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Guest Editorial JMIV Special Issue SSVM'21

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This special issue highlights some recent developments in the field of computer vision and image analysis. The emphasis of the issue is on the interplay between advanced mathematical methods (such as optimization, variational methods, statistics, inverse problems, multiscale analysis, partial differential equations), machine learning, and their application to a variety of problems in image processing and computer vision. The special issue comprises eleven papers which cover a wide range of topics as outlined below.

- Image generation and metamorphosis:
  The paper *"A Generative Model for Texture Synthesis based on Optimal Transport between Feature Distributions"* (DOI JMIV-D-22-xxxx), by Houdard et al., proposes GOTEX, a general framework for texture synthesis by optimization that constrains the statistical distribution of local features relying on optimal transport distances. The authors study the resulting Wasserstein generative model and its implications for texture synthesis, inpainting and interpolation. They also use their framework to learn a feed-forward neural network that can synthesize on-the-fly new textures of arbitrary size in a very fast manner.
  In *"Consistent Approximation of Interpolating Splines in Image Metamorphosis"* (DOI JMIV-D-22-xxxx), Rajković et al. propose and investigate a generalization of the image metamorphosis approach that involves splines. It is studied in a continuous and discrete setting. Mosco-convergence results are presented, and in the fully discrete case a variant of the iPALM algorithm is used. Various experiments show the quality of this metamorphosis approach, also in comparison to a piecewise geodesic method.
- Variational models for inverse problems:
  The paper *"Towards off-the-grid algorithms for total variation regularized inverse problems"* (DOI JMIV-D-22-xxxx) by De Castro et al. introduces an algorithm to solve linear inverse problems regularized with the gridless total (gradient) variation. Contrary to most existing methods, that produce an approximate solution which is piecewise constant on a fixed mesh, their approach exploits the structure of the solutions and consists in iteratively constructing a linear combination of indicator functions of simple polygons.
  In *"A unified surface geometric framework for feature-aware denoising hole filling and context-aware completion"* (DOI JMIV-D-22-xxxx), Calatroni et al. integrate denoising, hole filling and completion of 3D triangulated surfaces within a unified geometric framework and variational model. The underlying non-convex optimization problem incorporates two regularisation terms: a discrete approximation of the Willmore energy and a (approximate) sparsity-promoting regularization. The proposed numerical method solving the model is parameterization-free and based on the ADMM algorithm. Numerically, the proposed framework provides accurate restorations even in the presence of severe random noise and large damaged areas.
  The goal of the paper *"ADMM-based residual whiteness principle for automatic parameter selection in single image super-resolution problems"* (DOI JMIV-D-22-xxxx), by Pragliola et al., is to propose an automatic parameter selection strategy for single image super-resolution problem for images corrupted by blur and

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additive white Gaussian noise with unknown standard deviation. The proposed approach is based on a suitably defined residual whiteness measure. The paper provides both the theoretical properties of the proposed model and a comprehensive numerical study.

Bednarski and Lellmann propose in *"Inverse Scale Space Iterations for Non-Convex Variational Problems: The Continuous and Discrete Case"* (DOI JMIV-D-22-xxxx) an extension of the Bregman iteration to the non-convex setting. In order to deal with the non-convexity, lifting and convex relaxation techniques are used. The focus of the paper is the theoretical connection between the Bregman iterations on the lifted functional and the original iteration in discrete and continuous setting, and the main contribution is the generalization of known results for positively homogenous convex regularizers such as total variation to more general ones. An illustration to the problem of stereo matching is reported.

- Machine learning in imaging:

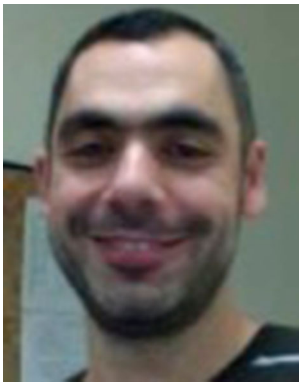
  In *"On Maximum-a-Posteriori estimation with Plug & Play priors and stochastic gradient descent"* (DOI JMIV-D-22-xxxx), De Bortoli et al. investigate the plug-and-play (PnP) framework for image reconstruction in the Bayesian setting. In particular, the paper proposes a stochastic gradient descent (SGD)-based PnP approach to advances the understanding of PnP-based modeling of the image prior in terms of stability of the resulting posterior, and shows convergence of PnP-SGD to its stationary points under more realistic conditions than in the literature. Case studies reported are image denoising, deblurring and inpainting.

  The paper *"Learning Linearized Assignment Flows for Image Labeling"* (DOI JMIV-D-22-xxxx), by Zeilmann et al., proposes Riemannian gradient descent algorithm method for learning linearized assignment flows for image labeling. This relies on an exact formula derived for the parameter gradient of any loss function that is constrained by the linear system of ODEs determining the linearized assignment flow. Experiments show that unlike methods employing automatic differentiation, the approach developed by the authors yields a low-dimensional representation of internal parameters and their dynamics which helps to understand how assignment flows and more generally neural networks work and perform.

  Alt and his co-authors examine in *"Connections between Numerical Algorithms for PDEs and Neural Networks "* (DOI JMIV-D-22-xxxx) the connections between numerical diffusion solvers and some standard neural network (NN) architectures. It shows how ideas of successful numerical solvers may guide architecture choices for NNs, and when a stability result is available, it is reinterpreted in term of stability of the NN. Numerical evaluation of the results is also discussed.

  In the work *"PDE-based Group Equivariant Convolutional Neural Network"* (DOI JMIV-D-22-xxxx), by Smets et al., the authors describe an approach to construct CNNs that are equivariant under translations and rotations by using a set of PDE layers coupled in cascade as opposed to the more traditional approach of using convolutional layers with non-linearities in between. The main advantage of the approach is a reduction of the number of parameters of the CNN model for a similar expressive power. Additional interesting features include (i) automatic roto-translation equivariance properties, without the need for data augmentation strategies, (ii) a better interpretability of the network parameters, due to their reduced number and their geometric significance. The authors also describe experimental results of applying their approach to retinal vessel segmentation and the Rot-NIST dataset.

  Ramzi et al. deal in *"Wavelets in the Deep Learning Era"* (DOI JMIV-D-22-xxxx) with the design of a network architecture mimicking the behavior of wavelet denoising, called Learnlets, whose parameters can be trained from a database of images, while possibly maintaining some particularities of wavelets such as exact reconstruction. This network is compared with U-nets on image denoising problems. The authors conclude from their study that Learnlets achieve a trade-off between performance (achieved by U-nets) and the generalization capacity (well embodied by wavelets).



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Julien Rabin is an Associate Professor at GREYC, a computer science laboratory at ENSICAEN and University de Caen Normandy, France, since 2011. He graduated from ENS Cachan, France, in 2006. He received his Ph.D. in image processing and computer vision from Télécom ParisTech in 2009. His research mainly focuses on two themes: robust statistical methods in computer vision and optimal transport for imaging problems. His current projects are about generative image models.

Yvain Quéau obtained his PhD in computer science from the University of Toulouse (France) in 2015. Since 2018 he holds a CNRS researcher position ("chargé de recherche") at the GREYC laboratory (University of Caen Normandy and ENSICAEN, France). His research focuses on inverse problems arising in imaging and computer vision, and their numerical solving using variational methods. He is particularly interested in inverse problems involving light-matter interactions, e.g. 3D-reconstruction by shape-from shading and photometric stereo.