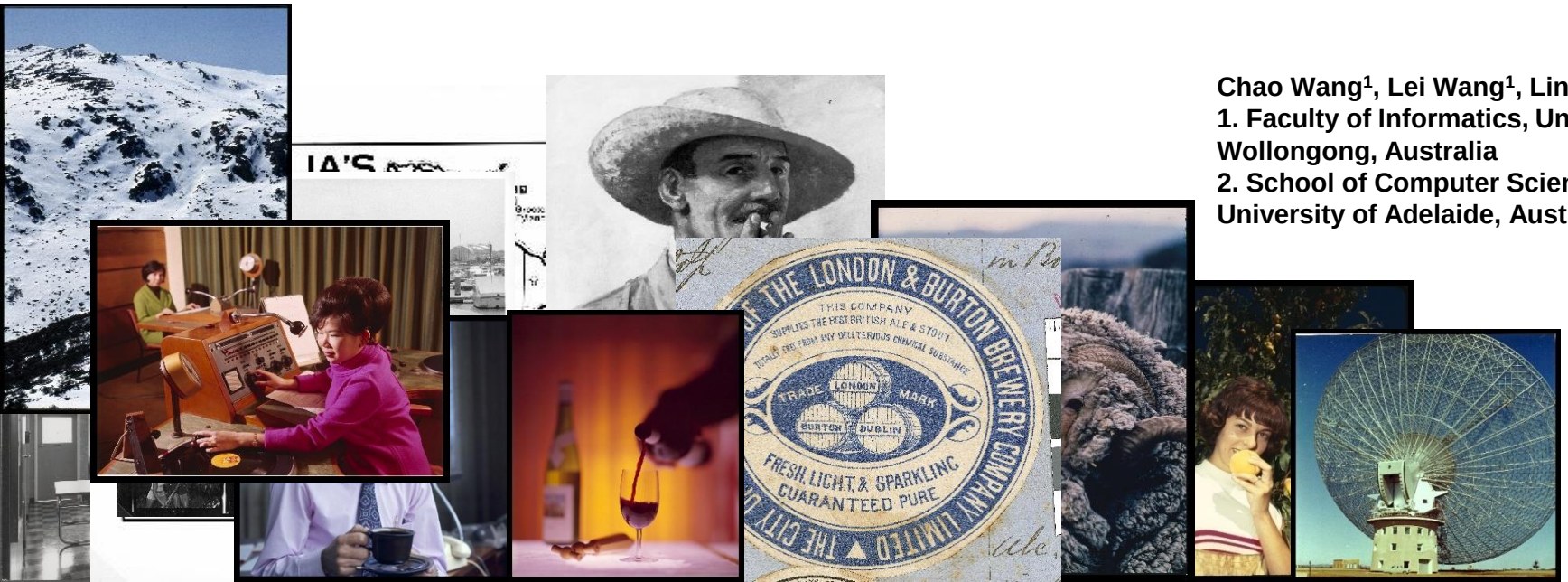
Progressive mode-seeking on graphs for sparse feature matching



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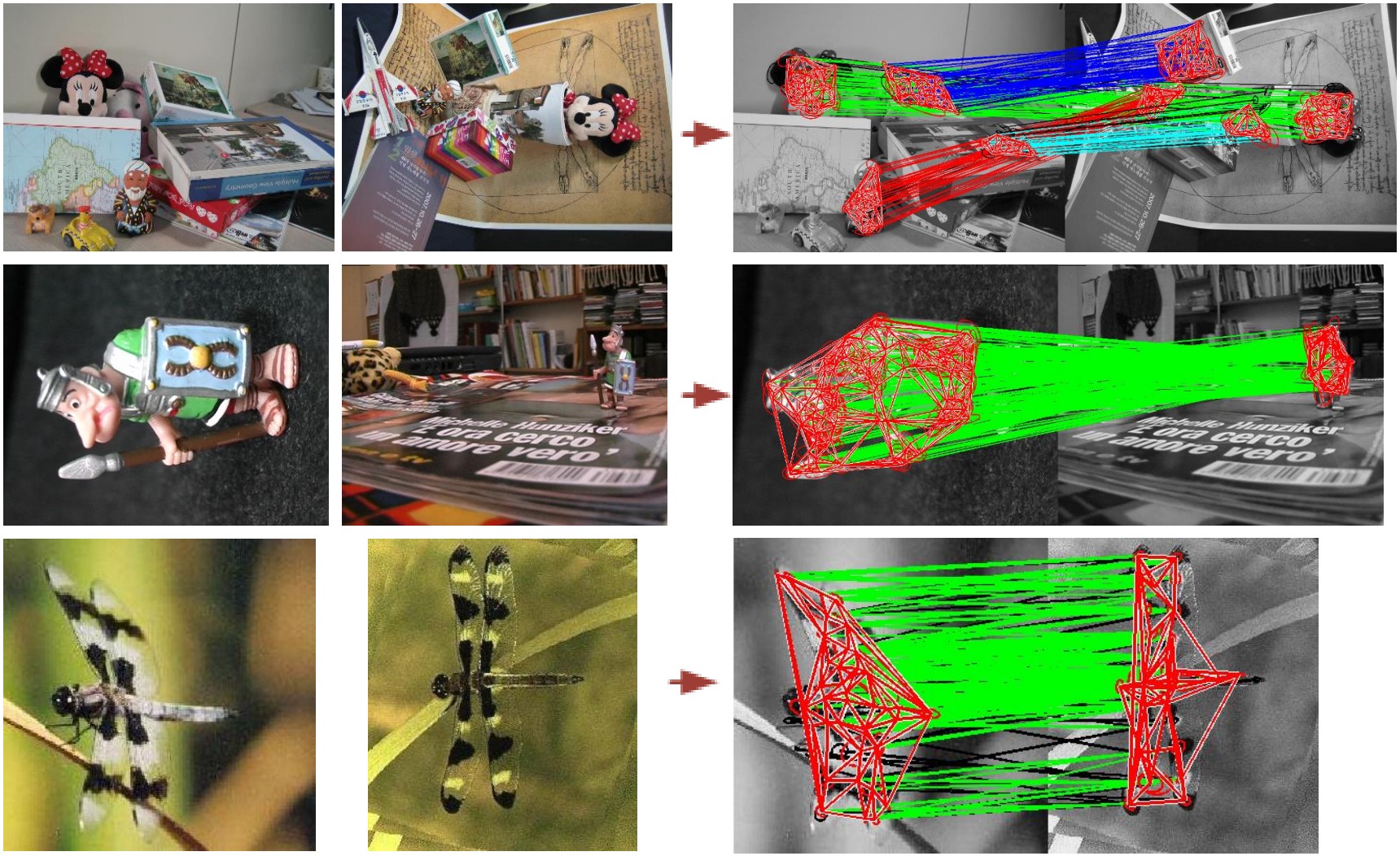
Outline

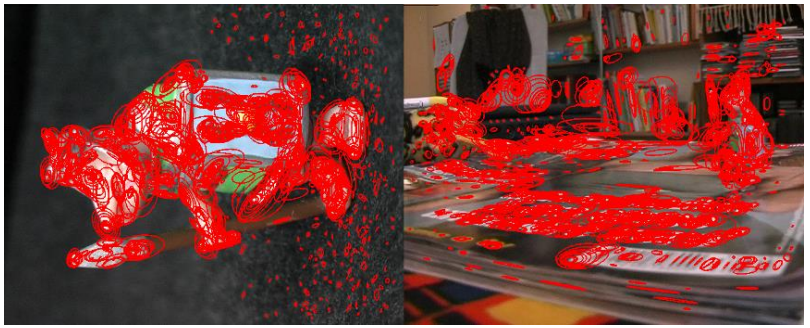
- ***Introduction***
  - **Sparse Feature Matching**
  - **Motivation**
- ***Proposed Method***
  - **Progressive Mode-seeking Algorithm (PMA)**
    - **Guided Graph Density**
    - **Density-aware Sampling**
- ***Experiments***
  - **PMA vs. the state of the arts**
- ***Limitations***
- ***Conclusion***

- **Sparse feature matching**
  - **Target**



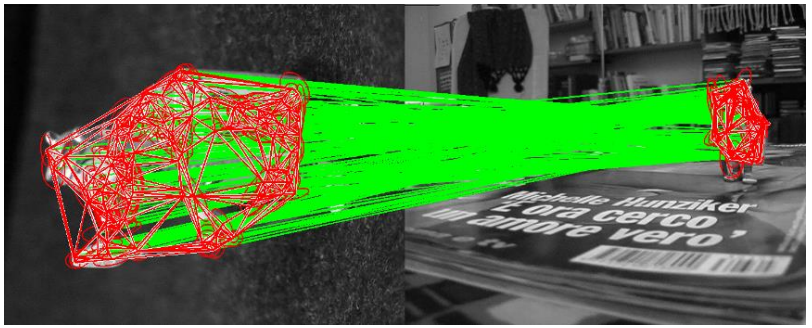
- **Sparse feature matching**
  - **Difficulties**

Input image pair



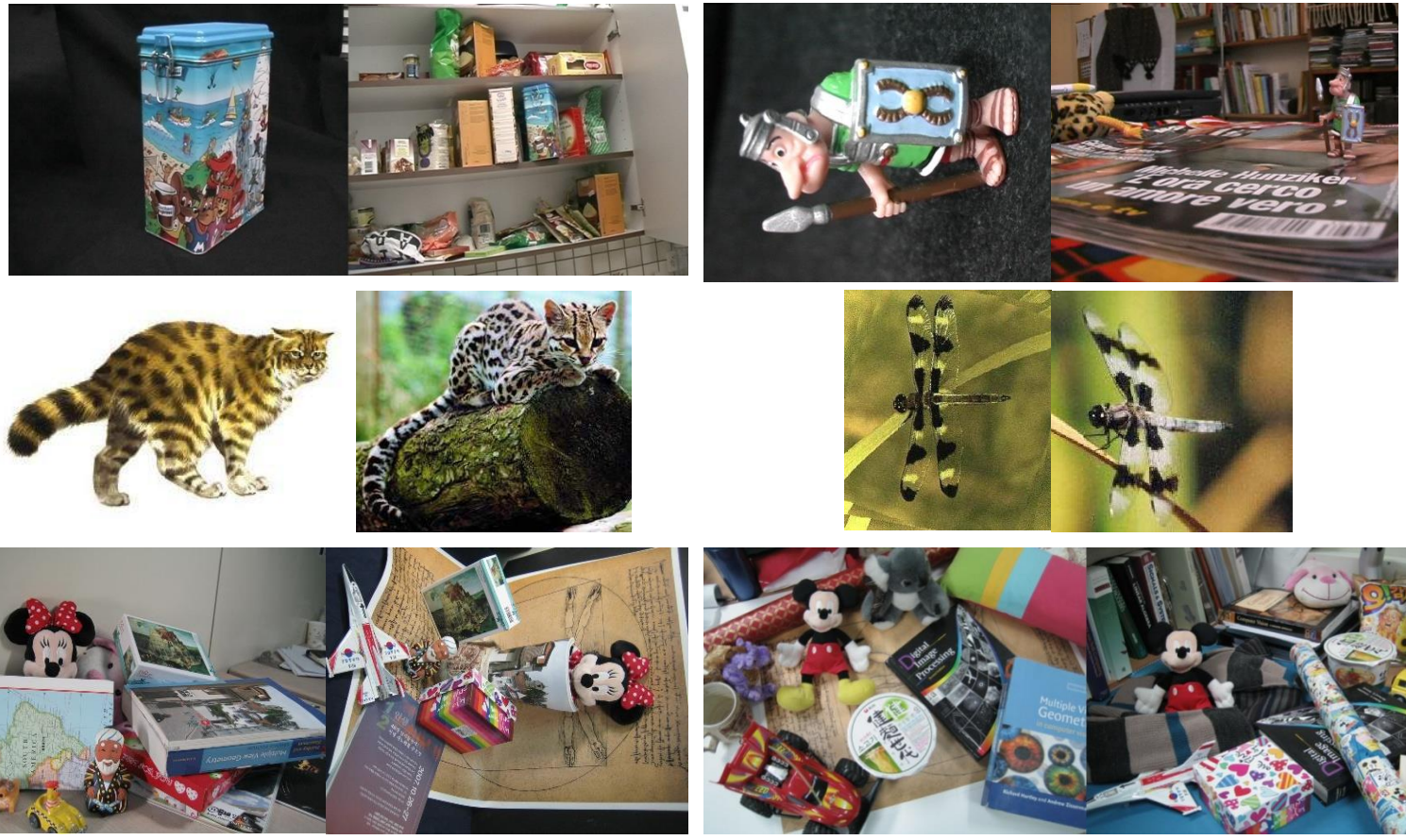
2539 and 3013 features

All possible 2539*3013 matches



Only 281 true matches

- **Sparse feature matching**
  - **Difficulties**



- **Sparse feature matching**

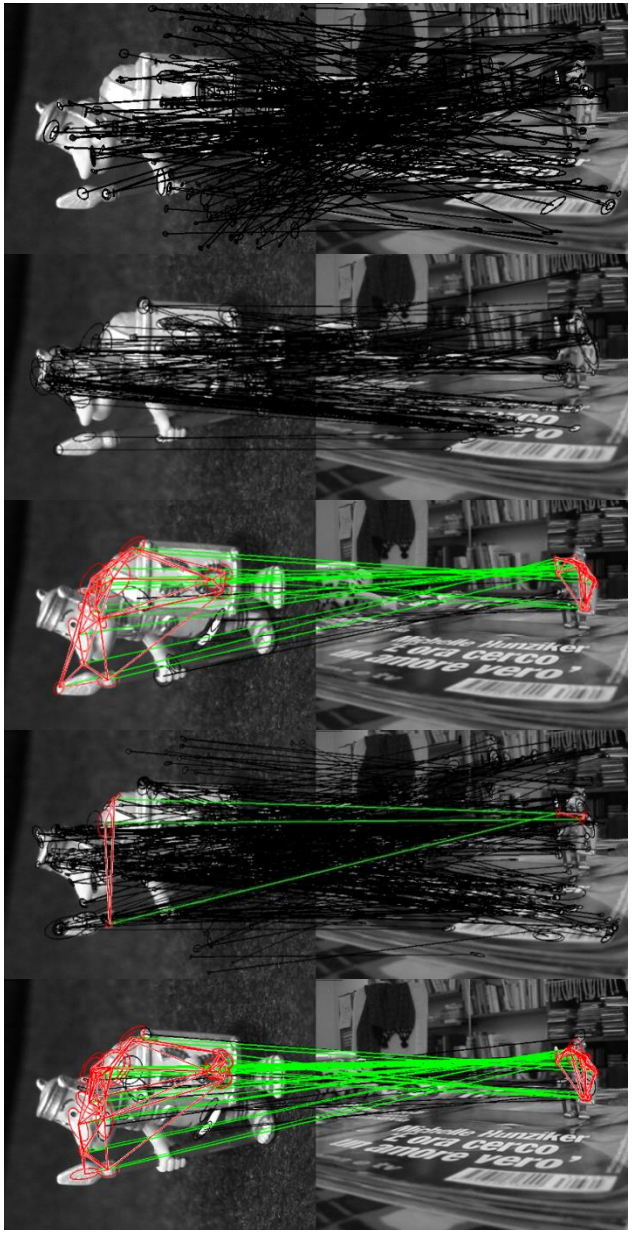
  – **Graph Matching:**
  (Cho et al. 10)

  – **Hyper-graph Matching:**
  (Duchenne et al. 09)

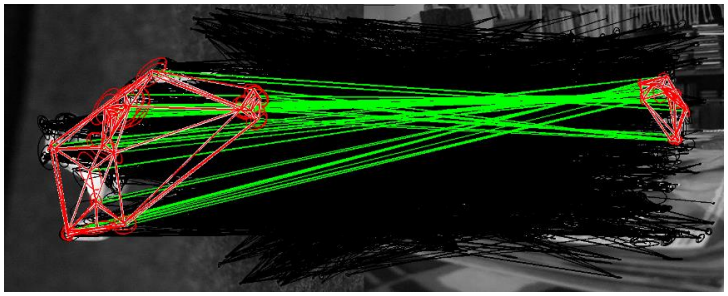
  – **Agglomerative clustering:**
  (Cho et al. 09)

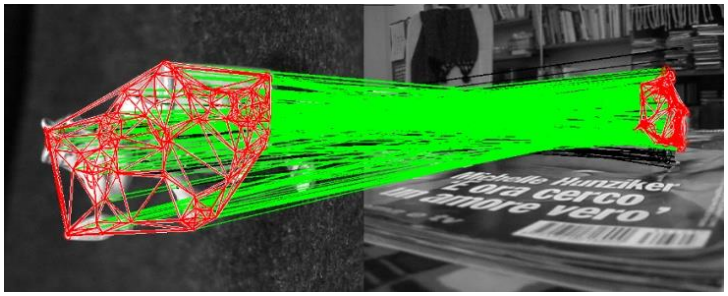
  – **Graph shift:**
  (Liu et al. 13)

  – **Mode Seeking:**
  (Cho et al. 12)



- **Motivation**
  - **Problem**
    - **Building an graph of $n_1 \times n_2$ nodes is intractable**
    - **The candidate matches by SIFT include only a small portion of all the true matches.**





How to detect true matches in the huge matching space?

- **Motivation**
  - **Problem**
    - **Progressive Graph Matching (PGM) (Cho et al. 12)**
      - **Tend to introduce many outliers**
      - **Fail for many-to-many object correspondences**

Graph Matching

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Progression

- **Motivation**
  - **Graph matching: Integer Quadratic Programming (IQP)**

$$\mathrm{G}^{\mathrm{P}} = (V^P, E^P, A^P) \qquad \mathrm{G}^{\mathrm{Q}} = (V^Q, E^Q, A^Q)$$

Objective: $x^* = \arg\max_x x^T W x$

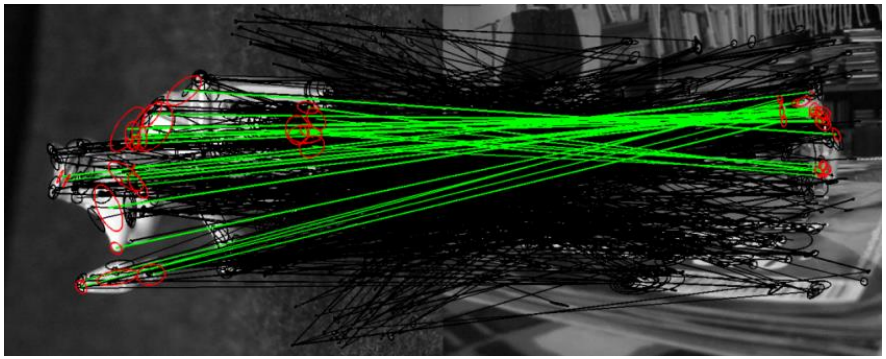
$$x \in \{0,1\}^{n^P n^Q} \qquad \forall i \sum_{a=1}^{n^Q} x_{ia} \le 1 \quad \forall a \sum_{i=1}^{n^P} x_{ia} \le 1$$

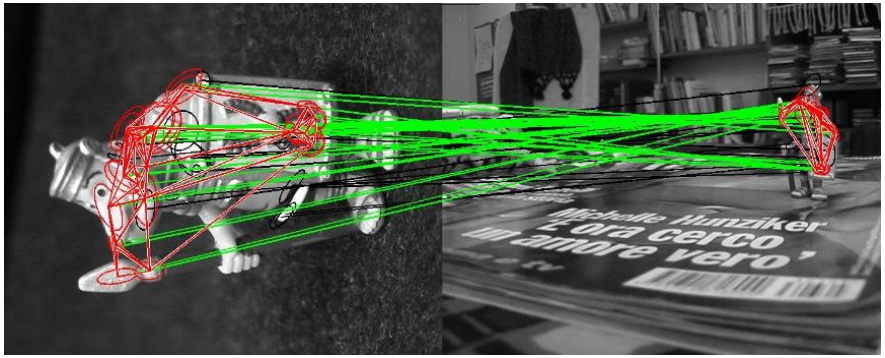
$W_{ia;ia}$ represents a unary similarity of a match

$W_{ia;jb}$ refers to a pair-wise similarity of two matches (v_i^P, v_a^Q) and (v_j^P, v_b^Q)

- **Motivation**
  - **Drawbacks of IQP: prefer more matches**

$$x^* = \arg\max_x \ f(x) = \arg\max_x \ x^T W x$$

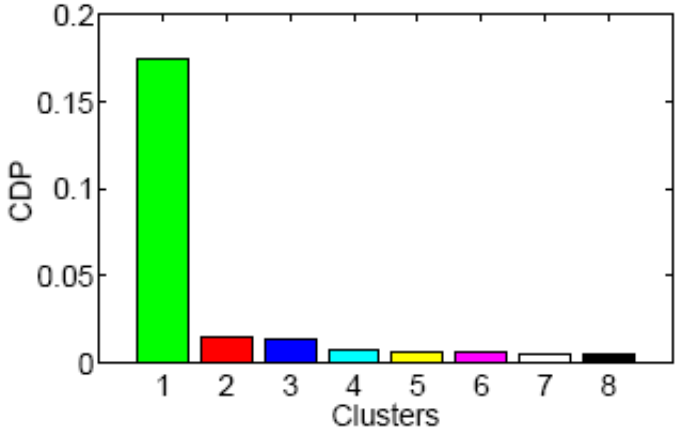
$f($  $) >$

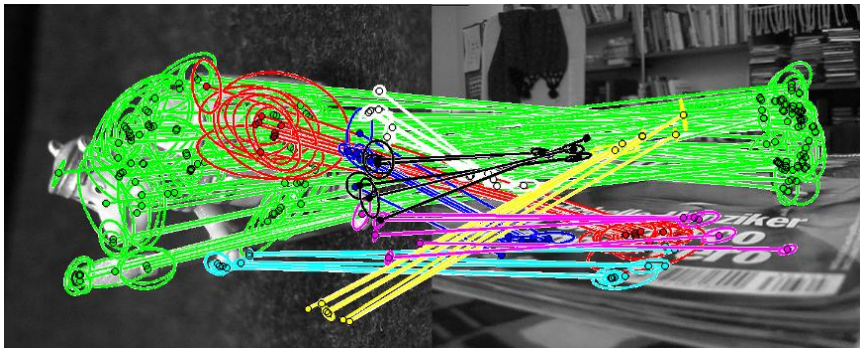
$f($  $)$

- **Motivation**
  - **Drawbacks of IQP: assumes a single cluster**

Contribution of (v_l^P, v_m^Q) : $C(l,m) = x_{lm}\left(\sum_{i \neq l, a \neq m} W_{ia;lm} x_{ia} + \sum_{j \neq l, b \neq m} W_{lm;jb} x_{jb} \right)$

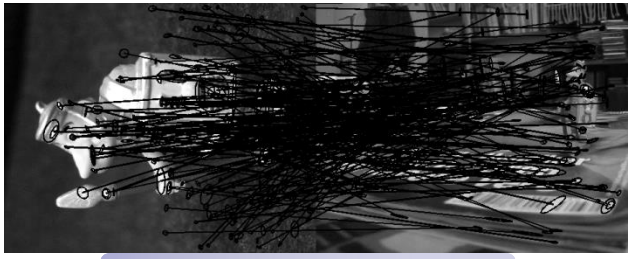
- **Motivation**
  - **Mode-seeking**
    - **Few outliers**





- **Motivation**
  - **Mode-seeking**
    - **Works well for many-to-many object correspondence**

- **Motivation**
  - **Solution**



Graph Matching

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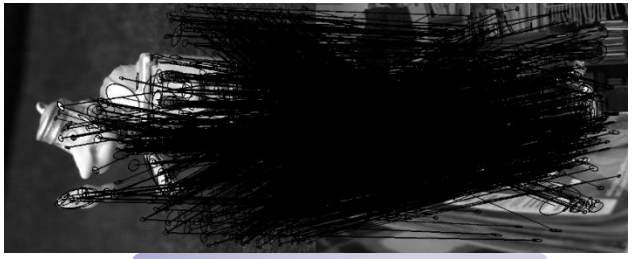

Progression

Mode-seeking

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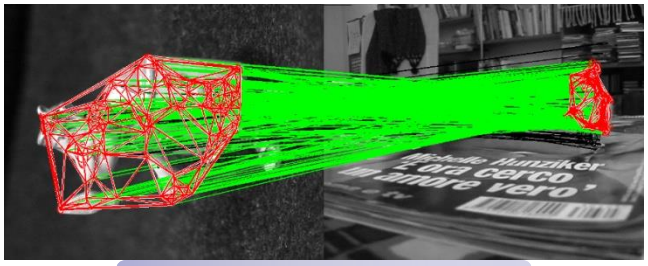
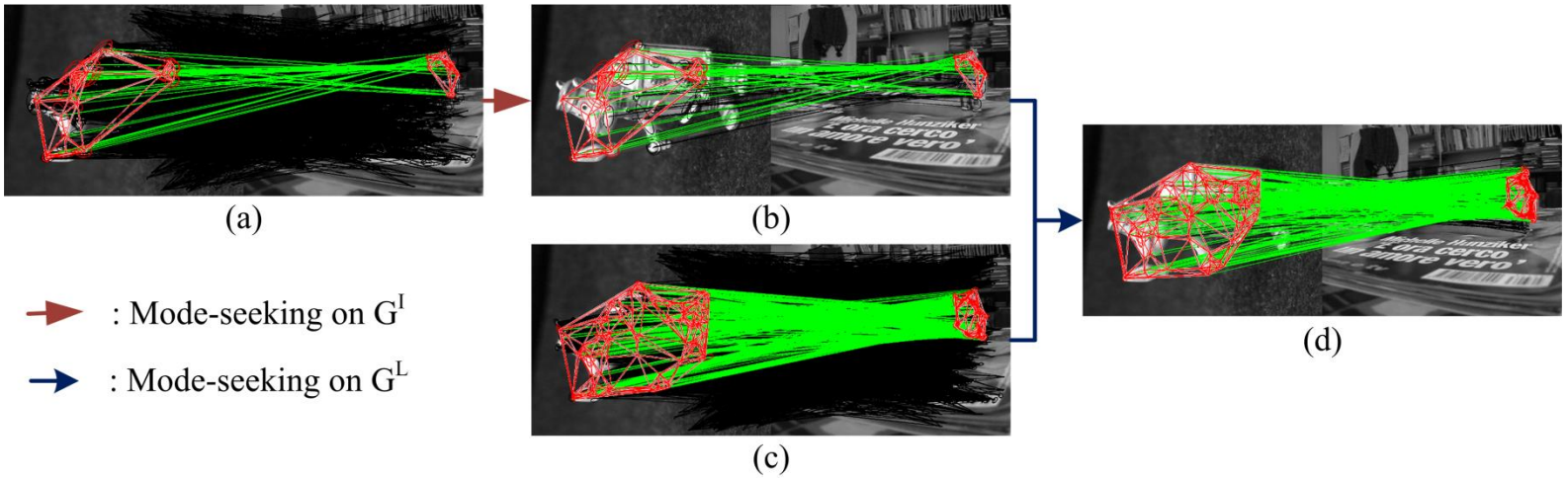
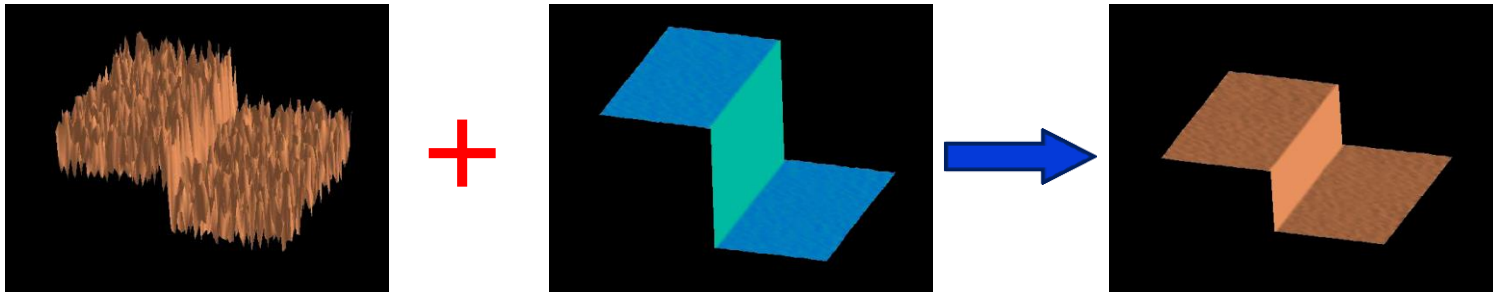


Mode-seeking

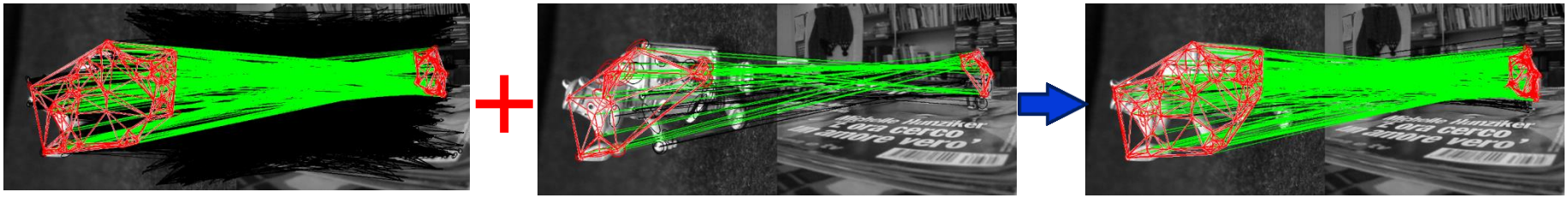
- **Proposed method**
  - **progressive mode-seeking**



- **Proposed method**
  - **Guided Graph Density**

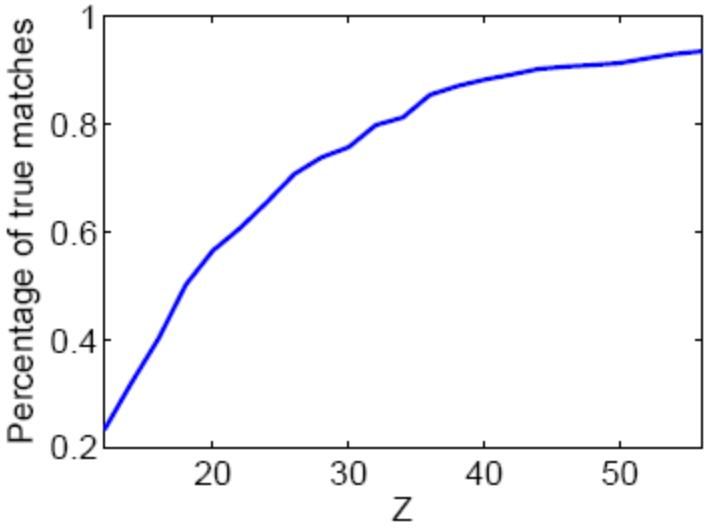


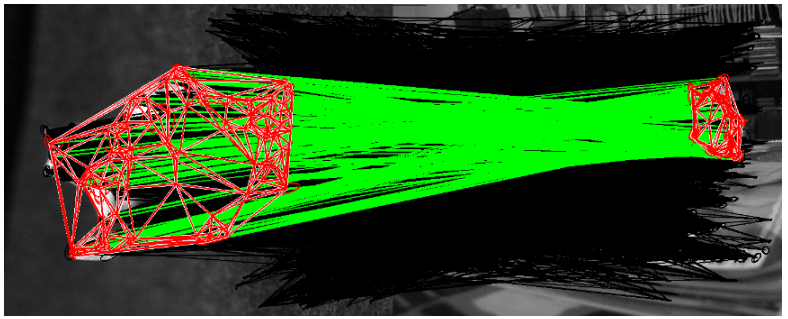
Guided filter/Joint bilateral filter



Guided Graph Density

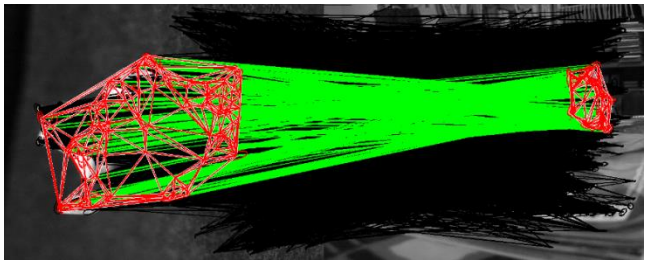
- **Proposed method**
  - **An association graph including most true matches**

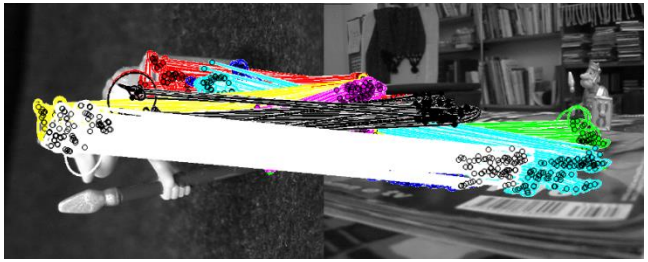




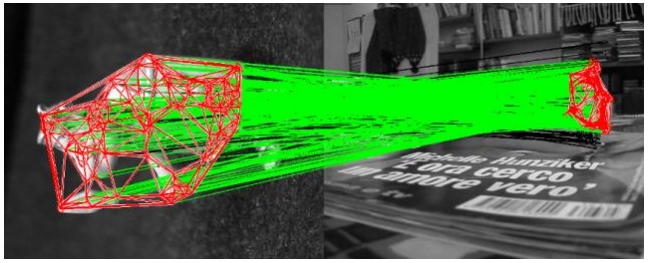
Z=40

- **Proposed method**
  - **Impact of the Guide Graph on Mode-seeking**





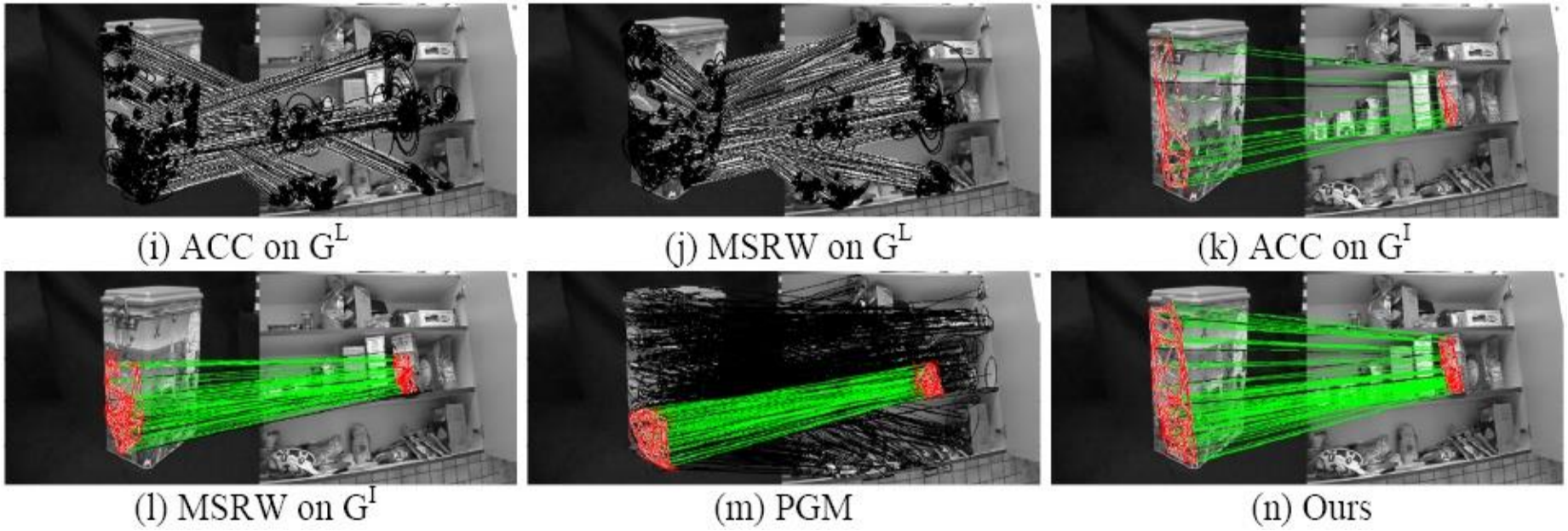
Without the Guide Graph



With the Guide Graph

- **Proposed method**
  - **Problem**
    - **Complexity: $O((Zn_1)^2)$**
  - **Density-aware sampling: $O(Zn_1m)$**
    - **Sample m nodes according to graph density**
    - **Mode-seeking on m nodes**
    - **Map backwards from large graph to the m nodes**

- **Experiments**
  - **Large transformations and background clutters**
    - **ETHZ toys dataset**

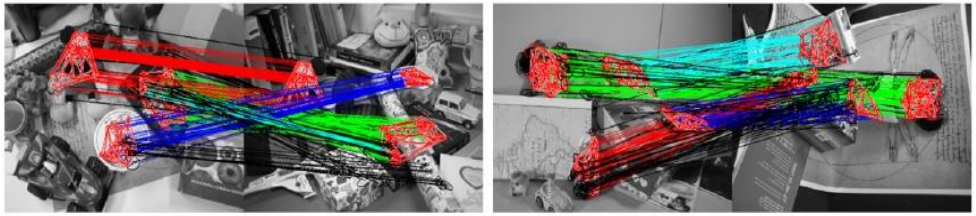


(i) ACC on G^L (j) MSRW on G^L (k) ACC on G^I

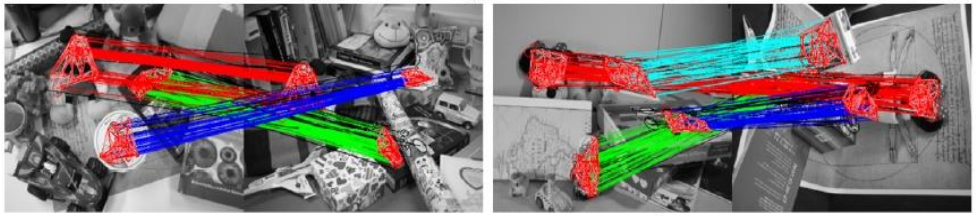
(l) MSRW on G^I (m) PGM (n) Ours

ACC: ECCV 2009, MSRW: ECCV 2010, PGM: CVPR 2012

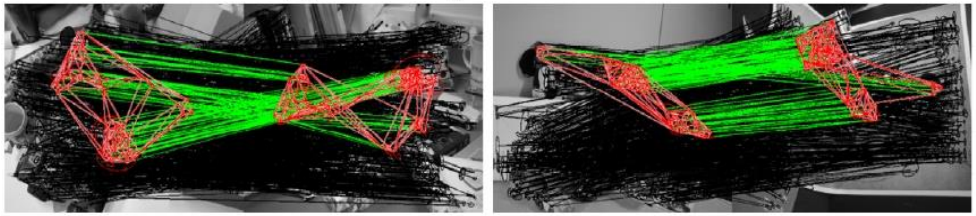
- **Experiments**
  - **Many-to-many object correspondences**



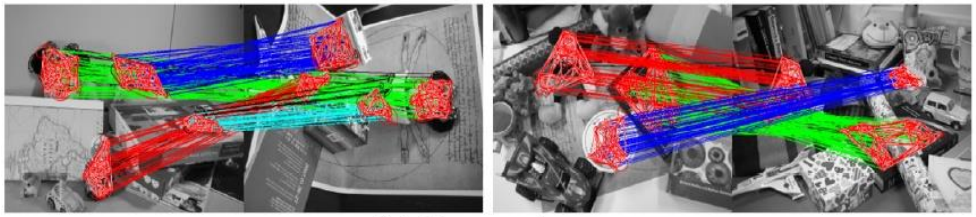
(b) Results by ACC on G^I



(c) Results by MSRW on G^I

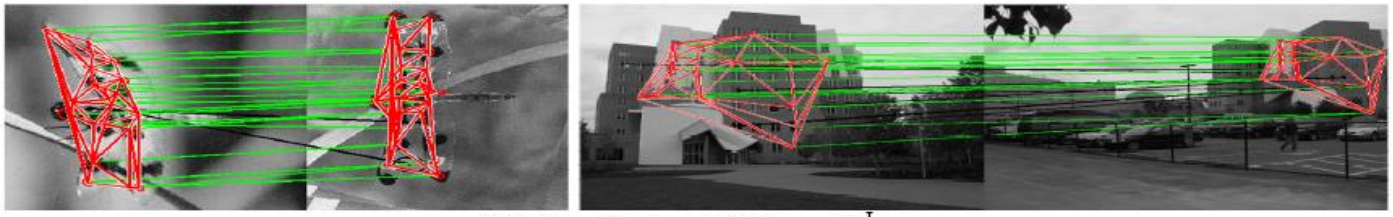


(d) Results by PGM

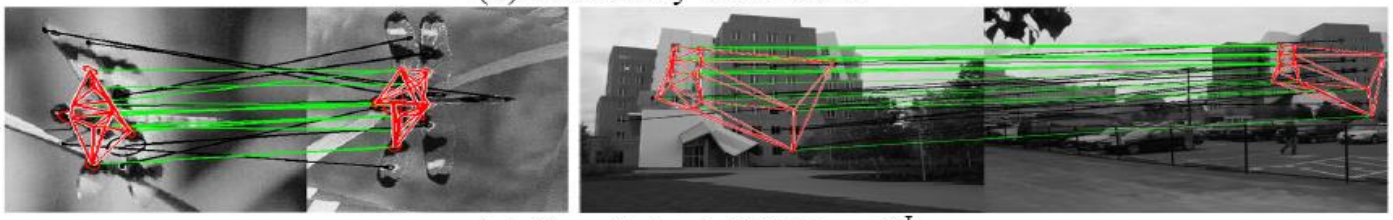


(e) Our results

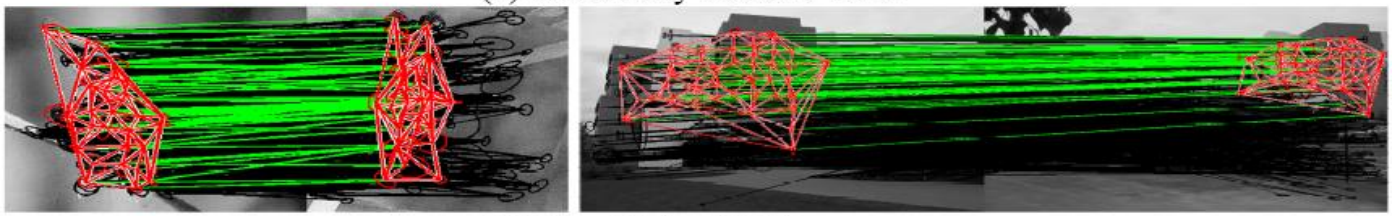
- **Experiments**
  - **Large intra-class variance**



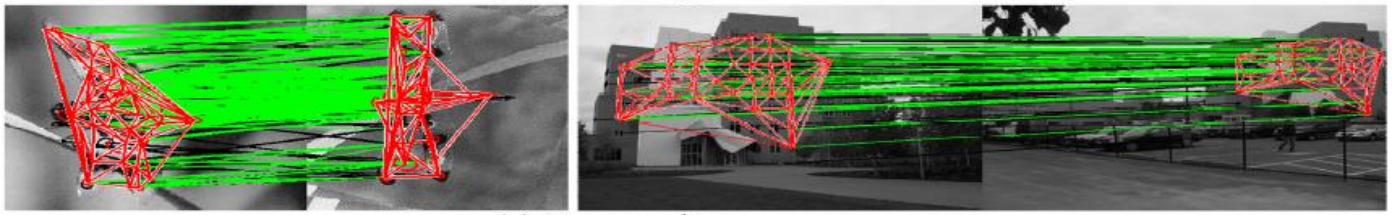
(b) Results by ACC on G^I



(c) Results by MSRW on G^I



(d) Results by PGM



(e) Our results

- **Limitations**
  - **Constrained by SIFT feature matching**
  - **Large smooth regions with little texture**
  - **Tiny-sized objects with few features**

- **Conclusion**
  - **We go from PGM to PMA**
    - **Less outliers**
    - **Handle many-to-many object correspondences**
    - **Much faster**

Thank you!