CMSC 426

Problem Set 1

Due: Tuesday, February 18, 2003, 11:00, at the start of class.

Readings:
Forsyth & Ponce: Chapter 1 (you need not follow all equations in 1.2), Chapter 4 (all), Chapter 5 (sections 5.1, 5.2, and 5.3).

The programming in this assignment may take a while. Please don't wait till the night before, especially if you're unfamiliar with Matlab, and may need to ask questions.

1. **Programming:** The goal of this problem is to get familiar with some Matlab basics and some methods of projection. You will construct a simple object consisting of some 3D points. You will then write code to project these points onto an image using two methods, perspective and weak perspective projection. You will then judge the accuracy of the weak perspective approximation to true perspective.

   You will need to turn in a hardcopy of all code, plots, and a write-up of your experiment. You will also need to email files containing all Matlab code to the TA (Hyoungjune Yi aster@cs.umd.edu). We will leave to you many specific decisions about how to set up this experiment. Read through the whole assignment before starting, and think through your decisions. In addition to your write-up, all code should be documented.

a. **Construct an object:** Write a function to generate a matrix representing four 3D points with coordinates: (-1, 0, 1), (1, 0, 4), (0, 1, 3), (0, -1, 2). We will call this object **O**.

b. **Image the object:** Imagine that you have a perspective camera with a focal point at (0,0,0), a focal length of 1, and an image plane equal to the $z=1$ plane. Write a function that will take as input a set of 3D points, and return as output a set of 2D points that are the projection of the 3D points with this perspective camera.

c. Write a second function to project the points using weak perspective projection. Note that the scale factor should be based on the average distance to all points.

d. Test these functions. **O** + (0,0,1) denotes object **O** translated by one unit in the z direction. Print out a figure showing the 2D projection of **O** and **O** + (0,0,1) using weak perspective and perspective projection. The functions: `figure`, `plot` and `print` may be useful Try, for example, `plot(5,5,'o','LineWidth', 6)`, to get an idea of how to display a point in a figure so that it's easily visible. The function axis may also be helpful. You should show projections of different objects or different projections of the same object by using different shapes or colors with plot. Label everything.

e. Image Difference: Write a function to compute the sum of square differences (SSD) between two sets of image points. That is, for point sets: $(p_1, \ldots, p_n), (q_1, \ldots, q_n)$ compute: $\sum_{i=1}^{n} \left\| p_i - q_i \right\|^2$. Test it on the images generated in parts **b** and **c**.

f. Write a function that takes an object and translates it further and further away from the camera. Decide how to measure the distance from the object to the camera and document your choice. For ten different distances, compute the SSD between **O**'s projection using perspective and its projection using weak perspective. Make a plot showing how the SSD varies with the distance to the camera. Before plotting, try the command:
plot([1,2,3],[5,3,7],'o','LineWidth',3).

g. Write-up: Write about half a page describing your experiment and what it tells you about the accuracy of the weak perspective approximation to perspective projection. In your experiment you measured error as distance varied. What other factors might you vary in future experiments?

Turn in all code written, the plots from parts d and f**,** and the write-up from part g.

2. **Pen and paper exercise for perspective:**

a. Consider a point that at time *t=0* is at the position (1,0,3). The point travels in the *x* direction at a speed of one unit of distance per unit of time. For example, at time *t=1*, the point is at (2,0,3). Suppose this point is being imaged using the perspective camera in problem 1b. Write an equation that gives the x coordinate of the image of the point as a function of time.

b. Now, suppose instead that the point travels in the z direction at the same speed. For example, at time *t = 1*, the point is at (1,0,4). Write an equation that gives the x coordinate of the image of the point as a function of time.

c. What type of geometric object does this second equation describe?

3. Reflectance:

a. Take three shiny objects. Look at them in lighting dominated by a small, compact light source, such as a light bulb or the sun. Try to see the specular reflection of the light source in the object. How clearly can you see it? What does this tell you about how shiny the object is? Describe each object, the material it's made from, and its degree of shininess.

b. A soda can is very shiny. Why is it so difficult to clearly see the shape of the compact light source reflected in the side of the soda can? Why is it easier to see the shape of an object that is close to the can than it is to see the shape of a distant object?

c. How shiny do you think the moon is? Why?

This document was created with Win2PDF available at http://www.daneprairie.com.
The unregistered version of Win2PDF is for evaluation or non-commercial use only.