Query Expansion with Diffusion on Mutual Rank Graphs

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Introduction

Image Retrieval with Query Expansion

- Assume that most high-ranked images, referred to as pivots, are true positives.
- Reissue pivots as an expanded query to improve the coverage of visual aspects.

Danger of Query Drift

False positives among pivots make the inference of the expanded query diverge from the object of interest.

Query Expansion with Feature Selection

- Discard noisy image features from pivots by imposing similarity and frequency constraints [Tolias’14] or spatial consistency constraints (spatial verification) [Chum’07][Tolias’14][Shen’14][Wu’18].
- Limited to specific image representations.

Image Retrieval with Diffusion

- Diffuse image similarities through an image graph defined on all database images.
- Require large-scale matrix manipulations.
- Suffer from the presence of false positives in the image graph.
- Implicitly assume that images of different object classes are uniformly distributed in a descriptor space.

Contributions

Incorporation of Diffusion into Query Expansion

- A more efficient solution for diffusion.
- More robust as regards false positives in the image graph.

Proposal of Mutual Rank Graph

- Account for varying local densities of different object classes in the descriptor space.

Query Expansion as Marginalization

The probability of a database image being relevant to the query is estimated by marginalizing over the distribution of pivots.

Learning Pivot Distribution with Diffusion

- Incorporates the diffusion process into the learning of pivot distributions.

Previous affinity definitions

Assume that data of different classes are distributed according to the same scale.

Example of affinity graph (ASMK*)

The pivots surrounded by the dashed circle were underrated after diffusion due to their small query similarities.

Example of mutual rank graph

Our method took their low densities into account and greatly increased their learned probabilities.

Reciprocal of mutual rank

\[ r(x, y) = \frac{1}{1 + d(x, y)} \]

Example of affinity graph (ASMK*)

Our method emphasizes the green point more because it has a higher mutual rank with respect to the blue point.

Experiments

Parameter Investigation

MAP comparison with state of the art using handcrafted features

Qualitative Results

Precision at the position where each instance is retrieved is shown under the corresponding image for ASMK* without and with our QE method.

Table: Precision at different #pivot in KNN Graph

<table>
<thead>
<tr>
<th>QIE</th>
<th>SP</th>
<th>#pivot</th>
<th>Oxford5K</th>
<th>Oxford105K</th>
<th>Paris6K</th>
<th>Rand10k</th>
<th>Rand100k</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASMK*</td>
<td>X</td>
<td>50</td>
<td>84.9</td>
<td>79.5</td>
<td>82.4</td>
<td>75.1</td>
<td>76.9</td>
</tr>
<tr>
<td>ASMK+DP-LC (GLOBAL)</td>
<td>X</td>
<td>50</td>
<td>89.3</td>
<td>88.0</td>
<td>87.3</td>
<td>88.6</td>
<td>89.0</td>
</tr>
<tr>
<td>ASMK+DP-LC-MR</td>
<td>X</td>
<td>100</td>
<td>90.1</td>
<td>88.6</td>
<td>87.3</td>
<td>88.0</td>
<td>89.0</td>
</tr>
</tbody>
</table>

The query and the three pivots surrounded by the dashed circle in the graphs above.