Subspace Learning with Structured Sparsity for Compressive Video Sampling

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Existing sparse representation with subspace learning is hampered by the intersection of subspaces of bases. With structured sparsity to enable the prior knowledge of signal statistics, this paper proposes a novel compressive video sampling by subspace learning to minimize the intersection of subspaces. As the measurement, the block coherence is optimized with the regularized learning to generate a class of independent bases associated with the subspaces. Thus, the proposed framework can make a compact block sparse representation based on the derived basis in an efficient and adaptive manner. The block-based recovery of video sequences is demonstrated to be stable under the constraint of block RIP. Experimental results show that the proposed method outperforms existing compressive video sampling schemes.

Given an image (e.g. reference frame), the training set $X = [X_1, X_2, \ldots, X_t]$ and the initialization basis $\Psi^* = [\Psi_1^*, \Psi_2^*, \ldots, \Psi_t^*] \in \mathbb{R}^{n \times r}$ can be obtained by the UoDS model. Each cluster X_i contains similar signals and each basis Ψ_i^* is learned from X_i by PCA, respectively. In turn, the optimized basis $D = [D_1, \ldots, D_t]$ desires to be attained, over which signals admit compact block-sparse representation, by block sparse subspace learning (BSSL) with minimization of block-coherence:

$$D = arg \min_{\Psi_i^*, C_i} \sum_{i=1}^{t} \{\|X_i - \Psi_i^* C_i\|_2^2 + \lambda \sum_{j=1}^{p_i} \|c_i^j\|_1\} + \eta \sum_{i \neq j} \Omega(\Psi_i^*, \Psi_j^*). \quad (1)$$

where $C_i = [c_i^1, \ldots, c_i^{p_i}] \in \mathbb{R}^{d_i \times p_i}$, each column vector c_i^j is the sparse representation vector corresponding to signal $x_i^j, i \in [1, t], j \in [1, p_i]$. The first term in the optimization makes each basis D_i optimized for the signal from its own cluster, therefore signal x in X_i will have a sparse representation over D_i. While the second term makes each basis D_i incoherent with the other bases, thus the nonzero coefficients of representation vector c of signal x in X_i will concentrate only in the block index corresponding to D_i, instead of others. The proposed scheme outperforms UoDS because it can obtain compacter block-sparsity which makes fewer necessary measurements needed for perfect recovery. By validations, the proposed model for video sampling is demonstrated to achieve more improvements than existing compressive schemes.

[1] Y. Li and H. Xiong, "Union of data-driven subspaces via subspace clustering for compressive video sampling," in *Proceedings of the IEEE Data Compression Conference*, Snowbird, UT, USA, pp. 63-72, Mar. 2014.

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