Heterogeneous Graph Propagation for Large-Scale Web Image Search

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Abstract—State-of-the-art web image search frameworks uses the bag-of-visual-words (BoVWs) model and the inverted index structure. In spite of its simple, efficient, scalable, they often face problem of low precision and/or recall, because it is not well stable of its local features and the information loss is high on the stage of quantization. To improve the quality of images that are retrieved, various post processing methods have been applied after the initial process of search. In this paper, we evaluate the online querying process from a graph-based approach. We introduce a graph model containing both image and feature nodes explicitly, and state an efficient approach of reranking consisting of two modules, i.e., incremental query expansion and image-feature voting. Like, conventional reranking algorithms, the method does not require usage of geometric information of visual words, hence enjoys low consumptions of both time and memory. The method is also independent of the initial search process, and could work with many BoVW-based image search pipelines, or applied after other post processing algorithms. We study our approach on big-scale image search tasks and verify its competitive search performance.

1 Introduction

The online query process is investigated from a graph-based perspective introducing a heterogeneous graph-based model containing both image and feature nodes explicitly and an effective reranking approach is proposed consisting of two successive modules namely (i) incremental query expansion and (ii) image feature voting. The proposed approach consumes low time and memory due to its independence of the initial search process and cooperation with many bag-of-visual-words (BoVW) model.

A graph-based perspective is inherited to formulate the post-processing stage. For each query, retrieved images are partitioned into four categories, *i.e.*, true positive (highly ranked, relevant), false-negative (lowly ranked, relevant), false-positive (highly ranked, irrelevant) and true-negative (lowly ranked, irrelevant) sets, and reveal full use of the relationship between (global) images and (local) features is amde to boost the search performance. For this, a **heterogeneous** graph is constructed containing two types of nodes, *i.e.*, images and features. Based on the graph structure, two efficient algorithms are proposed, *i.e.*, Incremental Query Expansion (IQE) and Image-Feature Voting (IFV), to improve the recall and precision of initial search results, respectively.

To search among a large-scale image corpus, the Bag-of-Visual-Words (BoVW) model with the inverted index structure is widely adopted. Offline indexing and online searching are the two main stages. On the offline stage, local descriptors are extracted on each image. On the online stage, local descriptors are also extracted on the query image, and are used to access the corresponding entries in the inverted index. Finally, the retrieved image candidates are accumulated as the search results.

2 Previous work done

An incremental IQE process for query expansion, which is different with previous methods [Y. –H. Kuo 2009] proposed query expansion for hash-based image object retrieval in which all the images are considered and added simultaneously. IQE allows to update the image ranking after each iteration and select the most competitive candidate for expansion. Consequently, it increases the probability that each expansion is made on a true-positive. [L. Xie 2014] proposed fast and accurate near-duplicate image search with affinity propagation on the image web.

3 Literature survey

[J. Philbin 2007] proposed the approach of object retrieval with large vocabularies and fast spatial matching. [Y. –H. Kuo 2009] proposed query expansion for hash-based image object retrieval in which all the images are considered and added simultaneously.

4 Proposed methodology

Two modules IQE and IFV are proposed, which play different but equally important roles in post-processing. Intuitively, IQE is aimed at discovering new connections between the query and originally false-negatives, whereas IFV is focused on re-calculating the weights of images and features for filtering false-positives. According to the results observed, IQE and IFV help to boost the recall and precision of the initial search results, respectively, which comes up to the expectation for which the algorithms are designed. Moreover, IQE and IFV cooperate with each other very well, using one of them alone produces worse results than integrating them together. Since both IQE and IFV algorithms include a quantization stage, and the accumulated scores are manually defined, it is difficult to provide a strict mathematical estimation on their convergence rates. However, according to the application of RandomWalk theory on the HITS algorithm, convergence could be mostly guaranteed if the higher ranked elements (images or features) are always assigned with larger values. Other successful ap-

plications of Random Walk in information retrieval, also provide evidences that such affinity propagation algorithms have good mathematical properties.

5 IMPLEMENTATION OF PROPOSED METHODOLOGY

If you are using Word, An image search and re-ranking problem is investigated from an alternative prospective building a heterogeneous graph consisting of both image and feature nodes explicitly and two geometry-free post-processing algorithm is proposed to improve precision.

- From homogeneous to heterogeneous

First of all, initial image search results are visualized using a graph structure. Each node in the graph denotes an image and there is a directed edge from one image to another if and only if other image is ranked among the top-10 candidates when one image is the query. Other images in the graph could be categorized into four exclusive groups:

- **true-positives** These relevant images share a large number of common features with the query, and are naturally ranked among the top.
- **false-negatives** These relevant images do not have enough feature matches with the query, therefore are not ranked among the top. The ranking of these images is promoted.
- **false-positives** These irrelevant images somehow share a few common features with the query and are ranked among the top. False matches on these images are filtered.
- **true-negatives** These irrelevant images could be ignored.

5.1 Tools Used

Search engines like Google, Live and Yahoo
not abbreviate "Table."

6 RESULTS

6.1 Results

Two novel algorithms are proposed, *i.e.*, Incremental Query Expansion (IQE) and Image-Feature Voting (IFV), to boost the recall and precision of the initial search results, respectively. Since the proposed algorithms do not require using geometric information, time and memory consumptions on the online querying stage are significantly reduced.

6.2 Advantages

- The re-ranking approach achieves competitive search performance on a variety of image search tasks.
- This approach is applicable after other post-processing methods for better result.
- It is more efficient in time and memory consumptions compared to complicated post-processing algorithms.

6.3 Disadvantages

This approach does not use geometric information to reduce storage space.

4 CONCLUSION

The post processing stage is the major innovation, on which the search process is investigated from a graph-based perspective. With an intuition to emphasize the importance of features, a **heterogeneous** graph is introduced consisting of both image and feature nodes explicitly. They are beneficial for time and memory comsumptions. It is best for baselined approaches.

FUTURE WORK

The future work includes to use geometric information to reduce the consumption of storage spaces.

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