CS100433
Shadows
Junqiao Zhao 赵君峤
Department of Computer Science and Technology
College of Electronics and Information Engineering
Tongji University
Why shadows?

- 3D cueing
  - location, even motion
How shadows are generated?

• Areas hidden from the light source by occlusion cause by objects
• Hard shadows and soft shadows

[Tom Thorne, Edinburgh]
Shadow techniques

• Ground shadow
• Shadow texture
• Shadow map
• Shadow volume
Ground shadow

- Shadow cast by objects onto the ground (y=0)
Point light ground shadows

- Blinn 88
- The matrix transform the object onto the ground

\[
\begin{bmatrix}
X_{sw} \\
0 \\
Z_{sw} \\
1
\end{bmatrix}
= \begin{bmatrix}
1_y & -1_x & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & -1_z & 1_y & 0 \\
0 & -1 & 0 & 1_y
\end{bmatrix}
\begin{bmatrix}
X_p \\
Y_p \\
Z_p \\
1
\end{bmatrix}
\]
Draw the ground shadow

• The matrix transform the object onto the ground
• Thus
  • Draw the object
  • Multiply the shadow matrix
  • Redraw the object in grey
Problem of ground shadow

- The shadow only cast onto (ground) planes
- The shadow is hard shadow
- The performance is not optimal in static scene
Shadow texture

- Using a shadow image as a texture
  - Occluder from light’s view
- Project the image onto the object
  - Can be curved surface or other objects

[Tom Thorne, Edinburgh]
Shadow map

• Preparation
  • Prepare a depth buffer for each light
  • Render the scene from the light position
  • Save the depth information in the Depth buffer

• Rendering the scene
  • Render the objects; whenever rendering an object, check if it is shadowed or not by transforming its coordinate into the light space
  • After the transformation, if the depth value is larger than that in the light’s depth buffer it should be shadowed

Shadow map

• Using Depth buffer
Figure 2: A conventional $2,048 \times 2,048$ pixel shadow map (left) compared to a 16 MB ASM (right). Effective shadow map size: $65,536 \times 65,536$ pixels.
Shadow volume

• In the reality, the shadow cast by an object blocking light is a volume which is 3D!

• Project a ray from the light source through each vertex/silhouette in the shadow caster to infinity

• Any objects intersecting with the volume will get shadow on them.
  • Self-cast shadow
  • General-purpose
Shadow volumes

• Cast by silhouette
shadowed scene

wireframe shadow volumes

Stencil buffer

- Stencil buffer
  - A data buffer
  - Used as a Stencil
  - An integer per pixel

- Depth fail method
  - [http://ogldev.atspace.co.uk/www/tutorial40/tutorial40.html](http://ogldev.atspace.co.uk/www/tutorial40/tutorial40.html)
  - 1 Render the scene into Depth buffer
  - 2 Create shadow volume
  - 3 Render the volume in Stencil buffer following rules
  - 4 Render the scene under Stencil test
• Computation intensive
• Hard shadow
Stencil buffer based implementation

- Doom3 Made it popular
Soft shadows

• Made by area light
  • umbra – totally blocked from the light source
  • Penumbra – partially blocked from the light source
• Can be modelled by a collection of point light sources
Shadow map vs Shadow volume

• Faster than shadow volume
  • GPU based

• Less accurate because the resolution of the depth buffer
  • Aliasing at edges
• Questions?