CSC 240 Computer Graphics
Day 12: Introduction to 3D
Q. When working in 3D, are you always using multiple coordinate systems?

A. You’ll always need to be aware of different coordinate systems. The most important one to think about is world coordinates, since this defines the scene you are building.

Q. Can you review 2d coord systems and compare them with the 3d just to clarify where we started and where we are now?

A. Good idea.
Coordinate Systems

Modeling transform: places object in world coordinates

\[ P_{\text{world}} = T_{\text{model}}P_{\text{object}} \]

Rendering transform: maps world coordinates into viewport*

\[ P_{\text{view}} = T_{\text{render}}P_{\text{world}} \]

*Note: in 2D, the world coordinates and viewport coordinates are often the same. In 3D they will differ.

https://www.stockio.com/free-icon/nature-icons-orange-flower
Each point has a location in every coordinate system.
Q. Can you explain more about projected coordinates and screen coordinates please? These two are way too similar.

A. Both are 2D coordinates. Projected coordinates are basically a direct conversion of camera coordinates to 2D. Screen coordinates make sure the axes are pointing in the right direction, units are in pixels, etc.

Q. So to confirm, does the y-axis point up in all of the coordinate systems except for screen coordinates?

A. That depends on what you mean by “up”.

Q. Is there a standardized way that the axes are supposed to point in relation to each other for the model and world coordinates?

A. No. An object can be placed in the scene in any orientation. (But...)
Q. How is the size and depth of the view frustum determined? How is the focal length determined?

A. These are parameters of the scene you can choose. We’ll see examples in code soon.

Q. Why does the view frustum have a near clipping plane? And where would it be in the diagram on slide 7?

A. The near clipping plane is an artificial boundary. We choose not to display anything closer to the camera than this limit.

Q. Would the x- or y- axis ever be dropped in an orthographic projection, and if so, how would that work?

A. Mathematically, it is possible. By convention we never do it.
Q. Could you go over what homogenous coordinates are again?
Q. Why does the matrix of all points have a whole row of ones at the bottom, what does that represent?
A. In homogeneous coordinates, we add an extra 1 at the bottom of each column vector representing a point. Matrices also have an extra row & col.
Q. I thought homogeneous coordinates meant that we usually have a one in the bottom right corner of the matrix, why didn't the perspective projection matrix have this?
A. Perspective projection is special. Instead of all 1’s in the bottom row, it generates other values, which then need to be normalized.
Q. What happens if we do not normalize the bottom row of a homogeneous coordinate matrix?
A. We won’t get a perspective effect. Further transformations won’t work properly.
Your Questions

Q. In question 4 of the second section, why did the perspective projection matrix have a .5 in it? Isn't the projection matrix made up of just 1's and 0's?

A. The perspective projection matrix has a $\frac{1}{f}$ term in the bottom row.

Q. What is the range of focal lengths we'll most often find ourselves using?

A. For hand problems we’ll stick to simple values.

Q. It seems like you'd need to keep mapping individual points. How does this work recursively?

A. 3D rendering does indeed require mapping many points. That’s why we have spent some time focusing on efficient computation.
Review

Midterms:
The delicious ice cream center of your semester.
This is a self-scheduled, closed book exam.
While completing the exam you are allowed to use one page of notes, 8.5x11, both sides.
Testing hours are Friday 3:00-9:00 pm, Saturday and Sunday 12:00-6:00 pm.
You have two hours to complete the exam from the time you sign it out.
Students with accommodations allowing extra time can compute their time accordingly.
Exams must be turned in by the end of the testing window, so please plan ahead.
Students with accommodations for individual space can reserve a room in advance.
If you are unable to make progress on any part of the exam, tell me what you tried: describe your thought process. I may be able to grant partial credit.
When your exam is complete, before submitting it, please copy, sign, and date the statement below:

“I certify that my work on this exam adheres to the Smith Honor Code and the instructions given above.”
Questions

Q. Will we need to know how to draw lines using the antialiasing algorithm in different coordinates, such as pixel center origin vs corner origin? If so, could we go over that in class?
A. You should understand qualitatively what the antialiasing algorithm is doing. Lines that don’t pass exactly through pixel centers will shade two pixels in proportion to proximity.

Q. Will we have the code for line clipping on the exam?
A. If you want the exact code, you should include it in your sheet of notes.

Q. For the fall 2020 midterm practice exam, in part 2, the recursion depth I found for each problem was always 1 less than the solution. Where did we get the last recursion call?
A. There is always a final call that hits a stop condition and returns.
Q. Can we go over the line formulas, and what each one do?

A. Different forms of the line equation are suitable for different purposes. This list is not necessarily comprehensive.

- Slope intercept form: \( y = mx + b \)
- Inverted slope form: \( x = wy + c \)
- General form: \( Ax + By + C = 0 \)
- Form given points: \( F = (y_1 - y_2)x + (x_2 - x_1)y + x_1y_2 - x_2y_1 = 0 \)
- Converted back to slope-intercept: \( y = \frac{y_2-y_1}{x_2-x_1} x + \frac{x_2y_1-x_1y_2}{x_2-x_1} \)
Questions

Q. Can we go over more examples of problems where given a graph and an image of the transformation, find the transformation matrices?

a.) \[
\begin{bmatrix}
0.5 & 0 & -3 \\
0 & 0.5 & -3 \\
0 & 0 & 1 \\
\end{bmatrix}
\]

b.) \[
\begin{bmatrix}
0 & -1.5 & 3 \\
0.25 & 0 & -3 \\
0 & 0 & 1 \\
\end{bmatrix}
\]

c.) \[
\begin{bmatrix}
-0.5 & -0.5 & 3 \\
0.5 & -0.5 & 3 \\
0 & 0 & 1 \\
\end{bmatrix}
\]

d.) \[
\begin{bmatrix}
-1 & 0 & 4 \\
1 & 1 & -4 \\
0 & 0 & 1 \\
\end{bmatrix}
\]

e.) \[
\begin{bmatrix}
2 & 0 & -4 \\
0 & -2 & 4 \\
0 & 0 & 1 \\
\end{bmatrix}
\]
Q. Specially for transformations, can we go over setTransform, and also how to transformations work.

A. setTransform is used to completely replace the current transform with a new one. For example, if we have three moving objects and we keep track of separate transforms for each, we might call setTransform before drawing each one.

Transformations in general apply to any thing drawn on the canvas. They can be composed of multiple basic transformations multiplied.

Q. Can we go over Handout 3?

A. Sure. Any specific part?
Questions

Q. Can we go over Hierarchal Modeling?

A. Each part in the hierarchy applies its own transformation in addition to the transformation of its parent part.

- Body: $M_{body}$
- Head: $M_{body}M_{head}$
  - Left ear: $M_{body}M_{head}M_{L\_ear}$
  - Right ear: $M_{body}M_{head}M_{R\_ear}$
- Tail: $M_{body}M_{tail}$
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

\[
\frac{x_p}{f} = \frac{x}{y} \quad \Rightarrow \quad x_p = \frac{fx}{y}
\]

\[
P\hat{v} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1/f & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} x \\ y/f \\ 1 \end{bmatrix} = \begin{bmatrix} fx/y \\ 1 \end{bmatrix} = \begin{bmatrix} x_p \end{bmatrix}
\]

\[
P\hat{v} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1/2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 4/3 \\ 3/2 \\ 1 \end{bmatrix} = \begin{bmatrix} 8/3 \\ 1 \end{bmatrix}
\]

The visible range is ±2 so this point is not seen