Efficient Diffusion on Region Manifolds: Recovering Small Objects with Compact CNN Representations
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Motivation

- Euclidean distance not appropriate for severe visual variations
- Solution: Ranking on manifolds via graph-based approach, i.e. diffusion [1]

Standard Diffusion [3]

- Normalized affinity (reciprocal kNN) matrix: $S := D^{-1/2}AD^{-1/2}$
- The query is part of the graph $y = (y_i) \in \mathbb{R}^n$, $y_i = 1$ if $i$-th node is a query, $y_i = 0$ otherwise
- Iterative solution preferred in prior work [1]
  $F^t = (1 - \alpha)F^{t-1} + \alpha y$
- Closed-form solution [3] commonly avoided
  $F^t = (1 - \alpha)C^{-1}y$, where $C = I - \alpha S$

Diffusion for Unseen Queries

- Toy with 2D database points, query point, and iso-contours for manifold similarity

Efficient Diffusion

- Iterative solution is not efficient: long to converge
- Closed-form solution $F^t = (1 - \alpha)C^{-1}y$ is not scalable: $C^{-1}$ not sparse
- Contribution: Solve linear system $C^{-1}F = (1 - \alpha)y$ with conjugate gradients (CG)
  - Conjugate directions with initial large step size: only a few iterations for good approximation

Regional diffusion

- Global descriptors not effective for small objects, occlusion.
- Represent images by uniformly sampled overlapping regions [2]: each image represented by $m$ vectors
- Contribution: Diffusion with regions as nodes, multiple regional queries issued with the cost of one $y_i = 1$ (or equal to similarity) if $i$-th node is a kNN of any query region, $y_i = 0$ otherwise

Large Scale Diffusion

- (Off-line) Reduce number of vectors: learn Gaussian Mixture Model (GMM) per image
- (Off-line) Use approximate NN-search for offline graph construction
- (On-line) Regional diffusion as re-ranking: only on top ranked images by truncated affinity matrix

Retrieval of Small Objects

- Toy with multiple query points
- Toy with 2D database points, query point, and iso-contours for manifold similarity

Experiments

- Speed and convergence comparison for regional diffusion between the iterative solution (PPG) and with conjugate gradient (CG)

References: