

High resolution three-dimensional imaging with optical diffraction tomography

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There has been considerable interest in the development of methods which extend the spatial resolution of optical microscopy beyond the classical diffraction limit, $\lambda/2NA$ where NA is the numerical aperture of the system, λ is the incident wavelength, without bringing a probe in the near-field of the sample.

We develop a new visualization tool, called optical diffraction tomography (ODT) which can be an interesting solution for high resolution imaging. It consists in illuminating the sample from many different directions and collecting the diffracted field under many scattered angles. Contrary to optical microscopy, in which the object is visualized in an analogical way with little or no numerical treatment for deblurring the image, ODT relies entirely on a numerical inverse procedure for reconstructing the map of permittivity of the sample from the data of the scattered field. The drawback of this technique compared to optical microscopy is that it requires to measure the intensity and phase of the scattered field [1] and that the image is not obtained in real time. On the other hand, it permits to take advantage of a priori information on the object, to account for multiple scattering, to avoid the aberrations due to lenses, to use non trivial incident beams and to give a quantitative information on the permittivity of the object.

In this work, we simulate 'rigorously' an experiment of optical tomography in transmission and we propose a non-linear inversion procedure that accounts for multiple scattering [2]. This algorithm requires to solve Maxwell equations at each estimation of the permittivity. We show that multiple scattering permits one to ameliorate the resolution of the image. We next study the influence of the incident field by generating evanescent waves thanks to a prism on which the objects are deposited. We show that a resolution smaller than $\lambda/6NA$ can be obtained for 3D objects, with synthetic data.

[1] V. Lauer, 'New approach to optical diffraction tomography yielding a vector equation of diffraction tomography and a novel tomographic microscope', *J. of Microscopy*, 205, 165-176, (2002).

[2] K. Belkebir et A. Sentenac 'High resolution optical diffraction microscopy' *J. Opt. Soc. Am. A*, 20, 1223-1229, (2003)