Guest Editorial: Scale Space and Variational Methods

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Published online: 11 April 2015
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Linking the concept of “scale” in filtering images with a Gaussian kernel to “time” in diffusing (later: evolving) an image driven by the so-called heat equation, a Partial Differential Equation (PDE), has started a fruitful pollination of these two areas. In filtering, it was realized that not just a single scale is relevant, but a whole range of scales needs to be considered: the scale space. On the other side, low-level image features like edges and corners started to find their way into PDE-driven image enhancement. A dominant part is covered by variational methods, in which image-based features define an energy of which a minimum is sought.

Nowadays, more than 55 years after Iijima’s groundbreaking concept, researchers for both communities still benefit from each other. In this special issue we collected 8 papers representing state-of-the-art research covering both areas.

In “Image matching using generalized scale-space interest points,” Tony Lindeberg investigates the performance of

interest points used for image-based matching and object recognition methods. It depends on both the properties of the underlying interest points and the choice of associated image descriptors. When accompanied by associated local scale-invariant image descriptors, generalized scale-space interest points should allow for better performance of interest point-based methods.

The theoretical analysis of structure-adaptive median filter algorithms that approximate curvature-based PDEs for image filtering and segmentation is the focus of “Analysis of Amoeba Active Contours” by Martin Welk. These so-called morphological amoeba filters achieve similar results as the well-known geodesic active contour and self-snakes PDEs. Welk derives the PDE approximated by amoeba active contours for a general geometric situation and general amoeba metric. It is structurally similar but not identical to the geodesic active contour equation.

Clemens Kirisits, Lukas Lang, and Otmar Scherzer extend the concept of optical flow with spatiotemporal regularization to a dynamic non-Euclidean setting in “Optical Flow on Evolving Surfaces with Space and Time Regularisation.” They introduce variational motion estimation for images that are defined on an evolving surface with volumetric microscopy images depicting a live zebrafish embryo as both biological motivation and test data.

In “Mathematical Foundations and Generalisations of the Census Transform for Robust Optic Flow Computation,” David Hafner, Oliver Demetz, Joachim Weickert, and Martin Reifel discuss two important properties of the census transform, a key ingredient of various methods for computer vision problems: the strong reliance on local extrema and the induced anisotropy of the data term by acting along isolines. By transferring the inherently discrete transform to the continuous setting and embedding it into a variational framework for optic flow estimation, their findings open the door to

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generalizations of the census transform that are not obvious in the discrete formulation.

Yvain Queau, Francois Lauze, and Jean-Denis Durou show how total variation can be used to reduce the ambiguities of uncalibrated photometric stereo in “Solving Uncalibrated Photometric Stereo using Total Variation.” Estimating the parameters of the generalized bas-relief (GBR) transformation as the minimizers of the total variation of either the M field (which encodes the albedo and the normals) or the depth function reduces the GBR ambiguity to the classical bas-relief ambiguity, which is considerably easier to solve.

Tracing out target figures hidden in teeming figure pictures is known as figure hunt games, a popular genre of visual puzzles. Julia Diebold, Sibel Tari, and Daniel Cremers argue and experimentally demonstrate that diffusion is a key to algorithmically search for a target figure in a binary line drawing. In “The Role of Diffusion in Figure Hunt Games” they propose a diffuse representation which diffuses the image while retaining the contour information

Guillaume Tartavel, Yann Gousseau, and Gabriel Peyré propose in “Variational Texture Synthesis with Sparsity and Spectrum Constraints” a unified framework that both imposes first-order statistical constraints on the use of atoms

from an adaptive dictionary, as well as second-order constraints on pixel values. An advantage of the proposed method is its ability to truly synthesize textures, without verbatim copy of small pieces from the exemplar.

Finally, in “No-reference image quality assessment and blind deblurring with sharpness metrics exploiting Fourier phase information” Arthur Leclaire and Lionel Moisan propose a deeper insight into three recent sharpness metrics (Global Phase Coherence, Sharpness Index, and a simplified version of it), that all measure in a probabilistic sense the surprisingly small total variation of an image compared to that of certain associated random-phase fields. Exhibiting several theoretical connections between these indices, they study their behavior on a general class of stationary random fields and highlight the behavior of these metrics with respect to blur, noise, and deconvolution artifacts.

These papers cover a wide range of current research in scale space and variational methods, thereby appealing to both the experts in the field as well as to those who wish a snapshot of the current breadth of scale space and variational methods research. We thank the authors for submitting their high-quality papers and the reviewers for carefully evaluating and commenting them.