IMPROVEMENT OF 2D-SIM ACHIEVED BASED ON TUNABLE STRUCTURED ILLUMINATION

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In Ref. [1], Doblas *et al.* showed that a Fresnel biprism illuminated by a plane wavefront emerging from one incoherent linear source produces an axially-extended structured illumination (SI) pattern whose modulation frequency depends on the emission wavelength of the source and the refractive index and refringence angle of the biprism. This configuration provides SI equivalent to the SI pattern created by the optical interference of two plane waves coming from two symmetrical orders of a diffraction grating as proposed by Gustafsson [2]. The advantage of using a Fresnel biprism is that it can produce a SI pattern of tunable modulation frequency [3,4. This optical configuration is achieved by placing the linear source at the front focal plane of a converging lens and inserting the biprism between these two elements. Therefore, the modulation frequency of the sinusoidal fringes can be continuously varied by changing the axial position of the Fresnel biprism with respect the source (see Fig. 1). Specifically, one can find: (i) the axial position of the Fresnel biprism whose modulation frequency is one half of the cutoff frequency (f_c) of the objective lens used (panel (a) of Fig. 1) and, from which, optical-sectioned images of a 3D object can be obtained; or (ii) the axial position of the biprism for which the lateral resolution of the native imaging system is doubled, which means that the modulation frequency of the SI fringes is equal to f_c (panel (b) of Fig. 1). However, the main problem in using a 2D-SIM-like scheme is that the performance of the structured illumination microscope (SIM) depends significantly on the modulation frequency of the fringes, due to the tradefoff between optical sectioning and super resolution [5].

In this contribution, we present a computational method that takes advantage of the tunable SI system obtained with the Fresnel biprism. By recording 3 phase-shifted images using the two modulation frequencies illustrated in Fig. 1, our method combines the information in the 6 intermediate SIM images and reconstructs an optically-sectioned 2D image with double the lateral resolution compared to the conventional image of the same field of view. The advantages of the combination of this tunable-frequency SI system with the proposed method is that high-resolution images can be obtained in almost real time independently of the objective lens used and without the presence coherence noise.

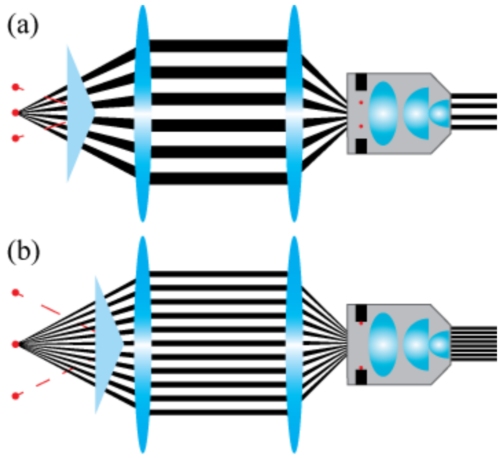

Fig. 1. Optical configuration of the tunable-frequency structured illumination system implemented with a Fresnel biprism: (a) modulation frequency of the pattern to obtained optical-sectioned images and (b) modulation frequency equals to the cutoff frequency of the objective lens used.

References

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