Acceleration of optical photon Monte Carlo simulations using the Macro Monte Carlo method

The photon transport code MCML was modified to incorporate the macro Monte Carlo method (MMC). Traditional optical photon Monte Carlo via MCML models the behavior of optical photons by simulating individual absorption and scattering interactions. MCML also models reflection and refraction at boundaries (1).

The MMC version of the code makes use of large, multi-interaction steps (as opposed to traditional single-interaction Monte Carlo steps) when photons are in large, homogeneous regions. These large steps are pre-computed and stored in a database featuring many step sizes in many materials. The database is loaded into memory during the MCML simulation and allows the large steps to be quickly recalled and used by the code. The large steps allow photons to propagate through the simulation geometry more quickly.

Sample of the Results: The MMC version of MCML was tested in a number of geometries. One such geometry was a multi-layered model of the skull. This geometry is of interest in near-infrared spectroscopy (2). The model consists of four layers: the skull, cerebrospinal fluid, grey brain matter and white brain matter. The figure below on the left shows the absorption pattern for an 800-nm pencil beam light source impinging on the geometry. The graph on the right shows that the original MCML (labeled mcmlt) and the MMC version (labeled lmmc) are in excellent agreement. Similar results were obtained for reflection and transmission for the skull model. The MMC version of MCML was 2.37 times faster than the original MCML.

Innovation/Impact: Macro Monte Carlo methods have not been applied to optical photon transport before. This method has the potential to decrease calculation times in Monte Carlo modeling for photodynamic therapy and near-infrared spectroscopy.

References: