Online Discriminative Dictionary Learning for Image Classification

Shu Kong, Donghui Wang, - Zhejiang University
{AimeryKong, dhwang}@zju.edu.cn

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Contribution

We propose a new online algorithm with the numerical solution for learning a discriminative dictionary. It enables online framework and learning discriminative dictionary to merge into a unifying framework. In other words, our proposed approach can efficiently and effectively derive the discriminative dictionary, meanwhile it overcomes large scale classification problem. We show experimentally our approach achieves encouraging performance compared with some other dictionary learning algorithms. Moreover, we find a novel, effective and efficient dictionary construction scheme for face recognition.

Abstract

Dictionary learning (DL) is an important technique for many vision perception tasks, e.g., classification. But there are two problems of the classical DL (reconstructive DL) arising in classification task, i.e., large-scale problem and better discriminability. For the two issues, Online and discriminative framework are proposed, which means the ability to deal with large-scale dataset, and the capability of distinguishing different kinds of objects, respectively. We believe it makes sense to merge the two frameworks into one, and our work is focused on this issue.

Selected References

[1] J. Mairal, F. Bach, J. Ponce, and G. Sapiro. Online learning for matrix factorization and sparse coding, in *Journal of Machine Learning Research*, 2010

[2] J. Mairal, F. Bach, J. Ponce, G. Sapiro, and A. Zisserman. Discriminative learned dictionaries for local image analysis, in *CVPR*, 2008.

[3] J. Mairal, F. Bach, J. Ponce, G. Sapiro, and A. Zisserman. Supervised dictionary learning, in *NIPS*, 2008.

[4] J. Mairal, F. Bach, J. Ponce, G. Sapiro, and A. Zisserman. Discriminative learned dictionaries for local image analysis, in *CVPR*, 2008.

[5] L. Bottou and O. Bousquet. The tradeoffs of large scale learning, in *NIPS*, 2007.

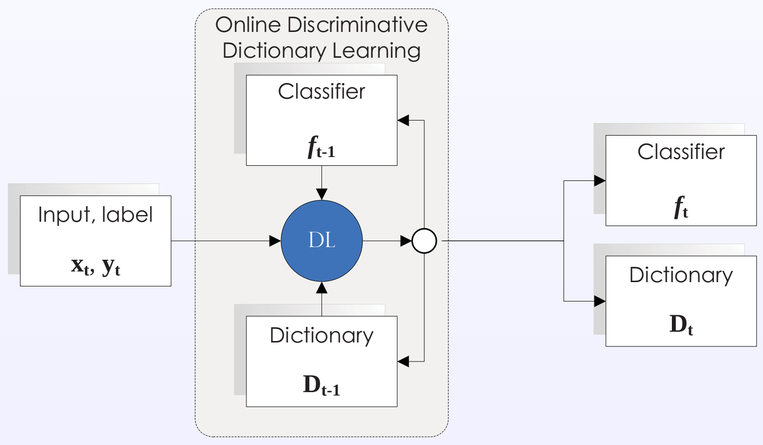
Proposed Approach

To overcome the lack of discriminability for learned dictionary, we introduce a discriminative term to the original dictionary learning problem, by considering a linear classifier for simplicity. Additionally, we also apply an online framework here. As Bottou et al. [5] say, the minimization of the empirical cost is not the focus of researchers, but instead the minimization of the expected cost. Finally, we obtain our objective function as below:

$$\min_{\mathbf{D},\mathbf{W}} \mathbb{E}_{\mathbf{x},\mathbf{y}}[\|\mathbf{x}-\mathbf{D}\alpha^*\|_2^2+\lambda_0\|\mathbf{y}-\mathbf{W}\alpha^*\|_2^2] +\lambda_1\|\mathbf{W}\|_F^2$$

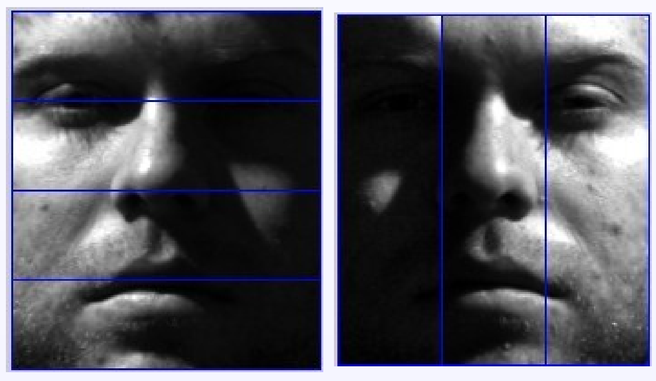
Model Explanation

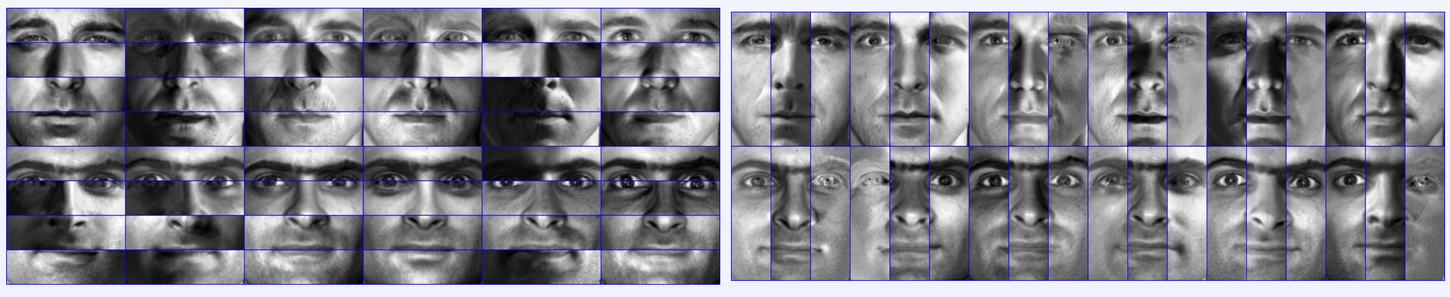
There are two stages in our proposed algorithm, flow diagram below shows the training stage of our method. The two stages are sparse coding, and dictionary and classifier updating, we apply an iterative procedure to complete the numerical solution.



A Selected Experiment

we divide each **original** face image into four non-overlapping patches from top to bottom, and into three non-overlapping patches from left to right. After doing this, we have seven patch classes for each person. Then we vectorize all the patches and normalized them to have unit ℓ^2 norm. In this experiment, seven classifier and the corresponding dictionaries with 228 atoms are learned. Figure below displays one such example with the learned dictionaries. As for recognition, we apply the whole dictionaries and classifiers altogether. The average error rate is reduced to **0.02%**. This illustrative experiment demonstrate the good performance of our method, as well as provides a novel, effective and efficient dictionary construction scheme for face recognition.





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