Efficient Free Path Sampling in Inhomogeneous Media

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Particle tracing:

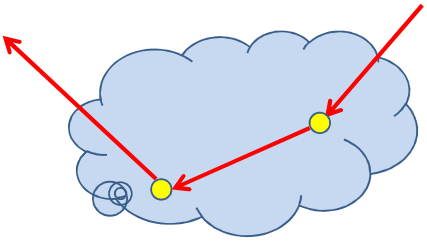
1. ***Free path between scattering points***
   Expensive in inhomogenous media!
2. Absorption or scattering
3. Scattering direction

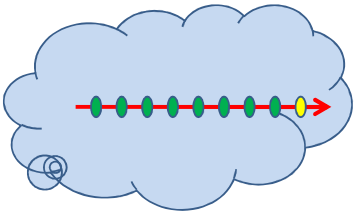
Ray marching:

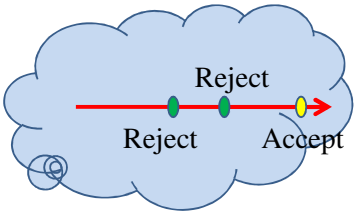
Problem: many texture fetches when the voxel array has high resolution and the density is low

Woodcock tracking:

Random length with max density σ_{max}
Accept with the probability of σ/σ_{max}
Problem: many rejected scattering points if the density has high variation

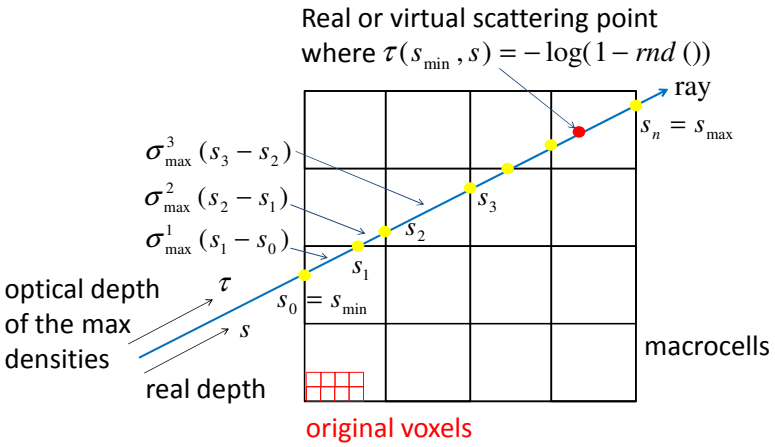


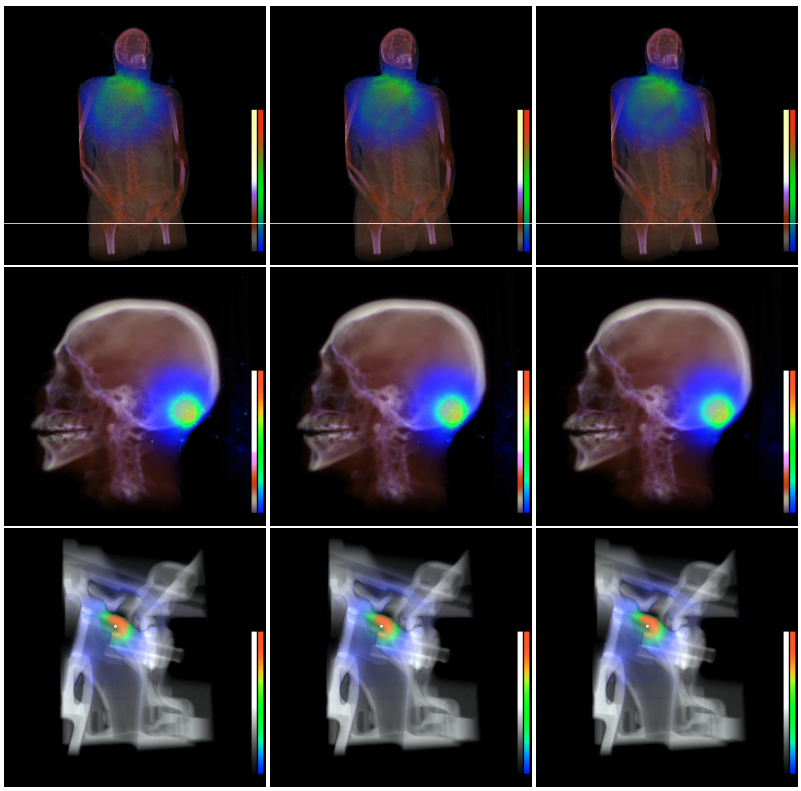




New free path sampling:

1. Use a low resolution grid of macrocells
2. Assign its maximum density σ^i_{max} to each macrocell
3. 3D DDA on the macrocell grid to locate the cell of the scattering point
4. Solution of a linear equation in the found macrocell to obtain the scattering point
5. Accept with probability $\sigma(s)/\sigma^i_{max}$





2.5 million photons 5 million photons 25 million photons

A photon is traced up to 5 scattering events

Performance:

Average number of texture fetches to find the next scattering point of a ray in 512^3 resolution volume:

Method	Texture fetches of the 512^3 resolution original volume	Texture fetches of the 16^3 resolution macrocell volume
Original ray marching	100	
New method	1.3	3.2

Much fewer number of texture fetches!

CUDA implementation provides interactive multiple scattering simulation.

Applications:

- Participating media rendering
- Radiotherapy treatment design