Query-time Image Descriptor Selection using Information Gain

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*Abstract*— Many methods exist to describe the visual contents of an image, each with strengths and weaknesses. Prior work has focused on combining descriptors, or dynamic weighting schemes. In this paper, we show a method for choosing between a local descriptor and a global color descriptor at query-time. Using information gain, we are able to quantify the descriptive ability of candidate algorithms for a given query. Initial results show that this approach works well for many categories of images, and future work will focus on expanding the collection of candidate descriptors.

Keywords: Computer vision; image processing; image retrieval; information theory; bag of words

# Introduction & Related Work

The explosion of multimedia content on the internet has highlighted the need for efficient search techniques for visual information. People store and share images with their phones, cameras, laptops, and desktop computers. Manual tagging images with keywords is not scalable, and thus searching visual media has become a laborious task. Content-Based Image Retrieval (CBIR) refers to the concept of analyzing the visual content in images and videos and using this information to search for similar content in a collection of visual media.

Various methods quantify the image content and store an associated visual fingerprint as an array of numbers. This is referred to as a descriptor. Images are then compared by comparing their respective descriptors. In this work, we use Speeded-Up Robust Features (SURF) [1] and a Bag-of-Colors (BoC) [2] descriptors.

The SURF and BoC descriptors are based on a technique called Bag-of-Visual-Words that originates from text search methods. The idea was first proposed in [3] as a way to generate visual words and then describe images through histograms of occurrences of each word in the vocabulary. The first step involves extracting descriptors for a specific algorithm from a training set. Then these descriptors are clustered into a set of k clusters using k-means. Each cluster centroid becomes a visual word. Then, for a given image and a pre-calculated vocabulary, descriptors are extracted, and each descriptor is mapped to a visual word in the vocabulary. Each time a visual word is detected, its bin in the histogram is incremented. Similarity between images is then typically calculated as the sum of square differences for all bins in the histogram.

# Data

The CalTech256 data set is a widely used collection of images that is useful for research in image classification and image search. It expands upon a prior dataset that was called the CalTech101. It consists of 256 object categories as well as an extra “clutter” category. Each class has at least 80 images, with some classes containing up to 800 images. The categories range from animals to buildings to smaller objects such as baseball bats and bowling pins. All images are in jpg file format and features were extracted from them without any preprocessing.

Figure - Sample images from the CalTech 256 Data Set

# Methodology

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

## Units

* Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
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The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in

 

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not “Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

## Some Common Mistakes

* The word “data” is plural, not singular.
* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
* In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
* A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
* Do not use the word “essentially” to mean “approximately” or “effectively”.
* In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
* Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
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* The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
* There is no period after the “et” in the Latin abbreviation “et al.”.
* The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

# Results

# Conclusions & Future Work

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Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

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### Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

1. Table Type Styles

| Table Head | Table Column Head | | |
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| Table column subhead | Subhead | Subhead |
| copy | More table copya |  |  |

a. Sample of a Table footnote. (Table footnote)

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

1. Example of a figure caption. *(figure caption)*

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##### Acknowledgment *(Heading 5)*

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##### References

1. H. Bay, T. Tuytelaars, and L. Van Gool. 2006. SURF: speeded up robust features. InProceedings of the 9th European conference on Computer Vision - Volume Part I (ECCV'06), Aleš Leonardis, Horst Bischof, and Axel Pinz (Eds.), Vol. Part I. Springer-Verlag, Berlin, Heidelberg, 404-417.
2. C. Wengert, M. Douze, and H. Jégou. 2011. Bag-of-colors for improved image search. In Proceedings of the 19th ACM international conference on Multimedia (MM '11). ACM, New York, NY, USA, 1437-1440.
3. J. Sivic and A. Zisserman, “Video google: efficient visual search of videos,” Toward Category-Level Object Recognition, Springer, Volume 4170, 2006, pp 127-144,
4. Griffin, G. Holub, and A. D. Perona. *P. The caltech-256*. Caltech Technical Report.