ABSTRACT

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Title: A Numerical Study of Mie Scattering and Light Propagation Through Scattering Media Using Monte Carlo Simulations

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Year: 2021

Mie theory describes the elastic scattering of light by particles which are modeled as homogeneous spheres. It is based on the solution to Maxwell's equations which was developed by Gustav Mie in 1908. Mie theory is very useful in situations where the size of the scattering particles is comparable to the wavelength of the light, rather than much smaller or much larger. It may be used to approximate the scattering behavior of biological tissues, and to develop light transport models for imaging through biological tissues.

Our work is primarily focused on network scatter events, where Mie scattering happens multiple times as photons propagate through a large network of spherical scatterers. The latter is done by using Monte Carlo simulations in which many photons are launched and traced as they propagate through a scattering medium. Each photon undergoes a random walk process comprised of multiple single scattering evens. The direction of a photon after scattering is a random value generated using the angular probability distribution based on Mie scattering. An open-source set of programs were designed to simulate Mie scattering for various types of scattering media. Christian Matzler’s 2002 MATLAB code on single scattering served as the foundation which was built off for the coding.

Using the code, we can generate the distribution of photons throughout the scattering media over time after a bunch (pulse) of photons enter the medium, and make time-integrated two-or-three-dimensional measurements of the light distribution, as well as time-resolved light distribution or photon counting measurements at the boundary of the medium. By varying the size parameters, we demonstrated the difference between Rayleigh with particle size much smaller than the wavelength of the incident light and typical Mie scattering with the particle size comparable to the wavelength. We also evaluated the effects due to reflection on the boundary.