Use Online Dictionary Learning to Get Parts-based Decomposion of Noisy Data

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***Abstract*—Huge amount of data are generated every day. Extracting interpretable features from the data is becoming important. Meanwhile, dimension reduction and low rank approximation are also becoming important as people want to factorize big matrix into smaller ones, which are easier to handle. Sparse coding is such a technique that can factorize matrix into sparse linear combinations of basis elements. We found that through online dictionary learning, an efficient sparse coding algorithm, we could decompose large data matrix with noise into interpretable dictionary atoms. Such atoms are useful in reconstructing a denoised data matrix.**

Keywords—machine learning, sparse coding, online dictionary learning, dimension reduction

I. Introduction

Large amount of high dimensional data are generated every day, thanks to the prosperity of the Internet and big data technology. Due to the difficulty of processing high dimensional data, people intend to factorize or decompose large data matrices into smaller ones. The linear decomposition of a matrix into a few basis elements has been a hot research spot for a long time. At first, general purposed basis matrices were used to represent the large matrix. Later, using ad hoc matrix learned from specific input data produces better results. However, although many such decomposition methods could produce smaller matrices, these matrices are hardly interpretable, especially when the input data are noisy. Such popular methods include PCA, CUR, etc. We found that online dictionary learning (ODL) methods, introduced in [], could not only reduce the matrix dimension, but the atoms in the learned dictionary are interpretable as well. We applied this technology to two different set of noisy data and found the extracted atoms very close to the ground truth.

We compared our method with UoI NMF cluster and found our accuracies are at the same level. Meanwhile, online dictionary learning runs faster. The following sections are organized as below:

- We first review the core part of ODL
- We then introduce the application of ODL on our datasets
- We finally compared our results with NMF and discussed potential advantages and disadvantages.

At last, we discussed future improvements.

II. Preliminaries

A. Online Dictionary Learning

Online dictionary learning was first introduced in []. Assume we have a finite training dataset as $X = [x_1, \ldots, x_n]$ in R First, confirm that you have the correct template for your paper size. This template has been tailored for output on the US-letter paper size. If you are using A4-sized paper, please close this file and download the file "MSW_A4_format".

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[1] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

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