CS 4620 Midterm 1

Friday 3 October 2008—50 minutes

Problem 1: Transformations (4 pts)

Express the homogeneous 3D transformation defined by the matrix

$$\begin{bmatrix} 0 & -1 & 0 & 2 \\ 1 & 0 & 0 & 3 \\ 0 & 0 & 1 & 4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

as a sequence of transformations in the following ways:

1. A rotation followed by a translation.
2. A translation followed by a rotation.

Express the 2D linear transformation defined by the matrix

$$\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$$

as a sequence of transformations in the following ways:

3. A rotation followed by a nonuniform scale followed by a rotation.
4. A shear along the x axis followed by a nonuniform scale followed by a shear along the y axis.

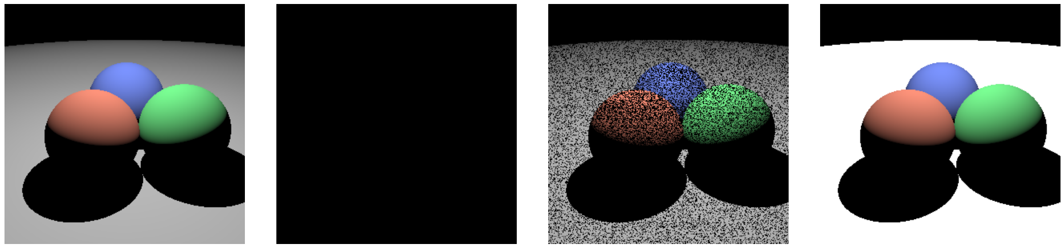
Problem 2: Perspective (2 pts)

The two photographs in Figure **??** were taken in the same hallway using two different zoom settings. In both pictures, the height of the far wall (the one with the exit sign) is one quarter of the picture height, and the far wall appears vertically centered in the image. The lights on the right hand wall are spaced 20 feet apart, and the farthest light is 20 feet from the far wall. In the left picture, the height of the wall at the position of the fourth light (counting from the far wall) is half the picture height. In the right picture, the height of the wall at the position of the second light is half the picture height. The ceiling height is 10 feet.

1. How far from the end of the hallway is the camera in each picture?
2. What is the field of view of each picture? It's fine to express the angle in terms of trigonometric functions.

You can assume this camera does not produce oblique views.

Figure 1: Two photos of a hallway. The black bars are one-fourth and one-half of the total picture height.



correct 1 2 3

Figure 2: Four images from a ray tracer. The left image is correct, and the other three were produced by introducing single-statement bugs into the program.

Problem 3: Ray tracing (6 pts)

Look at each of the three images in Figure **??** that were produced by a Ray I ray tracer with various bugs. For each one:

(a) Could it have been caused by a problem with ray generation?

(b) Could it have been caused by a problem with ray intersection?

(c) Could it have been caused by a problem with shading computations?

For each "yes" answer, back it up with an example of an error that would cause the observed symptoms. There is no right or wrong explanation; only plausible and implausible ones. But when there is a clearly plausible cause, very far-fetched explanations (which are roughly equivalent to a "no" answer) won't make full credit.

Shadow computations count as part of shading. Computing surface normals counts as part of ray intersection.

Problem 4: Gamma correction (3 pts)

In the presence of viewing flare, we can model the intensity emitted by a display as

$$I(n) = I_{\text{flare}} + \left(\frac{n}{N}\right)^{\gamma} I_{\text{max}}$$

where n is the pixel value, which runs from a minimum of 0 to a maximum of N, and I_{max} is the maximum emitted intensity (so that the maximum total intensity is $I_{\text{flare}} + I_{\text{max}}$).

Suppose we do not know the value of I_{flare}, I_{max}, or γ. Recall a standard technique for estimating γ is to find the pixel value n_{half} that matches a stripe pattern composed of equal parts $n = 0$ and $n = N$.

1. Write an expression for γ in terms of n_{half}.
2. Suppose that we use a stripe pattern that mixes $n = 0$ and $n = n_1$ and find the pixel value n'_{half} that matches this pattern. Write an expression for γ in terms of n'_{half}.
3. Instead of relying on the user's eyes and the stripe pattern, we could use a light meter to measure $I(n)$ for any n we want. How many such measurements are required to deduce γ?
4. Explain what pixel values you would measure, and write an expression for γ in terms of those measurements.