

DeepSIM: Adaptive optics enhancing deep super-resolution imaging in difficult samples

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Super-resolution imaging has dramatically extending image detail in many areas. Structured Illumination Microscopy (SIM) is a particularly useful technique for biological questions which require high spatial-temporal resolution. However, as it has been noted previously, optical aberrations (particularly at depth in live samples) significantly reduce the achievable resolution.[1] Incorporating adaptive optics (AO) offers the opportunity to significantly reduce the aberrations present thereby improving both the image resolution and the achievable imaging depth of an imaging system.[2]

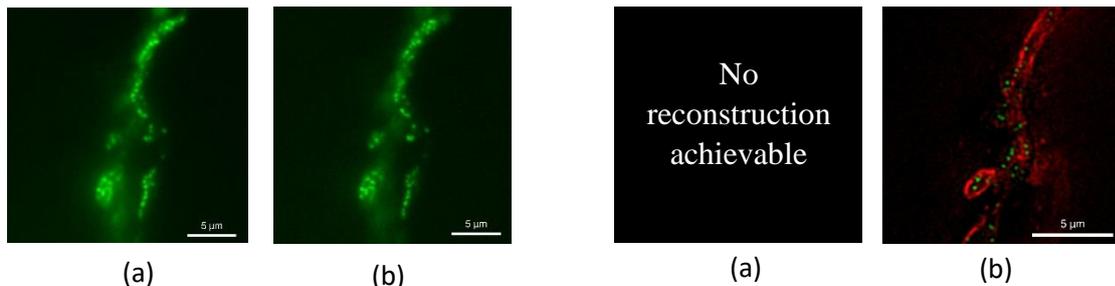


Figure 1: Neuro Muscular Junctions (NMJs) in drosophila. a) Pseudo-widefield without AO correction b) pseudo-widefield with AO correction

Figure 2: Neuro Muscular Junctions (NMJs) in drosophila. a) 2D SIM reconstructions without AO correction b) 2D SIM reconstructions with AO correction

Here we present data from DeepSIM, a microscope optimised for producing rapid 3D image stacks in large samples, as well as enabling super-resolution imaging in these samples via 3D-SIM. The system is an upright microscope, allowing sample access for solution exchange or neurophysiology and with AO to dramatically improve image quality at depth. The data shows the improvement in image quality obtained by utilising AO elements. The FWHM of the pseudo-widefield images without AO correction is approximately 400 nm and with correction is approximately 340 nm. Due to the aberrations present at this depth, SIM reconstruction is impossible. However, with AO correction reconstruction is possible (Figure 2b) and has a FWHM of approximately 250 nm.

References:

[1] Débarre, Delphine, et al. "Adaptive optics for structured illumination microscopy." *Optics express* 16.13 (2008): 9290-9305.

[2] Booth, Martin J. "Adaptive optical microscopy: the ongoing quest for a perfect image." *Light: Science & Applications* 3.4 (2014): e165.