Task: find pixel-level image correspondences
Task: find pixel-level image correspondences
Task: find pixel-level image correspondences
Task: find pixel-level image correspondences
Task: find pixel-level image correspondences
Task: find pixel-level image correspondences
Task: find pixel-level image correspondences

day-night matching
Task: find pixel-level image correspondences

changes across time
Task: find pixel-level image correspondences

repetitive structures
Task: find pixel-level image correspondences

intra-class variation
Motivation:
Motivation:

robot localization

Taira et al. CVPR 2018
Motivation:

robot localization

Taira et al. CVPR 2018
Agarwal et al. CACM 2011

3d reconstruction
Motivation:

- Robot localization
- 3D reconstruction
- Annotation transfer

Taira et al. CVPR 2018
Agarwal et al. CACM 2011
Rocco et al. CVPR 2017
Review - classical pipeline
Review - classical pipeline

1. Feature extraction
2. Tentative matching
3. Match filtering

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Review - classical pipeline

1. Feature extraction
2. Tentative matching
3. Match filtering

SIFT

Lowe et al. IJCV 2004
Review - classical pipeline

1. Feature extraction
2. Tentative matching
3. Match filtering

Mutual matches

$I_A$ $\rightarrow$ $\text{NN}_{A \rightarrow B}$ $\rightarrow$ $I_B$

$\text{NN}_{B \rightarrow A}$
Review - classical pipeline

1. Feature extraction
2. Tentative matching
3. Match filtering

Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Review - classical pipeline

1. Feature extraction
2. Tentative matching
3. Match filtering

Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

$I_A$

$I_B$

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

$I_A$  $I_B$

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

$\mathcal{I}_A$  $\mathcal{I}_B$

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

\[ I_A \quad I_B \]

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

\[ I_A \]

\[ I_B \]

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Neighbourhood consensus

Schmid et al. PAMI 1997
Schaffalitzky et al. CIVR 2002
Sivic et al. ICCV 2003
Proposed method
Proposed method

Proposed method

1. Dense CNN features
2. Exhaustive matching
3. Neighbourhood Consensus Network
Proposed method

1. Dense CNN features
2. Exhaustive matching
3. Neighbourhood Consensus Network
Proposed method
Proposed method

Feature extraction

\[ I^A \]

\[ I^B \]
Proposed method

Feature extraction

$F$: feature extraction CNN

$IA \rightarrow F \rightarrow IB$
Proposed method

\[ F : \text{feature extraction CNN} \]

\[ f^A, f^B : \text{dense feature maps} \]
Proposed method

$F$: feature extraction CNN

$f^A, f^B$: dense feature maps
Proposed method

Matching

\[ F: \text{feature extraction CNN} \]
\[ f^A, f^B: \text{dense feature maps} \]
\[ c_{ijkl}: \text{4D correlation tensor} \]

\[ c_{ijkl} = \frac{\langle f^A_{ij}, f^B_{kl} \rangle}{\| f^A_{ij} \|_2 \| f^B_{kl} \|_2} \]
Proposed method

\( F \): feature extraction CNN

\( f^A, f^B \): dense feature maps

\( c_{ijkl} \): 4D correlation tensor

Number of matches: \( N^2 \)

Correct matches: \(~N\)
Proposed method

Feature extraction and matching

Neighbourhood Consensus Network

$f^A_{(i,j)}

f^B_{(k,l)}

C_{ijkl}$
Proposed method

Feature extraction and matching

\[ f_A \]

\[ f_B \]

Neighbourhood Consensus Network

\[ N(\cdot) \]

Filtered matches
Proposed method

Feature extraction and matching

\[ f_A \]
\[ f_B \]

Neighbourhood Consensus Network

\[ N(\cdot) \]

4D convolutional layers

Filtered matches
Proposed method

Neighbourhood Consensus Network

4D convolutional layers

Filtered matches

Feature extraction and matching
Proposed method

Feature extraction and matching

\[ f_A \]

\[ f_B \]

Neighbourhood Consensus Network

\[ N(\cdot) \]

Filtered matches

4D convolutional layers
Proposed method

Feature extraction and matching

4D convolutional layers

Neighbourhood Consensus Network

Filtered matches
Proposed method

Feature extraction and matching

\[ f_A \]

\[ (i, j) \]

\[ f_B \]

\[ (k, l) \]

\[ c_{ijkl} \]

Neighbourhood Consensus Network

\[ N(\cdot) \]

4D convolutional layers

Filtered matches
Weakly supervised training
Weakly supervised training

Only image-level supervision is required
Weakly supervised training

Only image-level supervision is required
Weakly supervised training

Only image-level supervision is required

Positive pair
Weakly supervised training

Only image-level supervision is required

Negative pair
Weakly supervised training

Training objective:
Weakly supervised training

Training objective:

Positive pair
Weakly supervised training

Training objective:

Maximize overall matching score
Weakly supervised training

Training objective:

Maximize overall matching score
Weakly supervised training

Training objective:

Minimize overall matching score

Maximize overall matching score
Category-level matching (PF-Pascal)
Category-level matching (PF-Pascal)

- Task: match similar semantic parts
Category-level matching (PF-Pascal)

- Task: match similar semantic parts
Category-level matching (PF-Pascal)

- Task: match similar semantic parts

annotated object parts

Ham et al. PAMI 2017
Category-level matching (PF-Pascal)

- Task: match similar semantic parts

annotated object parts

Ham et al. PAMI 2017
Category-level matching (PF-Pascal)

- Task: match similar semantic parts
Category-level matching (PF-Pascal)

- Task: match similar semantic parts

NCNet results
Instance-level matching (InLoc)
Instance-level matching (InLoc)

- Task: recover query camera pose
Instance-level matching (InLoc)

- Task: recover query camera pose

query image

Taira et al. CVPR 2018
Instance-level matching (InLoc)

- Task: recover query camera pose

query image

Taira et al. CVPR 2018
Instance-level matching (InLoc)

- Task: recover query camera pose

query image  RGBD database image

Taira et al. CVPR 2018
Arandjelović et al. CVPR 2016

image retrieval (NetVLAD)
Instance-level matching (InLoc)

- Task: recover query camera pose

query image → pixel-wise correspondences → RGBD database image

Taira et al. CVPR 2018
Arandjelović et al. CVPR 2016
Instance-level matching (InLoc)

- Task: recover query camera pose

query image \[\leadsto\] RGBD database image

\[\begin{align*}
\text{PnP} \\
R, t
\end{align*}\]

Taira et al. CVPR 2018
Arandjelović et al. CVPR 2016
baseline: InLoc
[Taira et al. CVPR’18]
baseline: InLoc
[Taira et al. CVPR’18]
mismatch

baseline: InLoc
[Taira et al. CVPR’18]

Pose error: 6.65m, 23.8°
InLoc+NCNet
InLoc+NCNet

Pose error: 0.41m, 0.83°
Ground-truth pose

Estimated pose (ours) 0.41m, 0.83°

Estimated pose (InLoc) 6.65m, 23.8°
Thank you!

Code and trained models at: https://www.di.ens.fr/willow/research/ncnet/

Poster AB #118 @ Wed Session A