AbstractID: 4904 Title: Macro Monte Carlo simulation of visible light transport in heterogeneous media

Purpose:
Although Monte Carlo (MC) simulation has become the gold standard in the transport of visible and near infra-red photons in turbid media such as tissue, its computational intensity limits its practical application. To increase the computational efficiency of visible MC, we have adapted a macro-Monte Carlo (MMC) method (Neuenschwander, *et al.* 1995, Phys. Med. Biol. **40**, 543-574) to the modeling of light transport in heterogeneous media.

Method and Materials:
Traditional MC routines trace individual photons step-by-step through the tissue. Instead, the MMC approach relies on a data set consisting of spheres or 'kugels' in which the light absorbed in each voxel is pre-calculated using a traditional MC routine. At each MMC step, the pre-calculated absorbed light dose in the appropriate sphere, aligned to the current position and direction of the sphere, is recorded in the dose matrix. The position and direction of the photon exiting the sphere are chosen from the exit distribution of the pre-calculated sphere, and the process is repeated. By choosing the size of the pre-calculated sphere appropriately, arbitrarily complex boundary geometries can be simulated. To allow the simulation to remain accurate arbitrarily close to boundaries, we have it automatically switch to photon-by-photon MC for points less than one kugel radius.

Results:
We compare the accuracy and calculation time of the MMC method with a traditional MC algorithm for a variety of tissue optical properties and geometries. We find that the MMC algorithm can increase the speed of calculation by as much as two orders of magnitude, depending on the optical properties and geometry being simulated, without a significant loss in accuracy.

Conclusions:
The drastic improvement in efficiency accomplished by implementing the Macro Monte Carlo algorithm for visible photons makes it fast enough to be potentially useful in photodynamic therapy treatment planning and optical measurement analysis.