Joint Recovery of Dense Correspondence and Cosegmentation in Two Images

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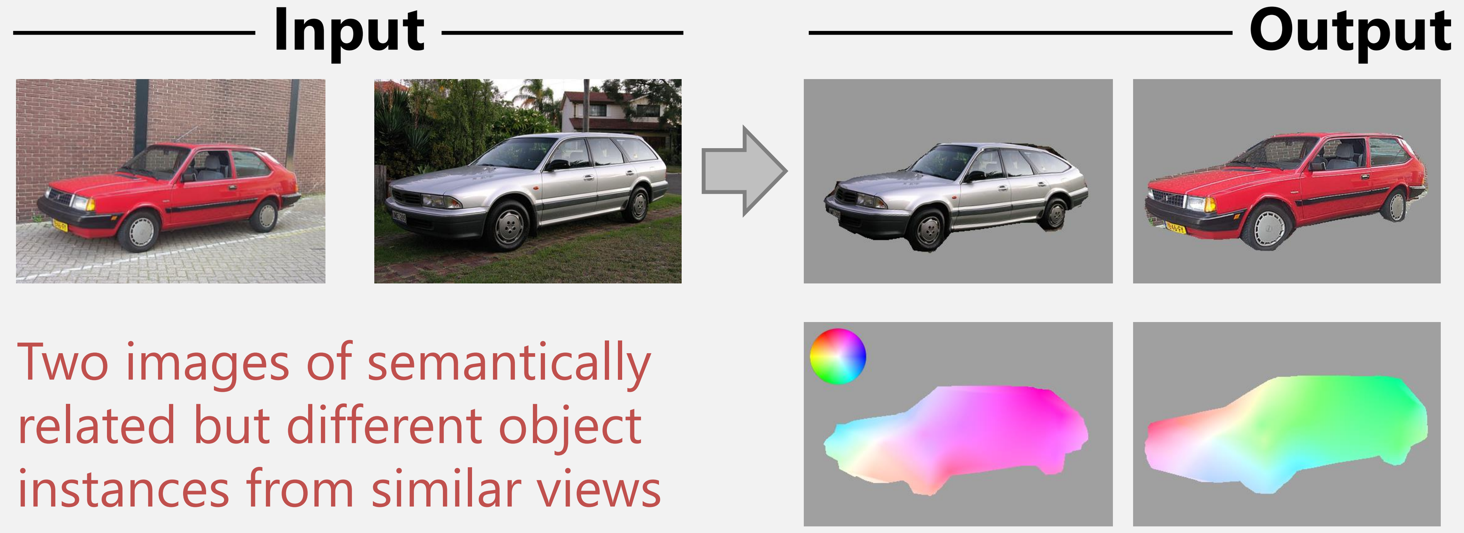
Introduction



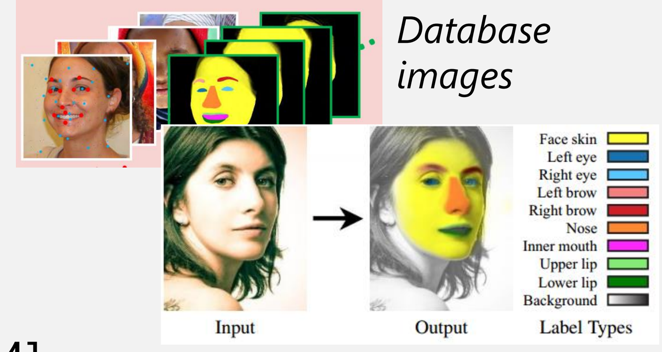
Two images of semantically related but different object instances from similar views

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

- We propose a method to simultaneously recover cosegmentation and correspondence (or flow) maps.
- Our joint formulation improves performance on both tasks; more accurate than existing methods that solve either task.

Applications

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



Label transfer [Smith+ CVPR'13]

Contributions

http://taniai.space/...

New dataset with ground truth/evaluation toolkit

- 400 image pairs, 7 object categories

New joint model and inference technique

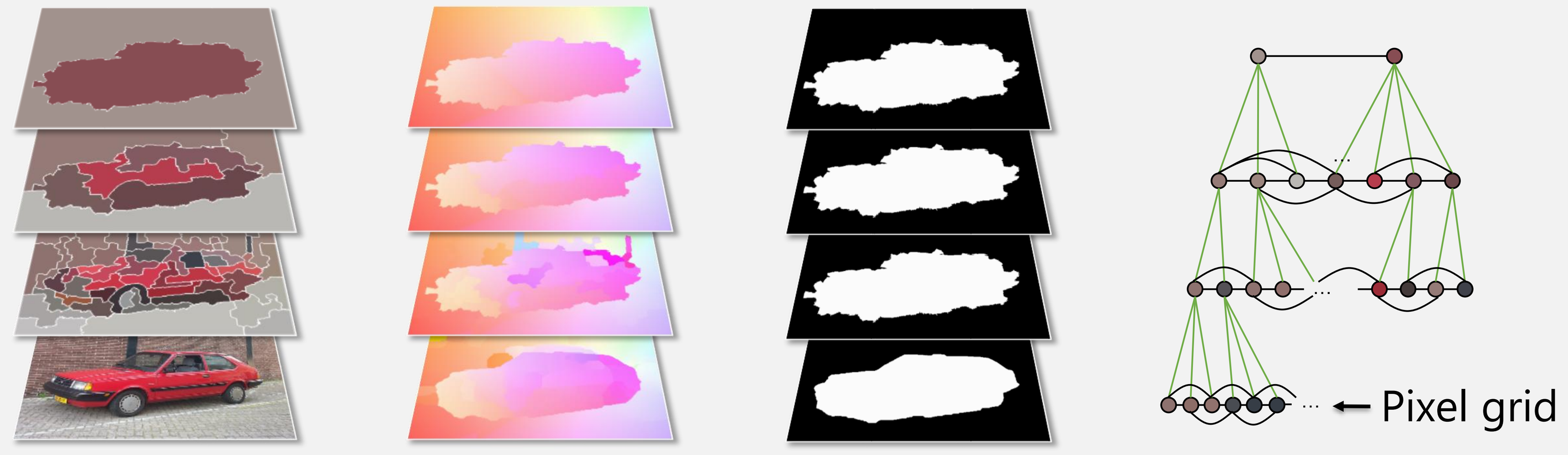
- Discrete-continuous labeling problem for flow and segmentation estimation in a hierarchical MRF model.
- Joint inference of hierarchical structure and labeling via an energy minimization framework using iterated graph cuts.
- Recovers layered structure of nested image regions.

Hierarchical (layered graph) model

$$F(G,f,\alpha) = E_{\mathrm{graph}}(G) + E_{\mathrm{flow}}(f|G) + E_{\mathrm{seg}}(\alpha|G) + E_{\mathrm{reg}}(f,\alpha|G)$$

Graph structure term | Flow data term | Cosegmentation data term | Pairwise smoothness term

Layer K
⋮
Layer 2
Layer 1 (final result)



- Node sparsity
- Color consistency of superpixels

- HOG features for appearance matching
- Similarity transform

- FG/BG color likelihood (learned during initialization)

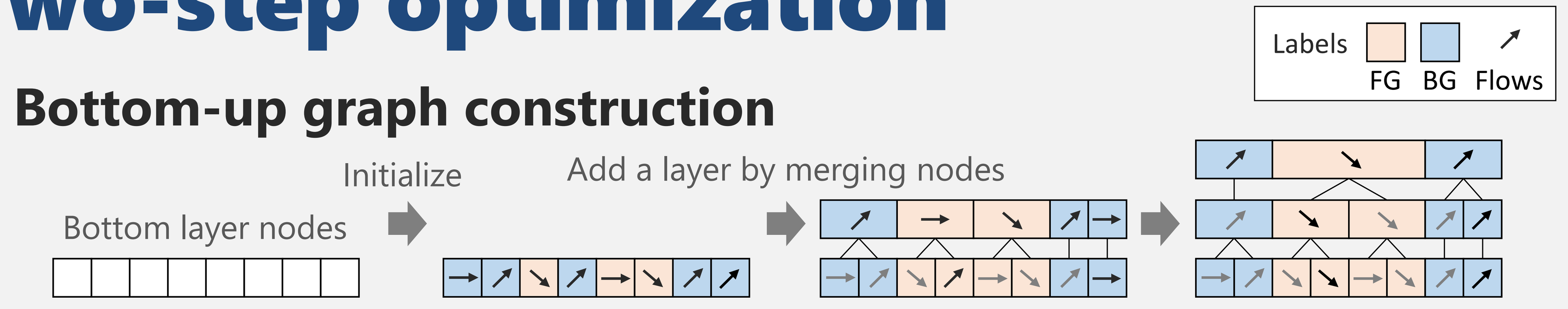
- Spatial neighbors
- Parent child edges

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.

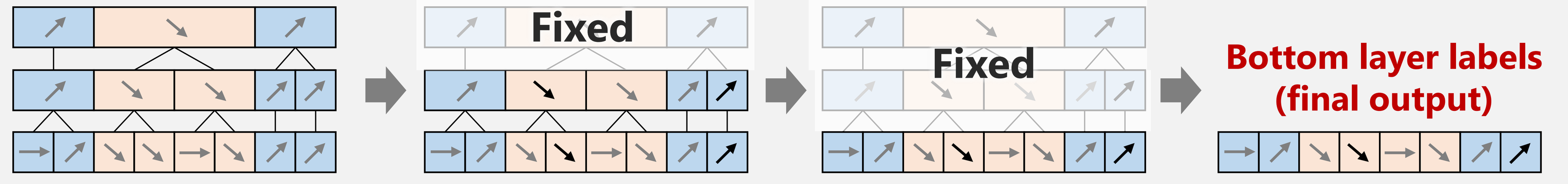
Two-step optimization

1) Bottom-up graph construction



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

2) Top-down labeling refinement



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

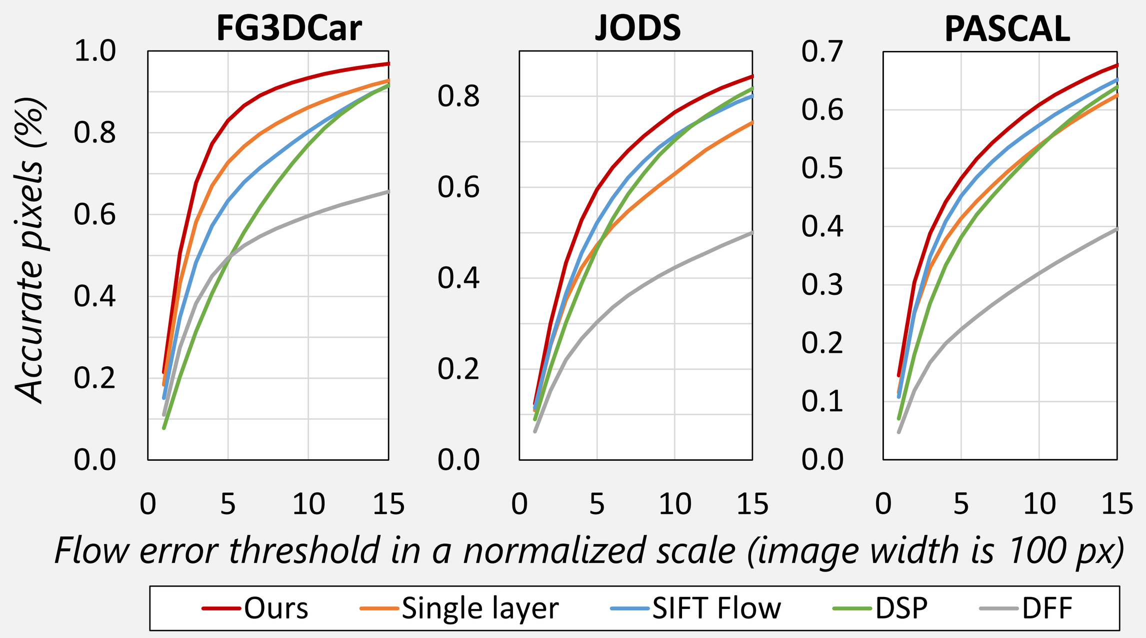
Methods	Flow	Coseg.	Regularization
Our method	✔	✔	Hierarchical MRF
Our method (no hierarchy)	✔	✔	2D MRF
SIFT flow [Liu+ TPAMI'11]	✔		2D MRF
DSP [Kim+ CVPR'13]	✔		Pyramid hierarchy
DAISY filter flow [Yang+ CVPR'14]	✔		No explicit regularization
Faktor & Irani [ICCV'11]		✔	—
Joulin+ [CVPR'10]		✔	—

Dataset info

Images in our dataset are grouped by their source

- **FG3DCar** [Lin+ '14]
- **JODS** [Rubinstein+ '13]
- **PASCAL** [Hariharan+ '11]

Flow accuracy



Cosegmentation accuracy