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Guest Editorial: Scale-Space and Variational Methods

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This special issue highlights some recent developments in the field of mathematical image processing. The emphasis of the issue is on the interplay between advanced mathematical methods (such as non-smooth convex optimization, variational methods, partial differential equations, scale-space approaches) and their application in image processing or computer vision. The special issue comprises nine papers representing state-of-the-art research on these topics as outlined below.

Non-smooth and possibly non-convex optimization as well as automatic parameter estimation have become major trends of research in the community. In this context, P. Ochs, R. Ranftl, T. Brox and T. Pock propose a new approach for bilevel optimization. In "Techniques for Gradient-Based Bilevel Optimization with Non-smooth Lower Level Problems" (doi:10.1007/s10851-016-0663-7), they show how solving non-smooth optimization problems while computing optimal regularization parameters by considering suitable nonlinear proximal distance functions.

In "Convex Image Denoising via Non-convex Regularization with Parameter Selection" (doi:10.1007/s10851-016-0655-7), A. Lanza, S. Morigi, and F. Sgallari introduce a novel algorithm to solve regularization problems involving parameterized non-convex regularizers by turning them into convex one.

Looking at continuous optimization problems from a discrete point of view is a natural consideration when dealing with images that are essentially discrete data. This makes possible the use of tools devoted to discrete objects, as proposed in "Multicuts and Perturb & MAP for Probabilistic Graph Clustering" (doi:10.1007/s10851-016-0659-3) by J. H. Kappes, P. Swoboda, B. Savchynskyy, T. Hazan and C. Schnörr, where a graph clustering algorithm is proposed using globally optimal MAP inference by integer programming and perturbation-based approximations of the log-partition function.

A famous hot topic in image processing these last years is the use of optimal transport to deal with images (in particular with image histograms). In "A Sparse Multiscale Algorithm for Dense Optimal Transport" (doi:10.1007/s10851-016-0653-9), B. Schmitzer proposes a novel method to deal with large-scale dense optimal transport with a sparse and fast multiscale strategy that exploits the geometric structure of the cost function.

Image processing research also shares strong links with movie industries that keep calling for new methods to analyze and or synthesize images and videos with fast and efficient approaches. In this context, L. Raad, A. Desolneux, and J.-M. Morel propose in "A Conditional Multiscale Locally Gaussian Texture Synthesis Algorithm" (doi:10.1007/s10851-016-0656-6) a method for the synthesis of locally Gaussian textures using a multiscale approach. Relying on the modeling of texture self-similarity with conditional Gaussian distributions in the patch space, this new approach is able to extend the use of stitching techniques.

In the work "A Variational Aggregation Framework for Patch-Based Optical Flow Estimation" (doi:10.1007/

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s10851-016-0664-6) by D. Fortun, P. Bouthemy, and C. Kervrann, an original variational approach merging parametric motion models and patch-based motion candidates is designed to capture large displacements without requiring any coarse-to-fine strategy.

A natural counter-part to variational approaches is PDEs ones. In "Nonlinear Spectral Analysis via One-Homogeneous Functionals—Overview and Future Prospects" (doi:10.1007/s10851-016-0665-5), G. Gilboa, M. Moeller, and M. Burger introduce new ideas as well as new scale-space concepts to realize nonlinear spectral analysis of images, via PDEs derived from one-homogeneous functionals.

The focus in "Multivariate Median Filters and Partial Differential Equations" (doi:10.1007/s10851-016-0645-9) by M. Welk is to approximate the mean curvature motion PDE for multichannel images using filtering. The author explores the affine equivariants Oja and transformation–retransformation L1 medians. He derives the corresponding PDEs and gives their geometric interpretation.

In "Morphological Counterparts of Linear Shift-Invariant Scale-Spaces" (doi:10.1007/s10851-016-0646-8), M. Schmidt and J. Weickert establish a formal connection between linear shift-invariant and morphological systems, which finally closes the gap between them. Thus, any evolution equation from the first system can be translated to its counterpart in the second system, and vice versa. Their approach is based on the symbols of the (pseudo)differential operators corresponding to scale-space representations.

This special issue of JMIV thus gathers innovative papers on a large range of active topics in the field of scale-space and variational methods for image processing applications. We thank the authors for submitting their high-quality papers and the relevant reviewers for carefully evaluating and commenting them.