



Cutting-Plane Training of Non-associative Markov Network for 3D Point Cloud Segmentation

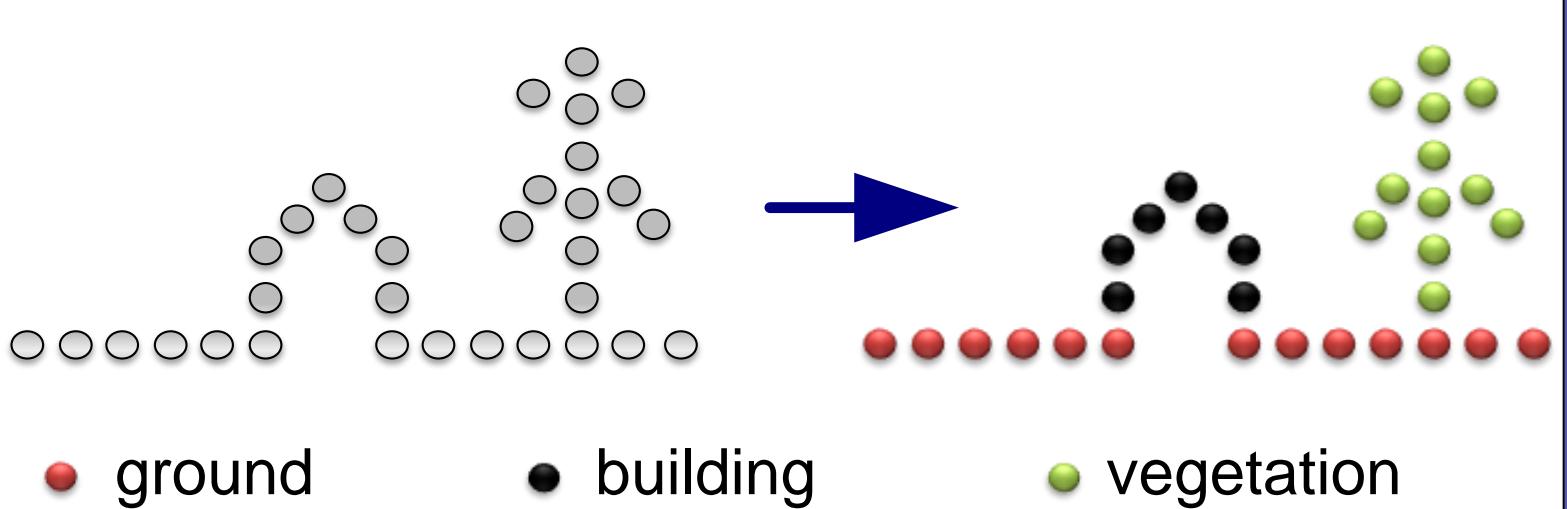


3DIMPVT 2011

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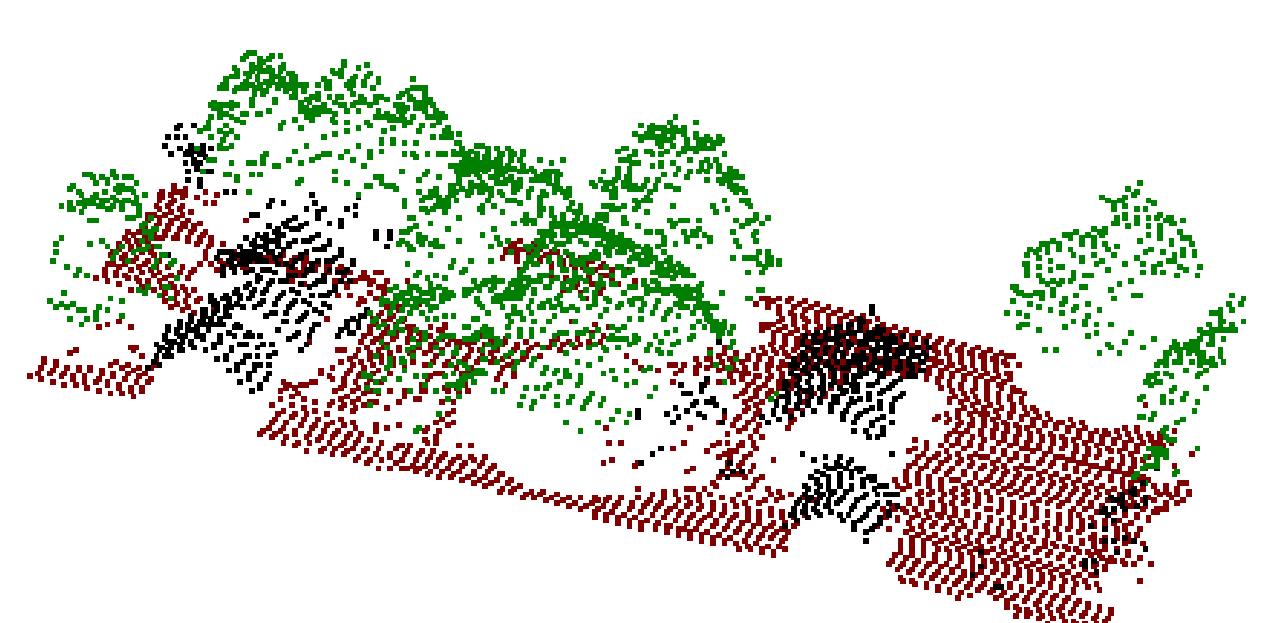
Alexander B. Velizhev

Goal: Semantic segmentation

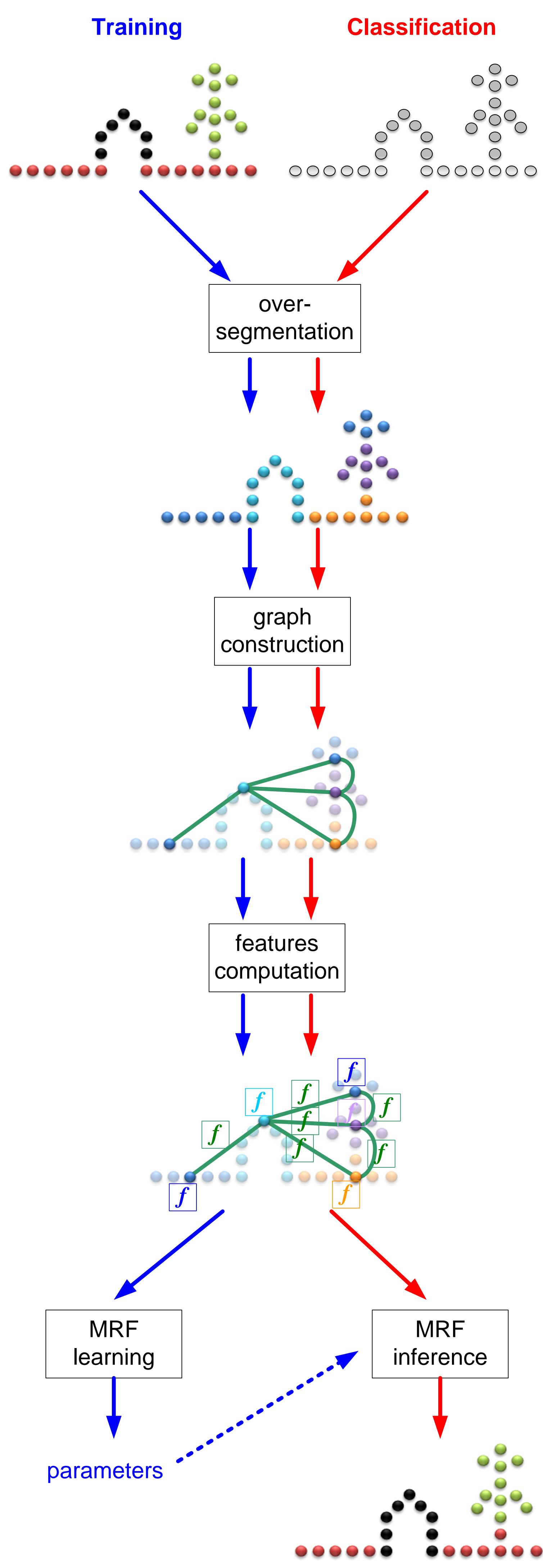


Contributions:

- principled way to train non-associative CRFs
- handles class imbalance
- non-linear model via kernelization (RBF)

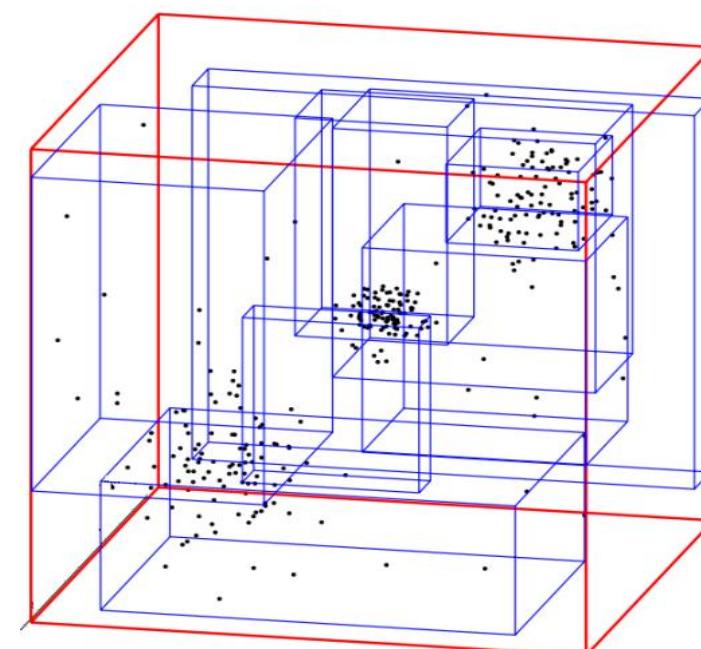


Overview



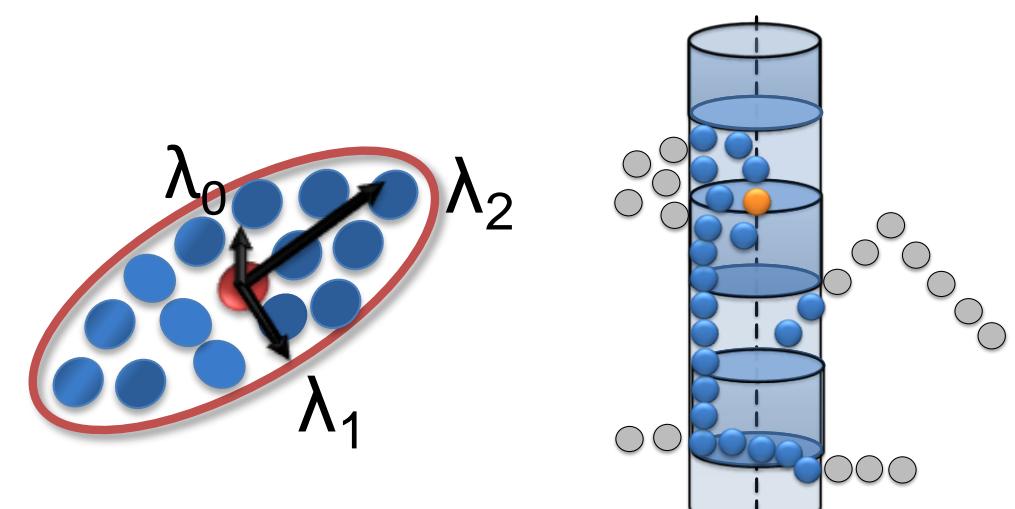
Over-segmentation

- R-Tree based algorithm:
- k-means clustering for split
 - tailored strategy for inserting points to get compact segments



Features

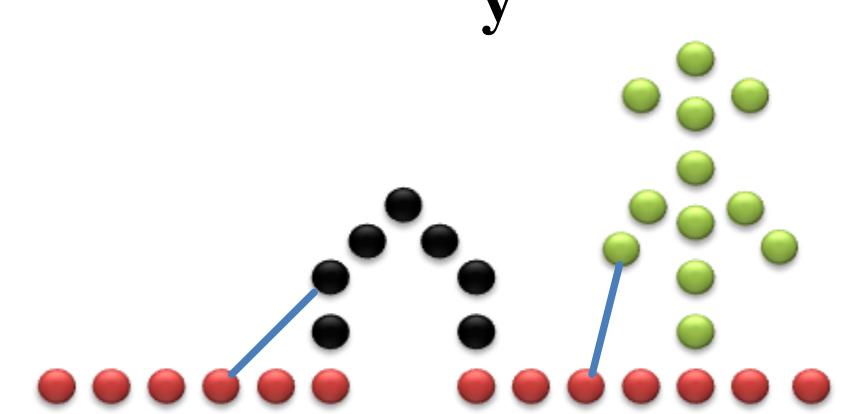
- spectral and directional features [Lalonde, 2005]
- spin images [Johnson, 1999]
- angular spin images [Endres, 2009]
- distribution of z-coordinates in infinite vertical cylinder



Inference: Non-associative CRFs

$$\sum_{i \in N} \phi(\mathbf{x}_i, y_i) + \sum_{(i,j) \in E} \phi(\mathbf{x}_{ij}, y_i, y_j) \rightarrow \max_y$$

- no associative constraints [Anguelov, 2005]
- $\phi(\mathbf{x}_{ij}, y_i, y_j) \leq \phi(\mathbf{x}_{ij}, k, k)$
- TRW-S for inference



CRF Training

$$\begin{aligned} \phi(\mathbf{x}_i, y_i) &= \mathbf{w}_{n,i}^T \mathbf{x}_i y_i \\ \phi(\mathbf{x}_i, y_i, y_j) &= \mathbf{w}_{e,ij}^T \mathbf{x}_{ij} y_{i,k} y_{j,l} \end{aligned} \quad \left\{ \begin{array}{l} \text{linear model} \\ \mathbf{w}^T \Psi(\mathbf{x}, \mathbf{y}) \rightarrow \max_y \end{array} \right.$$

Maximize margin between the best labeling and others w.r.t. structured loss:

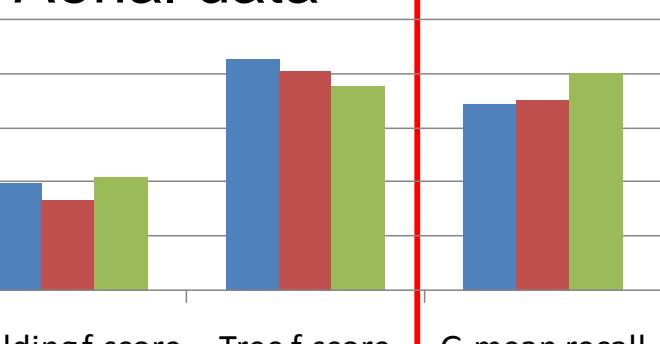
$$\begin{aligned} \mathbf{w}^T \Psi(\mathbf{x}, \dots) &> \mathbf{w}^T \Psi(\mathbf{x}, \dots) + \Delta(\dots, \dots) \xrightarrow{19} \\ \mathbf{w}^T \Psi(\mathbf{x}, \dots) &> \mathbf{w}^T \Psi(\mathbf{x}, \dots) + \Delta(\dots, \dots) \xrightarrow{12} \\ \mathbf{w}^T \Psi(\mathbf{x}, \dots) &> \mathbf{w}^T \Psi(\mathbf{x}, \dots) + \Delta(\dots, \dots) \xrightarrow{7} \\ &\dots \\ \mathbf{w}^T \Psi(\mathbf{x}, \dots) &> \mathbf{w}^T \Psi(\mathbf{x}, \dots) + \Delta(\dots, \dots) \xrightarrow{13} \end{aligned}$$

Exponential number of constraints

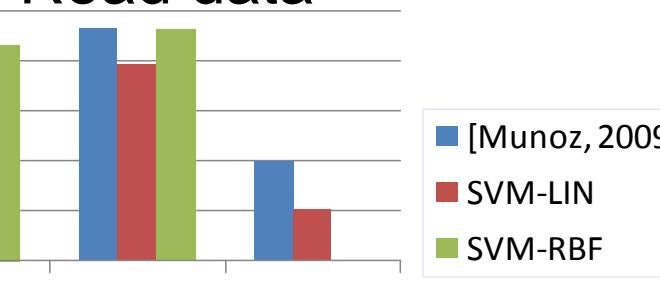
Cutting-plane scheme: iteratively add the most violated constraint [Joachims, 2009]

Results

Aerial data



Road data



References

- Anguelov**, Taskar, Chatalbashev, Koller, Gupta, Heitz, Ng. Discriminative Learning of Markov Random Fields for Segmentation of 3D Scan Data. IEEE CVPR 2005.
- Endres**, Plagemann, Stachniss, Burgard. Unsupervised Discovery of Object Classes from Range Data using Latent Dirichlet Allocation. RSS 2009.
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- Johnson**, Hebert. Using Spin Images for Efficient Object Recognition in Cluttered 3D Scenes. IEEE PAMI 21 (1999): 433-449.
- Lalonde**, Unnikrishnan, Vandapel, Hebert. Scale selection for classification of point-sampled 3D surfaces. IEEE 3DIM 2005.