Multimedia Systems and Applications

Real Time Google and Live Image Search Re-ranking

James Wang

Based on ACM Multimedia 2008 paper and poster by:

Cui et al., Real Time Google and Live Image Search Re-ranking, in Proceedings of ACM Multimedia 2008, pp. 729 – 732, October 26–31, 2008

Problem, Idea and Existing Approaches

- **Problems:**
  - *Search engines use only text information to find images.*
  - *many of returned results are noisy, disorganized, or irrelevant.*
- **Idea**
  - *Using visual information to re-rank and improve text based image search results*
- **Existing Approaches:**
  - *Assume that there is one dominant cluster of images inside each image set returned by a keyword query, and treat images inside this cluster as "good" ones.*
    - *require online training, so cannot be used for realtime online image search.*
    - *cannot handle ambiguity inside a keyword query.*

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Contribution

- **A framework is proposed to build a system to re-rank text based image search results in an interactive manner.**
  - After query by keyword, user can click on one image, indicating this is the query image.
  - Then all the returned images are re-ranked according to their similarities with the query.
- **A fast and effective online image search re-ranking algorithm based on one query image only without online training.**
- **Search by adaptive similarity based on the user intention.**

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Method

- **The query image is firstly categorized into one of several predefined categories.**
- **Inside each category, a specific weight schema, which combines the features adaptive to this kind of images, is used to measure the user's intention when using this image to query.**
  - This weighting schema is based on minimizing the rank loss for all query images on a training set through the proposed method modified from RankBoost [8].

[8] Y. Freund, R. Iyer, R. E. Schapire, and Y. Singer. An efficient boosting algorithm for combining preferences. J. Mach. Learn. Res., 4:933–969, 2003.

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Search by Adaptive Similarity

- **Given F different features of an image, the normalized similarity between image i and j on feature m is denoted as $s_i^m(j)$, which takes value in the range of [0; 1].**
- **A vector α_i is defined for each image i to express its specific "point of view" towards different features. The larger α_{im} is, the more important the mth feature will be for image i.**
- **Assume $\alpha \succeq 0$ and $\|\alpha\|_1 = 1$, the adaptive similarity measurement at image i is a linear combination of its similarities on different features weighted by α_i: $s_i(\cdot) = \sum_{m=1}^{F} \alpha_{im} s_i^m(\cdot)$**
  - adjust the weight α adaptively for each query image i.

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Intention Categories

- **Images containing close-ups of general objects;**
- **Object with Simple Background;**
- **Scenery images;**
- **Images containing portrait of a single person;**
- **Images with general people inside, and are not "Portrait".**

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Attributes for intention categorization

- **Face existence:**
  - Whether the image contains faces.
- **Face number:**
  - Number of faces occurred in the image.
- **Face size:**
  - The percentage of the image frame taken up by the face region.
- **Face position:**
  - Coordinate of the face center relative to the center of the image.
- **Directionality:**
  - Kurtosis of Edge Orientation Histogram (EOH, Section3). The bigger the Kurtosis is, the stronger the image shows directionality.
- **Color Spatial Homogeneousness:**
  - Variance of values in different blocks of Color Spatialet (CSpa, Section3), describing whether color in the image is distributed spatially homogeneously.
- **Edge Energy:**
  - Total energy of edge map obtained from Canny Operator on the image.
- **Edge Spatial Distribution:**
  - First divide the image into 3 by 3 regular blocks, then calculate the variance of Edge Energy in the 9 blocks. Describe whether edge energy is mainly distributed at the image center

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Intention Specific Feature Fusion

Algorithm 1 Learning Feature Weight Inside Intention Category

1. **Input:** initial weight D_i for all possible query images i in the current intention category Q, similarity matrix on each feature $s_i^m(\cdot)$ for all i and m;
2. Initialize: Set $D_i^1 = D_i$ for any i. Set step $t = 1$;

while Algorithm not converged **do**

  for each $i \in Q$ **do**

3. Select best feature and corresponding similarity $s_i^t(\cdot)$ for current re-ranking problem under weight D_i^t;
4. Calculate real value α_i^t according to Equation 1;
5. Adjust weight $D_i^{t+1}(j,k) \propto D_i^t(j,k) \exp\left\{\alpha_i^t\left[s_i(j) - s_i(k)\right]\right\}$;
6. Normalize D_i^{t+1} with factor Z_i^t so that D_i^{t+1} will be a distribution;
7. t++;

  end for

end while

8. **Output:** Final optimal similarity measure for current intention category: $s(\cdot) = \sum_{i,t} \alpha_i^t s_i^t(\cdot)$.

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Feature Design

- **Attention Guided Color Signature:**
  - A color signature that accounts for varying importances of different parts of an image. An attention detector [10] is used to compute a saliency map for the image, then perform k-Means clustering weighted by this map.
- **Color Spatialet.**
  - An image is first divided into n £ n patches by a regular grid. Within each patch, we calculate its main color as the largest cluster after k-Means clustering. The image is finally characterized by Color Spatialet (CSpa), a vector of n2 color values.

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Feature Design (cont.)

- **Gist.**
  - Gist is proposed in [15] to characterize the holistic appearance of an image, and is proven to work well for scenery images.
- **Daubechies Wavelet.**
  - The 2nd order moments of wavelet coefficients in various frequency bands (DWave) are used to characterize texture properties in the image[16].
- **SIFT.**
  - A 128-dimension SIFT [11] is used to describe regions around Harris interest points. A codebook of 450 words is obtained by hierarchical k-Means on a set of 1.5 million SIFT descriptors extracted from the training set. Descriptors are then quantized by this codebook.

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Feature Design (cont.)

- **Multi-Layer Rotation Invariant EOH.**
  - Edge Orientation Histogram (EOH) [7], which describes histogram of edge orientations, has long been used in vision applications.
  - Rotation invariance is used when comparing two EOHs, resulting in a Multi-Layer Rotation Invariant EOH (MRI-EOH).
  - To calculate the distance between two MRI-EOHs, one of them is rotated to best match the other, and take this distance as the distance between the two.

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Feature Design (cont.)

- **Histogram of Gradient (HoG).**
  - HoG [4] is the histogram of gradients within image blocks divided by a regular grid.
  - HoG reflects the distribution of edges over different parts of an image, and is especially effective for images with strong long edges.
- **Facial Feature.**
  - Face existence and their appearances give clear semantic interpretations of the image.
  - Face detection algorithm [17] is applied to each image, and to obtain the number of faces, face size and position as the facial feature (Face).
  - The distance between two images is calculated as the summation of differences of face number, average face size, and average face position.

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Experimental Data

- **a collection of 451,352 images associated with 483 keywords crawled from Google Image Search and Microsoft Live Image Search.**
  - contains many concepts including object, scenery, people name, place name, etc., and covers a large range of keywords (http://mmlab.ie.cuhk.edu.hk/intentsearch).
- **26,908 images from 30 keywords labeled, among which 46% are labeled as good, consisting of 128 sub classes and 70 main classes.**

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Experimental Method

- **Evaluation Criteria.**
  - P20 and P40 (Proportion of images within the same sub class in top 20 and 40 returned ones) are used to evaluate performance
- **Evaluation baselines.**
  - Select the feature which have the largest variance of similarity scores, based on the assumption that an effective feature should give good image much larger score than a mediocre one.
  - Use global weights to combine features.

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Training and Testing Results

- **Divide the labeled benchmark database into two sets.**
  - One includes 9017 images from 10 keywords, and is used for SIFT codebook training (Sec. 3), intention classifier training, and feature combination weights training.
  - Another includes 17,891 images from other 20 keywords, and is used for testing.
- **For each intention category, 200 images are manually labeled from the training set and a C4.5 decision tree is trained.**
  - Use this decision tree to classify all "good" images (3021 images) of the training set into 5 intention categories.
  - Then optimal weight for each intention category is learnt using the algorithm described in Section 2.2.

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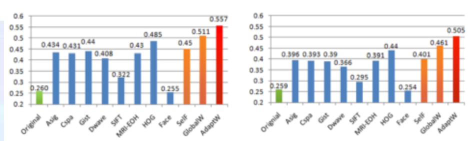
Performance Evaluation

Keywords	Precisions of each feature								Selected Feature	Global similarity	Adaptive similarity
	ASig	CSpa	Gist	DWave	SIFT	MRI-EOH	HoG	Face			
airplanes	0.333	0.320	0.327	**0.353**	0.165	0.305	0.348	0.152	**0.350**	**0.363**	**0.424**
beach	**0.633**	0.607	0.608	0.565	0.475	0.578	0.625	0.482	**0.620**	**0.687**	**0.727**
car	**0.430**	0.406	0.372	0.362	0.132	0.349	0.405	0.214	**0.378**	**0.406**	**0.492**
dolphin	**0.620**	0.583	0.491	0.573	0.319	0.446	0.467	0.272	**0.520**	**0.591**	**0.646**
guitar	0.207	0.213	0.446	0.400	0.265	0.339	**0.485**	0.103	**0.446**	**0.449**	**0.513**
paris	0.312	0.340	0.357	0.319	0.286	0.328	**0.373**	0.333	**0.3252**	**0.461**	**0.502**
rice	0.511	0.489	0.478	0.438	0.384	0.464	**0.579**	0.284	**0.499**	**0.591**	**0.656**



(a) Precision in Top 20 (b) Precision in Top 40

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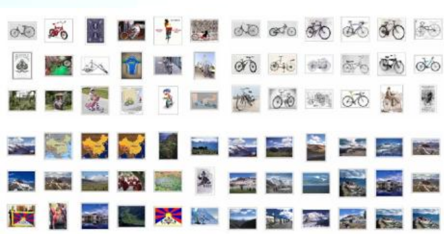
Some Search Results

- **Results of searching keywords "bicycle" and "Tibet" respectively:**



(a) (b)

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Conclusion

- **a realtime re-ranking algorithm is proposed to enhance the performance of Google Image Search and Microsoft Live Image Search, by letting user select a query image from text search results.**
  - An intention categorization model to integrate a set of complementary features adaptive to the query image.
  - A large labeled database is built to share with the community.
  - A realtime online image search engine, combining text and IntentSearch, is implemented.

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