Joint Recovery of Dense Correspondence and Cosegmentation in Two Images

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Introduction

- **Input**
  - Common object cosegmentation (binary mask) and dense flow map that aligns the common region in the images

Applications

- 3D reconstruction from object categories
  - [Vicente+ CVPR’14]
- Non-parametric scene parsing
  - [Liu+ TPAMI’11, Smith+ CVPR’13, Karsch+ TPAMI’14]

Contributions

- New dataset with ground truth/evaluation toolkit
  - 400 image pairs, 7 object categories
- New joint model and inference technique
  - Discrete-continuous labeling problem for flow and segmentation estimation in a hierarchical MRF model.
  - Joint inference of hierarchical structure and labeling via an energy minimization framework using iterated graph cuts.
  - Recovers layered structure of nested image regions.

Hierarchical (layered graph) model

\[ F(G, f, a) = E_{\text{graph}}(G) + E_{\text{flow}}(f) + E_{\text{seg}}(G) + E_{\text{smooth}}(f, a) \]

Graph structure term

- Node sparsity
- Color consistency of superpixels
- HOG features for appearance matching
- Similarly transform
- FG/BG color likelihood (learned during initialization)
- Spatial neighbors
- Parent child edges

Flow data term

Cosegmentation data term

Pairwise smoothness term

Why hierarchy? - We need powerful regularization to be robust against significant appearance dissimilarity of different object instances.

Why not precompute hierarchical structure? - A good hierarchical structure must respect object boundary and smoothness of the flow map. However, these are not available a priori and thus, jointly inferred with the flow and segmentation.

Two-step optimization

1) Bottom-up graph construction

- Initialize
- Add a layer by merging nodes

Incrementally add layers from lower levels, while estimating flow and segmentation labels.

2) Top-down labeling refinement

- Update all labels
- Update lower layers labels

Update flow and segmentation labels, while keeping the graph structure fixed.

Based on continuous MRF optimization technique (via graph cuts).

Taniai+ “Continuous Stereo Matching Using Local Expansion Moves” (arXiv 2016)

Experiments

Methods

- Flow
- Graph
- Regularization

Our method
- Hierarchical MRF
- 2D MRF
- No explicit regularization

Dataset info

- Images in our dataset are grouped by their source
  - FGIDCar [Liu+ ’14]
  - JODS [Rubinstein+ ’13]
  - PASCAL [Hariharan+ ’11]

Flow accuracy

Cosegmentation accuracy

Accurate pixels (%)

Flow error threshold in a normalized scale (image width is 100 px)

Flow accuracy

Cosegmentation accuracy

Accurate pixels (%)

Intersection over union ratio

Accurate pixels (%)

Flow error threshold in a normalized scale (image width is 100 px)