TECHNISCHE UNIVERSITÄT CHEMNITZ

Fakultät für Mathematik

Chemnitzer Mathematisches Colloquium

In der Reihe „Chemnitzer Mathematisches Colloquium“ der Fakultät für Mathematik der TU Chemnitz spricht

Herr Prof. Dr. Michael Hintermüller (Humboldt Universität Berlin)

über das Thema

TV^q-models in Image Processing:
Multiscale Regularization, Possible Pitfalls in Variable Splitting Approaches, and Sparsity Enhancing Quasi-Norm Regularization.

Der Vortrag findet am

Donnerstag, dem 16. Juli 2015, um 16.00 Uhr im Raum B202, Reichenhainer Straße 70

statt.

Ich möchte Sie hiermit recht herzlich zu dieser Veranstaltung einladen. Das Kolloquium wird von Herrn Prof. Dr. Roland Herzog geleitet.

Abstract: Total variation (TV) regularization has been used very successfully as an edge preserving filtering technique over the past years. The corresponding regularization term is non-smooth and challenges both, theory as well as numerical realization. While analytical results such as existence and uniqueness of a solution, as well as lagged diffusivity solvers or solvers based on smoothing have been available for quite some time now, duality-based algorithms are rather recent. Further, with the aim of simplifying subproblem solves, various variable splitting schemes (Douglas-Rachford, split Bregman,...) have been (re)discovered and applied successfully very recently. Some of the remaining challenges in this field are related to (i) appropriated automatized and possibly localized regularization parameter choice rules, (ii) an understanding of primal/dual variable splitting in infinite dimensions, and (iii) aspects of yet even further sparsifying total-variation-type regularization techniques. In this colloquium talk, the following three aspects will be addressed: (i) The talk will start be highlighting multi-scale total variation models for image restoration. The models utilize a spatially dependent regularization parameter in order to enhance image regions containing details while still sufficiently smoothing homogeneous features. The fully automated adjustment strategy of the regularization parameter is based on local variance estimators. For robustness reasons, the decision on the acceptance or rejection of a local parameter value relies on a confidence interval technique based on the expected maximal local variance estimate. In order to improve the performance of the initial algorithm a generalized hierarchical decomposition of the restored image is used. The corresponding subproblems are solved by a superlinearly convergent algorithm based on Fenchel-duality and inexact semismooth Newton techniques. This part of the talk ends by a report on numerical tests, a qualitative study of the proposed adjustment scheme and a comparison with popular total variation based restoration methods. (ii) Then, in a second part of the talk, variable splitting schemes for the function space TV-model

in its primal and pre-dual formulations are considered. In the primal splitting formulation, while existence of a solution cannot be guaranteed, it is shown that quasi-minimizers of the penalized problem are asymptotically related to the solution of the original TV-model. On the other hand, for the pre-dual formulation a family of parameterized problems is introduced and a parameter dependent contraction of an associated fixed point iteration is established. Moreover, the theory is validated by numerical tests. Additionally, the augmented Lagrangian approach is studied, details on an implementation on a staggered grid are provided and numerical tests are shown. (iii) The talk finishes off with a brief outlook on (finite dimensional) non-convex regularization techniques which, depending on the context, may be used, e.g., for sparse gradient or sparse signal recovery. The associated regularization term contains an lq, 0 < q < 1, quasi-norm. For the efficient numerical treatment a Newton-type solution algorithm is introduced and its global as well as local superlinear convergence towards a stationary point of a locally regularized version of the problem is established. The potential non-positive definiteness of the Hessian of the objective during the iteration is handled by a trust-region based regularization scheme. The performance of the new algorithm is studied by means of a series of numerical tests. For the associated infinite dimensional model an existence result based on the weakly lower semicontinuous envelope is established and its relation to the original problem is discussed.

Prof. Dr. Peter Stollmann
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