# Efficiently Retrieving Images that We Perceived as Similar

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**Abstract**

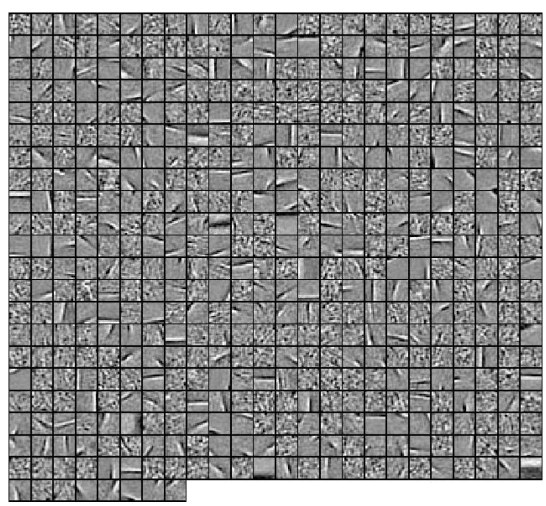
Despite growing interest in using sparse coding based methods for image classification and retrieval, progress in this direction has been limited by the high computational cost for generating each image's sparse representation. To overcome this problem, we leverage sparsity-based dictionary learning and hash-based feature selection to build a novel unsupervised way to efficiently pick out a query image's most important high-level features that can determine to which group we would visually perceived as similar. The preliminary results show the method's efficiency and high accuracy from the visual cognitive perspective. Finally, we consider a more general problem of how to make the pre-learned dictionary to adaptively refine the features contained according to past queries.

## Motivation and Introduction

Similar image retrieval has become an important problem with many real-world applications in artificial intelligence field. To be able to process the growing amount of data, more efficient and reliable algorithms are needed. Until now, there is still a lack of an effective guideline to decide similarity for a computer, though the problem posts no difficulty to human beings. This motivated us to incorporate the biology-inspired sparse coding and hashing techniques for more intuitive, real time retrieval results. There are many researches studying about how to make image retrieval effective. Conventionally, there are three steps in large-scale content-based image retrieval when given a set of indexed images and a query image. The first is feature extraction. Many complex approaches are developed to find effective image representation to encode a variety of images. Secondly, dimension reduction is important to speed up the retrieval process. Finally, effective metric is needed to compute the similarity between features. Compared to the traditional framework we propose a different solution without the part of feature extraction to solve this problem by the plausible model of visual cortexsparse coding.

Sparse coding with an overcomplete basis representations (Olshausen and Field 1996), inspired from mammalian striate cortex by neural science community has been widely applied in many computer sciences fields, such as data compression, speech recognition and image denoising, etc. (Sivaram 2010), (Wright et al. 2009). One important property of sparse coding is that it can extract effective higher-level features from the data by simulating partial activity of neurons. According to promising neural science theory and the high performance of algorithms developed within decades, we assume that sparse coding which simulates mammalian visual cortex activities is a very efficient approach to find the latent features compared to traditional unsupervised learning such as PCA. We also assume that neuron simulation-based approach for image representation is better than other widely used computer vision features including SIFT (Lowe 1999), GIST (Oliva et al. 2001), HOG (Dalal et al. 2005) and etc. because we have our visual system as promising evidence to support.

Some people have images search problem with the representation of sparse codes proposed by (Ge et al. 2013). However, finding sparse codes has high computational costs on doing effective real time search. We propose a novel approach to solve this problem by using overcomplete basis in dictionary rather than computing sparse codes and we will show that our approach is effective in natural image.



## Preprocessing-Unsupervised dictionary learning

Sparse-based dictionary learning has proven been effective in natural images which are mostly scene image. Given input unlabeled scene images, the effective sparse coding proposed by (Lee et al. 2007) captures succinct feature with higher meanings and generate a dictionary with overcomplete bases which are effective to represent the image in data set given the corresponding sparse code. The basic descriptions such as edges and line segments are efficiently encoded into atoms of dictionary so we will pre-trained the dictionary as our dimension reduction projection bases. (dictioanry)

## System framework

Given a query natural image, we firstly decorrelate the image to equalize the variance which is also employed in preprocessing for dictionary due to potential factual and corrupted and this also roughly simulate spatial-frequency reponse characteristic of retinal ganglion cells proposed by (Olshausen 1997) in our cognitive system. We then uniformly select several image patches to extract a certain pattern of the image. We feed all extracted vectors into our auto-learned feature selection algorithms to encode the data. Finally, we use L2 distance as default metric to compute similarity score. The system diagram is shown in Figure 2.

## Auto-learned feature selection algorithms

Since our retrieval framework encode the image pattern of natural images into sparsity-based dictionary, we are motivated to select effective feature, especially those have high response to patches of natural images. Inspired by localitive sensitive hashing proposed by (Andoni et al. 2008), where high dimensional data can be projected to lower dimensional space with similarity preserving promise, we propose our novel algorithm to find out the atom of feature pattern in the dictionary to perform our hash-based dimensional reduction.

Firstly, we project our patches vector onto the atom of dictionary to get the highest values of the result for each vector of patches and have another zero array with the same size. We call those atoms strong responsive to the corresponding patches vector. Then, we set the value of each patches vector at corresponding atom of dictionary to be one.

Secondly, we substract the strong responsive atom from the corresponding patches vector in order to select second strong responsive atom with respect to the corresponding patches vector.

Iteratively, we will rank out the top n strong responsive atoms as our output for each patch vector. By this way, we can encode the raw data directly by the ranking of the response of corresponding atom based on sparsity based dictionary and we will show that the result has some effects consistent with our visual system.

## Experimental results

- show the recall and precision for some image
- show the result images

## Conclusion

Rather than traditional human-turned feature extraction our cognitive system based on sparse coding successfully combine proposed novel auto-learned feature selection algorithm with sparsity-based dictionary to retrieve natural images with high performance. The sparsity-based dictionary which capture basic elements consisting a natural image is a well learned structure to encode images. Although it needs more powerful algorithm and research in large-scale image retrieval or other big data, this is the promising direction of relative application.

## How to work with big data?

When the world is filled with big data, effective approach is needed to deal with such a challenge. Large-scale image with effective and reliable performance is one of examples. Recently, we are attempting to address an open question if there is new approach based our framework to handle this old but not well-solved problem. Our work lies in how we design the connection between visual neuron encoding simulation and image retrieval problem and how we investigate an effective large-sale image retrieval new candidate.

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## key sentence

Critical question or point we had better contain or answer:

- **software systems: emulate actual neurophysiological mechanisms and algorithms that support human cognition**
- **what are the emerging machine learning technologies that address the big data challenges implied by cognitive computing applications?**
- **How can cognitive computing techniques improve human computation, and what demands do the latter put on the former?**
- **Sparsity-based techniques and process unstructured data**

  Our point:
- **sparse coding**
- **images patches rather than human-turned feature extraction**
- **unsupervised dictionary learning**
- **hashing rather than sparse code computing**
- **large-scale data search (future work and our vision)**
- **effective similarity preservation by auto-learned feature selection algorithm**

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**Drawings.** We suggest you use computer drawing software (such as Adobe Illustrator or, (if unavoidable), the drawing tools in Microsoft Word) to create your illustrations. Do not use Microsoft Publisher. These illustrations will look best if all line widths are uniform (half- to two-point in size), and you do not create labels over shaded areas. Shading should be 133 lines per inch if possible. Use Times Roman or Helvetica for all figure call-outs. **Do not use hairline width lines** — be sure that the stroke width of all lines is at least .5 pt. Zero point lines will print on a laser printer, but will completely disappear on the high-resolution devices used by our printers.

**Photographs and Images.** Photographs and other images should be in grayscale (color photographs will not reproduce well; for example, red tones will reproduce as black, yellow may turn to white, and so forth) and set to a minimum of 266 dpi. Do not prescreen images.

**Resizing Graphics.** Resize your graphics **before** you include them with LaTeX. You may **not** use trim or clip options as part of your \includgraphics command. Resize the media box of your PDF using a graphics program instead.

**Fonts in Your Illustrations** You must embed all fonts in your graphics before including them in your LaTeX document.

## References

The aaai.sty file includes a set of definitions for use in formatting references with BibTeX. These definitions make the bibliography style fairly close to the one specified below. To use these definitions, you also need the BibTeX style file "aaai.bst," available in the author kit on the AAAI web site. Then, at the end of your paper but before \enddocument, you need to put the following lines:

\bibliographystyle{aaai} \bibliography{bibfile1,bibfile2,...}

The list of files in the \bibliography command should be the names of your BibTeX source files (that is, the .bib files referenced in your paper).

The following commands are available for your use in citing references:

\cite: Cites the given reference(s) with a full citation. This appears as "(Author Year)" for one reference, or "(Author Year; Author Year)" for multiple references.
\shortcite: Cites the given reference(s) with just the year. This appears as "(Year)" for one reference, or "(Year; Year)" for multiple references.
\citeauthor: Cites the given reference(s) with just the author name(s) and no parentheses.
\citeyear: Cites the given reference(s) with just the date(s) and no parentheses.

**Warning:** The aaai.sty file is incompatible with the hyperref and natbib packages. If you use either, your references will be garbled.

Formatted bibliographies should look like the following examples.

*Book with Multiple Authors*
Engelmore, R., and Morgan, A. eds. 1986. *Blackboard Systems.* Reading, Mass.: Addison-Wesley.

*Journal Article*
Robinson, A. L. 1980a. New Ways to Make Microcircuits Smaller. *Science* 208: 1019–1026.

*Magazine Article*
Hasling, D. W.; Clancey, W. J.; and Rennels, G. R. 1983. Strategic Explanations in Consultation. *The International Journal of Man-Machine Studies* 20(1): 3–19.

*Proceedings Paper Published by a Society*
Clancey, W. J. 1983b. Communication, Simulation, and Intelligent Agents: Implications of Personal Intelligent Machines for Medical Education. In Proceedings of the Eighth International Joint Conference on Artificial Intelligence, 556–560. Menlo Park, Calif.: International Joint Conferences on Artificial Intelligence, Inc.

*Proceedings Paper Published by a Press or Publisher*
Clancey, W. J. 1984. Classification Problem Solving. In *Proceedings of the Fourth National Conference on Artificial Intelligence,* 49–54. Menlo Park, Calif.: AAAI Press.

*University Technical Report*
Rice, J. 1986. Poligon: A System for Parallel Problem Solving, Technical Report, KSL-86-19, Dept. of Computer Science, Stanford Univ.

*Dissertation or Thesis*
Clancey, W. J. 1979b. Transfer of Rule-Based Expertise through a Tutorial Dialogue. Ph.D. diss., Dept. of Computer Science, Stanford Univ., Stanford, Calif.

*Forthcoming Publication*
Clancey, W. J. 1986a. The Engineering of Qualitative Models. Forthcoming.

## Producing Reliable PDF Documents with LaTeX

Generally speaking, PDF files are platform independent and accessible to everyone. When creating a paper for a proceedings or publication in which many PDF documents must be merged and then printed on high-resolution PostScript RIPs, several requirements must be met that are not normally of concern. Thus to ensure that your paper will look like it does when printed on your own machine, you must take several precautions:

- Use type 1 fonts (not type 3 fonts)
- Use only standard Times, Nimbus, and CMR font packages (not fonts like F3 or fonts with tildes in the names or fonts—other than Computer Modern—that are created for specific point sizes, like Times~19) or fonts with strange combinations of numbers and letters
- Embed all fonts when producing the PDF
- Do not use the [T1]fontenc package (install the CM super fonts package instead)

### Creating Output Using PDFLaTeX Is Required

By using the PDFTeX program instead of straight LaTeX or TeX, you will probably avoid the type 3 font problem altogether (unless you use a package that calls for metafont). PDFLaTeX enables you to create a PDF document directly from LaTeX source. The one requirement of this software is that all your graphics and images must be available in a format that PDFLaTeX understands (normally PDF).

PDFLaTeX's default is to create documents with type 1 fonts. If you find that it is not doing so in your case, it is likely that one or more fonts are missing from your system or are not in a path that is known to PDFLaTeX.

**dvipdf Script** Scripts such as dvipdf which ostensibly bypass the Postscript intermediary should not be used since they generally do not instruct dvips to use the config.pdf file.

**dvipdfm** Do not use this dvi-PDF conversion package if your document contains graphics (and we recommend you avoid it even if your document does not contain graphics).

### Ghostscript

LaTeX users should not use GhostScript to create their PDFs.

### Graphics

If you are still finding type 3 fonts in your PDF file, look at your graphics! LaTeX users should check all their imported graphics files as well for font problems.

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## Additional Resources

LaTeX is a difficult program to master. If you've used that software, and this document didn't help or some items were not explained clearly, we recommend you read Michael Shell's excellent document (testflow doc.txt V1.0a 2002/08/13) about obtaining correct PS/PDF output on LaTeX systems. (It was written for another purpose, but it has general application as well). It is available at www.ctan.org in the tex-archive.

## Acknowledgments

AAAI is especially grateful to Peter Patel Schneider for his work in implementing the aaai.sty file, liberally using the ideas of other style hackers, including Barbara Beeton. We also acknowledge with thanks the work of George Ferguson for his guide to using the style and BibTeX files — which has been incorporated into this document — and Hans Guesgen, who provided several timely modifications, as well as the many others who have, from time to time, sent in suggestions on improvements to the AAAI style.

The preparation of the LaTeX and BibTeX files that implement these instructions was supported by Schlumberger Palo Alto Research, AT&T Bell Laboratories, Morgan Kaufmann Publishers, The Live Oak Press, LLC, and AAAI Press. Bibliography style changes were added by Sunil Issar. \pubnote was added by J. Scott Penberthy. George Ferguson added support for printing the AAAI copyright slug. Additional changes to aaai.sty and aaai.bst have been made by the AAAI staff.

Thank you for reading these instructions carefully. We look forward to receiving your electronic files!