Learning Stable Multilevel Dictionaries for Sparse Representation of Images

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Dictionaries adapted to the data provide superior performance when compared to predefined dictionaries in applications involving sparse representations. Algorithmic stability and generalization are desirable characteristics for dictionary learning algorithms that aim to build global dictionaries which can efficiently model any test data similar to the training samples. In this paper, we propose an algorithm to learn dictionaries for sparse representation of image patches, and prove that the proposed learning algorithm is stable and generalizable asymptotically. The algorithm employs a 1-D subspace clustering procedure, the K-lines clustering, in order to learn a hierarchical dictionary with multiple levels. Furthermore, we propose a regularized pursuit scheme for computing sparse representations using a multilevel dictionary. Using simulations with natural image patches, we demonstrate the stability and generalization characteristics of the proposed algorithm. Experiments also show that improvements in denoising performance are obtained with multilevel dictionaries when compared to global K-SVD dictionaries. Furthermore, we propose a robust variant of multilevel learning for severe degradations that occur in applications like compressive sensing. Results with random projection-based compressive recovery show that the multilevel dictionary and its robust variant provide improved performances compared to a baseline K-SVD dictionary.

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