

Realistic Simulation of Complex Materials

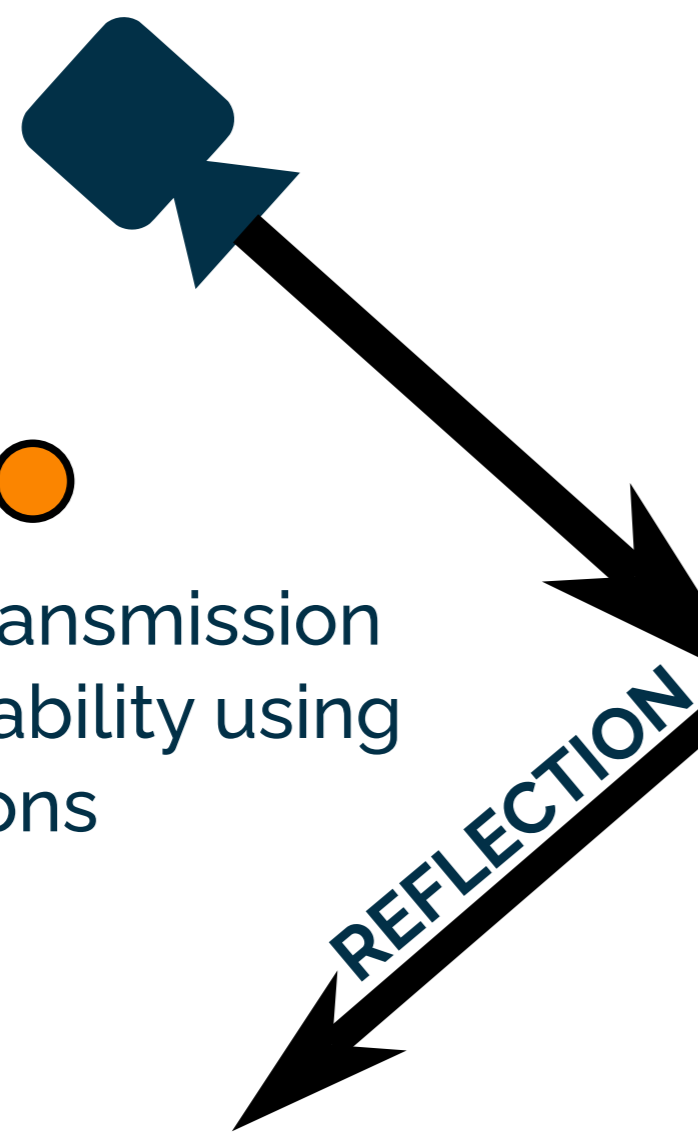
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Path Tracer

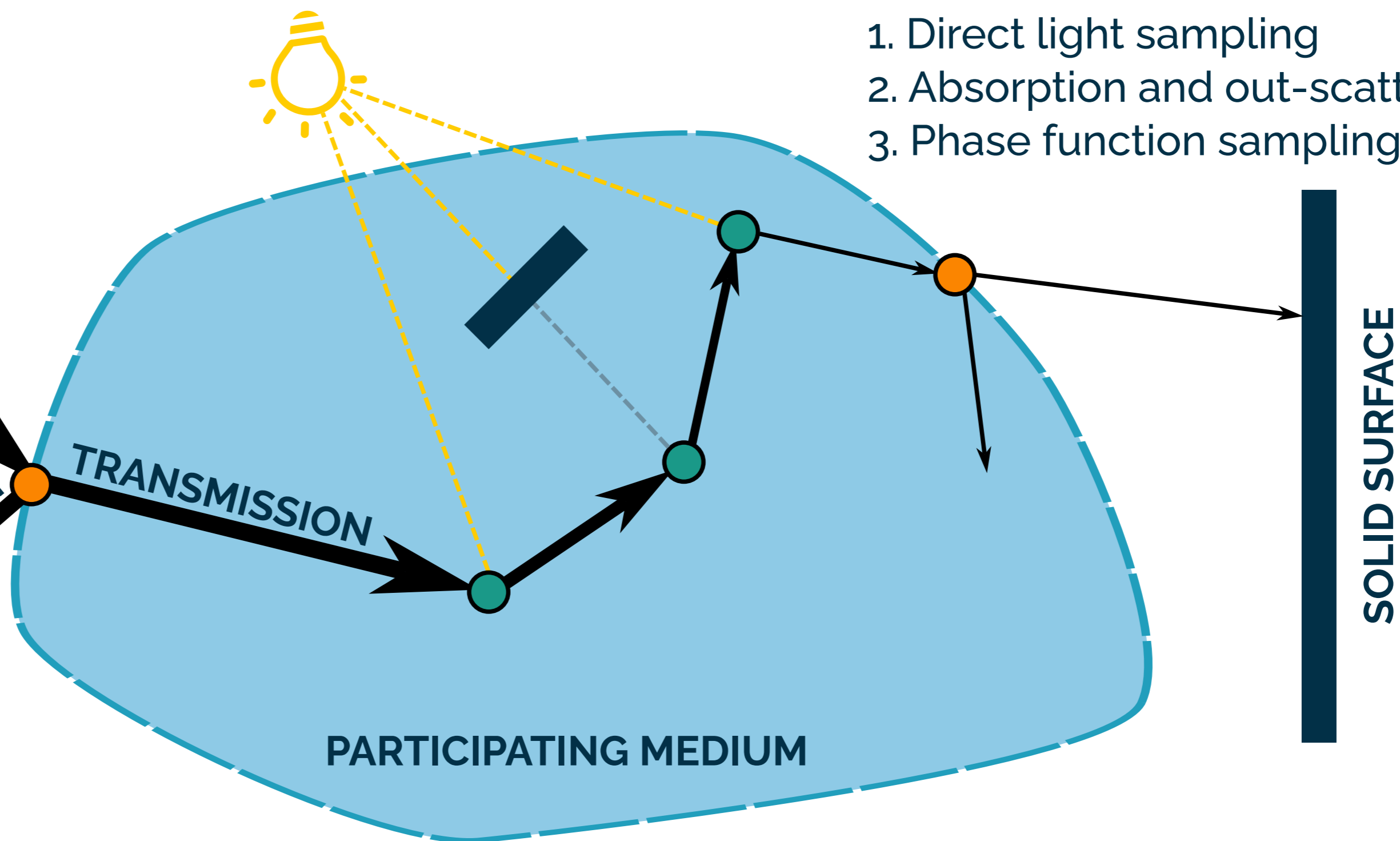
Fresnel ●

Reflection or transmission based on probability using Fresnel equations



Medium Interaction ●

1. Direct light sampling
2. Absorption and out-scattering
3. Phase function sampling



$$L(\mathbf{x}, \vec{\omega}) = \int_0^s T_r(\mathbf{x} \leftrightarrow \mathbf{x}_t) \sigma_s(\mathbf{x}_t) L_i(\mathbf{x}_t, \vec{\omega}) dt + T_r(\mathbf{x} \leftrightarrow \mathbf{x}_s) L(\mathbf{x}_s, \vec{\omega})$$

Figure 1: Path tracer schema

Equation 1: Rendering equation

In the Medium

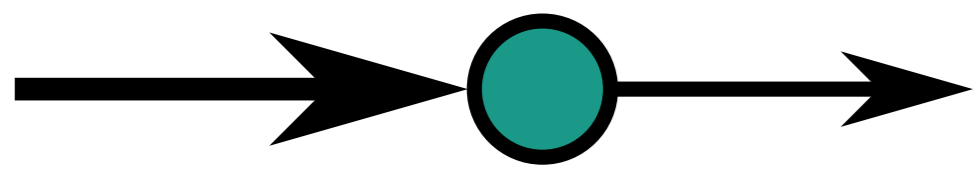


Figure 2a

Absorption

Portion of incoming light gets absorbed by the medium

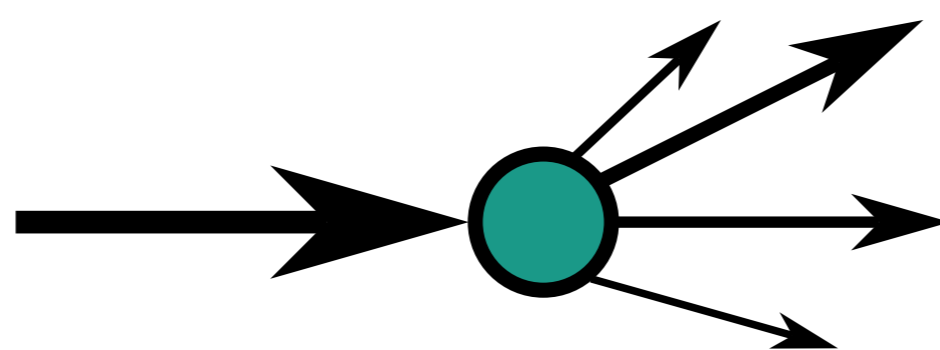


Figure 2b

Out-scattering

Portion of incoming light gets scattered in various directions

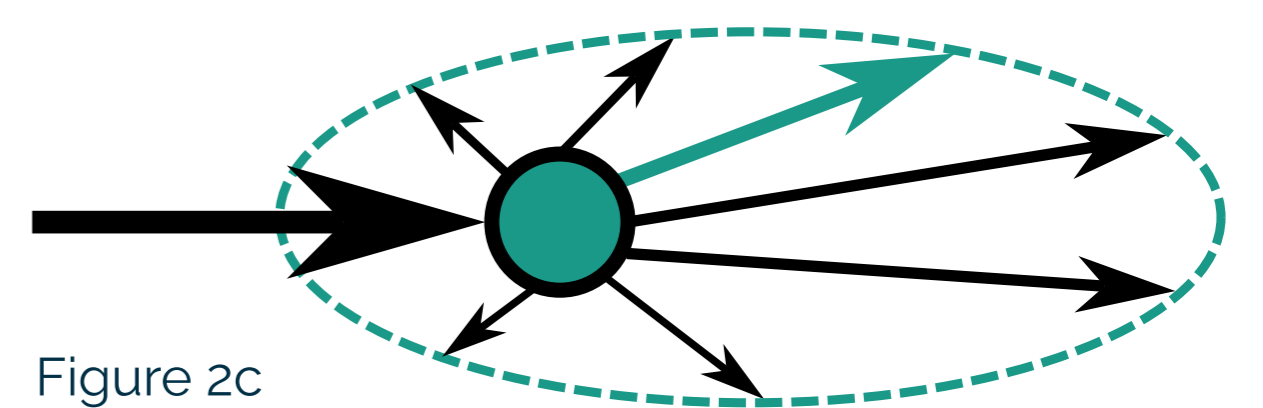


Figure 2c

Phase function

Determines the ray direction after medium interaction

Implementation

Host (CPU-side)

- Implemented using Vulkan API and Nvidia's `nvpro_core` library
- Input OBJ scenes get parsed into acceleration structures
- Media are defined in a separate JSON file, utility script provided

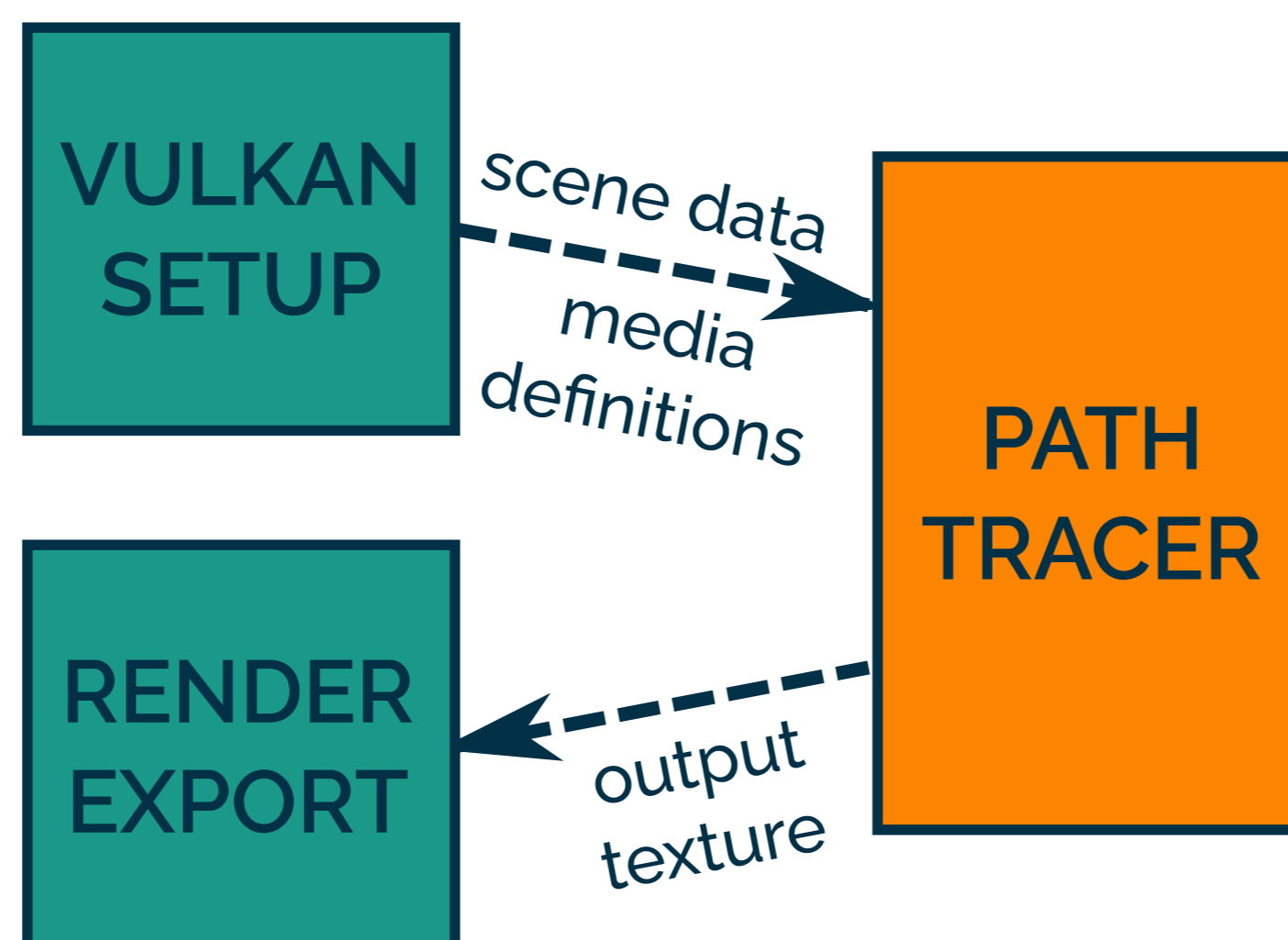


Figure 3: Schema of transfers between CPU and GPU

Device (GPU-side)

- Monte Carlo path tracer
- Output is stored in device-only texture, then gets copied to CPU

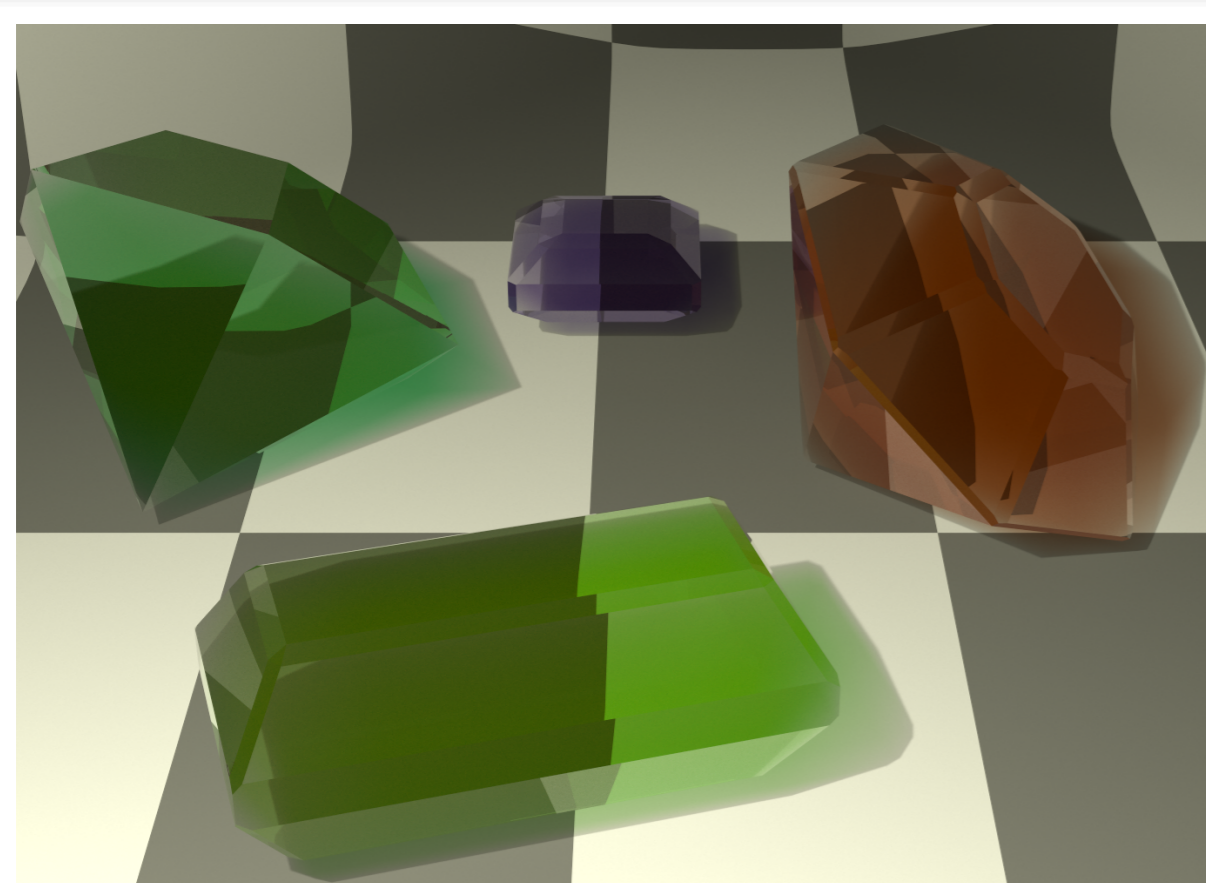


Figure 4a: Crystals filled with media

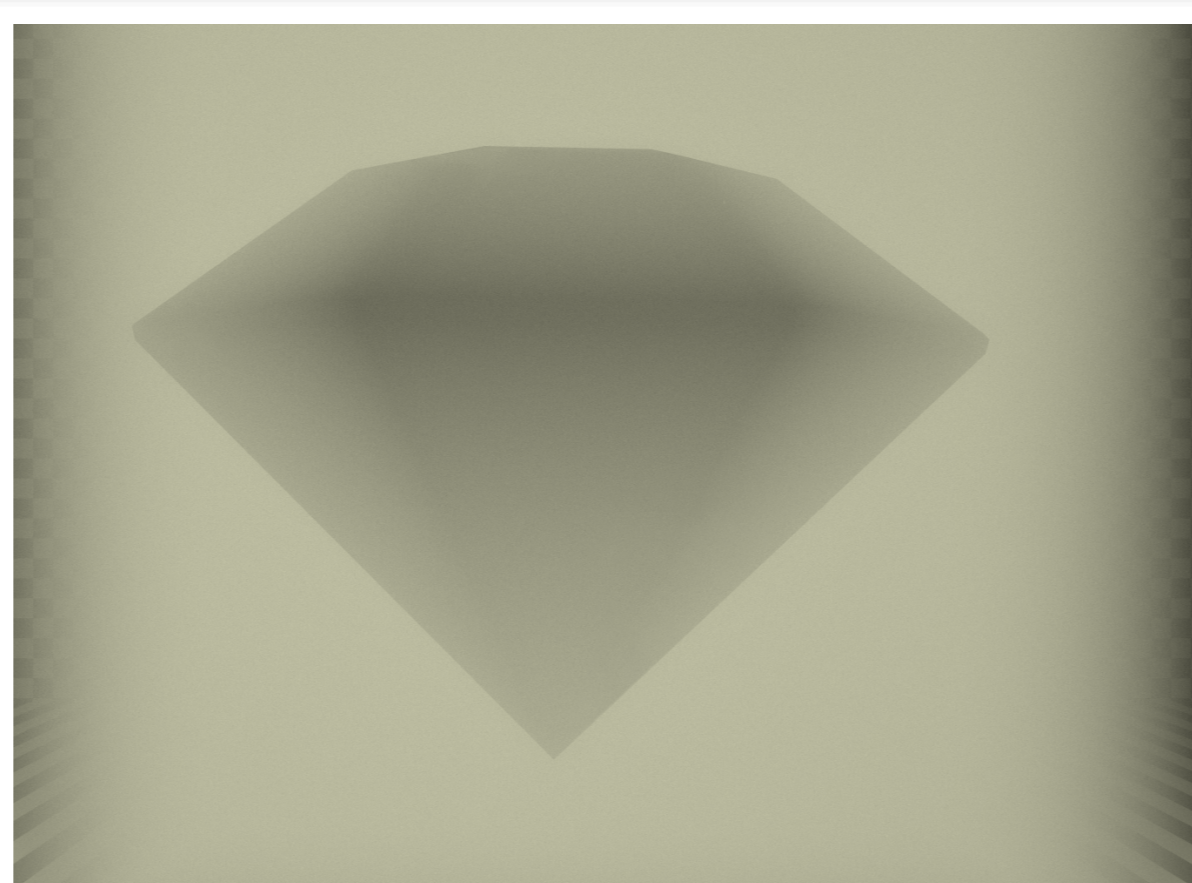


Figure 4b: Diffuse crystal in fog

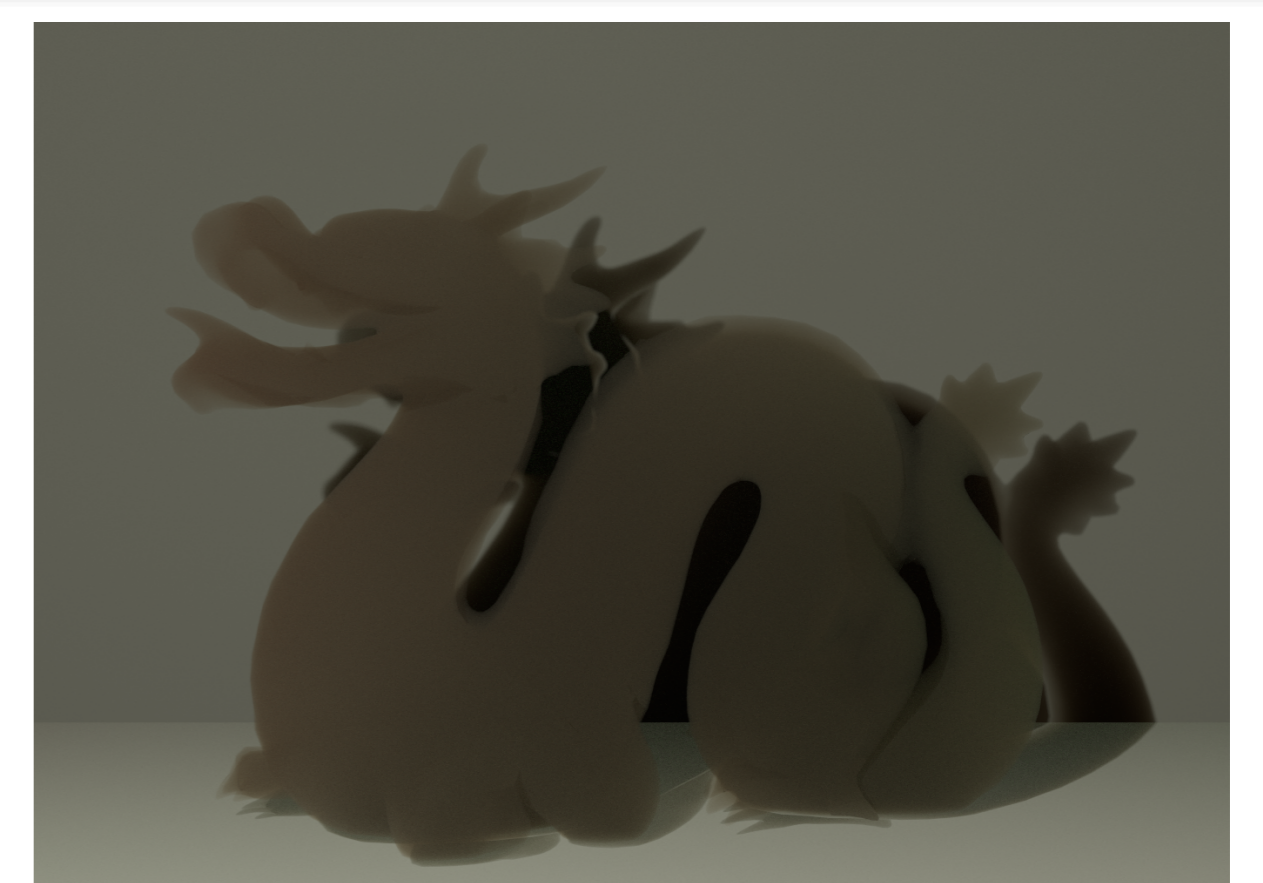


Figure 4c: Stanford dragon made of smoke