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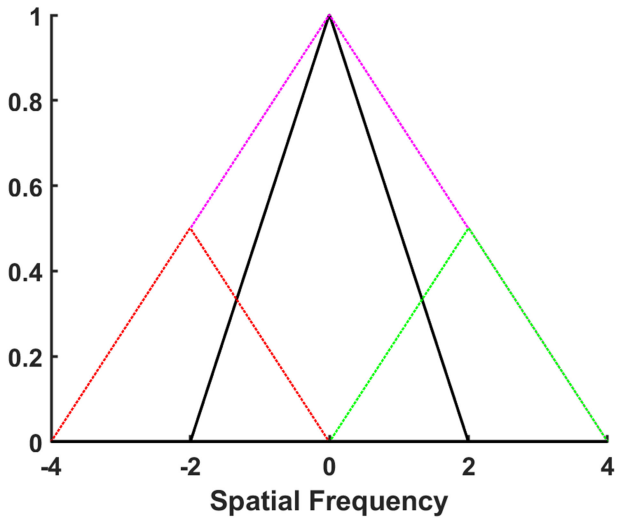

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Comments on "Rapid Image Reconstruction of Structured Illumination Microscopy Directly in the Spatial Domain"

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In [1] the authors describe the improvements in structured light microscopy (SIM) that can be achieved using a reconstruction algorithm that operates entirely in the spatial domain. The authors demonstrate that this offers advantages in speed of reconstruction, since the need to perform the 2D Fourier transforms, as used in conventional SIM reconstruction, is removed. The paper shows that the reconstructions using the spatial domain algorithm are equivalent in terms of image quality but have considerable advantages in terms of speed of reconstruction.

The underlying basis for [1] is Equation (1), which shows how the structured light reconstruction may be performed by multiplying the images obtained for different grating positions by a trigonometric function. This equation is reproduced below.

$$R_{SDR}(x) = \frac{1}{3I_0} \sum_{j=1}^{3} \left\{ 1 + \frac{2}{m} \cos\left[2\pi k_0 x + \varphi_0 + \frac{2\pi}{3}(j-1) \right] \right\} D_j(x) \tag{1}$$

Where the subscript SDR refers to spatial domain reconstruction, I_0 is a normalization factor that does not affect the form of the reconstruction, m is the modulation index of the grating pattern, k_0 is the reciprocal of the grating period projected onto the sample, φ_0 is the initial phase of the illumination and $D_j(x)$ is the j^{th} image used in the reconstruction.

The algorithm is described as novel and no reference is made to previous work, however, a virtually identical formulation was presented in [2] over a decade ago. The notation used in [2] differs from that given in [1] so the Equation (8) in [2] is reproduced below with the similar notation to [1].

$$R_{SDR}(x) = \frac{1}{4} \sum_{j=1}^{4} \left\{ 1 + 2\cos\left[2\pi k_0 x + \frac{\pi}{2}(j-1) \right] \right\} D_j(x) \tag{2}$$

Equation (2) is equivalent to Equation (1) in all important respects. Equation (2) uses 4 equally spaced grating positions rather than 3, and the modulation index in Equation (2) is assumed to be unity rather than m. These differences are relatively trivial and, moreover, [2] provides a full derivation of the formula. For speed of reconstruction 3 phase steps is obviously quicker, while there is some improvement in noise immunity when 4 steps are used. The interesting thing about

the spatial reconstruction is the factor of 2 that appears before the trigonometric form of the grating equation.

Although the motivation to use the spatial domain reconstruction in both papers was to avoid the need to perform 2D Fourier transforms, the reason to do this is entirely different in each paper. The algorithm was used to facilitate quantitative noise analysis in [2], whereas it is used for rapid reconstruction in [1].

References

[1] D. Dan *et al.*, "Rapid image reconstruction of structured illumination microscopy directly in the spatial domain," *IEEE Photon. J.,* vol. 13, no. 1, Feb. 2021, Art. no. 3900411.

[2] M. G. Somekh, K. Hsu, and M. C. Pitter, "Resolution in structured illumination microscopy: A probabilstic approach," *J. Opt. Soc. Amer. A,* vol. 25, no. 6, pp. 1319–1329, 2008.