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Compressed Sensing with Poisson Noise

Compressed sensing has profound implications for the design of new imaging and network systems, particularly when physical and economic limitations require that these systems be as small and inexpensive as possible. However, several aspects of compressed sensing theory are inapplicable to real-world systems in which noise is signal-dependent and unbounded. In this work we discuss some of the key theoretical challenges associated with the application of compressed sensing to practical hardware systems and develop performance bounds for compressed sensing in the presence of Poisson noise. We develop two novel sensing paradigms, based on either pseudo-random dense sensing matrices or expander graphs, which satisfy physical feasibility constraints. In these settings, as the overall intensity of the underlying signal increases, an upper bound on the reconstruction error decays at an appropriate rate (depending on the compressibility of the signal), but for a fixed signal intensity, the error bound actually grows with the number of measurements or sensors. This surprising fact is both proved theoretically and justified based on physical intuition.