Robust Reconstruction Algorithms for Compressive Imaging

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Compressed sensing (CS) is a recently introduced signal acquisition framework that goes against the traditional Nyquist sampling paradigm. CS demonstrates that a sparse or compressible signal, such as images, can be acquired using a low rate acquisition process. Since noise is always present in imaging acquisition systems, sensing and reconstruction methods are developed assuming a Gaussian (light-tailed) model for the corrupting noise. However, when the underlying signal and/or the measurements are corrupted by impulsive noise, commonly employed linear sampling operators, coupled with Gaussian-derived reconstruction algorithms, fail to recover a close approximation of the signal. There exists a broad spectrum of applications where practice has shown non-Gaussian, heavy-tailed processes emerge. Examples of such applications are: image and video processing, atmospheric and underwater communications, synthetic aperture radar and sonar and seismic imaging. In this talk I will present robust reconstruction methods for compressed imaging systems in the presence of impulsive noise. To achieve this objective, I make use of robust statistics theory to develop appropriate methods addressing the problem of impulsive noise in CS systems.

To recover sparse signals from impulsive noise introduced in the measurement process, a geometric optimization problem based on L1 minimization employing a Lorentzian norm constraint on the residual error is introduced. Additionally, robust reconstruction strategies that incorporate prior signal information into the recovery process are developed. First, we formulate the sparse recovery problem in a Bayesian framework using probabilistic priors from the generalized Cauchy distribution family to model the image coefficients and measurement noise. An iterative reconstruction algorithm is developed from this Bayesian framework. Second, we develop a Lorentzian norm based iterative hard thresholding algorithm capable of incorporating prior support knowledge into the recovery process. The derived algorithm is a fast method capable of handling large-scale problems whilst having robustness against impulsive noise. Experimental results demonstrate that the proposed methods significantly outperform commonly employed compressed sensing reconstruction techniques in impulsive environments, while providing comparable performance in less demanding, light-tailed environments. Simulation results also show that the proposed algorithms with prior image information require fewer samples than most existing CS reconstruction methods.