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Towards a mathematical understanding of modern optimization methods for inverse problems

Motivated by an application to quantitative magnetic resonance imaging, we will analyze modern optimization-based methodology for inverse problems from a mathematical perspective. Sparsity-based methods gained widespread popularity in the 2000s when compressed-sensing theory provided groundbreaking insights on sparse recovery from randomized measurements. However, this theory does not explain the empirical success of these techniques when the measurements are deterministic and structured. In the first half of the talk we will present a theory of sparse recovery for deterministic measurement operators relevant to optics, electroencephalography, and signal processing. The second half of the talk will focus on learning-based methodology. Deep-learning techniques achieve remarkable empirical performance for a variety of inverse problems, but the mechanisms they implement are shrouded in mystery. We will present a local linear-algebraic analysis that uncovers the strategies implemented by networks trained for image denoising. This analysis reveals intriguing connections to traditional methodology such as nonlinear filtering and sparsity-based approaches.