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Spatially varying deconvolution for light-sheet microscopy

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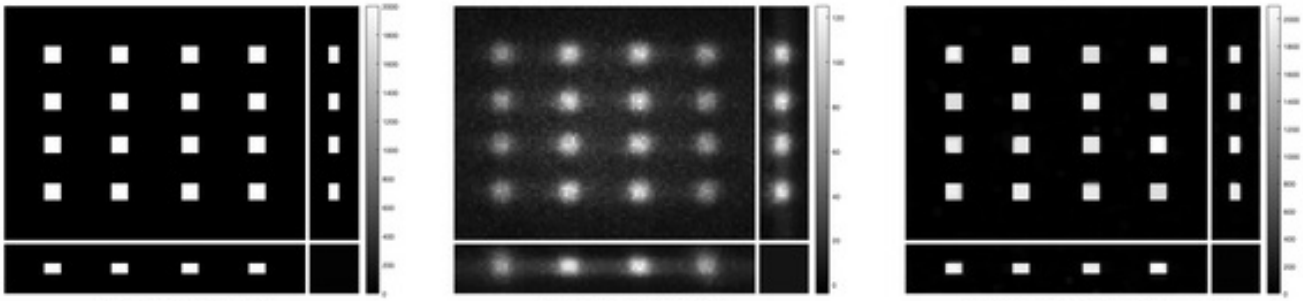
Abstract Text

Light-sheet microscopy is a type of fluorescence microscopy used in cell biology due to its fast acquisition times and low photo-damage to the sample. This is achieved by selectively illuminating a slice of the sample using a sheet of light and detecting the emitted fluorescence signal using a dedicated objective orthogonal to the plane of the sheet. Consequently, the effective point spread function (PSF) of the microscope is spatially varying, which adds an additional layer of complexity to the problem of deconvolution of such images.

In this work, we propose a model for image formation that describes the interaction between the illumination PSF and the detection PSF which replicates the physics of the microscope. This is based on independent models of the two PSFs that incorporate optical aberrations by means of Zernike polynomials fitted using bead data. We then formulate a variational image deconvolution model where the data fidelity term explicitly accounts for the mixed Gaussian and Poisson noise. By combining the image formation model with the variational model, we obtain a tractable inverse problem that can be solved with standard optimisation algorithms.

Specifically, we solve the inverse problem using a version of the

primal dual hybrid gradient algorithm and we show preliminary results for simulated data where this method outperforms deconvolution with spatially invariant PSF (one example is given in the attached figure). We conclude with two examples of how our method performs on real data.



(a) Ground truth (b) Measured data (c) Reconstructed image

Figure 1. Spatially varying deconvolution on simulated data. 3D images shown as maximum intensity projections.