A NEW APPROACH TO SURPASS DIFFRACTION-LIMITED RESOLUTION BY LIMITING THE FIELD OF VIEW AND APPLYING IMAGE ANALYSIS

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We present a general approach to improve the spatial resolution of optical imaging systems beyond the diffraction limit. In our earlier work [1] (Fig. 1a), we demonstrate an imaging experiment that shows more than 3-fold resolution improvement in fluorescence microscopy by exciting the fluorescent sample with a scanning focal spot and numerically analyzing a sequence of sub-images. To our knowledge, this super-resolution phenomenon is not described or explained in any existing optical super-resolution imaging methods.

In this presentation, we discuss a probable mechanism for our newly discovered super-resolution phenomenon. This mechanism can rationalize the observed resolution improvement in both the spatial domain and frequency (Fourier) domain. Surprisingly, our proposed super-resolution mechanism also predicts resolution improvement in other imaging modes besides fluorescence. To examine this unexpected prediction, we performed a modified wide-field incoherent imaging experiment that does not require a focused illumination spot, and the results validate the prediction of super-resolution imaging (Fig. 1b).

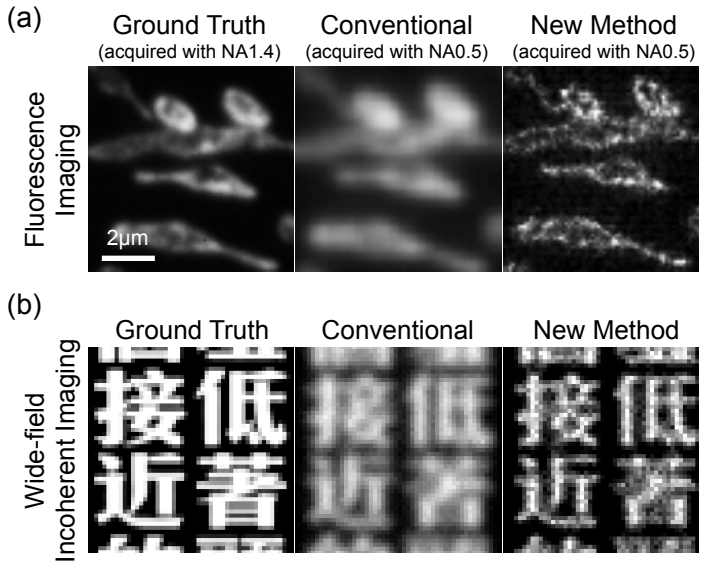

Fig. 1. Resolution improvement beyond the diffraction limit. (a) Fluorescence imaging: We use an NA1.4 lens to acquire an image of a fluorescent sample as the ground truth, and use an NA0.5 lens to verify the resolution improvement. (b) Wide-field incoherent imaging: We display the ground-truth object with a LCD display and acquire images using a 50mm camera lens ~2m away from the display, at a 1/11 f-number. In both cases our new method shows significant resolution improvement compared to conventional diffraction-limited imaging.

[1] J-Y. Yu et al., "A Simple Modification of Image Scanning Microscopy Enables Three-Dimensional Imaging at One Single Focus with Spatial Resolutions beyond the Diffraction Limit." Focus on Microscopy 2016, Taipei, Taiwan.