CSE 152 Assignment 1
Spring 2005
Due Thursday, April 21 in class

1. Properties of orthographic projection!

   a. Suppose we have a line given by a point $\mathbf{p}$ and a direction vector $\mathbf{v}$ so that the equation for the line is $\mathbf{l}(t) = \mathbf{p} + t\mathbf{v}$. A parallel line would be any line that has the same direction $\mathbf{v}$. Show that under orthographic projection, parallel lines project to parallel lines.

   b. Given a line from $\mathbf{a}$ to $\mathbf{b}$, and any point $\mathbf{c}$ along this line, show that the quantity

   $$\frac{|\mathbf{c} - \mathbf{a}|}{|\mathbf{b} - \mathbf{c}|}$$

   is invariant under orthographic projection. (Hint: $\mathbf{c}$ can be expressed as $\mathbf{a} + t(\mathbf{b} - \mathbf{a})$, where $0 \leq t \leq 1$.)

   c. Why do the above properties not hold for perspective projection? Give a short answer.

2. Let the vectors $\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}$ correspond to corners of a square mapped under perspective projection, where the homogeneous coordinates of the vectors are

   $$\mathbf{a} = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}, \; \mathbf{b} = \begin{bmatrix} 4 \\ 8 \\ 2 \end{bmatrix}, \; \mathbf{c} = \begin{bmatrix} 15 \\ 12 \\ 3 \end{bmatrix}, \; \mathbf{d} = \begin{bmatrix} 4 \\ 1 \\ 1 \end{bmatrix}.$$

   Calculate the vanishing point for each pair of parallel lines. Express your answer in homogeneous coordinates. (Hint: Try plotting the points on a plane.)

3. Write a Matlab script to convert an image in RGB color space to HSV color space. Do NOT use the built-in `rgb2hsv` function in Matlab. Test your script with the `color.bmp` image and display each color channel of the result image as an image in grayscale. i.e., display the H image, the S image, and the V image.

4. Write a Matlab script that does the following: given a point light located at

   $$\mathbf{p} = 2 \begin{bmatrix} \cos\frac{\pi}{4} \\ \sin\frac{\pi}{4} \\ -1 \end{bmatrix}$$

   and the surface

   $$z = f(x, y) = \begin{cases} \sqrt{1 - x^2 - y^2} & \text{if } x^2 + y^2 \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

   on the domain $x \in [-1, 1]$ and $y \in [-1, 1]$, calculate the Lambertian reflectance each point of this surface. You may assume that the albedo $a(x, y)$ at each point is 1, and also that the light source intensity s_0 is also 1. Display the reflectance for each x, y as an image. To help you get started, recall that the (unnormalized) surface normal for every point $[x, y, f(x, y)]$ on the surface is defined by

$$\mathbf{n} = \begin{bmatrix} \frac{\partial f}{\partial x} & \frac{\partial f}{\partial y} & -1 \end{bmatrix}^T.$$

What to hand in

- A hardcopy of your solutions to questions 1 and 2
- A printout of your Matlab script for questions 3 and 4
- A printout of each of the greyscale H, S, V components for question 3
- A printout of the resulting image for question 4
- Email your Matlab results (.m file for questions 3 and 4, and the greyscale components for question 3 and the final image for question 4) to wychang@cs.ucsd.edu with the title "CSE 152 Assignment 1" by the due date/time. Please gather your files into a single zip file.