Precise optical tomography of cell-scale objects

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Studies show that during action potential propagation in a neuron, a concurrent deformation travels along the axon [1,2]. While there is literature on electrophysiologic properties of the action potential and the deformation has been elucidated in a nerve (bundle of axons), no optical measurement of the deformation has been done on an individual axon. The main challenges are the physical characteristics of the axon including its shape and small size and the prohibitively small deformation of order 1nm, which happened within a short burst of time (less than 1ms), all leading to poor signal to noise ratio. Our project the goal is to develop a Spectral-Domain OCT based interferometry using a source with broad bandwidth which matches the size of the axon. We have implemented a simulation using MEEP (MIT electromagnetic equation propagation) package to initially evaluate the experimental data and to investigate the idea of improving the SNR by shaping the wave-front to match with cylindrical shape of the object. Subsequently, the SNR improvement would enable measurement of sub-nanometer changes in cell-scale objects, with a view of ultimately applying this to study live neurons.

[1] El Hady, Ahmed, and Benjamin B. Machta. "Mechanical surface waves accompany action potential propagation." *Nature communications* 6.1 (2015): 1-7.

[2] Hill, Bruce C., et al. "Laser interferometer measurement of changes in crayfish axon diameter concurrent with action potential." *Science* 196.4288 (1977): 426-428.