STUDIES ON SYNTHETIC DECONVOLUTION OF COMPLEX FIELDS WITH DIGITAL HOLOGRAPHIC MICROSCOPY

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1. INTRODUCTION

Due to its interferometric nature, digital holographic microscopy (DHM) provides access to the complex wavefront and holds the capability of imaging simultaneously amplitude and quantitative phase. Thus, DHM is an attractive research tool in many fields of biological research and an interesting alternative to classical fluorescence microscopy. For such intensity-based microscopy, however, super-resolution methods are available. Consequently, we propose a method to improve the resolution of coherent microscopy systems, too.

A coherent sub-wavelength resolution in a high-NA diffraction-limited optical system is demonstrated using a transmission DHM setup. By adapting inverse deconvolution post processing to coherent illumination conditions, a complex deconvolution procedure is derived. During the complex deconvolution, the phase imaging process does not need to be compromised since no additional optical components are required in the setup itself.

The comparison with conventional deconvolution in intensity suggests that complex deconvolution is suitable for super-resolution. It extends the limit of resolution with coherent illumination by a factor of 1.64×. Eventually, this gain in resolution arises by accessing the object's complex field - the information content coded in the phase [1] - and deconvolving it with the reconstructed complex transfer function (CTF).

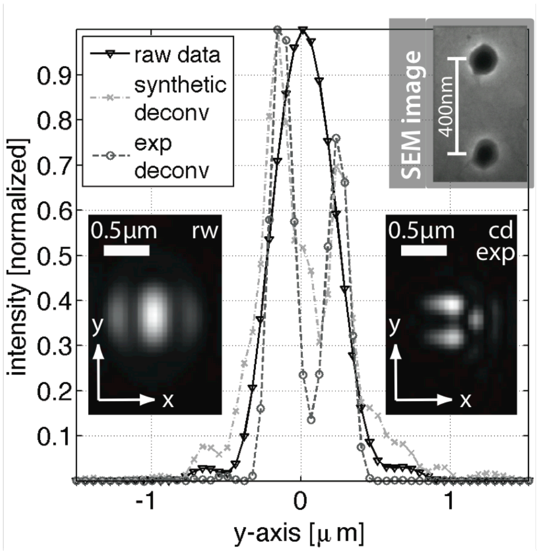

Figure: Comparison of unresolved and super-resolved profiles of two nano-holes with pitch 400nm (cf. top insert), in focal plane at λ=532nm and a NA=0.95. The 'raw data' profile shows the central y cross-section of the resolution limited raw data (cf. 'rw' insert). The 'exp deconv' profile shows the corresponding amplitude section after complex deconvolution (cf. 'cd exp' insert) with the experimental CTF. Additionally, 'synthetic deconv' compares the profile of complex deconvolution with a synthetic CTF.

2. RESULTS

The complex deconvolution method is experimentally verified with a test target, pairs of nano-holes (⌀=90nm) with pitches above and beneath the system's limit of resolution (cf. Figure). The optical system consists of a Zeiss ×63 NA0.95 air microscope objective (MO). Synthetic (modelled for MO) and experimental amplitude point spread functions (APSF) are used for the CTF reconstruction. Both of them serve for the complex deconvolution of the test target's fields. The role of synthetic CTF design with an appropriate diffraction model is discussed.

3. REFERENCE

[1]Y. Cotte, M. F. Toy, E. Shaffer, N. Pavillon and C. Depeursinge, "Sub-Rayleigh resolution by phase imaging", (to be published)