Learning Optimal Compressed Sensing

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Abstract

Compressed sensing is a term recently introduced by D. Donoho. It is based on the fact that sparse signals can be exactly reconstructed from a remarkably small amount of linear measurements. Roughly speaking, if a signal has K nonzero coefficients in some basis, cK generic linear measurements are sufficient to reconstruct it exactly (with $c \approx 3 - 5$). Furthermore, despite the fact that the manifold of sparse signals is highly nonlinear, the reconstruction can be done using convex optimization. Since many signals of interest (e.g. natural images, medical images) tend to have sparse representations , this theory has the potential to enable high resolution imaging with much smaller number of sensors than was previously thought possible.

The current theory of compressed sensing says little about what linear measurements should be used, and typical applications of the theory use random linear measurements. In this work we ask: given a training set of signals we wish to measure, what are the optimal set of linear projections for compressed sensing ? We show that this question can be addressed with well-understood tools from machine learning and derive learning algorithms for various cases. In particular, we show that the optimal projections are in general not the principal components nor the independent components of the training set, but rather a seemingly novel set of projections that we term *uncertain components*. We also present preliminary results indicating that the projections obtained by learning may far outperform random projections.

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