Dynamic structured illumination

Guillaume Noetinger*[1], Sébastien Popoff[1], Fabrice Lemoult[1], and Samuel Métais[2]

[1]Institut Langevin - Ondes et Images (UMR7587) – Ecole Supérieure de Physique et de Chimie Industrielles de la Ville de Paris, Sorbonne Universite, Centre National de la Recherche Scientifique : $UMR_7587 - -France$

[2]Institut FRESNEL – Centre National de la Recherche Scientifique : UMR7249/ UMR 6133, Ecole Centrale de Marseille, Aix Marseille Université : UMR7249/ UMR 6133 – France

Abstract

Diffraction limits the observation of objects small compared to the wavelength. In this work we combine the use of wavefront shaping and time as a new degree of freedom into a new approach of structured illumination (1) namely *dynamic structured illumination*.
Compared to a standard confocal microscope we add a DMD (Digital Micromirror Device) on the illumination path in the Fourier plane of the sample as a wavefront shaper to spatiotemporally modulate the illumination. The additional degrees of freedom provided allow to enhance the space-bandwidth product of the confocal microscope similarly to ptychographic imaging (2).

The illumination is chosen to be a pattern rotating with respect to the optical axis so that a periodic modulated signal is measured by the photodiode for each point of the sample instead of a single scalar.

On a Fourier point of view such a periodic temporal modulation consists in a frequency comb, each frequency corresponds to its own Point Spread Function (PSF). As a result multiple images of the same object with different PSFs are obtained at the same time.

A powerful feature is that we can extract different spatial frequencies of the observed sample including higher frequencies than the diffraction limit, the maximum frequency being two times higher similarly to tomographic imaging (3).

We provide an experimental proof of concept of this approach. Preliminary results demonstrate it's ability to enhance the signal-to-noise ratio of confocal imaging and, in some cases, to recover images with a better resolution than a confocal microscope.

(1) M.G.L. Gustafsson, "**Surpassing the lateral resolution limit by a factor of two using structured illumination microscopy**", *Journal of Microscopy, Vol. 198 Pt.2, May 2000*

(2) Guoan Zhen, Roarke Horstmeyer & Changhuei Yang, "**Wide field, high-resolution Fourier ptychographic microscopy**", *Nature Photonics, July 28 2013*
(3) O. Haeberlé, K. Belkebir A. Sentenac, "**Tomographic diffractive microscopy: basics, techniques and perspectives**", *Journal of Modern Optics, May 20 2010*

*Speaker