An inner-outer iterative method for edge preservation in image restoration and reconstruction

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Abstract

We present a new inner-outer iterative algorithm for edge enhancement in imaging problems. At each outer iteration, we formulate a Tikhonov-regularized problem where the penalization is expressed in the 2-norm and involves a regularization operator designed to improve edge resolution as the outer iterations progress, through an adaptive process. An efficient hybrid regularization method is used to project the Tikhonov-regularized problem onto approximation subspaces of increasing dimensions (inner iterations), while conveniently choosing the regularization parameter (by applying well-known techniques, such as the discrepancy principle or the L-curve criterion, to the projected problem). This procedure results in an automated algorithm for edge recovery that does not involve regularization parameter tuning by the user, nor repeated calls to sophisticated optimization algorithms, and is therefore particularly attractive from a computational point of view. A key to the success of the new algorithm is the design of the regularization operator through the use of an adaptive diagonal weighting matrix that effectively enforces smoothness only where needed. We demonstrate the value of our approach on applications in X-ray CT image reconstruction and in image deblurring, and show that it can be computationally much more attractive than other well-known strategies for edge preservation, while providing solutions of greater or equal quality.

Keywords: edge enhancement, hybrid regularization methods, Krylov subspace methods, parameter choice strategies, iterative reweighting, tomography, image deblurring

References

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