## Selected problems of radiative transfer in optical biomedical diagnostics

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Probing of biotissues with light has several significant advantages over the conventional methods of clinical diagnostics. In particular, optical methods are considered to be safe, non-invasive and often contactless. However, the peculiarities of light propagation in biotissues are often hinder the practical implementation of these methods.

Current report is a review of the numerical approaches aiming at evaluation and improvement of the sensitivity and applicability of several optical biomedical techniques developed and utilized in Optoelectronics and Measurement Techniques Laboratory of the University of Oulu. Specifically, we shall consider the adaption of Monte Carlo algorithm for modelling of radiative transfer in scattering media for biomedical optics applications and discuss the implementation of this algorithm for modelling of Optical Coherence Tomography (OCT), Doppler OCT [1], spatially resolved reflectometry, time domain, and frequency domain techniques [2].

In particular, using the developed approach to simulate OCT and Doppler OCT signals, it was demonstrated that in the case of low scattering, the scattering cross section, anisotropy, and flow velocity profile can be estimated from the Doppler OCT signal. For high scattering media, the slope of the OCT signal is strongly affected by the multiple scattering and the reconstructed flow velocity profile appears distorted. The deviation of the OCT slope from the value predicted by the single scattering model and the distortions in the measured flow velocity profile were analysed using the developed Monte Carlo model.

The applicability of spatial resolved reflectometry, time domain, and frequency domain techniques for the blood glucose sensing was also evaluated with the help of Monte Carlo method. The effect of glucose on the output signal of the considered techniques was numerically assessed. It was shown that the maximum sensitivity to variations in the glucose concentration within the physiological range in the three-layer tissue model considered in the study is observed for the source-detector separation equal to 0.4 mm. In this case, the maximal relative change of the detected signal is about 8% or 0.016% per mg/dl (relative change of the detected signal caused by the change in the glucose concentration of 1 mg/dl). The maximal possible sensitivity among the considered methods was observed for the time-of-flight technique. In this case, the relative sensitivity reaches the value of about 12% (or 0.024 % per mg/dl).

References:

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2. A.V. Bykov, M. Yu. Kirillin, A.V. Priezzhev, “Monte Carlo simulation of light propagation in human tissues and noninvasive glucose sensing”. In “Handbook of Optical Sensing of Glucose in Biological Fluids and Tissues”, Ed. V.V. Tuchin, Taylor & Francis (2008).