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Inverse Problems in Image Processing

Filip Sroubek
Institute of Information Theory and Automation, Czech Academy of Sciences
sroubekf@utia.cas.cz

Inverse problems in image processing comprise a spectrum of tasks, ranging from traditional denoising to more intricate challenges like (non-)blind deconvolution and superresolution, culminating in comprehensive scene understanding through tasks like motion estimation and 3D object reconstruction. This talk aims to provide a comprehensive overview of the mathematical methodologies employed to tackle these strongly ill-posed inverse problems.

Through the lens of image processing tasks, we explore various forms of loss functions and regularization techniques. Proximal methods, notably the alternating direction method of multipliers and primal-dual method [1], stand out as popular choices for efficiently solving convex problems. However, the limitation posed by convexity has been surmounted by stochastic gradient methods derived from deep learning, which exhibit remarkable performance on numerous non-convex problems encountered in image processing.

The conventional approach of representing discrete unknown images by pixels, commonly employed in optimization, is currently being challenged by neural representations like deep image priors [2] and neural fields [3]. Rather than optimizing in the space of pixels, contemporary methodologies optimize in the higher dimensional space of network parameters. Here, the network architecture not only provides the necessary regularization but also introduces novel ways to navigate the solution space effectively.

This presentation illustrates the evolution of mathematical approaches in addressing inverse problems within image processing, emphasizing the transition from traditional optimization methods to the integration of deep learning frameworks. By exploring examples across various image processing tasks, attendees will gain insights into the efficacy of different methodologies and the transformative impact of neural representations on modern image processing techniques.

References

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[3] V. Sitzmann, J. Martel, A. Bergman, D. Lindell and G. Wetzstein, Implicit Neural Representations with Periodic Activation Functions, Advances in Neural Information Processing Systems, 33 (2020), 7462–7473