Course Feedback

Would you mind release every homework before Friday morning?
It would be nice for the next lecture videos to be uploaded right after the class before.

- I hear your desire for earlier postings. Sometimes I will be able to do this, although not always depending on my other course and duties. And if I post it early, I hope you will also watch it early!
Course Feedback

I hope that we could spend some time talking about who to do the gold levels of the assignments in class (after their due dates).

I noticed that in a lot of CS courses at Smith there seems to be a very proficient crowd and a way less proficient crowd and professors tend to only notice the more competent coders and I personally feel very left behind.

- I include these two comments to illustrate that we all have different needs. I try to aim the planned activities at a comfortable level for as many as possible. In one-on-one office hours, I can offer more customized interaction.
Course Feedback

Could we decrease the amount of worksheets?

- I also prefer coding where possible. Unfortunately some topics are more amenable to paper and pencil.

I wish the course had linear algebra as a requirement.

- We can add it as a suggestion/recommendation.

I feel like the grading for homework focus too much on coding style.

- Coding style is always important!
  Even advanced English classes still insist on proper spelling and grammar.
Course Feedback

Many of you said that TA hours were meeting your needs.

Others said:

- I wish there were more TA hours, or at least sometime earlier in the week, Tuesday, Wednesday even.
- [It’s] hard for me to attend TA hours at 7a.m.-8a.m. in the morning of my time zone
- I wish there were more TA hours/more TAs, or at least not on the night the assignment is due.

▷ I will explore whether Winnie can add another session earlier in the week, perhaps at a later time.
Thank you!
Q. Can you give some examples of transformations from one coordinate system to another?

A. As in 2D, you can combine primitive transformations. Often, this will be a rotation plus a translation, and possibly a scale.

Q. I'm not sure what you mean by the virtual image plane.

A. After projection, every point from the 3D scene has been mapped into 2D. The plane they map onto is called the virtual image plane. Positions on it are expressed in projected coordinates.

Although the plane where the image forms is behind the focal point and inverted, it is useful to think of an equivalent non-inverted plane placed between the focal point and the image.
Perspective Projection

- Perspective Projection
- Focal Point
- Camera Aperture
- Virtual Image Plane
- Camera Image Plane
Q. Can you explain what the focal length is?
A. It is the distance from the focal point to the image plane.

Q. Can you go over how the perspective projection points are computed? Specifically in the last question, why do we use a 2 x 4 matrix?

A. We have a 3x4 matrix (representing the perspective projection) times a 4x2 matrix (representing two 3D points in homogenous coords.)

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 0.5 & 0 \\
\end{bmatrix}
\begin{bmatrix}
6 & 4 & 4 & 2 \\
2 & 8 & 2 & 1 \\
1 & 1 & 1 & 1 \\
\end{bmatrix} =
\begin{bmatrix}
6 & 2 \\
4 & 8 \\
2 & 1 \\
\end{bmatrix} \rightarrow
\begin{bmatrix}
3 & 2 \\
2 & 8 \\
1 & 1 \\
\end{bmatrix}
\]
Your Questions

Q. Do we have a preference in which coordinate we are gonna use?

Q. Why do we need so many coordinate systems? For example, what's the use of model coordinates?

A. It’s not a question of picking one “best” coordinate system. Each one has a purpose, and they all work together.

Pairs of coordinate systems are linked together by a transformation matrix which converts one to the other (and if invertible, the inverse matrix converts back). We can string several such transformations together to get from the initial model to the final image.
Review: Projection Math

- Begin with object $P_M$ described in **model coordinates**
- Apply transformation $T$ to get **world coordinates** $P_W = TP_M$
- Apply transformation $K$ to get **camera coordinates** $P_C = KP_W$
- Projection $F$ gives 2D **projected coordinates** $P_F = FP_C$
- Final transformation $S$ gives **screen coordinates** $P_S = SP_F$
- All combined: $P_S = SFKTP_M$
Projection Math

$$P_s = S F K T P_M$$

- Also 3D rotation, scaling, translation
- 3D Rotation, scaling, translation
- Matrix of point coordinates as column vectors
- 2D rotation, scaling, translation
- 3D to 2D, either orthographic or perspective projection
Q. Why do we have a near clipping plane? Does that mean objects that are closer to camera than the near clipping plane would not be projected?
A. Correct. Only objects between the near and far plane are rendered.

Q. Why do we use 3 x 4 matrix for projection?
A. Homogeneous coordinates add an extra dimension to point representations. So a matrix of N 3D points is 4xN, and a matrix of 2D points is 3xN. Recall that $(3 \times 4) \cdot (4 \times N) \rightarrow (3 \times N)$

Q. More details about the solution to "Compute the perspective projection of the points (6,4,4), and (2,8,2) using focal length of 2"

Q. I am still a little confused with the math behind the projections, can you show another example?
Perspective Projection

Example: points: (0,0,4), (0,4,4), (2,0,8), (2,4,8)

Project using focal length of 2:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & \frac{1}{2} & 0
\end{bmatrix}
\begin{bmatrix}
0 & 0 & 2 & 2 \\
0 & 4 & 0 & 4 \\
4 & 4 & 8 & 8 \\
1 & 1 & 1 & 1
\end{bmatrix}
\begin{bmatrix}
0 & 0 & 2 & 2 \\
0 & 4 & 0 & 4 \\
2 & 2 & 0 & 4 \\
1 & 1 & 1 & 1
\end{bmatrix}
\]

Divide column by 2
Divide column by 2
Divide column by 4
Divide column by 4
Q. What are some examples of using Perspective Projection in 3-D animation?

A. Almost all 3D animation uses perspective projection.

Q. I'm still a bit confused about how the projected coordinates are different from screen coordinates. Are they just flipped over?

A. The y axis is inverted in screen coordinates, and they are probably scaled to match the number of pixels in the display.
Projection Handout
Projection Handout

- Focal point (FP) is the origin
- Lines from scene to FP intersect red image plane (line)
- Compute projected point $x_p$ using similar triangles

$$\frac{x_p}{f} = \frac{x}{y} \quad x_p = \frac{fx}{y}$$

$$\mathbf{P} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1/f & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} x \\ y/f \\ 1 \end{bmatrix} = \begin{bmatrix} fx/y \\ 1 \end{bmatrix} = \begin{bmatrix} x_p \end{bmatrix}$$

$$\mathbf{P} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1/2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 4/3 \\ 3/2 \\ 1 \end{bmatrix} = \begin{bmatrix} 8/3 \\ 1 \end{bmatrix}$$

The visible range is $\pm 2$ so this point is not seen.