Virtual Optics: Seeing through Turbid Media and Beyond

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Recently, optical wavelength is assuming greater importance in the development of biophotonics applications. However, due to the shallow penetration depth, most current optical techniques such as optical coherence tomography (OCT), photodynamic therapy (PDT) are limited to the epithelial level. With the help of simulations, our research goal is to enhance the penetration depth of optical wavelengths through turbid media (e.g. biological tissues). To accurately account for interference and diffraction, we employ the Pseudospectral time-domain (PSTD) simulation technique based upon Maxwell's equations. The PSTD technique is advantageous for simulating large-scale light scattering problems; by yielding numerical solutions of Maxwell's equations, a virtual optics platform is established to simulate the phenomenon of light multiply scattering through macroscopic turbid media. Specifically, we model the phenomenon of optical phase conjugation (OPC). As light multiply scatters through turbid media, the phase, amplitude, and direction of propagation are all randomized. After phase conjugation, the poynting vector of scattered light is inverted and causing light to propagate in reversed directions, multiply re-scatters through the turbid media, and focuses back to where it orginated. This process is similar to a time-reversal progress. Simulation effort is being devoted to explore practical schemes to *undo* the scattering effect to enhance light penetration *into* or *out-of* turbid media. Though a pragmatic method to harness this phenomenon for biophotonics application is yet to be found, preliminary simulation results indicate that, with precise knowledge of the *amplitude* and *phase*, it is possible to direct light to a specific target *through* turbid media *non-invasively*.