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High-order Compressive Sensing: A Target and Background Separation Tensor Approach

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Abstract: Various applications, e.g., video surveillance, hyper-spectral image processing and dynamic MR image reconstruction, can be cost as a high-order compressive sensing (hrdCS) problem in which the to-be-processed signals are of high-order tensors with target and background separation form. As highlighted in the 2nd order case (namely, the Low Rank Decomposition of Matrices), Sparsity measure has been central in modeling and solving such hrdCS problems. The existing approaches to measure the sparsity of a tensor are through unfolding the tensor into different matrix forms and then using the matrix sparsity. Such matriacization methodologies fail to exploit the global sparse structure and effectively eliminate the spatio-temporal redundancy of the tensor. In this talk we introduce a rational sparsity measure for any high-order tensors in terms of the number of fundamental Kronecker basis. The introduced measure unifies the sparsity adopted extensively in the 1st order case (namely, the number of nonzero components of a vector) and the 2nd order case (namely, the rank of a matrix), and also well characterizes the global sparse structure of a high-order tensor. With the new sparsity measure, we define a hrdCS model based on the target and background separation framework. Unlike the existing models, we model the target and background tensors respectively with their essential priors like sparsity, smoothness and similarities. The well-known alternating direction method of multipliers (ADMM) is then employed to solve the hrdCS model. To lay the theoretical foundation, we establish an recovery theory of the hrdCS based on tensor RIP, prove a convergence result of ADMM, and provide extensive simulated and real world experiments with video surveillance and hyper-spectral image reconstruction which support the superiority of the hrdCS model over the existing state-of-the-art methods.