Universal compressive sampling by spread spectrum and application to magnetic resonance imaging

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Abstract

We propose a novel compressed sensing technique to accelerate the magnetic resonance imaging (MRI) acquisition process. The technique consists of multiplying the signal of interest by a wide bandwidth modulation before projection onto randomly selected vectors of the Fourier basis. Firstly, in a digital setting with random modulation, we prove that the technique is universal in the sense that the required number of measurements for accurate recovery is optimal and independent of the sparsity basis. This universality stems from a drastic decrease of coherence between the sparsity and the sensing bases, which relates to a spread of the original signal spectrum by the modulation (hence the name spread spectrum). Secondly, we show that the spread spectrum technique remains effective in an analog setting with chirp modulation for application to realistic Fourier imaging. Finally, the proposed technique is thoroughly studied in the context of MRI by means of numerical simulations, as well as phantom and in vivo experiments on a 7T scanner. Our results suggest that our technique is superior to state-of-the-art variable density Fourier under-sampling approaches.

This work is supported by the CIBM of the Geneva, Lausanne Universities and EPFL, by the Leenaards and Louis-Jeantet foundations, by the SNSF (grant PP00P2-123438), by the EU FET-Open project FP7-ICT-225913-SMALL, and by the EPFL-Merck Serono Alliance award.