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NEURALRTE: A NEW PHOTON TRANSPORT SIMULATION ALGORITHMFORASSESSMENT OF LIGHT PROPAGATION IN BIOLOGICAL TISSUES

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The development of optical diagnostic modalities necessitates accurate in silico simulation of light propagation in turbid media, including biological tissues, the atmosphere, and various fluids. Such task poses significant challenges due to the complexities of multiple scattering of light. Traditional methods, employing a range of analytical and stochastic techniques (e.g. Monte Carlo (MC) method), have achieved considerable maturity in simulating light transport phenomena in translucent materials. However, the MC method, known for its high accuracy and regarded as the gold standard in the field, requires substantial computational and energy resources. Its performance is heavily dependent on the medium's optical properties and the configuration of the optical probe. This is particularly evident in specialized applications like Laguerre-Gaussian beams and Raman scattering, where the challenges are more pronounced.

In this work, we introduce NeuralRTE, a novel approach that harnesses the power of Artificial Intelligence to learn and subsequently provide an efficient and detailed evaluation of photon transport behaviours. This new method stands out for its independence from the medium's optical properties/geometry and its ability to maintain consistent execution time, contrasting with traditional unbiased stochastic solvers that typically require increasing the number of photons to enhance accuracy, as dictated by the Central Limit theorem. Through rigorous testing and comparison with conventional analytical and computational models, NeuralRTE has proven to surpass existing solutions, while upholding the required accuracy standards. This advancement in photon transport simulations offers modern, efficient, versatile and open-source solution for a wide range of applications. We demonstrate through numerous test cases how this new method can be effectively utilized in sensing, 3D graphics, and inverse problem solving tasks on embedded systems, showcasing its broad potential and utility.

Biography

Dr Alexander Doronin is an Assistant Professor in Computer Science at Victoria University of Wellington (New Zealand). His research interests are interdisciplinary and lie at the interface between Computer Graphics, Biomedical Optics and most recently Artificial Intelligence focusing on modelling of light transport in turbid media, development of novel optical diagnostics modalities, physically-based rendering, optical measurements/instrumentation, acquisition and building of realistic material models, colour perception, translucency, appearance and biomedical visualization. He has extensive recognized experience in the design of forward and inverse algorithms of light scattering in turbid tissue-like media simulations and created a generalized Monte Carlo model of photon migration which has found a widespread application as an open-access computational tool for the needs of light transport communities in Biophotonics, Biomedical Imaging and Graphics.