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A Compact Representation for Multiple Scattering in Participating Media using Neural Networks

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Figure 1: Equal time comparison for global illumination in participating media: our method based on neural networks (left), storing the full table [Wang and Holzschuch 2017], and Virtual Ray Lights (VRL) [Novák et al. 2012]. Right: reference solution.

CCS CONCEPTS
- Computing methodologies → Rendering;

KEYWORDS
Participating Media, Multiple Scattering, Neural Networks

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1 OVERVIEW
Many materials, such as milk or wax, exhibit scattering effects; incoming light enters the material and is scattered inside, giving a translucent aspect. These effects are computationally intensive as they require simulating a large number of events. Full computations are expensive, even with accelerating methods such as Virtual Ray Lights. The dipole approximation [Jensen et al. 2001] is fast, but a strong approximation. Precomputing the material response for multiple scattering [Moon et al. 2007; Wang and Holzschuch 2017] integrates well with existing rendering algorithms, allowing separate computation for single- and double- scattering, and fast computation for multiple scattering. Their main issue is efficient storage for the precomputed multiple scattering data.

We present a method to encode multiple scattering effects using a neural network. We replace the precomputed multiple scattering table of [Wang and Holzschuch 2017] (40 MB) with a trained neural network, with a cost of 6490 bytes (1623 floats). At runtime, the neural network is used to generate multiple scattering. We demonstrate the effects combined with Virtual Ray Lights (VRL), but our approach can be integrated with other rendering algorithms.

2 PREVIOUS WORKS

Moon et al. [2007] precompute multiple scattering effects and store the result on a set of concentric spheres. Müller et al. [2016] extend the approach with varying sphere size, and use it to convert granular materials to heterogeneous media.

Wang et al. [2016] precompute multiple scattering in a 2D table, using the symmetry of revolution, and use it for point-based global
We can see the precomputed multiple scattering as a complex mapping from a 4 dimension domain (input coordinates, \((\rho, z, \theta, \phi)\)) to a 3 dimension domain (the RGB channel), where the output function has an exponential falloff with the first two coordinates, and can be highly anisotropic for the last two coordinates (assuming anisotropic material).

We treat it as a regression problem and train a neural network to learn the multiple scattering function \(\Phi\), approximating it with \(\Phi_N(\rho, z, \theta, \phi, w)\), where \(w\) is the weights and biases of \(\Phi_N\), found by minimizing:

\[
E = \sum_i \| r_i - \Phi_N(\rho, z, \theta, \phi, w) \|^2. \tag{1}
\]

We have presented a neural network model to represent multiple scattering events in participating media. The model provides a very compact representation for precomputed multiple scattering, and can be combined with many existing rendering algorithms, providing similar results for a fraction of the memory cost. In future work, we want to extend the range of parameters for learning (albedo, phase function anisotropy), so the entire space of materials can be represented with a single neural network model.