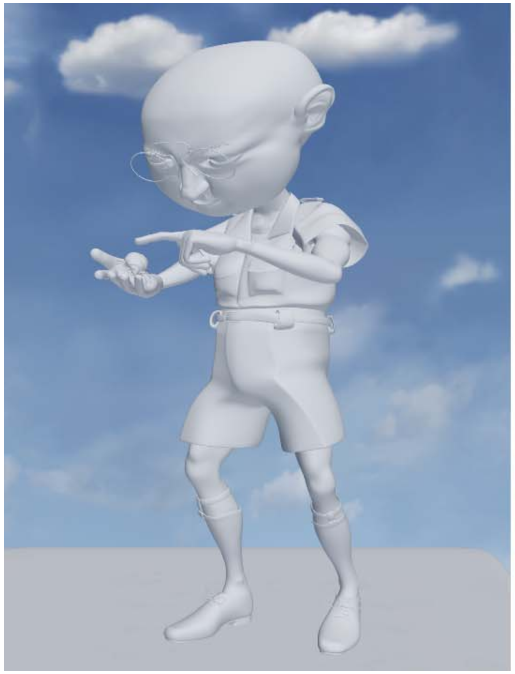
Dynamic Ambient Occlusion and Indirect Lighting

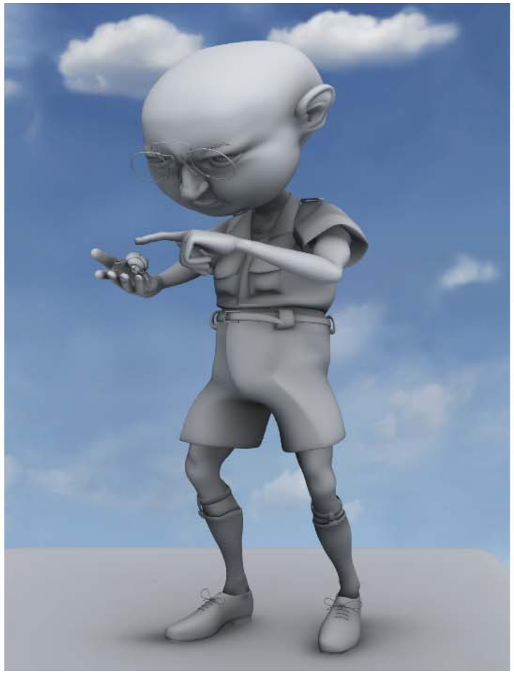
Michael Bunnell

NVIDIA Corporation

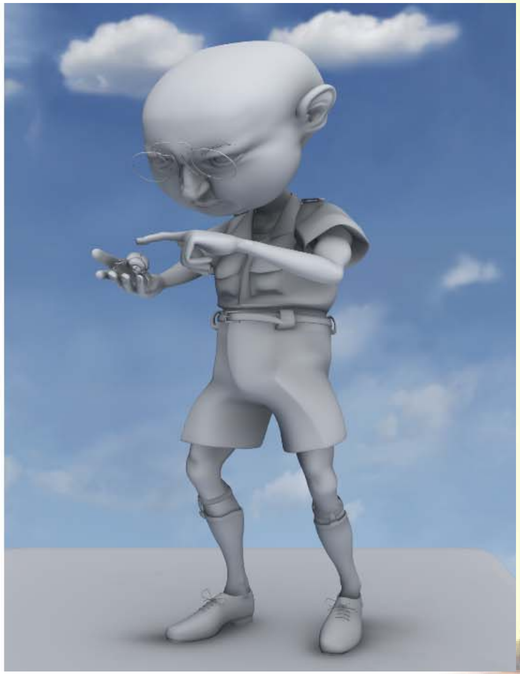
Environment Lighting



Environment Map



+ Ambient Occlusion

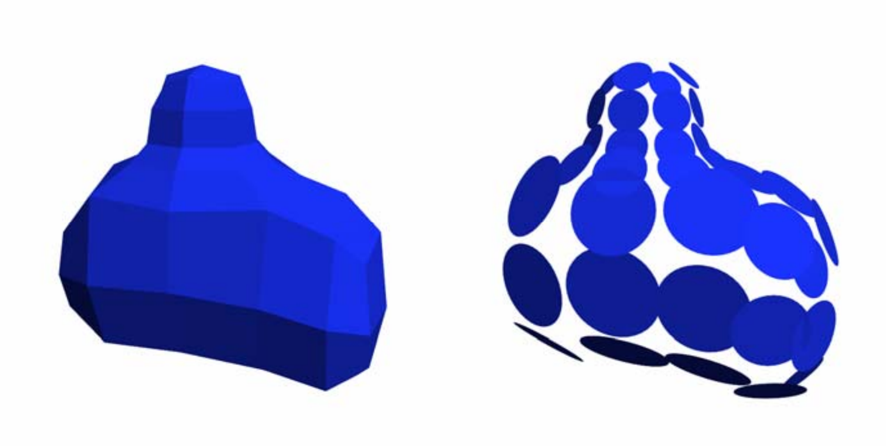


+ Indirect Lighting

New Radiance Transfer Algorithm

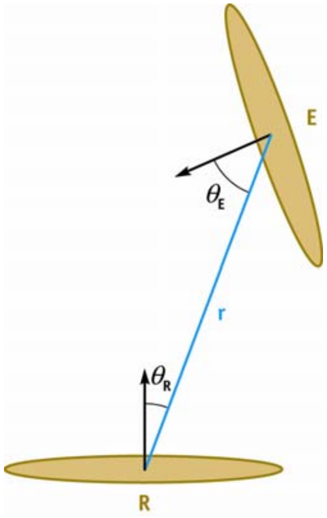
- Useful for calculating Ambient Occlusion and Indirect Lighting
- Efficient and parallelizable
- Implementation is real-time on GPU
- Ideal for non-rigid bodies and dynamic environments

Dynamic Ambient Occlusion



- **Define polygon meshes as disk-shaped elements**
  - **one element created for each vertex**
  - **elements defined by position, normal, and area**
  - **simplifies form factor calculation**

Form Factor



Emitter element E occludes receiver element R based on distance r and angles θ_E and θ_R

- **Percentage of the hemisphere above a point occluded by an element (Solid Angle)**
- **Like radiosity form factor with 100% visibility**

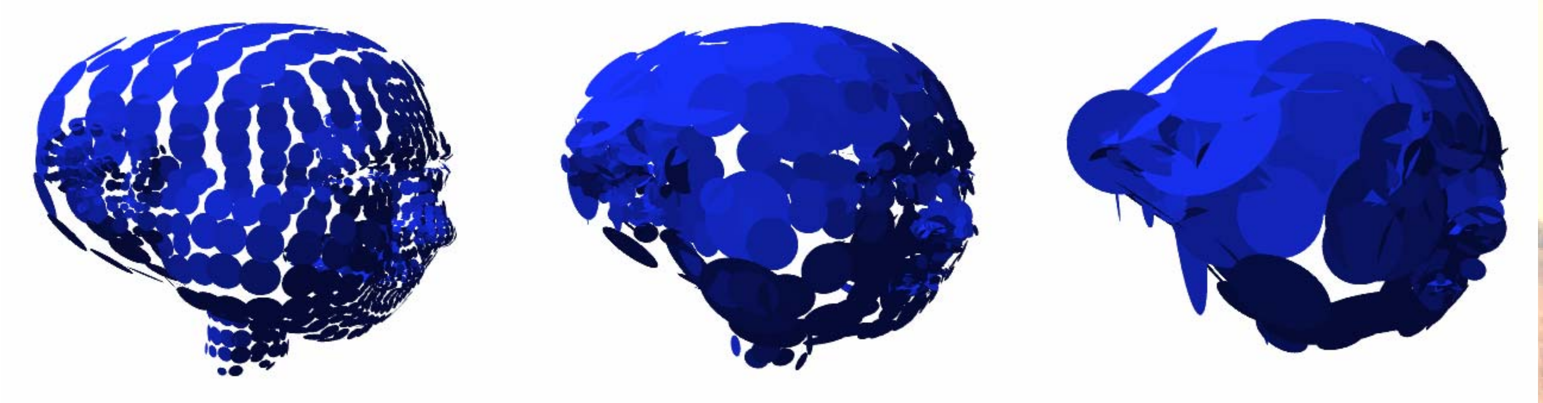
Calculating Occlusion

- Calculate occlusion at a receiver element by summing form factors:

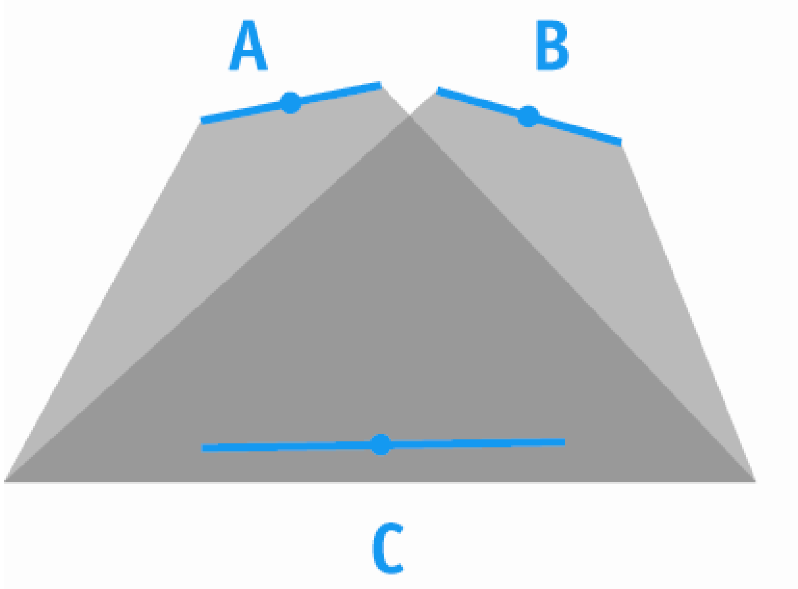
```
occlusion = 0;
for each element E
    occlusion += form factor of E;
```

Element Hierarchy

- We do not need to consider so many elements to get an accurate answer
  - A detailed head or simple ball will shadow distant objects the same
- Group elements together, forming larger elements
- Only traverse children when close to parent
- Easy to generate automatically since we don’t need actual geometry

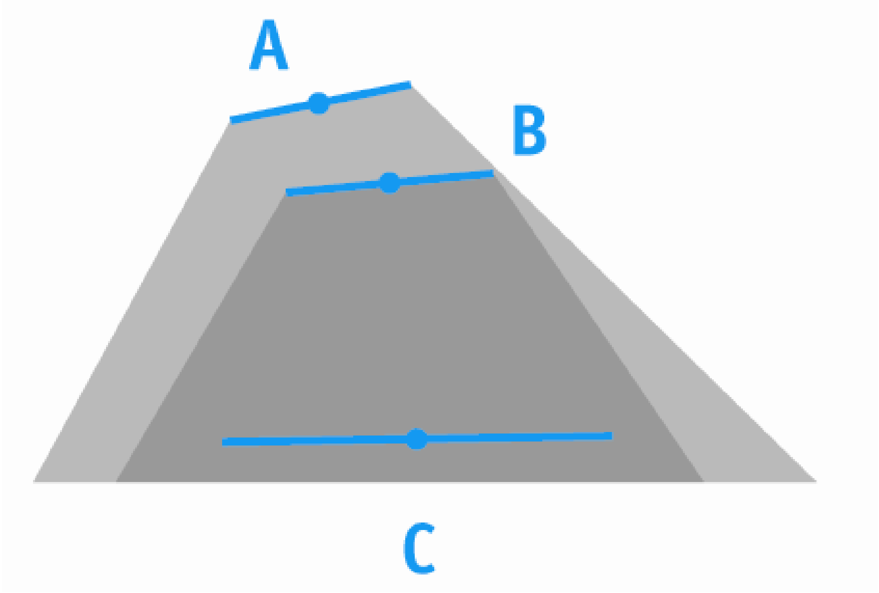


Double Shadowing



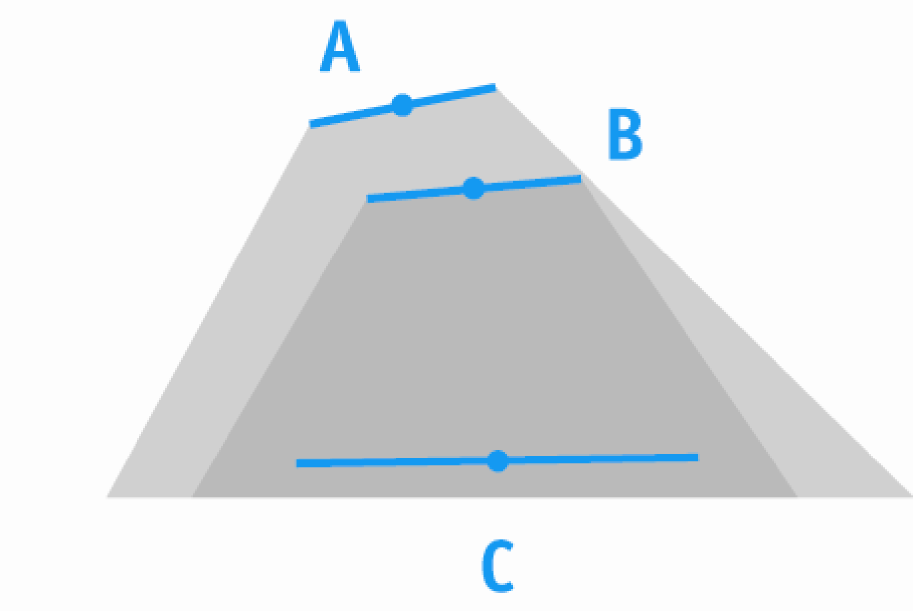
- A and B both shadow C
- C shadowed properly
- No double shadowing

Double Shadowing



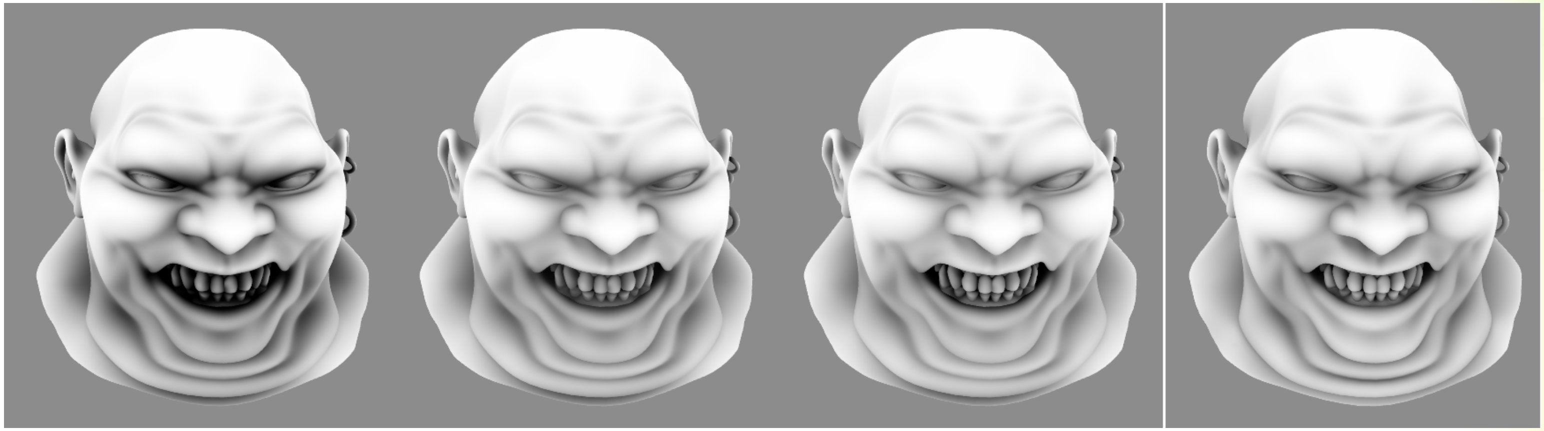
- A and B both shadow C
- C is shadowed too much
- Double shadowing after first pass

Double Shadowing



- **Lighten B's shadow in second pass since it is shadowed**
- **Double shadowing eliminated**

Eliminating Double Shadowing



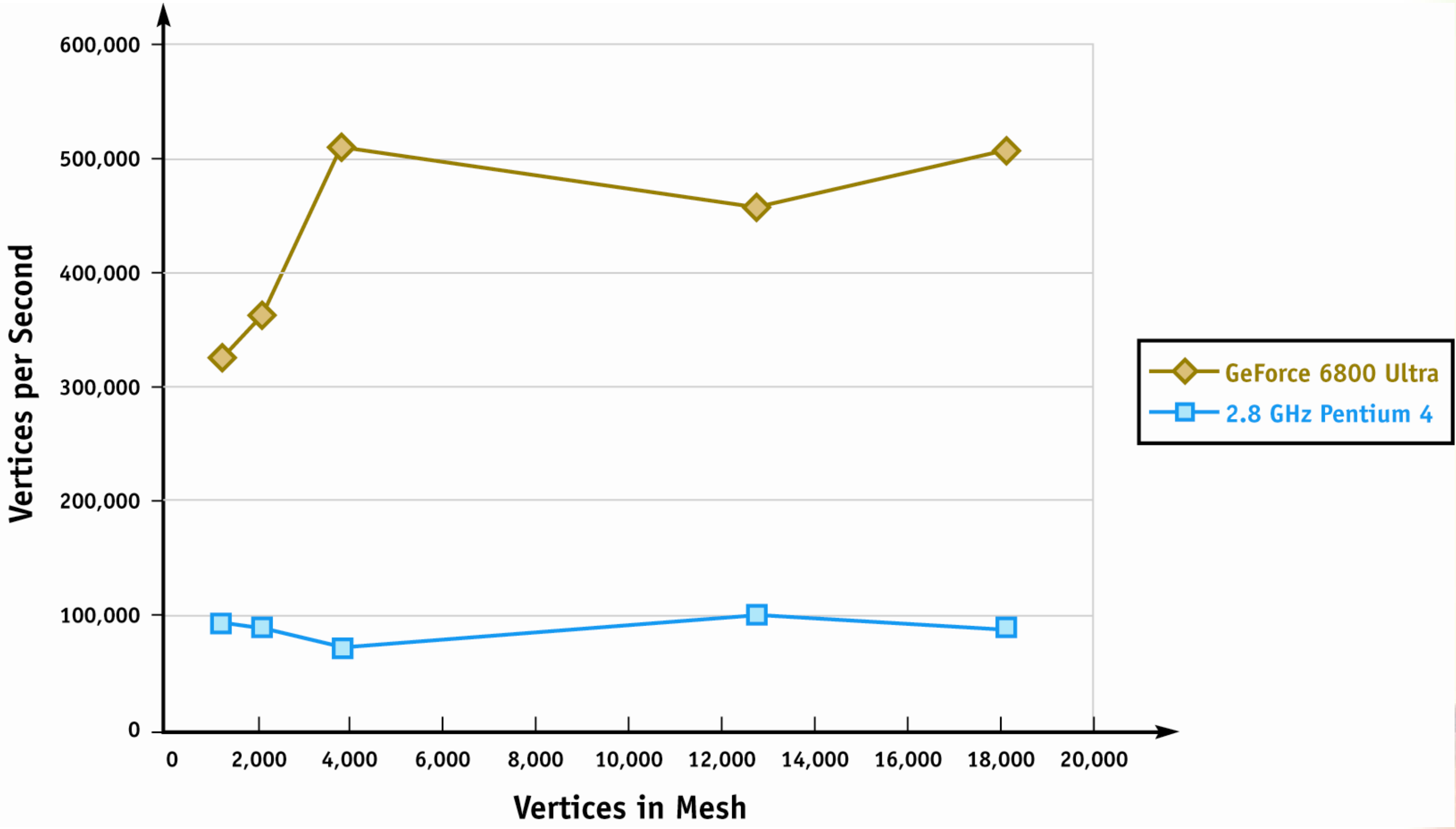
1 pass 2 passes 3 passes Ray traced

- **Multiply form factor by 1 - occlusion calculated in the previous pass**
- **Converges to correct shadowing quickly (2 passes are often enough)**
- **Results compare favorably with ray tracing**

GPU Implementation

- **Element data and index coordinates stored in a texture maps**
  - **Position, normal and area* are dynamic**
  - **index coordinates are pre-computed**
- **Shader traverses elements in a loop using** *next* **or** *child* **index coordinates**
- **Render a single quad (2 triangles) to complete a pass, 1 pixel per element**
- **Results are rendered to a texture for use in subsequent passes**

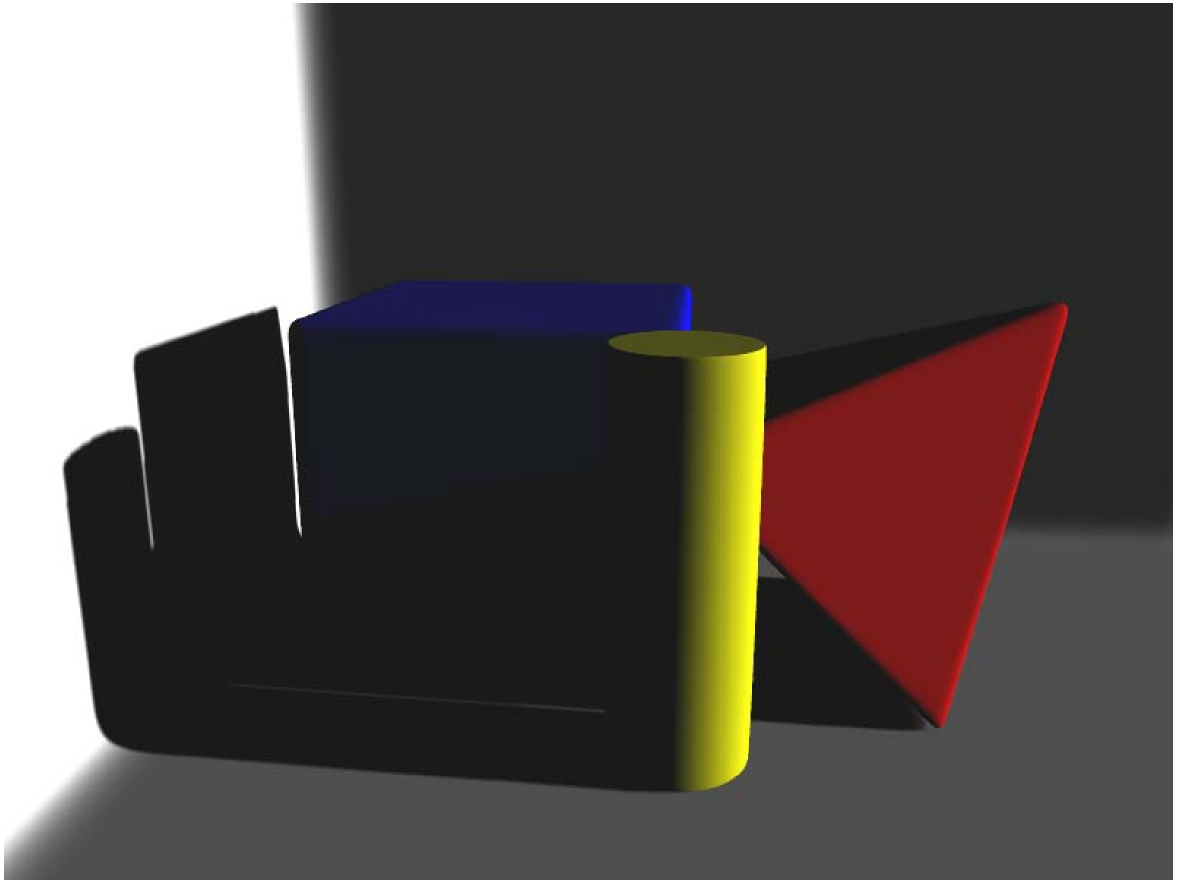
Performance



Indirect Lighting

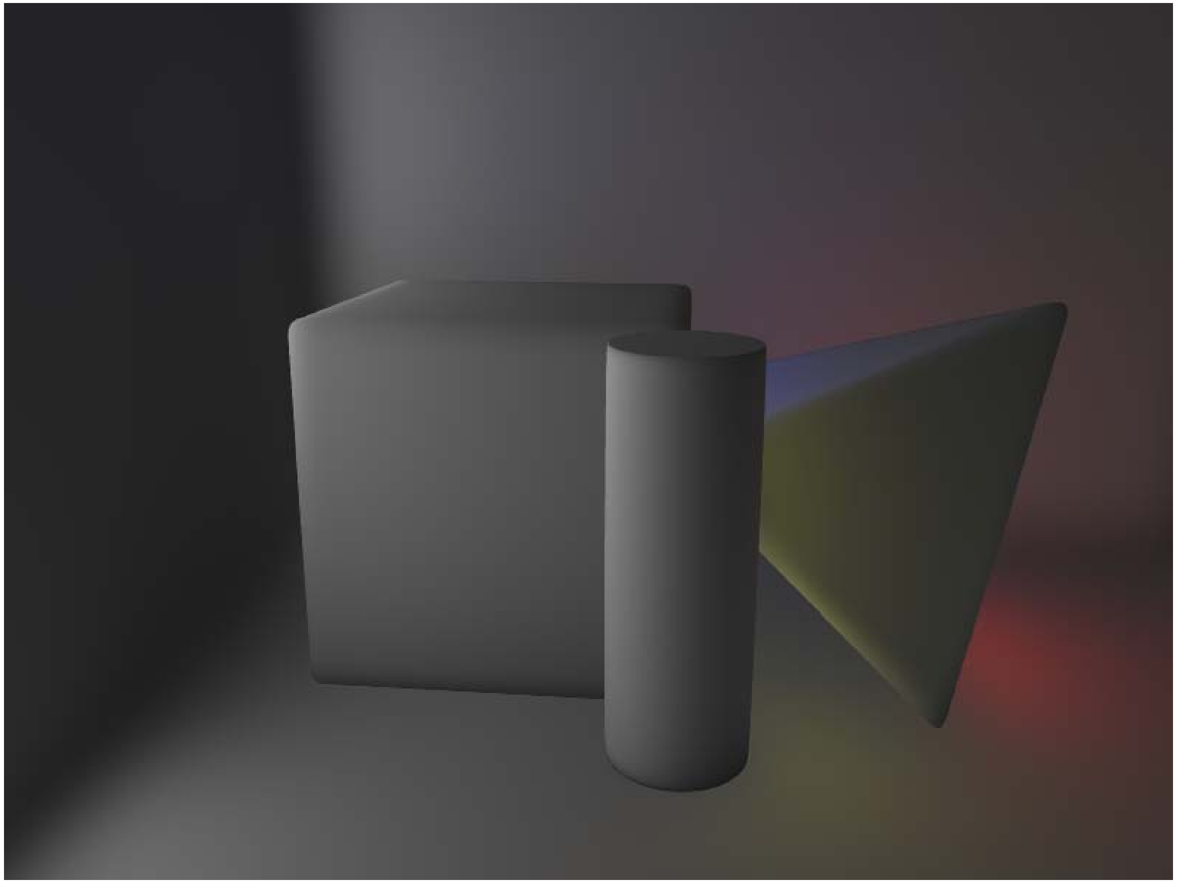
- Light reflecting off diffuse surfaces
- Used effectively in Shrek 2
- Adds an extra level of realism
- Can be used with traditional and environment lighting

Direct Lighting



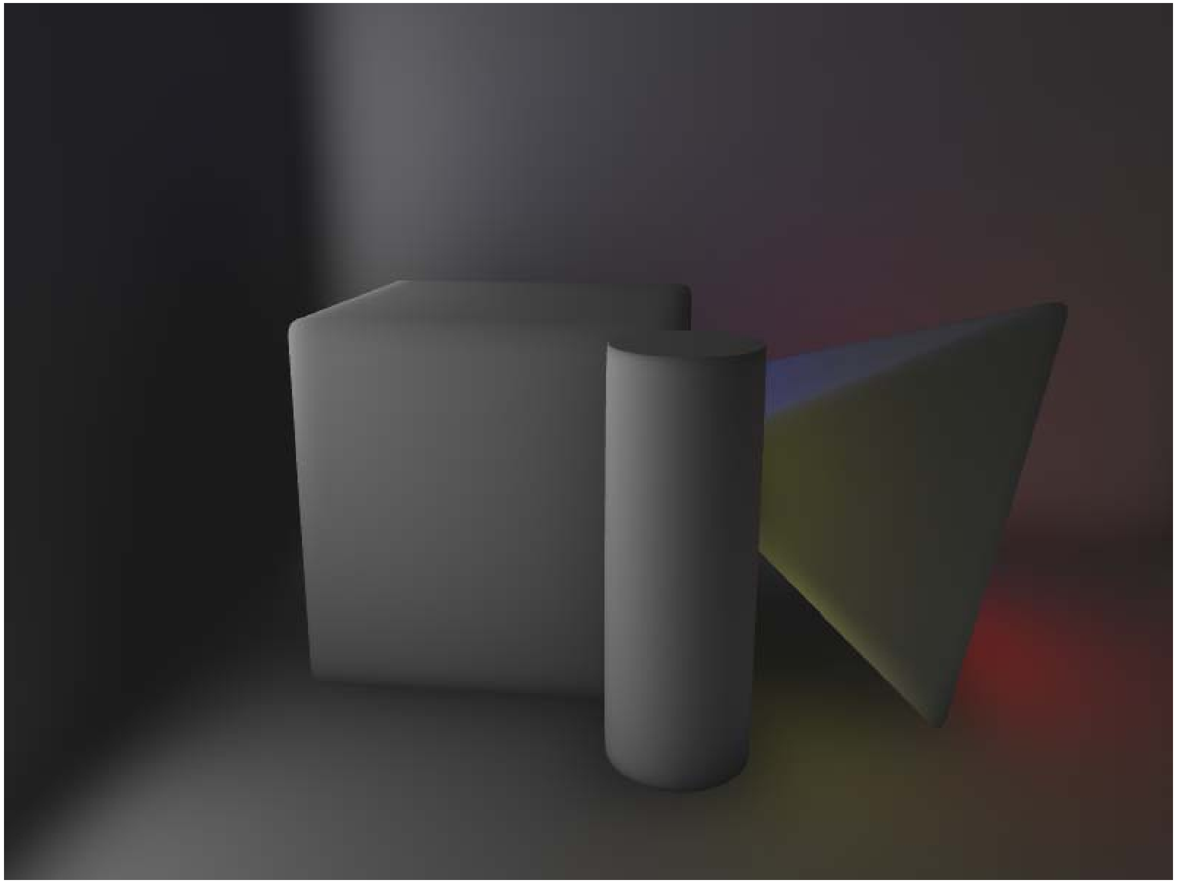
Scene lit with shadow mapped point light source

Indirect Light Pass 1



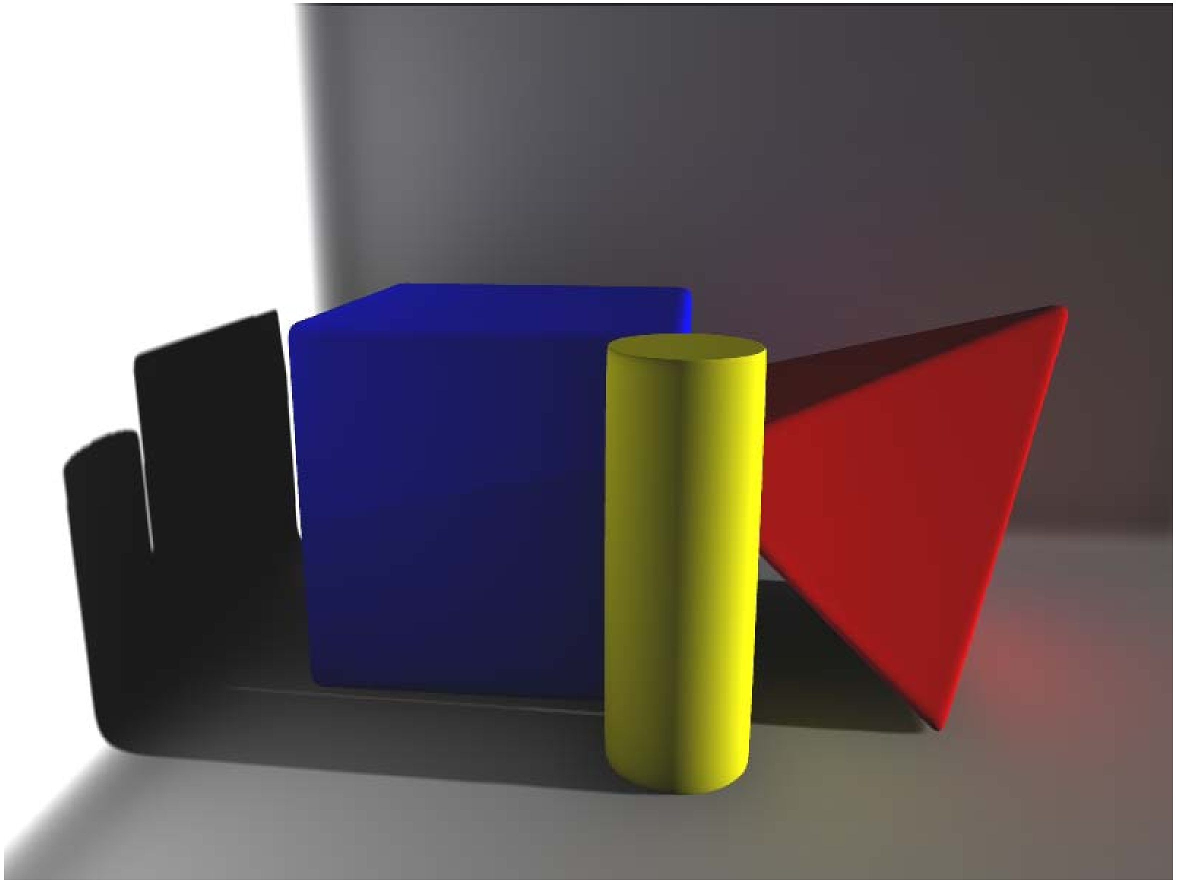
Distribute indirect light in first pass

Indirect Light Pass 2



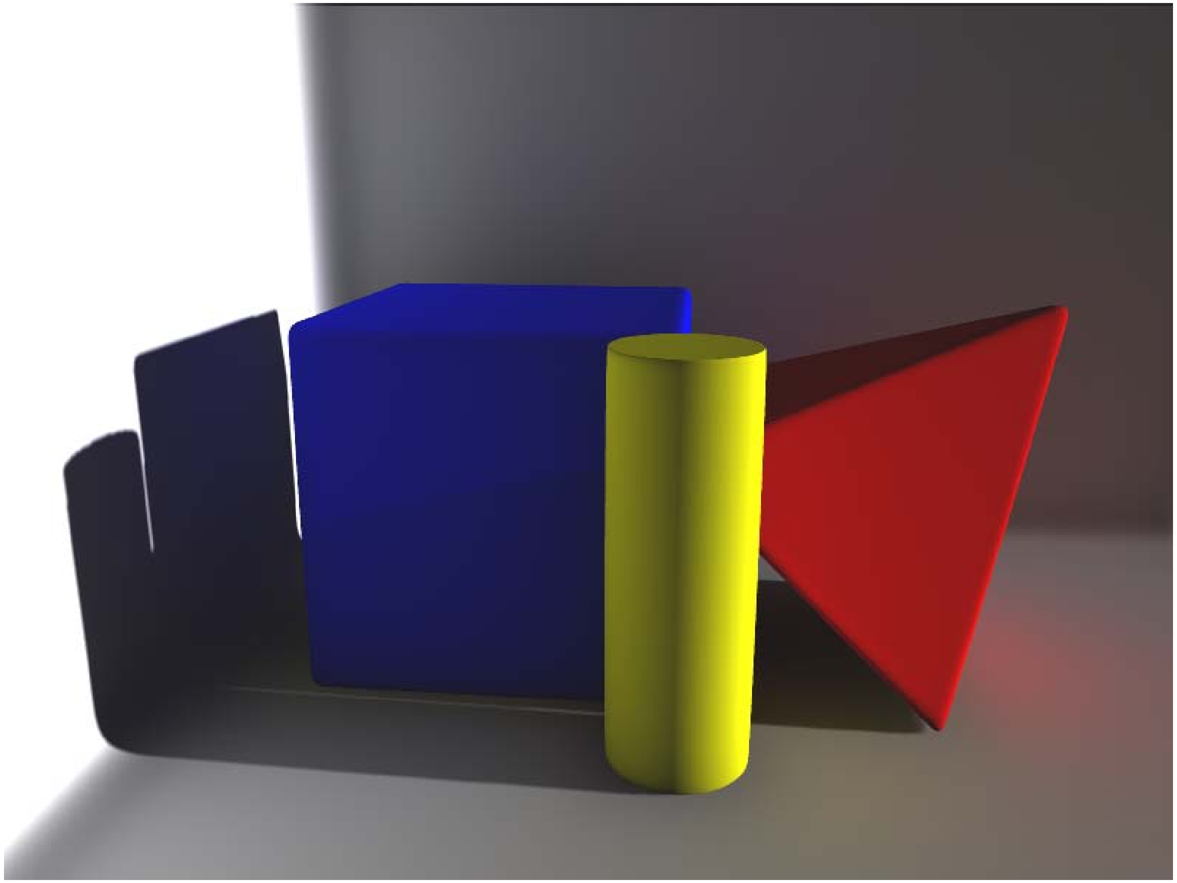
Shadow indirect light in second pass

Direct Light + 1 Bounce Indirect Light



Indirect light * surface color + direct light

Direct Light + 2 Bounces Indirect Light



Second bounce of indirect light takes 2 more passes

Indirect Lighting Shader

- Use the same basic shader as ambient occlusion
- Uses standard radiosity disk to disk radiance transfer approximation
- First pass distributes 3-component light values
- One or more subsequent passes shadow that light, subtracting from it
- Area lights can use the same shader

Applications

- Shadow environment lighting of non-rigid objects
- Indirect lighting
- Area lights
- Subsurface scattering*
- Accelerate generation of
  - pre-computed radiance transfer data
  - light maps
  - ambient occlusion data

GPU Gems 2

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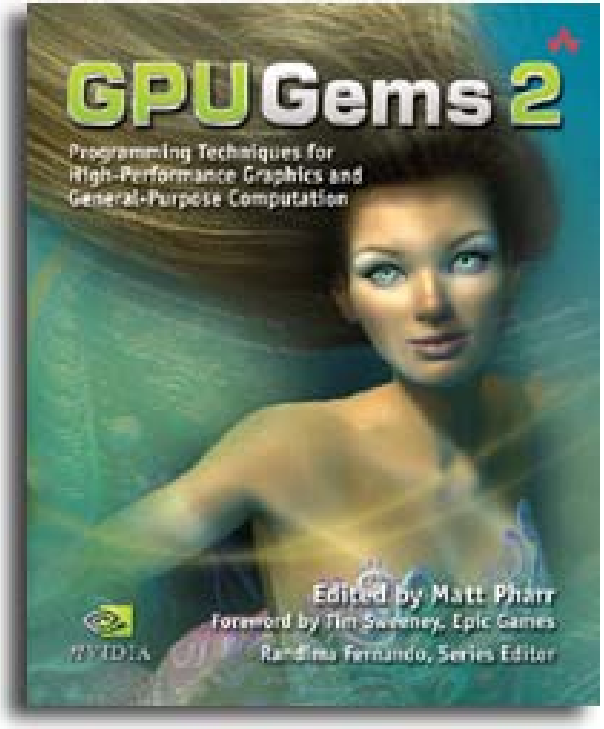
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