

CMSC 426 Homework 3

Due May 5th at 2:00 pm

This assignment is extra credit and can replace your lowest homework score or half your lowest project score (or 1/3 of project 3).

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 nonnegative 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.

Collaboration: You can discuss this assignment with other students, but the work must be your own.

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