Leveraging Exemplar and Saliency Model for Image Search Reranking – PCM2012, Singapore

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Outline

- Introduction
- Reranking Method
  - Region of Interest (ROI) introduction
  - Exemplar Based Model
  - Saliency Map Based Model
  - ExSM Model
- Experiment results
- Conclusions
Introduction: Image Re-ranking

How?

Reranking

Arc de Triomphe
Introduction: State of Art Methods

- Graph-based method. [Winston 2007]
- Classification model. [F.Schroff 2007]
- Clustering method. [Reinier 2009]
Region of Interest (ROI) Introduction

- **Vocabulary Generation**
  - Training images with weak labels
  - Extract local feature (SIFT) for each image
  - Perform k-means to build a vocabulary (k=3,000)

**Initialization**

**Iterative Optimization**

**Model Generation**
Region of Interest (ROI) Introduction

- Find discriminative words for each category using $D(w)$ function
- Find feature points in each image according to these discriminative words

Vocabulary Generation

Initialization

Iterative Optimization

Model Generation

Vocabulary Generation

Overall feature vocabulary

discriminative words for cat (sorted, top 64)
Region of Interest (ROI) Introduction

- **Vocabulary Generation**
- **Initialization**
- **Iterative Optimization**
- **Model Generation**

**Limited sliding window search to minimize the distance of each image pair**

Initial bounding box

Window search (size, position)

Bounding box after window search

**Examples:**
- Cat
- Cat
Region of Interest (ROI) Introduction

- **Vocabulary Generation**
- **Initialization**
- **Iterative Optimization**
- **Model Generation**

Select words with highest $D(w)$ values as discriminative words for each concept.
Reranking Method

- **Exemplar Based Model**
  
  [Chum & Zisserman 2007 CVPR]

- The score of each image:

$$S_{Ex} = \sum_{i=1}^{W} (e(\omega_i) \cdot n(\omega_i))$$

- $e(\omega_i)$ the number of $\omega_i$ appearing in the trained vocabulary. $n(\omega_i)$ in the test.
Reranking Method

- **Saliency Map Based Model** [Jonathan 2007]
- **The score formulation is given:**

\[ S_{SM} = \sum_{i=1}^{W} (s(\omega_i) \times m(\omega_i)), \text{ if } s(\omega_i) > \tau \]

\( m(\omega_i) \) represents the number of \( \omega_i \) in the test image.
Reranking Method

- **ExSM model**
  Combination of Exemplar Model and SM

\[
S_{ExSM} \propto p(\omega \mid SM, Ex)
\]

\[
\propto p(SM, Ex \mid \omega) p(\omega)
\]

\[
\propto p(SM \mid Ex, \omega) p(Ex \mid \omega) p(\omega)
\]

\(p(w)\) the probability of visual word \(w\).
Reranking Method

- **ExSM model**

  Assume \( p(SM) \) is independent of \( p(Ex) \)

  \[
  S_{ExSM} \propto p(SM \mid \omega) p(Ex \mid \omega) p(\omega)
  \]

  So we have.

  \[
  S_{ExSM} = \sum_{i=1}^{W} (e(\omega_i) \times p(Ex \mid \omega_i) \times s(\omega_i) \times p(SM \mid \omega_i))
  \]

  \( p(Ex \mid \omega_i) \) the probability when the \( \omega_i \) appears that it belongs to Exemplar model.
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Experimental setting and performance evaluation.

- **Experimental setting**
  - each class contains ~100 images.
- **NDCG (Normalized Discounted Cumulative Gain)**

\[
\text{NDCG}_n = Z_n \sum_{i=1}^{n} \frac{2^r_i - 1}{\log_2(1+i)}
\]
Experimental results

(a) Exemplar model key points

(b) SM key points

(c) ExSM key points

The key points on images of seven different classes: object (bottle, cat, chair, dog, person) and scene (sea, wedding) returned by three models.
Experimental results

Top 7 “bicycle” images from Flickr retrieval results, reranking results using Exemplar, SM, and ExSM.
Experimental results

Top 7 “wedding” images from Flickr retrieval results, reranking results using Exemplar, SM, and ExSM.
Performance of the reranking methods

(a) Object Results

(b) Scene Results
Experimental results

The mean and standard deviation of image reranking performance using three models.

<table>
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<th>$\mu_{all}$</th>
<th>$\mu_{obj}$</th>
<th>$\mu_{sce}$</th>
<th>$\sigma_{all}$</th>
<th>$\sigma_{obj}$</th>
<th>$\sigma_{sce}$</th>
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<tbody>
<tr>
<td>Exemplar</td>
<td>0.857</td>
<td><strong>0.939</strong></td>
<td>0.775</td>
<td>0.091</td>
<td><strong>0.028</strong></td>
<td>0.067</td>
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<tr>
<td>SM</td>
<td>0.872</td>
<td>0.836</td>
<td><strong>0.908</strong></td>
<td>0.065</td>
<td>0.067</td>
<td><strong>0.056</strong></td>
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<tr>
<td>ExSM</td>
<td><strong>0.946</strong></td>
<td><strong>0.951</strong></td>
<td><strong>0.941</strong></td>
<td><strong>0.047</strong></td>
<td><strong>0.024</strong></td>
<td>0.054</td>
</tr>
</tbody>
</table>

- Exemplar model performs better than SM on object classes.
- SM performs better for scene classes.
- ExSM model can obtain improved reranking performance.
Conclusions

- We propose a reranking method which combines Exemplar and SM model.
- Exemplar model performs better for object classes.
- Saliency Map model performs better for scene classes.
- Our combination method can obtain better performance for both object and scene classes.
Thanks for your attention!
Questions & Discussion?