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Simultaneous Measurement of Refractive Index and Thickness of Multi Layer Systems Using Fourier Domain Optical Coherence Tomography

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Purpose: To develop and validate a methodology for the simultaneous extraction of index of refraction, n(r), and physical dimension, t(r), profiles from the Spectral OCT data of multi-layered systems without any prior knowledge of the system under test.

Method: We first develop a theoretical framework for the simultaneous extraction of index of refraction and thickness. We then use the Transfer Matrix Method (TMM) to simulate Spectral OCT signals for a range of multi-layered systems simulating biological system to validate the methodology and quantify its potential accuracy.

Results: Our theoretical framework combines the traditional optical path information and raw spectral response information to generate a set of linearly independent equations that can be solved for the sample's indices and thicknesses and the rear medium index of refraction assuming that the front medium index of refraction is known. The accuracy of the extracted parameters depends on the sample's index contrast and is insensitive to the sample's thickness profile. We have used this methodology for two and three layers systems immersed in aqueous medium. For biological applications we can extract the indices within the error range of ±0.001 when the layers indices are <1.55.

Conclusions: We have developed the first methodology for extracting both physical dimension and index of refraction profiles of biologically relevant multi-layered systems without using any additional outside measurements.

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