An efficient gradient-based method for differential-interference-contrast microscopy

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Differential-interference-contrast (DIC) microscopy is an optical microscopy technique widely used in biology to observe unstained transparent specimens, in which a two-dimensional image is formed from the interference of two waves that have a lateral differential displacement (shear) and are phase shifted relative one to each other. Following the rotational-diversity model proposed in [1], one is interested in retrieving the specimen's phase function from a set of DIC intensity images acquired at different rotations of the specimen. This highly nonlinear, ill-posed problem is solved by adopting a least squares approach and thus looking for a regularized solution of a smooth nonconvex optimization problem.
As already done in [1], one can address the DIC problem by means of a nonlinear conjugate gradient method, which is particularly suited for least squares problems. However, the computation of the line search parameter at each iteration may require several evaluations of both the function and its gradient in order to ensure convergence [2], which significantly increases computational time when such evaluations are time-consuming, as is the case of the DIC problem.
In this light we propose an efficient gradient-descent method for the estimation of a specimen's phase function from polychromatic DIC images. The method minimizes the sum of a nonlinear least-squares discrepancy measure and a smooth approximation of the total variation and exploits a recent updating rule for the choice of the step size [3]. Numerical simulations on two computer-generated objects show significant improvements in terms of efficiency and stability with respect to widely used conjugate gradient methods.

References

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