NON-ASSOCIATIVE MARKOV NETWORKS FOR POINT CLOUD CLASSIFICATION

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Abstract

Associative Markov Networks are generally used for semantic segmentation of 3D point clouds. This implies that pairwise potentials are constant for a pair of different class labels. The constraint is too rigorous since it does not allow expressing some natural interactions between objects such as "roof is likely to be above the ground". We use general form of pairwise potentials instead. Oversegmentation is used to subsample a scan in order to improve efficiency and use natural edge features.

AMNs

MRF for point cloud classification:

- A scan $\mathbf{I}$ which contains N points
- For each 3D point one of K labels should be assigned: $\mathbf{Y} = \{Y_1, \dots, Y_N\}, Y_i \in \{1, \dots, K\}$
- Unary potentials $\phi_i(Y_i|\mathbf{I})$ and pairwise potentials $\phi_{ij}(Y_i, Y_j|\mathbf{I})$
- Minimize energy

$$E(\mathbf{Y}|\mathbf{I}) = -\sum_{i=1}^{N} \log \phi_i(Y_i|\mathbf{I}) - \sum_{(i,j)\in E} \log \phi_{ij}(Y_i, Y_j|\mathbf{I}) \quad (1)$$

Associative Markov Networks:

- Attractive pairwise potentials: $\log \phi_{ij}(k, k) = \lambda_{ij}^k \geq 0$, $\log \phi_{ij}(k, l) = 0, k \neq l$

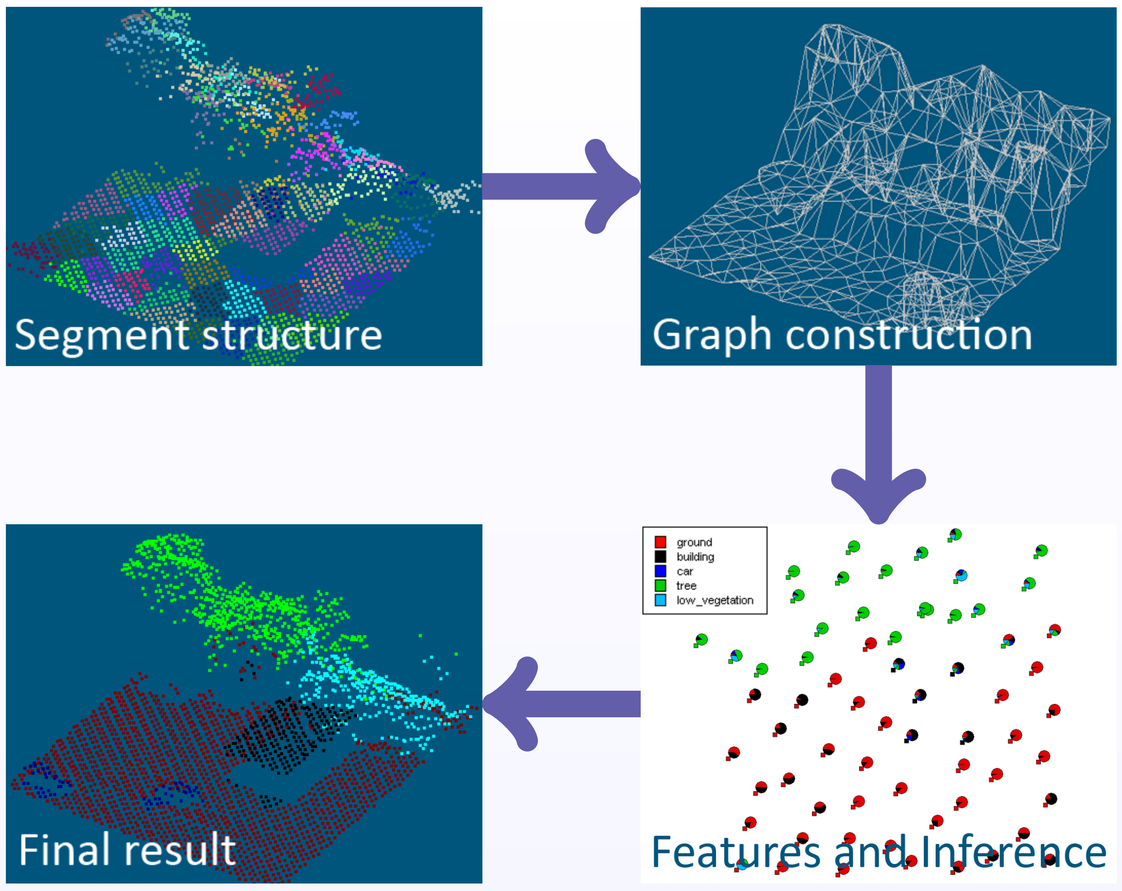
References

[1] http://graphics.cs.msu.ru/en/science/research/3dpoint/lidark

[2] http://www.cs.cornell.edu/People/tj/svm_light/svm_struct.html

[3] Kolmogorov, V., Convergent tree-reweighted message passing for energy minimization, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 28, 2006.

Proposed Method



- Over-segmentation is performed using modified R-Tree algorithm [1]. It allows using natural edge features like direction of an edge
- Coefficients for energy terms are tuned using SVM^{struct} [2] on training set of 3-d points. Features include:
  - log of probabilistic output from Random Forest for unary potentials
  - log of output from Naïve Bayes classifier for pairwise potentials
- General form of energy (non-submodular) allows us to utilize relations like "roof is likely to be higher than ground"
- Energy minimization by TRW-S [3], which is known to perform well for non-submodular energy

Experimental Results

- Scan is retrieved by an airborne scanner
- Training and test parts (~1M points in each); 30K segments
- Red color represents ground, black – building, navy – car, green – tree, cyan – low-vegetation
- AMN fails to find small objects like cars or roof