Ambient Occlusion

Matt Pharr
NVIDIA
Diffuse Shading
Diffuse + Ambient Occlusion
Diffuse + Ambient Occlusion + Environment Lighting
Overview

- Light scattering from surfaces
- Main Idea:
  - Use occlusion to modulate lighting
- Implementation details
- Demo
- Further resources
What do point lights and reflection maps have in common?

• Point or distant lights
  – Sum over light from single directions

• Environment maps
  – Add light from single reflected/transmitted direction

• Both are discrete: ignore continuous directional variation of illumination
Problems with These Simplifications

- Hard shadows
- Perfect, unblurred, reflections
- “Stark” lighting
Introducing Directional Variation

- Ambient occlusion
- Irradiance maps
- Blurred environment maps
- Soft shadows (smoothies, etc.)
- Spherical harmonic lighting
The Basic Idea

Compute fraction of visible hemisphere and average unoccluded direction at P
Cone of Unoccluded Directions Approximation
Computing Occlusion Values

Ray-tracing pre-process

generate rays over hemisphere
occlusion = 0
avgDir = (0,0,0)
foreach ray {
    if ray doesn’t intersect model
        avgDir += ray.dir
    else ++occlusion;
}
occlusion /= nRays
normalize(avgDir)
Computing Occlusion Values

• Multi-pass rendering in hardware with shadow maps
  – See article for details
GPU-Generated Occlusion Maps
(4 samples)
GPU-Generated Occlusion Maps
(32 samples)
GPU-Generated Occlusion Maps (128 samples)
GPU-Generated Occlusion Maps (512 samples), ~4 seconds
Using Occlusion Values I

- Simple blurred env map lookup

```cpp
half4 main(half3 avgDir, 
    half occlusion, 
    half3 Kd) : COLOR {
    half blur = 1 - occlusion; // ad-hoc
    return Kd * (1 - occlusion) * 
    texCube(envMap, avgDir, blur);
}
```
Using Occlusion Values II

- Modulate irradiance map lookup

```cpp
half4 main(samplerCUBE irradMap,
    half3 Kd, half occlusion,
    half3 N) : COLOR {
    return Kd * (1-occlusion) * 
    texCUBE(irradMap, N);
}
```
Demo
Animated Occlusion

Ogre Demo
Summary

- AO helps reduce the stark “CG” look
  - Medium expensive precomputation
  - Fast rendering
- Special case of some spherical harmonic approaches
Further Reading


• Hayden Landis, *Production-Ready Global Illumination,* “*RenderMan in Production*” SIGGRAPH Course Notes, 2002
Further Resources

• GPU Gems
• FX Composer
  – developer.nvidia.com/fxcomposer
• NVIDIA SDK Version 7
  – Ambient occlusion demo
Questions?

• mpharr@nvidia.com