FAKULTÄT FÜR MATHEMATIK
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Einladung zur öffentlichen Defensio

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Thema der Dissertation

Reconstruction of optical parameters in quantitative optical coherence tomography

Abstract:

Since its invention in the 1990s optical coherence tomography (OCT) has evolved from a promising optical imaging modality to a well-established and powerful modality with a broad spectrum of applications. Cross-sectional images are directly formed by an interferometric measurement of the answer of objects to the radiation by light. These images then provide detailed information about the internal microstructure of biological tissues which is used for clinical investigation and diagnosis.
The increasing interest in this modality over the past has shifted the focus to quantitative methods which are used to gain additional information, in the form of physical properties, which is hidden in the OCT data. This field of research is referred to as quantitative optical coherence tomography (QOCT).
The main achievement of this dissertation was the quantification of optical parameters from experimental OCT data which also forms the core of this presentation. Mathematically, we formulate the quantification in OCT as an inverse scattering problem based on Maxwell's equation system.
In the first part of this presentation, the direct scattering problem is discussed. Locally, we reduce it to an one-dimensional electromagnetic wave scattering problem. There, the object of interest is assumed to show a layered structure, a realistic scenario for biological samples imaged by OCT systems, which is expressed by a piecewise constant function (with respect to depth) as the optical parameter. The presented problem, herein, is based on a Gaussian beam model for the strongly focused laser light illumination within the OCT system. While the commonly applied plane wave model failed to be accurate enough, such a Gaussian beam model has proven to predict precisely the effects visible in an OCT system. We discuss experiments for the calibration of necessary features for this model, like the focus position within the imaging system. Finally, we verify by numerical experiments that the simulations on the basis of this model match with the experimental data.
In the second part, we discuss the corresponding inverse problem where we propose a layer-by-layer reconstruction method based on this Gaussian beam model. The quantification problem, herein, is recast for each step as a minimization problem between the forward prediction and the (experimental) data. We give a characterization of uniqueness and show the applicability of the method by reconstructing the refractive indices from both simulated and experimental OCT data. There the reconstructed parameters match with the available ground truth.

Prüfungssenat
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Zeit und Ort

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