Compressive Source Separation : Algorithms and Applications

Pierre Vandergheynst

Hyperspectral imaging (HSI) systems produce large amounts of data and efficient compression is therefore crucial in their design. However current HSI compression techniques, such as those based on 3D wavelets, rely on computationally costly encoding algorithms that are challenging, indeed often impossible, to implement on embedded sensor systems. Recently, Compressive Sensing (CS) has provided an efficient alternative to traditional transform coding, allowing the use of very simple encoders and moving the computational burden to the decoder. The efficiency of CS crucially depends on well-designed sparse signal models as well as provably correct decoding algorithms. While the literature describes several applications of CS to HSI using direct extensions of 2D image sparse models, few works attempt to exploit the strong joint spatial and spectral correlations typical to HSI.

We propose and analyze a new model based on the assumption that the whole hyperspectral signal is composed of a linear combination of few sources, each of which has a specific spectral signature, and that the spatial abundance maps of these sources are themselves piecewise smooth and therefore efficiently encoded via typical sparse models. We derive new sampling schemes exploiting this assumption and give theoretical lower bounds on the number of measurements required to reconstruct the HSI and recover its source model parameters. This allows us to segment HSI data into their source abundance maps directly from compressed measurements. We also propose efficient optimization algorithms and perform extensive experimentation on synthetic and real datasets, which reveals that our

approach can be used to encode HSI with far less measurements and computational effort than traditional CS methods. Finally we illustrate how our model can be used for various other applications, for instance molecular spectroscopy or functional brain data processing.

Joint work with M. Golbabaee.