Enhancing Spatial Consistency Enforcement By Using DPM-based Object Localizer

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General Instance Search Framework (1)

Hessian-affine + RootSIFT → Codebook with 1M codewords → Quantization → tf-idf weighting

DPM + RANSAC for post-processing ← Asymmetric measurement ← Inverted file ← Average Pooling

Our contribution this year (2014)
Our focus last year (2013)²

(1) *Three things everyone should know to improve object retrieval*, R. Arandjelović, A. Zisserman, CVPR 2012

Method Overview

1. Query images
2. Build DPM model
3. Retrieve top K shots using BOW model
4. Top K shots
5. Remove outlier shared words using RANSAC
6. Compute DPM score and bounding box
7. Compute new score (*)
8. Sort score
9. Final ranked list
BOW is Good

- Background is helpful.
But ...

- Small objects
But ...

- Burstiness
Why Geometric Verification?

- Avoid false matches.
- Take into account spatial arrangement of matched points.
Geometric Verification by RANSAC
Geometric Verification by RANSAC
Geometric Verification by RANSAC

Before

After
Our Proposal

● Existing methods
  ○ Same treatment for correct and incorrect matches.
  ○ Not effective with small objects (number of matches is below 4).

● Our method
  ○ Different treatments of correct and incorrect matches
    → HOW: to use estimated location returned by an object localizer
      (e.g. DPM-based object localizer)

● Benefit:
  ○ Since RANSAC is point-based and DPM is region-based spatial consistency verification, they are expected to be complementary each other.
DPM-based Object Localizer

- **Benefit:**
  - Model query object as a shape structure.
  - Work well with small and texture-less object.
  - Augment bounding box information.

Visualization of DPM model for query 9109
How useful is DPM

Wrong shared words case

No shared word case
DPM: The Good and The Bad
Geometric Verification by Our Method

- Assume matches are verified by RANSAC.
- Divide these matches into 3 categories
  - (green ones): high confident matches.
  - (blue ones): low confident matches.
  - (black ones): background matches.
  - (red ones): false matches removed by RANSAC.
- Re-scoring
  - Base score: (naive) fusion of BoW and DPM.
  - Boost the base score for high confident matches.
Re-scoring

\[ S_{new} = \left(1 + N_d\right)^2 \left(1 + N_{fg} - N_d\right) \log_2 \left(2 + N_{bg}\right) (w_1 S_{BOW} + w_2 S_{DPM}) \]

where:

\( N_d \): number of shared words of foreground inside bounding box (green lines)
\( N_{fg} \): number of shared word of foreground (both blue and green lines)
\( N_{bg} \): number of shared word of background (black lines)
\( w_1 \): weight of BOW score
\( w_2 \): weight of DPM score
## Experiments

<table>
<thead>
<tr>
<th>Run Name</th>
<th>MAP*</th>
<th>Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOW</td>
<td>22.51</td>
<td>Standard BOW with asymmetric dissimilarity.</td>
</tr>
<tr>
<td>DPM only</td>
<td>19.11</td>
<td>Run DPM on Top K shots returned by BOW.</td>
</tr>
<tr>
<td>BOW + RANSAC+ tf-idf weighting</td>
<td>25.67</td>
<td>Run RANSAC + tf-idf weighting as a new score.</td>
</tr>
<tr>
<td>BaseScore[BOW + DPM]</td>
<td>25.41</td>
<td>$w_1S_{BOW} + w_2S_{DPM}$: based score only.</td>
</tr>
<tr>
<td>Fusion[BOW+DPM w/o RANSAC]</td>
<td>26.25</td>
<td>Compute Nd, Nfg, Nbg including outliers.</td>
</tr>
<tr>
<td>Fusion[BOW+DPM with RANSAC]</td>
<td>29.24</td>
<td>$S_{new} = (1 + N_d) (1 + N_{fg} - N_d) \log_2 \left(2 + N_{bg}\right) \left(1S_{BOW} + 2S_{DPM}\right)$</td>
</tr>
</tbody>
</table>

(*) this score is computed using ourselves function

We obtain consistent results on both INS 2013 and INS 2014.
INS - Result

Performance of TRECVID Instance Search Task
Best Run Result

- Our 3 runs achieve the best performance for total 10 queries.
Unsolved problems → PERSON query
Conclusions

- **New flexible fusion scheme to improve the accuracy**
  - key idea: combine verified matches (RANSAC) and estimated object location (DPM).
  - Since RANSAC is point-based and DPM is region-based spatial consistency verification, they are complementary each other.
  - good in the cases:
    - small size object.

- **Experiments**
  - **Pros:** 30% MAP improved (both INS 2013 & INS 2014).
  - **Cons:** slow in DPM and RANSAC verification step.