Accelerated maximum likelihood based image restoration applied to three-dimensional fluorescence microscopy: a generalized approach

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For deconvolution applications in three-dimensional microscopy we derived and implemented a generic, accelerated maximum likelihood image restoration algorithm. A conjugate gradient iteration scheme was used considering either Gaussian or Poisson noise models. Poisson models are better suited for fluorescent image data. Typically, they show smaller restoration errors and smoother results. For the regularization, we modified the standard Tikhonov method. However, the generic design of the algorithm allows for more regularization approaches. The Hessian matrix of the restoration functional was used to approximate the step size. We compared restoration error and convergence behavior between the classical line search and the Hessian matrix method. Under typical working conditions, the restoration error did not increase over that of the line search and the speed of convergence did not significantly decrease allowing for a twofold increase in processing speed. To determine the regularization parameter, we modified the generalized cross validation method. Further, we introduced a stopping criteria by using a suitable threshold on the I-divergence of the estimate on successive iterations. Tests that were done on both simulated and experimental fluorescence wide-field data show reliable results. Another benefit, besides the acceleration aspect lies the simple implementation modularity owing to the generality of our approach [1].

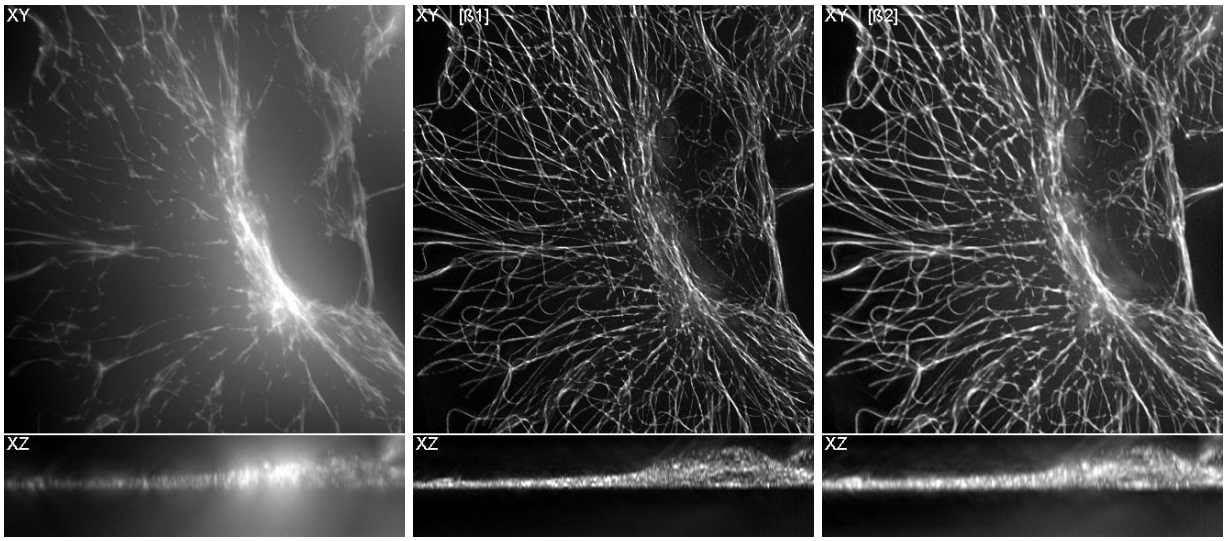

Figure 1: Maximum Projections through a Chinese hamster ovary cell before (left) and after restoration using the generalized cross validation (right) and an arbitrarily chosen, smaller regularization value (middle).

[1] L.H. Schaefer; D. Schuster and H. Herz, "Generalized approach for accelerated maximum likelihood based image restoration applied to three-dimensional fluorescence microscopy", *Journal of Microscopy*, (submitted).