SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

COMPUTABLE PERFORMANCE ANALYSIS OF RECOVERING SIGNALS WITH LOW-DIMENSIONAL STRUCTURES

DISSERTATION DEFENSE
by

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Abstract: The last decade has witnessed burgeoning development in the reconstruction of signals by exploiting their low-dimensional structures. Particular strides have been made in sparsity, block-sparsity, low-rankness, and low-dimensional manifold structures of general nonlinear data sets. The reconstruction performance of these signals is heavily dependent on the structure of the operating matrix used in sensing. In many applications, the operating matrix can be selected from a class of potential matrices. In order to select the optimal matrix, therefore, a method for computing the performance under different recovery algorithms is required.

We present a computational framework for analyzing the recovery performance of signals with low-dimensional structures. We define a family of measures of quality for arbitrary sensing matrices as the optimal values of a set of optimization problems. Our primary contribution is to associate the measures with fixed points of functions, defined by series of programs. Linear programs, second-order cone programs, or semi-definite programs can be used, depending on the specific problem. We then use fixed-point theory and bisection search to generate an efficient algorithm to compute the measure of quality with assured global convergence. As a by-product, we implement efficient algorithms to verify sufficient conditions for exact signal recovery in the noise-free case. These implementations perform orders-of-magnitude faster than state-of-the-art techniques.

The utility of these measures lies in their relation to the performance of reconstruction methods. We derive bounds on the recovery errors of convex relaxation algorithms in terms of these measures. Using tools from empirical processes and generic chaining, we analytically demonstrate that, given a sufficiently large number of measurements, our measures of quality are bounded away from zero for a large class of random sensing matrices. This result is parallel to results from probabilistic analysis using the restricted isometry property. Numerical experiments show that our error bounds are tighter and have wider applications than restricted isometry based performance bounds when the sparsity levels of the signals are relatively low. These computable performance bounds have wide applications in sensor arrays, radar, DNA micro-arrays, and many other areas where block-sparsity arises naturally.

DATE:	Thursday, July 28, 2011
TIME:	2:00 p.m.
PLACE:	Bryan Hall, Room 305

Dissertation advisor:
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SCHOOL OF ENGINEERING & APPLIED SCIENCE