

Hybrid RTE-DE light propagation modeling

Background

Within the field of tissue optics there are mainly two ways to model light propagation inside biological media. The gold standard is the radiative transport equation (RTE). If the light can be treated as diffuse, which is the case within the NIR wavelength range, the diffusion equation (DE) has shown to be a good approximation of the light propagation. The diffusion equation is today the most used since there exist analytical solutions in simple geometries as well as computational efficient finite element solvers.

When trying to describe the light propagation close to a light source, inside biological media, the DE breaks down and one should go for the RTE instead. Several groups are today trying to develop efficient numerical solvers for the treatment of the RTE. Another way of retrieving a solution to the RTE is to make a stochastic model. Here the process that occur inside biological media, i.e. absorption and scattering, are modeled as stochastic processes with some probability to occur. A widely used computer code (MCML) has been developed at the Oregon Medical Laser Centre in C and recently a Matlab version of this code was presented.

Within the Medical Laser Physics group research within interstitial photodynamic therapy is conducted. Here several optical fibers are inserted into the prostate gland and after administration of a light sensitive pharmaceutical therapeutic light, delivered through the fibers, induces the photodynamic effect. In order to treat the entire gland proper dosimetry calculations are performed to describe the light distribution throughout the tissue. Using the light distribution the light irradiation times can be retrieved.

A problem is the calculation of the light distribution close to the optical fibers. The DE has no validity here hence it is impossible to model the light propagation. The aim of the project is to develop a hybrid modeling scheme that solves the DE where the validity holds and switches to RTE close to boundaries and sources. The scheme should preferably be implemented in Matlab and or Comsol Multiphysics. To solve the DE a Finite Element Solver should be used while a stochastic solver should be used for the RTE (Monte Carlo, Random walk-theory).

Project Scope

The main objectives of the project are:

Study the theory of hybrid modeling schemes.

Implementation of stochastic solver for RTE in Matlab using a fixed FEM-mesh.

Adapting RTE-solver into Comsol Multiphysics FEM-solver.

Experimental validation of the modeling scheme using simple setup with two interstitial optical fibers where blood is coagulated around one fiber tip.

Student requirements

A theoretical interest in light propagation modeling

Taken the course in Tissue Optics

Some knowledge of Matlab programming will be a great advantage

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