

Shadows

- Shadow Regions
- Soft x Hard Shadows
- Shadow Algorithms
- Shadows in Game Programming
- Area Subdivision Shadows
- Radiosity Shadows
- Shadow Volumes
- Ray Traced Shadows
- Shadow Maps
- Light Maps
- Projective Texture Shadows

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadows

- Regions of a scene not completely visible by the light sources
- One of the most important clues about the spatial relationship among objects in a scene



CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadows (Cont.)

- Depend only on the visibility from the light sources
- Can be computed as a pre-processing for static scenes
- Most common shadow algorithms are restricted to direct light and point or directional light sources
- Area light sources are usually approximated by several points lights

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Illumination Function

$$I_l = ambient + \sum_i^{lights} S_i f_{diff} I_{li} (diffuse + specular)$$

- Point Light Sources
 - S_i equals to 1 if the point is visible from the light source; 0, otherwise
- Area Light Sources
 - S_i is the fraction of the area light source to which the point is visible

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Illumination Function (Cont.)

Multiple Point Light Sources



In shadow wrt L1,

but lit by L2
 $S_1 = 0, S_2 = 1$

Area Light Source



Partially in shadow

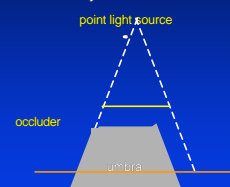
$S_i = 0.4$

CSE528, Fall 2000

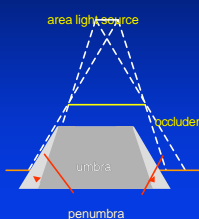
Copyright © Manuel M. Oliveira

Shadow Regions

Point Light Sources
Usually Hard Shadows



Area Light Sources
Soft Shadows

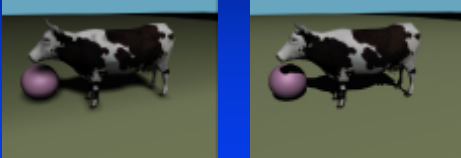


CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Soft x Hard Shadows

- Soft shadows
 - Produced by area light sources (umbra + penumbra)
 - Most common kind of shadow
 - More realistic effects (in general)



CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Soft x Hard Shadows (Cont.)

- Hard (Sharp) shadows
 - Produced by point light sources
 - More realistic effects for shadows cast by the sun or by a powerful light bulb placed far away from the object



CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadow Algorithms

- Object-based
 - Local illumination model
 - Area subdivision
 - Planar projection
 - Radiosity
 - Shadow-volumes
- Image-based
 - Shadow-maps
 - Layered attenuation Maps
 - Light maps
 - Projective texture shadows
- Hybrid
 - Scan-line approach
 - Ray-tracing

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Local Illumination Model

- Only accounts for some kinds of self-shadowing due to normals facing away from the light source
- Simplest to implement, it is supported in hardware



CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadows in Game Programming

- Simplest approach: shadow of constant shape and size
- Texture mapped polygon with some transparent texels
- Polygon and surface normals aligned



Courtesy of Alan Watt and Fabio Policarpo

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadows in Game Programming

- Artifacts if the texture mapped polygon penetrates the surface receiving the shadow



Courtesy of Alan Watt and Fabio Policarpo

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadows in Game Programming

- Shadow obtained by tracing rays from the light source through the vertices of the (five) bounding boxes defined for the car

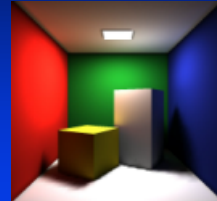


Courtesy of Alan Watt and Fabio Polcarpo
Copyright © Manuel M. Oliveira

CSE528, Fall 2000

Radiosity

- Shadows are determined by the form factors among the elements of the scene



CSE528, Fall 2000

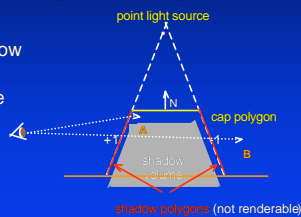
Copyright © Manuel M. Oliveira

Volumetric Shadows

- Set counter = # of shadow volumes containing the eye
- Trace rays from the eye and add +1 for each front facing and -1 for each back facing shadow polygon crossed

Counter = 0 → lit
Counter > 0 → shadow

Extension to multiple light sources is straightforward

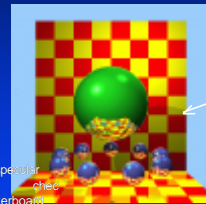


CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Ray Tracing

- Trace rays from the surface point to each (point) light sources and check if such rays intersect any objects



CSE528, Fall 2000

Copyright © Manuel M. Oliveira



Shadow cast by a single light source

Shadow Map [Williams78]

- Image-precision algorithm based on depth buffer values
- Generate a depth map (shadow map) of the scene from the point of view of each light source
- For each pixel in the camera view, the 3-D coordinates of the surface visible through that pixel are projected onto the "image plane" of each light sources
- The (x,y) coordinates of the projection are used to index the light's shadow map
- If the stored z_l is closer to the light source than the projected z value, the pixel is in shadow; otherwise, it is lit

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadow Map (Cont.)



Shadow-map from light 1



Shadow-map from light 2



Camera view

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Shadow Map (Cont.)

- Prone to aliasing problems
 - During the construction (point sampling)
 - During the access to the shadow map: a pixel from the camera's view might cover a large surface area, which in turn can map to several pixels in the shadow map
 - This second problem was addressed by [Reeves et al. 87]. The fraction of the projected area in the shadow map corresponding to shadow is used to attenuate the light intensity
- Precision problems can lead to self-shadowing

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Light Map

- Used in game programming



Images courtesy of Alan Watt and Fabio Policarpo (3D Games: Real-time Rendering and Software Technology)

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Projective Texture Mapping [Segal92]

- Imagine a light source as a projector



CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Projective Texture Shadows



Light's point-of-view

Shadow projective texture (modulation image or light-map)

Eye's point-of-view, projective texture applied to ground-plane (self-shadowing is from another algorithm)

Reproduced from Kenny Hoff's lecture slides on Shadows (http://www.cs.unc.edu/~hoff/projects/comp236_ta/shadow_presentation/shadows.ppt)

CSE528, Fall 2000

Copyright © Manuel M. Oliveira

Projective Texture Shadows



Reproduced from Kenny Hoff's lecture slides on Shadows (http://www.cs.unc.edu/~hoff/projects/comp236_ta/shadow_presentation/shadows.ppt)

CSE528, Fall 2000

Copyright © Manuel M. Oliveira