Computational Challenges and Advancements in Edge-Preserving Methods for Dynamic and Large-Scale Data

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Fast-developing fields such as data science, uncertainty quantification, and machine learning rely on fast and accurate methods for inverse problems. Three emerging challenges on obtaining meaningful solutions to large-scale and data-intensive inverse problems are ill-posedness of the problem, large dimensionality of the parameters, and the complexity of the model constraints. Tackling the immediate challenges that arise from growing model complexities (spatiotemporal measurements) and data-intensive studies (large-scale and high-dimensional measurements), state-of-the-art methods can easily exceed their limits of applicability. In this talk we discuss recent advancements on edge-preserving and computationally efficient methods for computing solutions to dynamic inverse problems, where both the quantities of interest and the forward operator change at different time instances. In the first part of the talk, to remedy these difficulties, we apply efficient regularization methods that enforce simultaneous regularization in space and time (such as edge enhancement at each time instant and proximity at consecutive time instants) and achieve this with low computational cost and enhanced accuracy. In the remainder of the talk, we focus on designing spatio-temporal Bayesian Besov priors for computing the MAP and UQ estimate in large-scale and dynamic inverse problems. Numerical examples from a wide range of applications, such as tomographic reconstruction, image deblurring, and multichannel dynamic tomography are used to illustrate the effectiveness of the described methods.