Reviews: Ambient Volume Scattering

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Outline

What Thing I Have Done

- Read the paper *Ambient Volume Scattering*.
- Found relavent
  - tutorials, references, books...
  - references, books...
  - references...
- Learned and deduced the theories.
- Wrote a report.

Visualization of Volume Data

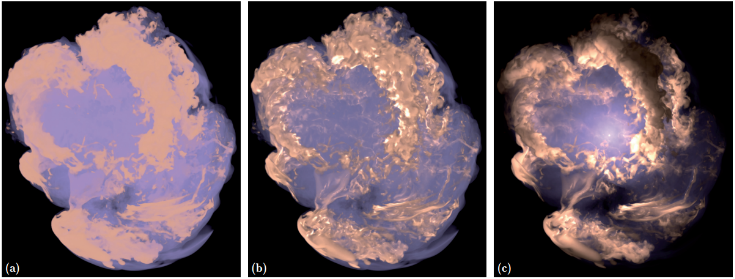

Fig. 1. Volume renderings of a supernova simulation with different optical models. (a) Standard emission–absorption model (64 fps). (b) Volumetric ambient occlusion (27 fps). (c) Our ambient scattering model with a light source in the center of the supernova (20 fps).

Figure: Supernova

Visualization of Volume Data

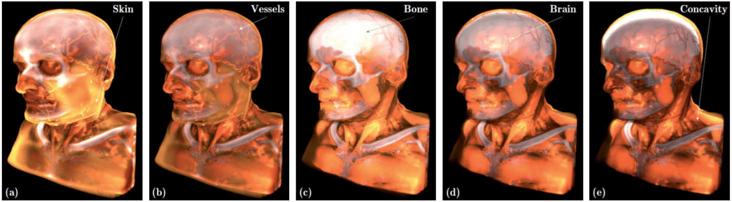

Fig. 7. Visualization of the Manix data set with ambient scattering and varying anisotropy values. The first light source is located in front of the data set and the second one is located behind. The anisotropy parameter of the HG phase function varies with (a) $g = -0.8$, (b) $g = -0.6$, (c) $g = 0.0$ (d) $g = 0.6$, and (e) $g = 0.8$. All other parameters remain constant.

Figure: Manix data set

Incredible! How Does It Work?

- Radiative transfer equation
- Scattering
- Path tracing (similiar to ray tracing)
- Monte-Carlo method
- Well-designed approximations
- Good phase function

Radiative transfer equation

- Ordinary form:
  - Scattering equation:

$$L^{r,out}(P,\omega_o) = \int_{\omega_i \in \boldsymbol{S}^2(p)} L^{in}(P,-\omega_i) f_s(P,\omega_i,\omega_o) \left|\omega_i \cdot \boldsymbol{n}_p\right| d\omega_i$$

  - Transport equation: $L(P,-\omega_i) = L(R(P,\omega_i),-\omega_i)$
- Volume rendering:
  - Radiative transfer equation:

$$L(x,\omega) = T(x_b,x)L_b(x_b,\omega) + \int_{x_b}^{x} T(x',x)\sigma_t(x')L_m(x',\omega)dx'$$

  - Transmittance: $T(x_1,x_2) = e^{-\int_{x_1}^{x_2}\sigma_t(x')dx'}$

Scattering

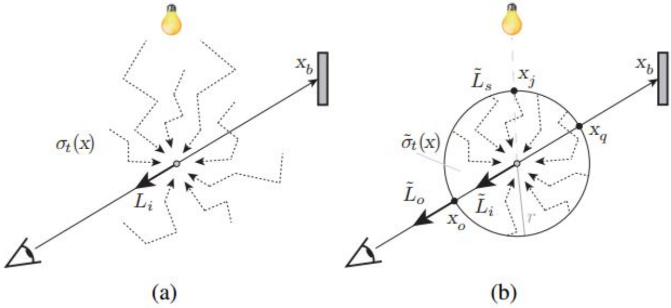

Fig. 2. (a) In-scattered radiance L_i on a global scale. (b) In-scattered ambient radiance $\tilde{L}_i$ on a mesoscopic scale. Scattering effects are restricted to a spherical region S_r of radius r with ambient extinction coefficient $\tilde{\sigma}_t$ and boundary condition $\tilde{L}_s$ on the surface. Moreover, the radially outgoing radiance $\tilde{L}_o$ integrates the in-scattered radiance $\tilde{L}_i$ along the line of sight inside the sphere.

Figure: In-Scattering in a Sphere

Path Tracing

```
for each pixel (x,y) on the image plane:
   ω = ray from the eyepoint E to (x, y)
   result = 0
   repeat N times:
      result += estimate of L(E,−ω)
   pixel[x][y] = result/N;
```

Figure: A Simple Path Tracer - 0

```
// Single-sample estimate of radiance through a point C
// in direction ω.
define estimateL(C, ω):
  P = raycast(C, −ω) // find the surface this light came from
  u = uniform(0, 1)
  if (u < 0.5):
    return Lᵉ(P,ω)/0.5
  else:
    ωi = randsphere() // unit vector chosen uniformly
    integrand = estimateL(P, −ωi) · fs(P,ωi,ω)|ωi · nP|
    density = 1/(4π)
    return integrand / (0.5 * density)
```

Figure: A Simple Path Tracer - 1

Path Tracing & Monte Carlo

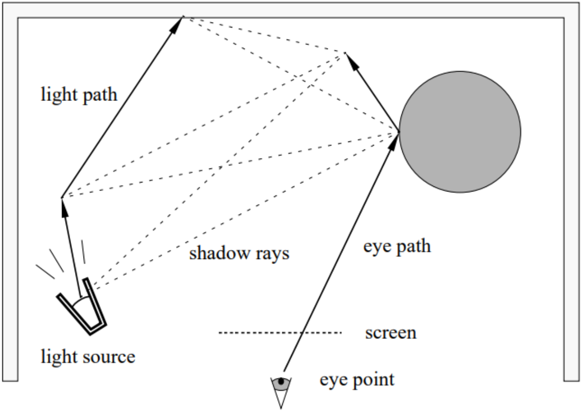

Fig. 4. A schematic overview of bidirectional path tracing in a participating medium. A pair of random walks is constructed: an eye path starting from the eye point, through a pixel, and a light path starting from a light source. The paths can scatter inside the medium or reflect at surfaces. The points on the respective paths are connected by means of shadow rays, which determine the contribution to the estimated flux of the pixel.

Figure: Random Walk and Importance Sampling

Well-Designed Approximation

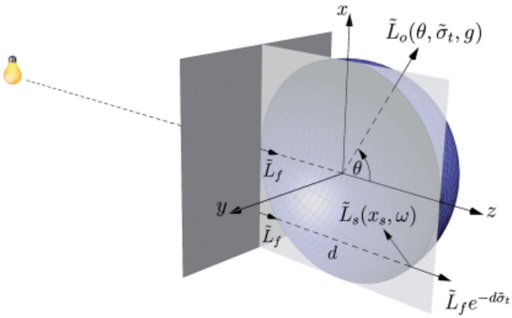

Fig. 4. Spherical geometry for preintegration of light transport. The dark shaded plane denotes a light front of approximately constant radiance $\tilde{L}_f$ from a far distant light source. The boundary condition $\tilde{L}_s(x_s, \omega)$ on the sphere surface is derived from $\tilde{L}_f$. Due to symmetry around the local z-axis, $\tilde{L}_o$ depends only on θ and the medium inside the sphere.

Figure: Preintegration and Dimensionality Reduction

Good Phase Function

- Henyey-Greenstein(HG) Phase Function:

$$P_{HG}(\alpha, g) = \frac{1 - g^2}{(1 + g^2 - 2g\cos\alpha)^{\frac{3}{2}}}$$

Thank You!