TUNABLE STRUCTURED ILLUMINATION MICROSCOPY FOR PARTIAL AND MULTIPLE SUPER-RESOLUTION REGIONS IN A SINGLE IMAGE

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1. INTRODUCTION

Structured illumination microscopy (SIM) holds unique advantages among the arsenal of super-resolution microscopy techniques, because of its short acquisition time and comparably low levels of phototoxicity. However, at least 7 raw images should be obtained to reconstruct one SIM image in conventional methods, which still limits the imaging speed [1]. Furthermore, all regions in a field of view (FOV) is typically super-resolved with low temporal resolution, even when some parts of the image does not require the enhancement in resolution. In this paper, we introduce a SIM method which enables to obtain partially super-resolved region in a single image. The number and the size of super-resolved regions are tunable. The regions that are not super-resolved enables measurement of dynamic processes that require high temporal resolution. This technique achieves simultaneous observation with different temporal resolution and spatial resolution in a single image.

2. METHODS

The illumination pattern is generated by a digital micro-mirror device (DMD, DLPLCR6500EVM, Texas Instruments). The DMD consists of 1920×1080 micro-mirrors, arranged with 7.56 um pitch. The period of a single fringe pattern is composed of 4 pixels of the DMD. By shifting the fringe by in counts of a single pixel, the phase of the fringe pattern is shifted by 0, 90, and 180 degree [2]. Using the conventional SIM scheme, three different orientations of the fringe patterned illumination enables isotropic resolution enhancement. This method was evaluated with numerical simulations and experiments.

3. RESULTS AND DISCUSSION

Numerical simulation was performed with the model containing moving targets with different speed. Partially sinusoidal patterns were applied to the regions including static and comparably slow targets. The other parts containing fast targets were imaged with wide-field view resolution. As a result, we could acquire the partial SIM images for the regions containing slow targets with super-resolution. The moving targets could be imaged by applying this method, with different temporal resolution and spatial resolution. Finally, we demonstrate dynamically tunable imaging with variable spatial and temporal resolution across the field of view for imaging dynamics of biological samples.

[1] Ströhl, Florian, and Clemens F. Kaminski, "Speed limits of structured illumination micros copy," *Optics Letters*, 42, 13, 2511-2514 (2017).
[2] Dan, Dan, et al. "DMD-based LED-illumination Super-resolution and optical sectioning microscopy." *Scientific reports*, 3 (2013).