



# Supervised dictionary learning with multiple classifier integration

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## ABSTRACT

Supervised sparse coding has become a widely-used module in existing recognition systems, which unifies classifier training and dictionary learning to enforce discrimination in sparse codes. Many existing methods suffer from the insufficient discrimination when dealing with high-complexity data due to the use of simple supervised techniques. In this paper, we integrate multiple classifier training into dictionary learning to overcome such a weakness. A minimization model is developed, in which an ensemble of classifiers for prediction and a dictionary for representation are jointly learned. The ensemble of classifiers is constructed from a set of linear classifiers, each of which is associated with a group of atoms and applied to the corresponding sparse codes. Such a construction scheme allows the dictionary and all the classifiers to be simultaneously updated during training. In addition, we provide an interesting insight into label consistency from the view of multiple classifier learning by showing its relation with the proposed method. Compared with the existing supervised sparse coding approaches, our method is able to learn a compact dictionary with better discrimination and a set of classifiers with improved robustness. The experiments in several image recognition tasks show the improvement of the proposed method over several state-of-the-art approaches.

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## 1. Introduction

In recent years, sparse models have been widely used in a variety of applications in computer vision and pattern recognition, e.g., image analysis [1,2], image processing [3–6] and image recognition [7–15]. The philosophy of sparse modeling comes from the parsimony principle which refers to representing objects using as few variables as possible [16], and the success of sparse modeling is attributed to the fact that high-dimensional data of particular types often lie on some low-dimensional manifolds. Given a set of input data, sparse modeling aims at expressing each input data by a linear combination of a few elements taken from a set of representative patterns. The representative patterns are called atoms, and the total set of patterns is called dictionary. The coefficients of the linear combination are often referred to as sparse codes.

The dictionaries for sparse modeling are usually learned from data to maximize the efficiency of sparse approximation in terms of sparsity degree, which have shown improvement over the analytic dictionaries like wavelets in signal processing; see e.g. [3,17,18]. However, it is not optimal to use these dictionaries for classification problems where not only the sparsity but also the discriminability of sparse codes are pursued.<sup>2</sup> To enforce discrimination in sparse codes, the *supervised dictionary learning* methods [19–32] have been proposed to learn dictionaries in a supervised manner. The main idea of these methods is to couple the process of classifier training and the process of dictionary learning, which have exhibited impressive performance in a variety of recognition tasks. But there is still plenty of room for improvement. One possibility comes from the fact that many existing approaches (e.g. [19,20,25,32]) only employ a single simple classifier in the learning process, whose discriminative power is insufficient to handle high-complexity data. This inspired us to integrate multiple classifier learning into supervised dictionary learning.

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<sup>2</sup> The dictionaries inducing discriminative sparse codes are often referred to as discriminative dictionaries.