Average-case analysis of an algorithm for compressive chirp reconstruction

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The Compressive Chirp Reconstruction (CCR) algorithm (Applebaum et al., 2009) was recently introduced for compressive reconstruction of a sparse superposition of discrete chirps, which are used extensively in radar, communications and image processing. CCR adopts a greedy strategy similar to Matching Pursuit (Mallat/Zhang, 1993), but uses the Fourier transform of the signal's autocorrelations rather than gradient information to detect active chirps. The use of the Fast Fourier Transform (FFT) ensures that the computational efficiency of CCR compares favourably with many compressed sensing recovery algorithms.

We present an average-case recovery analysis of CCR. More precisely, consider a signal of length n which is a superposition of k chirps chosen uniformly at random from a dictionary of size n^2. Then, if $k = \mathcal{O}(\sqrt{n})$, exact reconstruction is guaranteed with high probability. Intriguingly, a main building block of our analysis is an extension of a known result in combinatorics concerning random Sidon sets in prime fields (Godbole et al., 1999). We support our result with numerical experiments, comparing the performance of CCR and MP.

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