2 \end{bmatrix}.$$

Assume that signals are extended with zeros where they are not defined. Your result should be a vector of five numbers.

6. For each of the following functions $f(x, y)$, state whether they are separable. If they are separable under some conditions, state the conditions. For separable functions, show how they separate.

(a)

$$f(x, y) = \log(xy)$$

(b)

$$f(x, y) = \log(x + y)$$

(c)

$$f(x, y) = xy - x + 2y - 2$$

7. After running Canny's edge detector on an image, you notice that long edges are broken into short segments separated by gaps. In addition, some spurious edges appear. For each of the two thresholds (low and high) used in hysteresis thresholding, state how you would adjust the threshold (up or down) to address both problems. Assume that a setting exists for the two thresholds that produces the desired result. Explain your answer very briefly.

8. The Lucas-Kanade tracker tracks features between two frames by repeatedly solving a 2×2 linear system of the form

$$A\mathbf{x} = \mathbf{d}$$

where A is a function of image derivatives, and $\mathbf{d}$ is a function of the difference between the two frames.

(a) How can a trackable feature (usually called a "corner") be defined in terms of the eigenvalues $\lambda_1 \geq \lambda_2$ of A and some "sufficiently large" threshold τ?

(b) How can an edge be defined in terms of those eigenvalues?

9. A spherical ball of radius 10 cm is placed with its center at distance 100 cm from the center of projection of a camera, and so as to fill the image exactly (that is, the image of the ball barely touches the middle of each of the four sides of the image). The image has 512×512 pixels, and the camera sensor has square pixels. Assuming perfect pinhole projection, what is the focal distance of the camera in pixels?

10. Why does the epipolar constraint simplify stereo matching?

11. Given the essential matrix E for a stereo pair, write two systems of equations whose solutions are the epipoles in the left and right camera coordinate systems.

12. Continuing the previous question, what are the coefficients of the left epipolar line corresponding to the right image point with camera coordinates $\mathbf{p}_R$?

13. State two reasons why the "Sum of Squared Differences" measure for image correlation in stereo is generally not zero even at the correct disparity.