Reconciling Model-Based and Learning-Based Computational Imaging

There is a growing need in biological, medical, and materials imaging research to recover information lost during data acquisition. There are currently two distinct viewpoints on addressing such information loss: model-based and data-adaptive. Model-based methods leverage analytical signal properties (such as wavelet sparsity) and often come with theoretical guarantees and insights. Learning-based methods leverage flexible representations (such as convolutional neural nets) for best empirical performance through training on big datasets. The goal of this talk is to introduce a framework that reconciles both viewpoints by providing the "deep learning" counterpart of the classical image recovery theory. This is achieved by specifying "denoising" as a mechanism to infuse learned priors into recovery problems, while maintaining a clear separation between the prior and physics-based acquisition models. Our methodology can fully leverage the flexibility offered by deep learning by designing learned denoisers to be used within our new family of fast iterative algorithms. Yet, our results indicate that the such algorithms can achieve state-of-the-art performance in different computational imaging tasks, while also being amenable to rigorous theoretical analysis. We will focus on the application of the methodology to the problem of optical diffraction tomography.

This talk will be based on the following references:

U. S. Kamilov and H. Mansour, "Learning optimal nonlinearities for iterative thresholding algorithms," IEEE Signal Process. Lett., vol. 23, no. 5, pp. 747–751, May 2016.

Y. Sun, B. Wohlberg, and U. S. Kamilov, "An Online Plug-and-Play Algorithm for Regularized Image Reconstruction," *IEEE Trans. Comput. Imag.*, 2019.
https://ieeexplore.ieee.org/document/8616843

Y. Sun, S. Xu, Y. Li, L. Tian, B. Wohlberg, and U. S. Kamilov, "Regularized Fourier Ptychography using an Online Plug-and-Play Algorithm," Proc. IEEE Int. Conf. Acoustics, Speech and Signal Process. (ICASSP 2019) (Brighton, UK, May 12-17), pp. 7665–7669.
https://ieeexplore.ieee.org/document/8683057

Y. Sun, J. Liu, and U. S. Kamilov, "Block Coordinate Regularization by Denoising," Proc. Ann. Conf. Neural Information Processing Systems (NeurIPS 2019) (Vancouver, Canada, December 8-14).
https://arxiv.org/abs/1905.05113

Biography

Ulugbek S. Kamilov is an Assistant Professor and Director of Computational Imaging Group (CIG) at Washington University in St. Louis. His research area is computational imaging with an emphasis on large-scale image recovery and automated image analysis for applications such as optical microscopy, MRI, and tomographic imaging. His research interests include signal and image processing, large-scale optimization, machine learning, and statistical inference. He obtained the BSc and MSc degrees in Communication Systems, and the PhD degree in Electrical Engineering from EPFL, Switzerland, in 2008, 2011, and 2015, respectively. From 2015 to 2017, he was a Research Scientist at Mitsubishi Electric Research Laboratories (MERL), Cambridge, MA, USA. He is a recipient of the IEEE Signal Processing Society's 2017 Best Paper Award (with V. K. Goyal and S. Rangan). His Ph.D. thesis was selected as a finalist for the EPFL Doctorate Awardin 2016. His work on Learning Tomography (LT) was featured in Nature "News and Views" in 2015. He is a member of IEEE Technical Committee on Computational Imaging since 2016.