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| Title: | Mesh Based Monte-Carlo Scheme For Optical Fluorescence and Polarised Light Propagation |
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| Abstract: | In biomedical optics, a Monte Carlo approach for photon transport has become widely used to examine how light behaves in tissues. It is considered as the Gold Standard for validation and testing of other deterministic models of photon transport as well as for cross- validation of experiments. A mesh-based technique (a scheme of MC) can be more precise in modeling targets with curved boundaries or locally refined features than earlier research employing voxel-based media discretization. Intrinsic fluorescing proteins, which are associated with the onset and progression of diseases such as cancer, or extrinsic fluorophores, which can be tagged to specific molecules and proteins associated with the disease, help in the early detection of disease. Fluorescence Optical Tomography (FOT), a variation of optical tomography (OT), is a powerful non- invasive, in-vivo, early cancer detection technique. The solution to this nonlinear inverse problem requires an exact solution of the optical propagation model (i.e., the solution of the forward problem). So, in this work, we have developed mesh-based forward models for propagating fluorescence and polarised light. In this work, we have used ValoMC 1 as the base code which gives fluence in the com- putation domain and the exitance at the domain boundary as output. We have made many inclusions and modifications to this code to get the desired model of light propagation. First, we included code to calculate radiance in the computation domain and at the do- main boundary. This enabled us to accurately compare the Radiative transfer equation (RTE) solution with the Monte Carlo results. We have validated the radiance calculation by our code with Mesh-based RTE 2 solved with the finite element method (FEM). With a rel- ative difference of under 5%, the outcomes from the two models are a perfect complement. Second, we developed a parallelized mesh-based Monte Carlo scheme for optical flu- orescence propagation for 2D and 3D phantoms. Thus, with the above addition, we got fluence and radiance in the computation domain at excitation and emission wavelengths. Fluence and exitance are validated with FDMC 3 with a relative difference of under 5% both at the excitation and emission wavelength. We have also shown how fluorescence op- tical tomography provides improved contrast images over conventional optical tomography. Improvement in penetration depth of optical tomography is also demonstrated in this simu- lation. A simulation showing fluorescence light propagation in the real-life model (mouse) is also included in this work. Finally, we have developed a mesh-based Monte Carlo parallelized method for propa- gating polarised light. We have validated our code with mcMeridian 4 . Except for a few scattered points, the two models again had a great match in this validation study, with a rela- tive difference of under 5%. We have also simulated a situation that shows the superiority of polarised imaging over the forward model with regular conventional optics. This simulation shows potential for using polarised light to identify differences in tissue microstructure. |
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