Computer Vision I

Sample Test Problems

October 25, 2018

1. An imaging system contains a camera located at the center of the left wall of a room ($10m. \times 4m. \times 4m.$) as shown in Fig. 1(a). The optical axis is perpendicular to the wall and the lens is in front of the wall. The focal length of the camera is λ. The (x, z) plane of the camera is parallel to the (X, Y) world plane. The room has painted on the right wall a circle of radius 0.5m centered at $(0, 1, 3)$ in world coordinates.

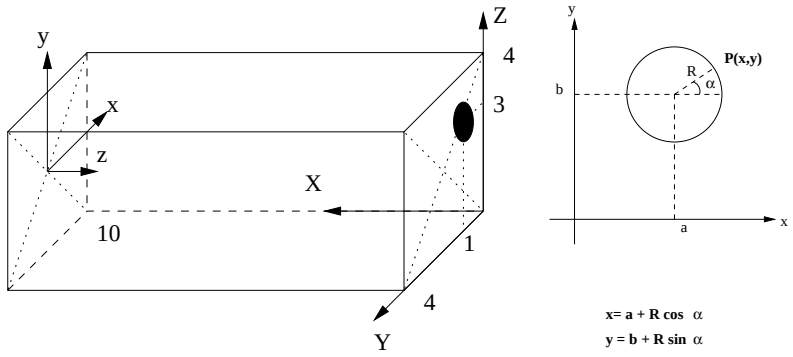

Figure 1: (a) Room with a circle. (b) Circle parametric equations.

(a) Prove that the image of the circle on the wall is also a circle. *Hint:* use the parametrization shown in Fig. 1(b), that is, a point P on a circle with center (a, b) and radius R on a plane (x, y) has coordinates:

$$\begin{aligned} x &= a + R\cos\alpha \\ y &= b + R\sin\alpha \end{aligned}$$

(b) Find the center and the radius of the image of the circle.

(c) Find a transformation matrix between the two coordinate systems.

2. Features Detection and Description

(a) Give a mask that can be used to approximate the first derivative of a (1D) image. Apply it to the image given below (ignore computing a value for the first and last image pixels). In addition to showing the result, indicate where edges would be detected and why.

56 64 79 98 115 126 132 133

(b) Compare the Canny edge detector with the Laplacian-of-Gaussian edge detector for each of the following questions:

i. the order of the derivatives that they use.

ii. the parameters they use

iii. which detector is more likely to produce long, thin, contours? Explain why.

(c) Consider a 3D image, where instead of having intensity values at pixels (x, y), we have intensity values at *voxels* (x, y, z). We want a corner detection algorithm to use with this type of 3D images. Describe a generalization of the Harris corner detection algorithm by giving the main steps of the algorithm, including a test to decide when a voxel is a corner point.

(d) The SIFT descriptor is a popular method for describing selected feature points based on local neighborhood properties so that they can be matched reliably across images. Assuming feature points have been previously detected using the SIFT feature detector, (i) briefly describe the main steps of creating the SIFT feature *descriptor* at a given feature point, and (ii) name three scene or image changes that the SIFT descriptor is (relatively) insensitive to.