

Spectroscopic optical coherence tomography

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For the imaging of sensitive body parts such as human eyes, there is an ongoing need for low cost non-dangerous and non-invasive but high resolution imaging methods. Optical coherence tomography (OCT) has proven its ability to perform non-invasive cross-sectional imaging of internal structures in biological tissues. Enclosed in the OCT signal we find spectral information about the sample tissue, which can be used as a powerful diagnostic tool. Namely spectroscopic OCT (SOCT) shows promise towards non-invasive assessment of blood oxygen saturation, blood glucose level or cancer detection.



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In recent years, modern medicine has shown an emerging need for imaging techniques that are easy to use, non-invasive and therefore painless and safe for the patient but still provide the highest possible resolution both spatially and in time. Widespread medical imaging methods such as X-ray, computer tomography (CT) or magnetic resonance imaging (MRI) are well developed but all suffer from unwanted side effects such as dangerous irradiations or high costs. Among others, a new approach to the challenge of providing a simple, high resolution imaging technique is called optical coherence tomography or OCT for short.

Nowadays, OCT systems are commonly used in ophthalmology because of their ability of generating images of the retina and cornea with micrometer resolution. Enclosed in the OCT signal are moreover information about spectral characteristics which can be extracted using certain post-processing steps. One of these techniques, called spectroscopic optical coherence tomography (SOCT), extracts informa-

tion about spectral attenuation from the sample signal in order to provide a tool for characterizing tissue or substances under investigation.

In the presented thesis, a spectroscopic OCT system for medical applications was designed, specified and constructed. The realized system was evaluated towards its ability to measure and quantify physiological parameters in vivo. Experiments with absorbing substances in the near-infrared range (ICG) were carried out in a single layer setup and depth resolved measurements in multiple layers of absorbing liquid were tested. Additional experiments in scattering media (Intralipid) and in a tubule setup were conducted for a better approximation of the properties of blood vessels covered by human tissue.

With the system realized, spatial resolutions of 13 μm axial and a lateral resolution of approximately 20 μm (depending on the NA of the sample lens) were achieved.

Concentration differences of 10-20 micro mole ICG per liter could have been distinguished and measurements in different sample

setups showed the general feasibility of depth resolved measurements of spectral absorption coefficients even behind scattering layers. Methods for the system calibration and for the removal of signal artifacts were developed and a software for the post-processing algorithm was written. The results obtained proved the ability of depth resolved spectral absorption measurements with the SOCT technique. Nonetheless, for a commercially deployable device in the field of medical applications, the stability and sensitivity of the measurements still has to be increased gradually. With further developments in the area of the used light sources, detectors, fibre couplers and diffraction gratings, as well as improved mathematical models including a better description of the physical processes of scattering and absorption, a working SOCT measurement device should possibly be presented within a further decade.