

IMAGE FORMATION IN STRUCTURED ILLUMINATION MICROSCOPY

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Structured illumination microscopy can enhance the resolution in fluorescence microscopy. This is accomplished by a spatially periodic illumination pattern that is translated and/or rotated with respect to the object (“phase shifting”), resulting in a sequence of images that is used in an inversion algorithm for obtaining the final high-resolution image (see [1] for a review and relevant references). We present a general image reconstruction algorithm that is applicable to any form of illumination pattern or phase shifting. The algorithm results in explicit analytical expressions for the effective transfer function and point spread function (see Figure 1 for various plots). This theoretical framework allows for a comparison between two ways of phase shifting: “polar” phase shifting in which a set of stripes is translated and rotated with respect to the object, and “Cartesian” phase shifting in which an array of spots is translated in both dimensions with respect to the object. In addition, it allows for investigating the effect of the type of illumination pattern. For Cartesian phase shifting it appears that the interference pattern between four plane waves at oblique incidence will do fine. It turns out that the polarization setting for these plane waves has a significant effect on the illumination pattern and on the achievable effective transfer function (compare 2nd and 4th row of Figure 1). Finally, we will go into the sensitivity

of structured illumination in its different forms to photobleaching, noise, and phase stepping jitter.

[1] A. Stemmer, M. Beck, and R. Fiolka, *Histochemistry and Cell Biology*, Vol. 130, pp. 807-817, 2008.

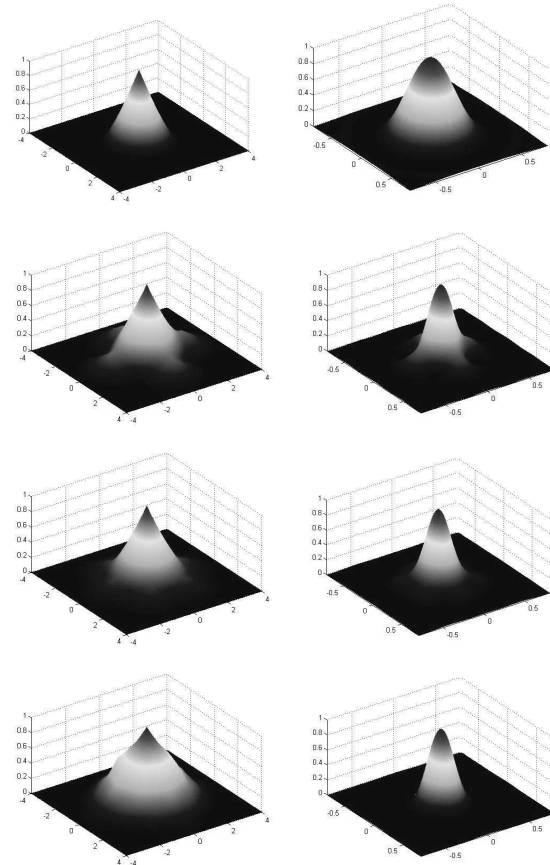


Figure 1. Effective transfer function (left column) and point spread function (right column) for the nominal case (1st row), illumination with four interfering s-polarized plane waves (2nd row), illumination with stripes for three azimuthal angles (3rd row), novel illumination scheme with four interfering circularly polarized plane waves (4th row).