PCBEX: Point-Based Color Bleeding With Volumes Thesis Defense

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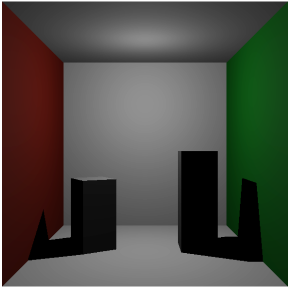
Schedule

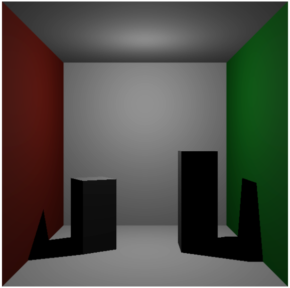
Outline

Graphics Intro

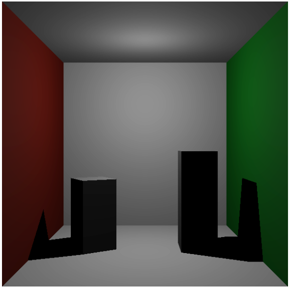
- Definition of graphics
- Graphics and light



Global Illumination



Definition of global illumination
Graphics and Light



Point-Based Color Bleeding

Cheap, accurate global illumination effects using color bleeding

Utilizes direct light point cloud representation of scene

Problem Statement

Most GA algorithms do not include volume contributions

Our Contribution

Modification to PCB to allow GA effects in scenes with volumes

Allows for render speedups of a factor of ten.

Outline

Flux and Radiance

Flux

The measure of total light emitted.

Radiance

$$L = \frac{d^2\,\Phi}{dw\;dA^{\perp}}.$$

Flux and Radiance

Radiance Invariance

$$L(x \to y) = L(y \to x).$$

Irradiance

Irradiance

Measure of *emitted* light

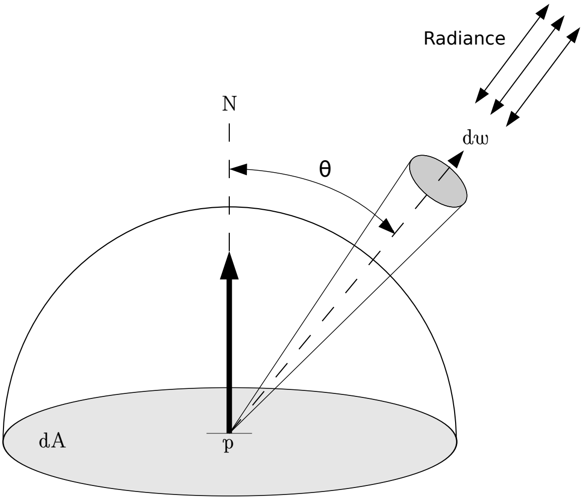
$$E = \frac{d\Phi}{dA}$$

Consider irradiance due to surrounding radiance...

Irradiance

$$E = \int L(\mathsf{p} \leftarrow w)\mathsf{cos}\theta dw.$$

Irradiance



BRDF

Bidirectional **R**eflectance **D**istribution **F**unction

Gives us a formalism for describing the reflection from a surface
Helps evaluate irradiance leaving the surface towards the viewer.
Recall:

Differential Irradiance

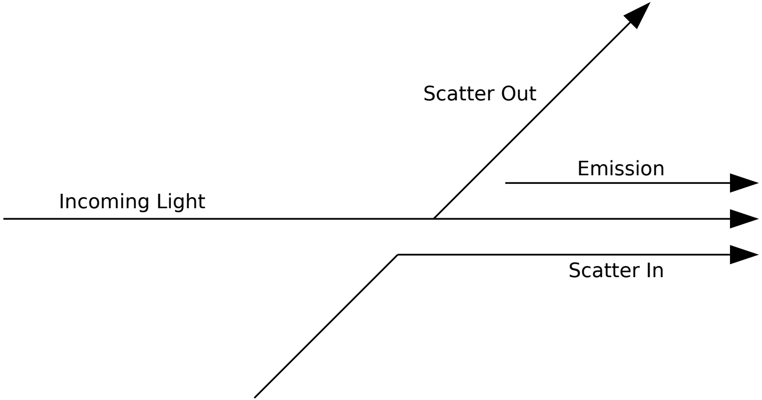
$$dE(\mathsf{p}, w_i) = \int L_i(\mathsf{p} \leftarrow w_i)\mathsf{cos}\theta_i dw_i.$$

BSRDF

Bidirectional **S**cattering-surface **R**eflectance **D**istribution **F**unction

- Describes complex behavior of light within surface (*subsurface scattering*.)
- Describes ratio of exitant light based on incoming light and outgoing direction.
- Exponentially more complex.

Volume Lighting



Volume Lighting

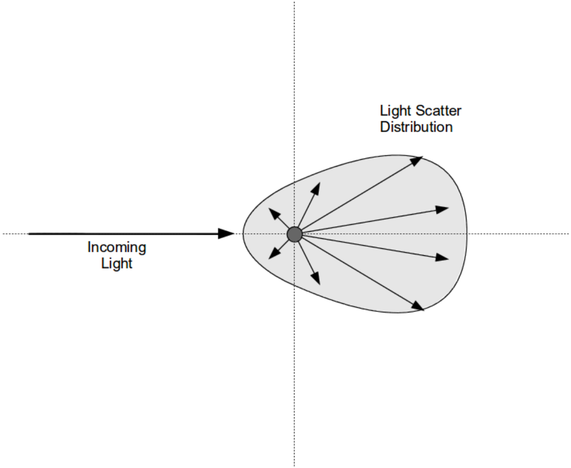
Absorption

$$e^{-\int_0^d \sigma_a(p+tw,w)dt}.$$

Scatter Out

$$\mathsf{d}L_o(\mathsf{p},w) = -\sigma_s(\mathsf{p},w)L_i(\mathsf{p},-w)\mathsf{d}t.$$

Volume Lighting



Volume Lighting

Phase Function

Described as $phase(w \to w')$

Source Normalization

$$\int_{\mathbb{S}^2} phase(w \to w') \mathrm{d}w' = 1.$$

Volume Lighting

Transmittance

$$T_r(\mathsf{p} \rightarrow \mathsf{p}') = e^{-\int_0^d \sigma(p+tw,w)dt}.$$

Scatter In

$$S(\mathsf{p}, w) = L_{\mathsf{ve}}(\mathsf{p}, w) + \sigma_{\mathsf{s}}(\mathsf{p}, w) \int_{\mathbb{S}^2} phase(\mathsf{p}, -w' \rightarrow w) L_i(\mathsf{p}, w') \mathsf{d}w'.$$

Monte Carlo Integration

Monte Carlo methods allow estimation of complex systems through use of probability functions and random numbers.

Most useful is Monte Carlo Integration.

Allows random, discrete sampling of a function.

Allows estimation of an arbitrary integral.

Outline

Related Works: Global Illumination

- Field of study in computer graphics.
- Photon Mapping.
- Radiosity.
- Monte Carlo Techniques.

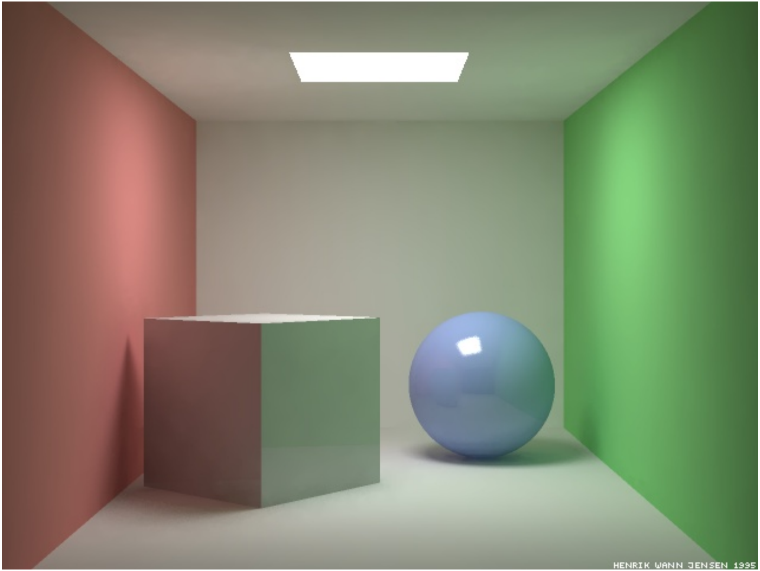
Related Works: Point-Based Color Bleeding

Point-Based Approximate Color Bleeding by Per Christensen.

Subset of scene geometry is thoroughly sampled, creating point cloud.

Point cloud is sampled to determin incoming radiance.

Related Works: Photon Mapping



Related Works: Volume Rendering

A number of approaches...
Polygonal representation based on isosurfaces
Opacity/Color arrays (interpolation across voxels)

Related Works: Volume Rendering

- Multi-Resolution Volumes
- Occlusion Techniques

Related Works: Volume Rendering

Volume Lighting

Outline

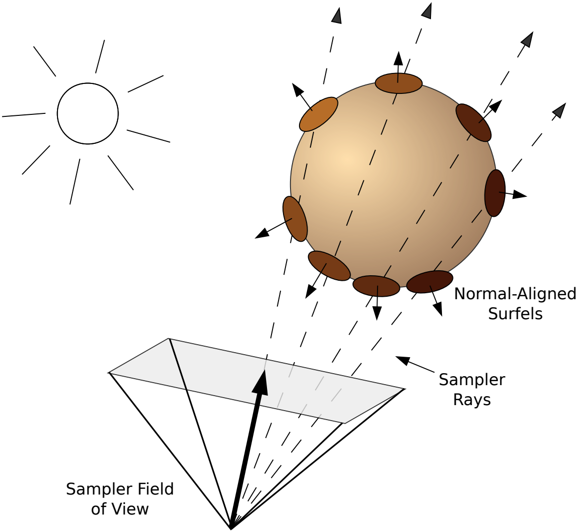
Point-Based Color Bleeding

1. Sample the scene and generate a point cloud
2. Perform ray tracing on regular geometry
3. Replace ambient estimates with a gather stage using surrounding point cloud

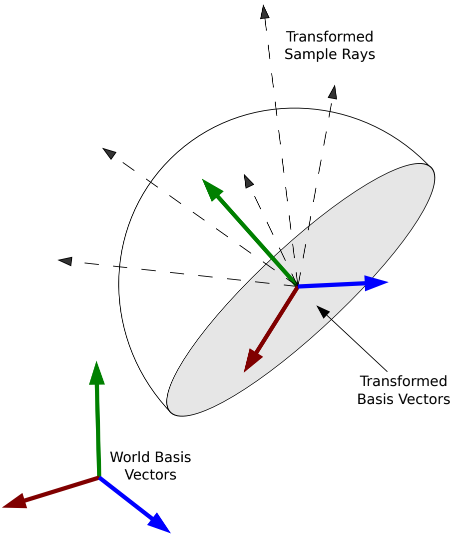
Extension Overview

1. Sample the scene and generate a point cloud
2. Sample the participating media and evaluate scatter, absorbtion and direct lighting
3. Cast rays as normal
4. Orient hemispherical samples along the normals of the surfaces intersected
5. Model scatter-out and scatter-in properties during lighting gather stage

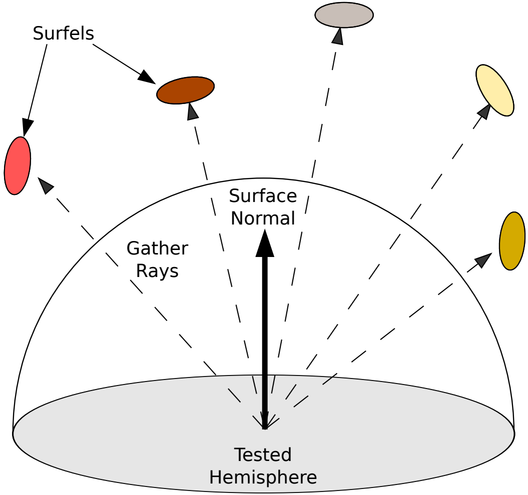
Sampling the Scene



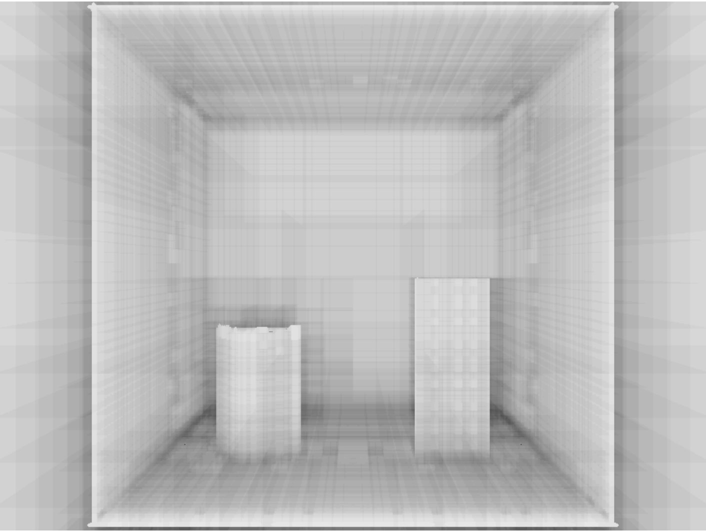
Gathering Light



Gathering Light



Integrating Volume Data



Outline

Results

Scene	Render Time (s)	Image Delta	Memory Overh
Monte Carlo w/o PCB	3351 sec	NONE	NONE
Traditional PCB	348 sec	11.0%	390 Mb (4.0
Extended PCB	397 sec	4.8%	395 Mb (4.1

Outline

Future Work

1. Multiple bounce
2. Phase functions for volumes
3. Parallelism
4. Optimal Sampling
5. GPU Acceleration

Outline

Conclusion

Oh yea!