Problem Set 5

CMSC 426

Assigned Tuesday, March 28, Due Tuesday, April 4

1. **10 points.** Suppose we have a camera with a focal point at (0,0,0). It is looking in the *z* direction with a focal length of 1/2, so that the image plane is *z=1/2.* Suppose there is a point in the world with coordinates (20, 10, 8).
    a. Give the 3D coordinates of the point in the image plane where this point will appear.
    b. Suppose instead that the camera has its focal point at (0,0,0) but it is looking in the *x* direction, so that the image plane is *x=1/2.* Give the 3D coordinates of the point in the image plane where this point will appear.
    c. Suppose instead that the camera has its focal point at (4,2,2) and is looking in a different direction, so that the image plane is at *x+y = 7.* Give the 3D coordinates of the point in the image plane where this point will appear.

2. **10 points.** Suppose we have a camera with a focal point at (0,0,0) and an image plane of *z=1.*
    a. What is the vanishing point for a line on the *y=-2* plane described by the equation *3x+7=z?*
    b. Consider the plane given by the equation *x+y=1.* What is the horizon for that plane? That is, the horizon is a line in the image such that the vanishing point for any line on this plane will lie on the horizon.
3. **10 points.** Suppose we have two cameras. They have focal points at (0,0,0) and (10,0,0). They have focal lengths of 1 and are looking in the *z* direction, so that the image planes are both *z=1.* Suppose a point appears in the Left image at (4,1,1) and in the Right image at (6,1,1). What are the 3D coordinates of the point in the world that produced these two image points?
4. Suppose we have two cameras. The Left camera has a focal point at (0,0,0). The cameras have focal lengths of 1 and are looking in the *z* direction, so that the image planes are both *z=1.*
    a. **5 points.** Suppose the right camera has a focal point at (10,0,0). Suppose a point appears in the Left image at the location (3,4,1). Where might this point appear in the right image? Give all possible locations. Hint: the solution should be a portion of a line that corresponds to points that are in front of the camera (have non-negative disparity).
    b. **5 points.** Suppose the right camera has a focal point at (0,10,0). What is the answer now to the question in (a)?
    c. **Challenge Problem (5 points):** Now suppose the Left camera has a focal point at (0,0,0) and an image plane at *x+z = 2.* The Right camera has a focal point at (10,0,0) and an image plane at *x+z=8.* Suppose we

observe a point in the Left camera at (1,2,1). Where might this point appear in the right image? Give all possible locations.

5. **10 points.** Suppose we have a camera with a focal point at (0,0,0) and an image plane of *x+z=2.*
    a. A point that is somewhere in the scene appears at the image location (3/2,3,1/2). If we took a picture using a camera with the same focal point but an image plane of *z=1*, where would this scene point appear in the image?
    b. Suppose the scene point appears at the image location *(x,y,z)*, with *x+z=2.* Suppose we took a picture using a camera with the same focal point but an image plane of *z=1*. Give a general formula that tells us where this point will appear in the image.