Colloquium

Exploiting Sparsity and Low-Dimensional Structure: Techniques and Applications

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Abstract: The apparent complexity of signals and data often belies a considerable amount of underlying structure that is characteristic of a particular source or application. A good example of such hidden structure is found in natural images, which are known to have an approximate sparse representation when expressed in certain wavelet bases. Knowledge of structure like this is highly valuable and can be utilized for various purposes such as data compression, denoising, signal reconstruction, or classification.

Sparse signal structure plays a crucial role in compressed sensing. In particular, the main theoretical results underlying this field show that sparse signals can be stably recovered from a limited number of linear measurements by finding the least one-norm solution to a particular set of linear equations. The same technique can be used for other sparse recovery problems, and extensions to different types of low-dimensional structure, such a low-rank matrices, have been successfully applied and analyzed.

In this talk, I will describe a specialized algorithm for solving an important class of sparse recovery problems in which a non-smooth convex objective is minimized subject to a two-norm constraint on a residual term. This class includes, as a special case, the one-norm minimization problem arising in compressed sensing. I will then outline the design of a silicon photomultiplier chip that takes advantage of spatial and temporal sparsity in photon arrival, thereby enabling a high spatio-temporal resolution while greatly reducing circuit complexity. As a third topic I will show how low-rank structure can be used to solve heterogeneous image registration and volume reconstruction problems arising in cryo-electron microscopy/tomography.

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