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Sobolev Duals of Random Frames and Sigma-Delta Quantization for Compressed Sensing

Compressed sensing, as a signal acquisition technique, has been shown to be highly effective for dimensionality reduction. On the other hand, quantization of compressed sensing measurements has been a relatively under-addressed topic. In particular, the results of Candes, Romberg and Tao, and of Donoho guarantee that if a uniform quantizer of step size δ is used to quantize m measurements $y = \Phi x$ of a k-sparse signal $x \in \mathbb{R}^N$, where Φ satisfies the restricted isometry property, then the reconstruction error via ℓ_1-minimization is $O(\delta)$. This is the simplest and most commonly assumed approach for quantization of compressed sensing measurements.

On the other hand, in this talk we show that if instead of uniform quantization, an rth order $\Sigma\Delta$ quantization scheme with the same output alphabet is used to quantize y, then there is an alternative recovery method via Sobolev dual frames which guarantees a reduction of the approximation error by a factor of $(m/k)^{(r-1/2)\alpha}$ for any $0 < \alpha < 1$, if $m \gtrsim_r k(\log N)^{1/(1-\alpha)}$. The result holds with high probability on the initial draw of the measurement matrix Φ from the Gaussian distribution, and uniformly for all k-sparse signals x that satisfy a mild size condition on their supports.