Machine Learning to Reconstruct 3D Scattering Data from Partially Coherent Imaging Data

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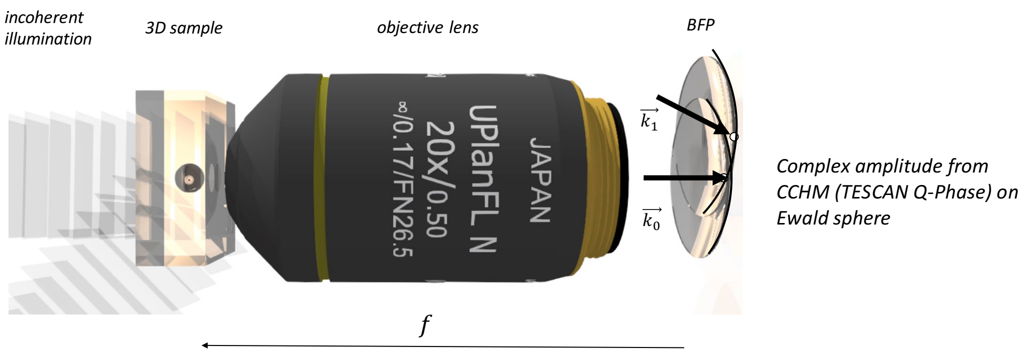
In recent years, constantly growing computational power brought the field of artificial neural networks (ANN) back to focus of the scientific community. Using the gradient-descent based optimization driven by auto-differentiation methods from open-source machine learning (ML) frameworks, we aim to recover the 3D refractive index (RI) distribution from an acquired z-stack. This is achieved by minimizing the error between the result of the forward model of a coherence-controlled holographical microscope (CCHM) applied to the RI distribution and the experimental results.
Each layer in the ANN corresponds to a slice of the 3D object. The beam propagation method (BPM) interconnects the layers and propagates the light originating from the incoherent illumination through the sample. This enables to account for multiple scattering. The convexity of the inverse problem is ensured by applying the isotropic total-variation (TV) regularizer, whereas the initialization of the neurons, the RI values respectively, is carried out by a trained U-NET for a faster convergence.
In our approach, we represent the forward model as a partially coherent imaging system which is suitable to reconstruct multiple scattering using the three-dimensional complex valued amplitude information acquired with a TESCAN Q-PHASE CCHM [2].

The 3D contour can then be used to derive the protein concentration in droplets formed from purified proteins which itself depends on the ionic strength and temperature. We also try to apply the algorithm to recover the 3D contour of in vivo HeLa cells considering multiple scattering.



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[2] T. Slaby et al.: Off-axis setup taking full advantage of incoherent illumination in coherence-controlled holographic microscope. Optics Express 21, 14747-14762 (2013). doi: 10.1364/OE.21.014747.