#### CSC 240 Computer Graphics Video 17: Hidden Surface Removal & Blender Basics

Nick Howe Smith College

Some slides & content courtesy Sara Mathieson

Given some scene geometry and camera viewpoint, in most cases many scene polygons will not be visible.



https://www.artstation.com/artwork/9Kx5F

Occlusion culling = rough but drastic occlusion handling

• Rule out occluded objects; don't even try rendering



https://docs.unity3d.com/560/Documentation/Manual/OcclusionCulling.html

View frustum culling uses geometry to weed out polygons

- Too near or far: compare z value to clipping planes
  Q. Why have both near and far clipping planes?
- Top/bottom/left/right: compute projected coordinates, then run 2D clipping algorithm





Backface culling skips polygons that face away from view

- How to quickly check?
  - > Sign of dot product: surface normal with camera normal  $\hat{p} \cdot \hat{c} < 0$
  - > Winding order: points are counter-clockwise in projection



Occlusion handling is critical to correct rendering

- Surfaces that are behind others should not be visible!
- Two simple ways to achieve:

Less memory overhead

- Painter's Algorithm Renders polygons by distance from camera (farthest first)
- Z-Buffering

Records z coordinate for all pixels; only overwrites if closer

Faster

Pros & cons?

Fine-grained





https://www.videoblocks.com/video/3d-wireframe-buildings-over-black-background-p9qls7t

Z-Buffering uses an extra image plane holding *z* values

- Each pixel draw checks its *z* value against the buffer
  Only draws if *z* is greater (closer to camera)
  - > Updates buffer with new value during draw (in hardware)



A simple three-dimensional scene

Z-buffer representation

"Z buffer" https://commons.wikimedia.org/wiki/

What will be the rendered image and z-buffer? (Assume orthographic projection of this 2D scene.)

> Render in this order: red, yellow, green, blue



## Z Fighting



Overlapping polygons at the same z value can interfere with each other.

- Z buffer cannot distinguish which is in front  $\rightarrow$  unpredictable result!
- Two possible causes:
  - Polygons actually at same position (solve via model change)
  - Polygons separated by less than Z buffer resolution
- Possible solutions:
  - Increase Z resolution less separation between near and far clip
  - Post-projection offset

#### Questions

**PAUSE NOW & ANSWER** 

- 1. Why is z-buffering generally preferred to the painter's algorithm? It runs faster and handles partial overlap
- 2. Give the z-buffer at right, list the shapes from nearest to farthest.

Pentagon, triangle, star, diamond, circle



3. Suppose that the camera is pointing in the -z direction. What has to be true of the normal vectors of polygons eliminated via backface culling?
 They must have positive z components: ĉ = (0,0,-1), p̂ = (x, y, z) ⇒

$$\hat{p} \cdot \hat{c} = 0x + 0y - 1z = -z$$

This is less than zero only if z is positive.



# Why Blender?



Blender is a digital art tool, not a programming tool. So why study it in a computer science class?

- It offers a platform for experimenting with geometry, texture, ray tracing, and other topics we have studied.
- It facilitates the creation of 3D models for use in programmed environments.

Our use of Blender will focus mostly on these topics. We will not study many advanced features.

Consider taking an ARS digital art course to learn more!

### **Blender Orientation**

#### Blender is a tool for developing high-quality 3D models.



#### **Blender Basic Controls**

Before you can interact with objects, you need to be able to view them.

#### Pan

Translate the point of view

#### Orbit

Rotate the point of view around center of scene

#### Zoom

Move the point of view in and out

Shift+Drag MMB / Shift-Alt-Drag

Drag MMB / Alt-Drag

Ctrl+Drag MMB / Ctrl-Alt-Drag

### **Editing in Blender**

Many details; some basic principles

- Many changes (scale, translate, rotate, etc.) controlled by mouse
- Type **x**, **y**, or **z** during edit operation to restrict to one axis
- Type X, Y, or Z during edit operation to restrict to two axes axis
- Type a number during edit operation to choose a precise value

• Other tricks we will learn during labs

## **Rendering in Blender**

- Process of turning 3D scene into 2D image
- For animated films, it can take hours to render a single frame
- Important steps:
  - Camera placement
  - Lighting
  - Materials
  - Render with low quality settings, repeat above steps
  - Render with high quality settings



https://www.amazon.com/Disney-Pixar-Talking-Amazon-Exclusive/dp/B01B7OY2M4

## Exporting from Blender



Objects and scenes built in Blender can be saved in a file for use elsewhere

- Many file formats out there
- Support growing for GLTF (**Graphics Language Transmission Format**)
- Online archives of free 3D models





**PAUSE NOW & ANSWER** 

- 1. Have you downloaded and installed Blender yet? If not, you should do so before Monday's class.
- Outline how you could scale an object in Blender to three times its size along the x and y axes, but hold it steady in z.
   Select the scale tool and begin a mouse drag. Type Z then 3.
- 3. Find the URL of an online source of free 3D models *Examples include free3D.com, archive3D.net, artist-3d.com, etc. Some government agencies provide public domain 3D models related to their operations, including the* <u>Smithsonian</u>, <u>NASA</u>, and more.

#### Review

After watching this video, you should be able to...

- List three major strategies for hidden surface removal
- Identify polygons outside the view or that face away from a camera
- Understand the z buffering algorithm and its limitations
- Apply offsets in Three.js to mitigate z fighting
- Perform basic operations in Blender
- Work with models from 3D archives