

Problem Set 5

CMSC 426

Assigned Tuesday, November 1, Due Tuesday, November 8

1. Projection

- a. **5 points:** Suppose we have a camera with focal point $(0,0,0)$ and image plane $z = 1$. We observe a point in the scene at the location $(18, 6, 3)$. Where does this point appear in the image?
- b. **10 points:** Suppose we have a camera with focal point $(3,2,3)$ and image plane $x + y + z = 11$. We are looking at a scene point at the location $(13,7,8)$. Where does this appear in the image plane? That is, give the coordinates of a 3D point that is in the image plane.
- c. **10 points:** Suppose we have a camera with a focal point at $(0,0,0)$, and an image plane at $z = 1$. We are looking at the line described by the equations $x = 1, y = z$. What is the vanishing point of this line?
- d. **10 points:** Suppose we have a camera with a focal point at $(0,0,0)$, and an image plane at $z = 1$. We are looking at the plane $x = 1$. What is the horizon of this plane?
- e. **Challenge problem, 10 points:** Suppose we have a camera with a focal point at $(0,0,0)$, and an image plane at $z = 1$. We are looking at a circle in the plane $x = 1$. It has its center at the location $(1, 0, 10)$, and a radius of 1 . What shape does the circle produce in the image? Describe this with an equation.

2. Reconstruction

- a. **5 points:** Suppose we have a camera with a focal point at $(0,0,0)$, and an image plane at $z = 1$. We see an image point at the location $(5, -2, 1)$. Give a line in 3D that this point must lie on.
- b. **10 points:** Suppose the point from part (a) is known to be on a ramp, which is described by the equation $3y - z = -140$. What are the 3D coordinates of the scene point we are looking at?

3. Stereo

- a. **5 points:** Suppose we have two cameras. One has a focal point at $(0,0,0)$, the second has a focal point at $(10,0,0)$. Both have the same image plane, $z = 1$. Suppose we see a scene point at $(2, 5, 1)$ in the first image, and at $(10,5,1)$ in the second image. Where is the scene point?

- b. **10 points:** Suppose the second camera instead has an image plane at $z = 2$. If we see a point in the first image at $(0, 1, 1)$, what is the corresponding epipolar line in the second image?
- c. **10 points:** Suppose the second camera instead has an image plane at $x = 9$. What is the epipole in the second image?
- d. **10 points:** Suppose the second camera has an image plane at $x = 9$, and we see a scene point at $(1, 2, 1)$ in the first image. What is the epipolar line in the second image? You may describe with any appropriate set of equations.

4. Rectification

- a. **5 points:** Suppose we take an image with a camera that has a focal point at $(0, 0, 0)$ and an image plane of $x + z = 1$. We observe a point at the location $(-4, 3, 4)$. Where would this point have appeared if we had taken the picture with a camera with the same focal point, but an image plane of $z = 1$?
- b. **10 points:** In the same setting, suppose we want to find the intensity that will be in our new image at $(1, 2, 1)$. Where would we look in the image that we took?