

# CMSC 426 Homework 3

Due May 5<sup>th</sup> 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  $(20, 10, 8)$ .

- Give the 3D coordinates of the point in the image plane where this point will appear.
- 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.
- 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  $z=1$ .

- What is the vanishing point for a line on the  $y=-2$  plane described by the equation  $3x+7=z$ ?
- 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  $z=1$ .

- 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).
- 5 points.** Suppose the right camera has a focal point at  $(0,10,0)$ . What is the answer now to the question in (a)?
- 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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