DIRECT SUPER-RESOLUTION IMAGE RECONSTRUCTION FOR STRUCTURED ILLUMINATION MICROSCOPY IN REAL SPACE

Baoli Yao, Dan Dan, Ming Lei, Xing Zhou, Zhaojun Wang, Tianyu Zhao, Jia Qian, Xianghua Yu, Shaohui Yan, Junwei Min
State Key Laboratory of Transient Optics and Photonics, Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences
No.17 Xinxi Road, Xi'an 710119, China
E-mail:yaobl@opt.ac.cn

KEY WORDS: Super-resolution, structured illumination microscopy (SIM), frequency domain reconstruction, spatial domain reconstruction, artifact, reconstruction speed.

Super-resolution image reconstruction for structured illumination microscopy (SIM) is routinely conducted in the frequency domain (FDR), which is prone to suffering from artifacts and time-consuming due to the post-data processing. Here, we propose a new approach to directly attaining super-resolution images for SIM in the spatial domain reconstruction (SDR). In the FDR scheme, the nine raw images from three orientation illumination patterns have to be made fast Fourier transform (FFT) to get their spectra. All the spectra are then separated, shifted and recombined to form an enlarged isotropic spectrum, which corresponds to a super-resolution image in spatial domain after an inverse FFT (iFFT). The multiple operations of FFT and iFFT severely consume the processing time. What's more, any mismatch and errors in each step may cause artifacts to deteriorate the quality of super-resolution image. In contrast, the SDR scheme is directly performed in the spatial domain with only two-step operations: image multiplication and summation. And the multiplied coefficient matrixes are only dependent on the parameters of the structured illumination light field, which can be pre-calculated to save the processing time. Therefore, the image reconstruction speed of SDR is much faster than that of FDR. Because there is no operation in frequency domain, the inherent problem of image artifacts is fully eliminated. The SDR approach obtains the super-resolution image about 50-fold faster than that of the conventional frequency domain reconstruction method, boosting SIM as an ideal tool for instant super-resolution imaging with the feature of "What You See Is What You Get". The validity of SDR approach is verified by both numerical simulation and experiments of biological samples and dynamic fluorescence beads.