Photon Transport Simulations in Turbid Media Aided by Artificial Intelligence

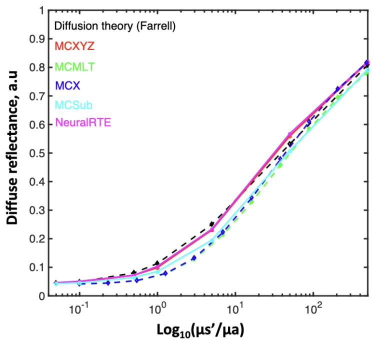
A Doronin[1]

[1]*School of Engineering and Computer Science, Victoria University of Wellington, Gate 7 Kelburn PD 6035, Wellington, New Zealand. Contact Phone: +6444639682*
Contact Email: alex.doronin@vuw.ac.nz

In this study, we introduce a novel hybrid method for forward solutions to the governing Radiative Transport Equation, crucial in Biomedical Optics. By leveraging emerging artificial intelligence-based techniques, our approach produces accurate estimates of light propagation through scattering media, independent of optical properties and without the need for specialized hardware such as graphics cards.

The aim of this work is to investigate the applicability of machine learning-based solutions in forward light transport simulations. We present a modular, comprehensive dataset generation, training, and testing pipeline and conduct direct comparisons with ground truth analytical and computational results. Our findings demonstrate the potential for high efficacy, speed, and accuracy in predicting photon transport behavior through turbid scattering media such as biological tissues.

NeuralRTE, our developed solution, is open-source and provides significant power efficiency for embedding options, making it available for innovative embedded, hybrid, or mobile light transport simulation applications. This method maintains the accuracy of existing techniques like the Monte Carlo method while offering greater flexibility and efficiency.



Source	Rd	Std Deviation
Giovanelli (1955)	0.2600	-
Adding-doubling, Prahl (1995)	0.26079	0.00079
MCML, Wang (1995)	0.25907	0.00093
03MC, Doronin (2011)	0.25957	0.00043
Neu(t)ralMC, Clennell (2023)	0.26048	0.00048
NeuralRTE (this work)	**0.26039**	**0.00039**

Figure 1: A direct comparison between the values of R_d produced by several currently notable supported analytical and stochastic techniques, including Diffusion theory by Farrell, MCXYZ, MCMLT, MCX, MCSub, and Neu(t)ralMC, has been conducted in comparison with our learning-based approach. On the left, a plot illustrates the variation in diffuse reflectance as a function of varying optical properties of the medium, while on the right, benchmark values are presented for a fixed set for semi-infinite geometry