2D AND 3D STRUCTURED ILLUMINATION MICROSCOPY WITH UNKNOWN PATTERNS AND A STATISTICAL PRIOR

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Structured illumination microscopy (SIM) is one of the most widely applied super-resolution microscopy techniques in bioimaging. It improves resolution by down-modulating a sample's high spatial frequency information to fit within the passband of the optical system. Normally, the reconstruction process requires prior knowledge of the illumination patterns. Aberrations from the optical system or from the sample itself will distort the patterns and degrade performance. Here, we propose a new algorithmic self-calibration strategy for both 2D and 3D SIM that does not need to know the exact patterns *a priori*, but only their covariance. The algorithm, termed PE-SIMS, includes a pattern-estimation (PE) step requiring the uniformity of the sum of the illumination patterns and a SIM reconstruction procedure using a statistical prior (SIMS). We achieve 2x better resolution than a conventional widefield microscope, without needing to know the illumination patterns and while remaining insensitive to aberration-induced pattern distortion.

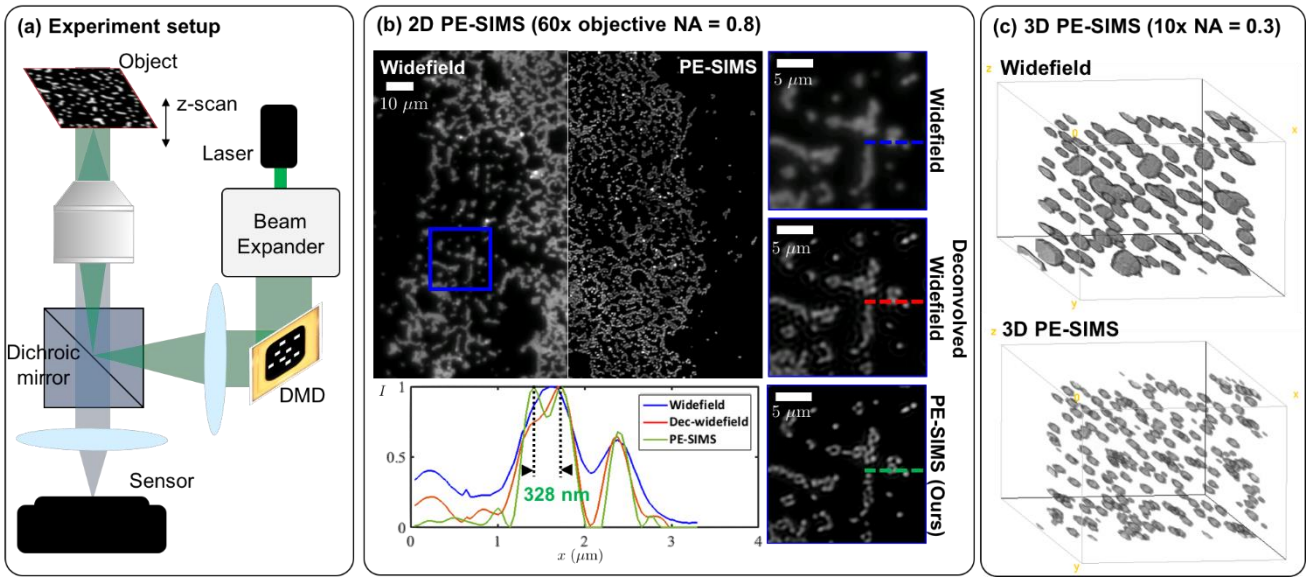

Figure 1 – (a) Experimental setup for Structured Illumination Microscopy (SIM), with random illumination patterns generated by a Deformable Mirror Device (DMD). (b) Our 2D self-calibrating PE-SIMS reconstruction result of 200 nm fluorescent beads imaged with a 60x objective (NA = 0.8). (c) Our 3D PE-SIMS reconstruction result of 1 um fluorescent beads imaged with a 10x objective (NA = 0.3).