

Abstract

This thesis aims to develop and assess the performance of sparsity-driven signal recovery methods. The proposed recovery methods are classified into two subclasses based on the type of measurements. The first type of recovery approaches deal with uncompressed measurements, and the second type of approaches employ measurements obtained by a linear projection (compression) of the source signal. The main contributions are as follows: i) a Huberized filtering approach is proposed by employing the robust estimators, such as Huber, reversed-Huber (Berhu) and the total variation (TV) function to recover piecewise signals, ii) a new nonlinear filtering approach is introduced by incorporating a class of non-smooth/non-convex functions via majorization-minimization (MM) technique, iii) a subspace projection-based joint sparse recovery algorithm is proposed to exploit the hidden sparsity and correlation structure of signals, iv) an anti-noise-folding (ANF) method is proposed to recover signals from measurements, corrupted by pre-measurement noise, i.e., the noise associated with the unprocessed source signal. The Huberized filtering approach addresses small residual values quadratically and large ones by their absolute errors to enhance the effectiveness of the proposed methods. The hidden sparsity-structures of various piecewise signals are exploited via finite-order difference matrices. The proposed majorized Moreau envelope-based methods relax the strict sparsifying penalties to preserve the smoothness of source signals. The optimality criteria for the proposed methods are derived. The subspace projection method starts with the sparse Bayesian learning-based support estimation, followed by a support-filtering step and a maximum projection-based support-estimation step. The proposed ANF method solves an MM-based constrained optimization problem followed by a denoising operation via the data-adaptive Stein's unbiased risk estimate (SURE). The sparse recovery analysis is established. The numerical test results obtained by employing various synthetic and noisy real-world biomedical measurements demonstrate the superior performance of the proposed methods as compared to the state-of-the-art techniques.

Keywords: Compressed Sensing, Majorization-minimization, Moreau Envelope, Noise Folding, Sparsity, Total Variation Denoising.