Robust Region Matching under Bounded Deformation

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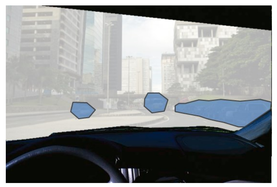
Motivation

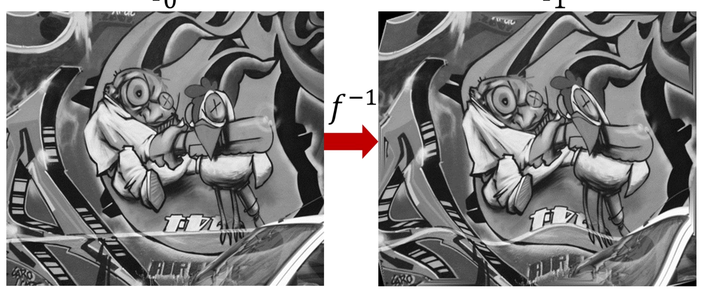
- **Application of robust region matching:**
  - Identification of vehicles and pedestrians for autonomous driving
  - Object recognition
  - Medical image registration



- **Challenges of region matching**
  - Most of deformation in real world is non-rigid
  - Matching under rigid deformation is well studied, but it does not work for non-rigid deformation, since this kind of transformation is arbitrary.

Methodology

Image Model



- Two images satisfy: $I_1(x) = I_0 \circ f(x)$

  Where $h_L(\| x - x' \|) \le \| f(x) - f(x') \| \le h_U(\| x - x' \|)$,

  $h_L(\rho) = (1 - K_d)\rho, \quad h_U(\rho) = (1 + K_d)\rho$

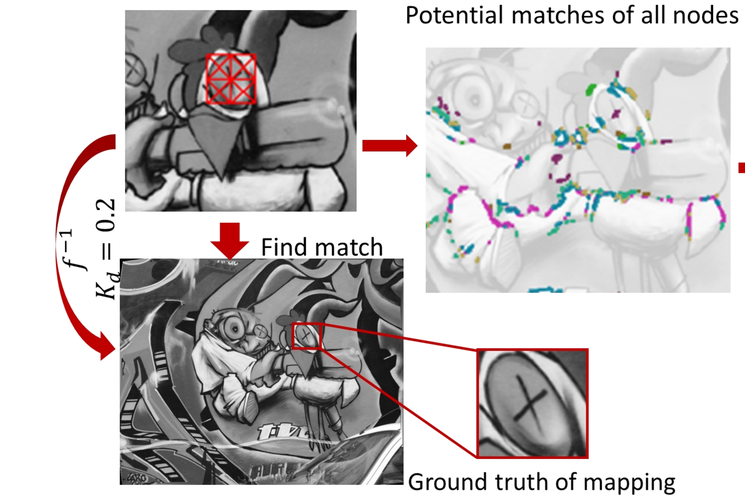
  K_d is known but f is unknown.

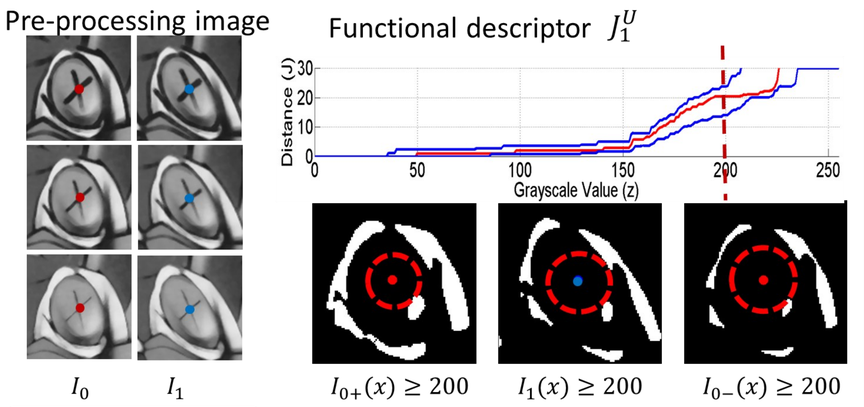
Functional Descriptor

- Image are pre-processed to guarantee that the features will be robust to unknown deformation, noise and discretization process.
- Corresponding points should satisfy:

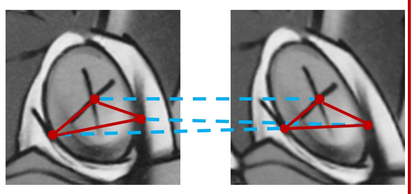
$$h_U^{-1}(J_{0+}^U(x_0, z)) \le J_1^U(f^{-1}(x_0), z) \le h_L^{-1}(J_{0-}^U(x_0, z))$$

- Potential matches for point x_0 in I_0 are all pixels satisfying this condition in I_1.

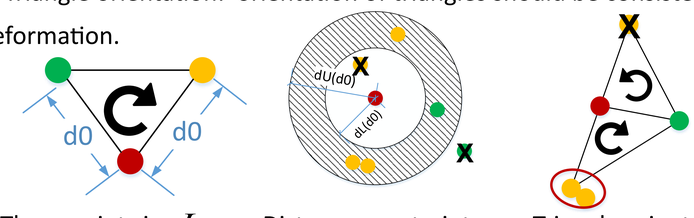




Region Matching



- To achieve region matching, construct a graph to represent a region and solve a graph matching problem.
- To remove wrong matches obtained by single point matching, two geometry constraints are used:
  - Distance constraint: distance of two points with original distance d_0 should satisfy: $h_L(d_0) \le d_1 \le h_U(d_0)$.
  - Triangle orientation: orientation of triangles should be consistent after deformation.

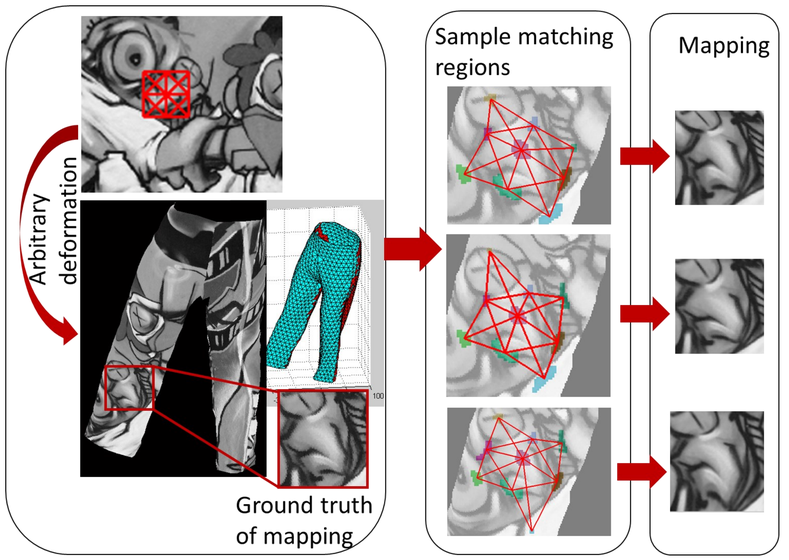


Three points in I_0 | Distance constraint | Triangle orientation

- Matching regions are obtained by constructing graphs using remaining matches of each node and f is estimated by radial basis function.

Results

- $K_d = 0.2$



Future Work

- Matching with arbitrary graphs
- Automatically select feature points to generate a initial graph
- Automatically choose sub graphs which need to be refined by uncertainty computation
- Remove more wrong matches by refining and growing of initial graph
- Apply different K_d to different part of a region