

Associative Hierarchical CRFs for Object Class Image Segmentation

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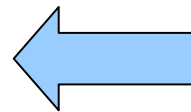
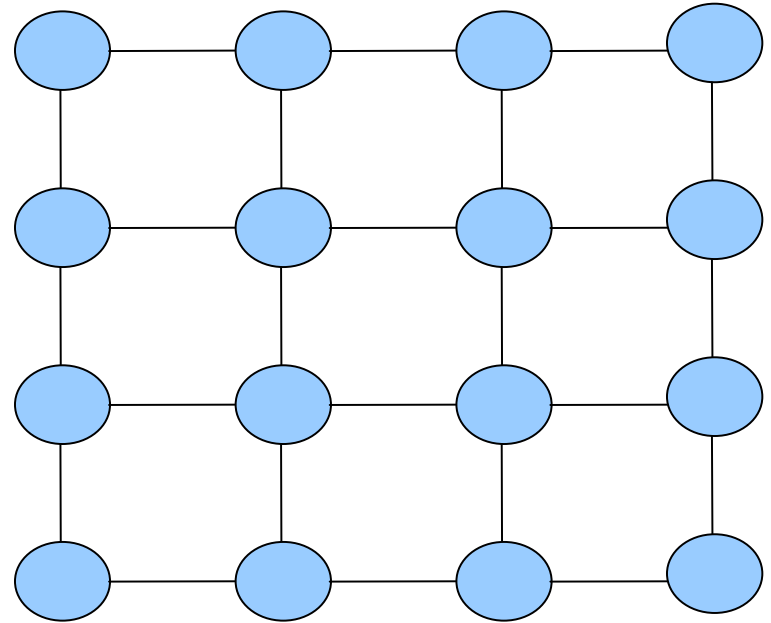
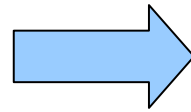


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Pairwise CRF over Pixels



CRF

$$E(\mathbf{x}) = \sum_{i \in \mathcal{V}} \psi_i(x_i) + \sum_{i \in \mathcal{V}, j \in \mathcal{N}_i} \psi_{ij}(x_i, x_j).$$

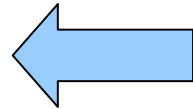
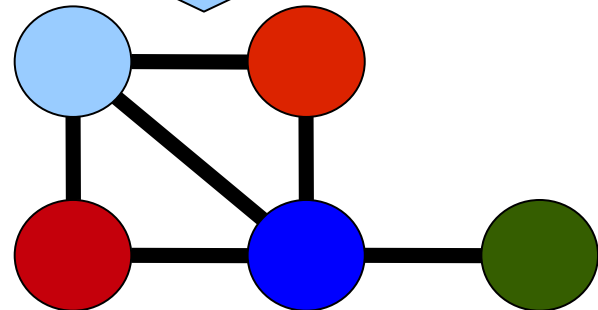
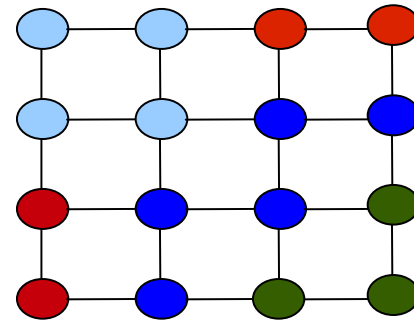
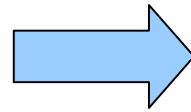
TextonBoost (Shotton ECCV06)

Pairwise CRF over Pixels



- No quantization errors
- Lacks long range interactions
- Results oversmoothed

Pairwise CRF over Segments



$$E(\mathbf{x}) = \sum_{i \in V} \psi_i(x_i) + \sum_{i \in V, j \in \mathcal{N}_i} \psi_{ij}(x_i, x_j).$$

Shi, Malik PAMI2000, Comaniciu, Meer PAMI2002,
Felzenschwalb, Huttenlocher, IJCV2004
Yang et al. CVPR07, Batra et al. CVPR08,

Pairwise CRF over Segments

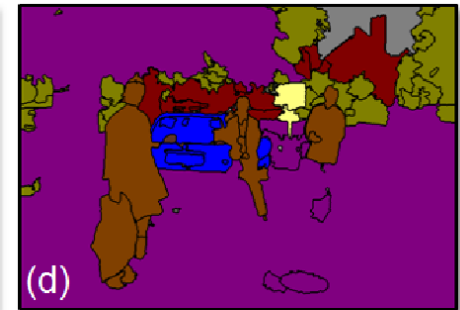
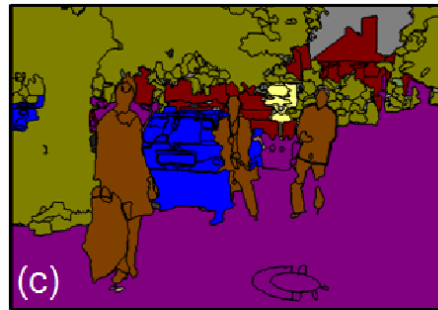
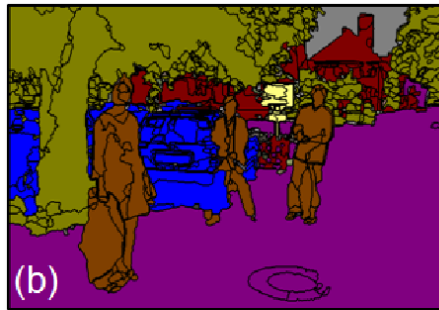


- Allows long range interactions
- Better performance for VOC dataset
- Can not recover from incorrect segmentation
- Impossible to obtain perfect unsupervised segmentation

Pairwise CRF over Segments



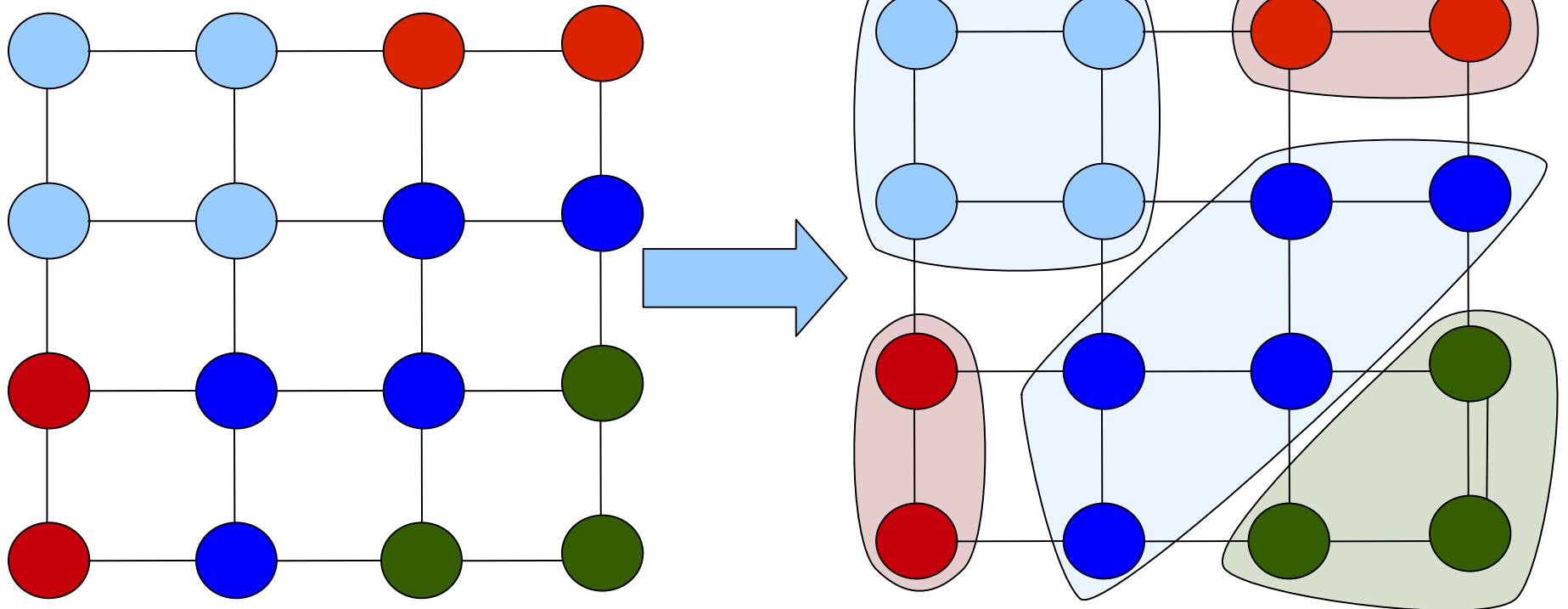
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Legend for segmentation colors:

Person	Road	Car	Tree	Building	Sky	Sign
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Robust P^N approach



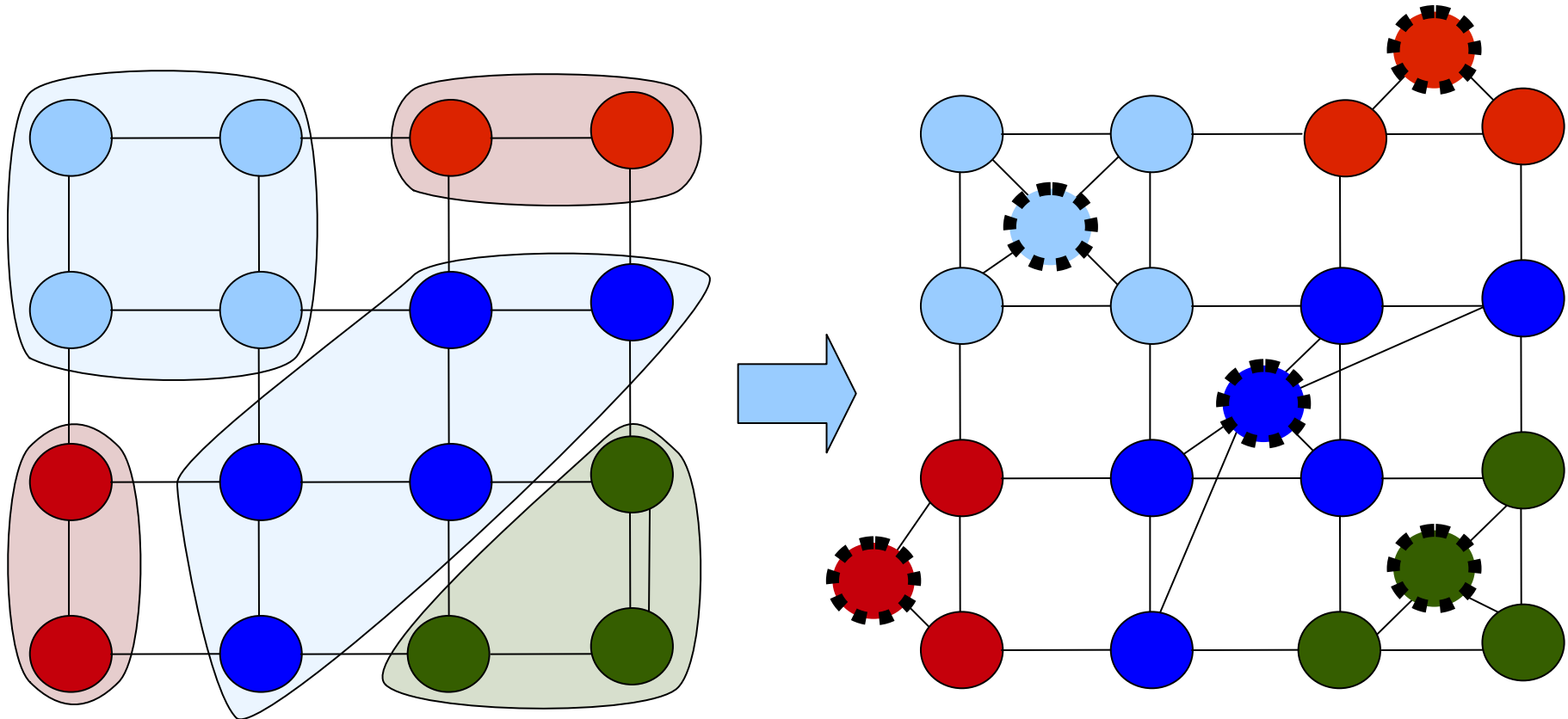
$$E(\mathbf{x}) = \sum_{i \in \mathcal{V}} \psi_i(x_i) + \sum_{i \in \mathcal{V}, j \in \mathcal{N}_i} \psi_{ij}(x_i, x_j) + \sum_{c \in \mathcal{S}} \psi_c^h(\mathbf{x}_c),$$

Robust P^N approach

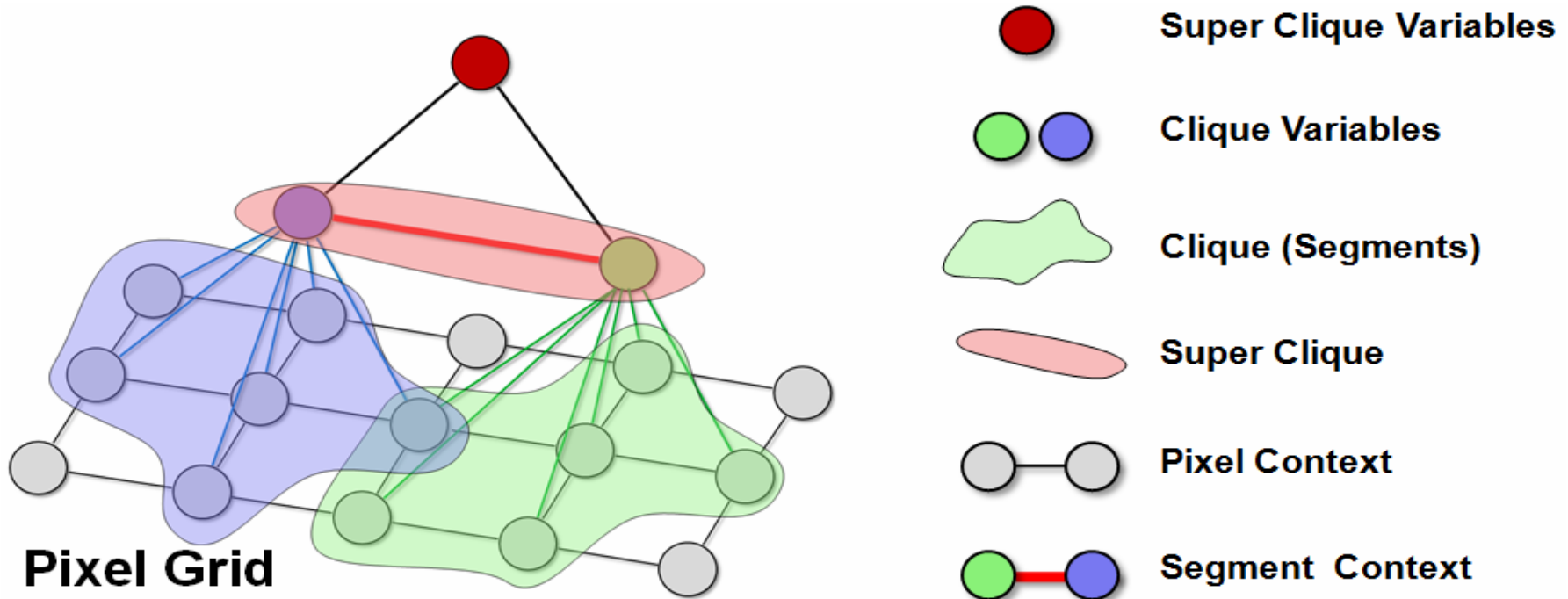


- Robust to misleading segmentations
- Segment consistency as a weak constraint
- Allows multiple segmentations
- Unary and pairwise potentials only at the pixel level

Robust P^N reformulation



Associative Hierarchical CRF



- Allows unary potentials for region variables
- Allows pairwise potentials for region variables
- Allows multiple layers and multi hierarchies

Analysis of the new model



Let's have one segmentation and potentials
only over segment level

Analysis of the new model



Let's have one segmentation and potentials only over segment level

Interlayer connection is symmetric and semi-metric

- Minimum will be segment-consistent

Analysis of the new model



Let's have one segmentation and potentials only over segment level

Interlayer connection is symmetric and semi-metric

- Minimum will be segment-consistent
- The cost of every segment consistent labelling is the same as the cost of the pairwise CRF labelling over segments
- Equivalent to pairwise CRF over segments

Associative Hierarchical CRF



- Merges information over multiple scales
- Allows multiple hierarchies
- Allows long range interactions
- Easy to train weights
- Interlayer connection limited(?) to associative relationship

Inference over Hierarchical CRF



Inference over Hierarchical CRF



- Problem is NP-hard

Inference over Hierarchical CRF



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- Any message passing algorithm (TRW-S, BP, ..) or ICM can be applied to pairwise model

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- $\alpha\beta$ -swap (potentials must be semi-metric)
 - Ishikawa construction over (α -F- β transition)

Inference over Hierarchical CRF



- Problem is NP-hard
- Any message passing algorithm (TRW-S, BP, ..) or ICM can be applied to pairwise model
- $\alpha\beta$ -swap (potentials must be semi-metric)
 - Ishikawa construction over (α -F- β transition)
- α -expansion (potentials must be metric)
 - Reparametrization of interlayer connection to metric potential
 - Ishikawa construction over (α -F-old transition)
 - **For more details read our technical report**

Associative Hierarchical CRF



- Pixel layer
 - TextonBoost-like unary potential with multiple features (texton, SIFT, Opponent SIFT)
 - Intensity dependent pairwise potential
- Superpixel layer
 - Consistency potential
 - EMD-distance of colour histograms pairwise potential
- Segment layer
 - Unary potential based on histograms of features (texton, SIFT, Opponent SIFT, Location)
- And one other layer..

Results



Take home message



Take home message



- Use our model
 - Inference code available soon!

Take home message



- Use our model
 - Inference code available soon!
- Use your favourite potentials

Take home message



- Use our model
 - Inference code available soon!
- Use your favourite potentials
- Use your friend's favourite potentials

Take home message



- Use our model
 - Inference code available soon!
- Use your favourite potentials
- Use your friend's favourite potentials
- Use your friend's friend's favourite potentials

Take home message



- Use our model
 - Inference code available soon!
- Use your favourite potentials
- Use your friend's favourite potentials
- Use your friend's friend's favourite potentials
- Vision solved

Take home message



- Use our model
 - Inference code available soon!
- Use your favourite potentials
- Use your friend's favourite potentials
- Use your friend's friend's favourite potentials
- Vision solved (..almost)

Thank you



- Questions?