3D Classification of Crossroads from Multiple Aerial Images Using Markov Random Fields

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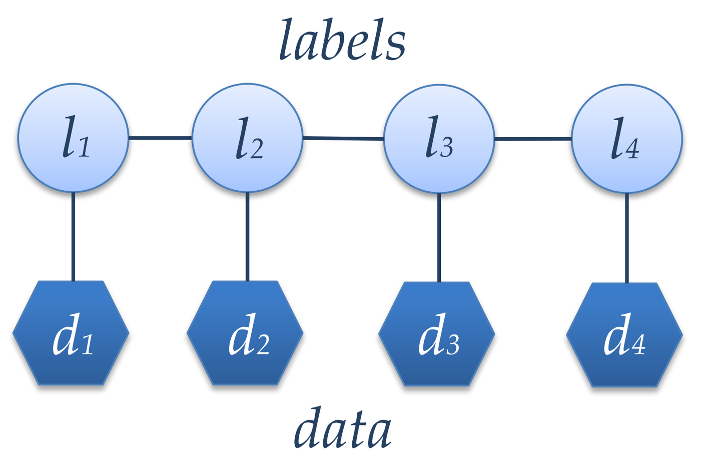
The precise classification of crossroads from multiple aerial images is a challenging problem in remote sensing.

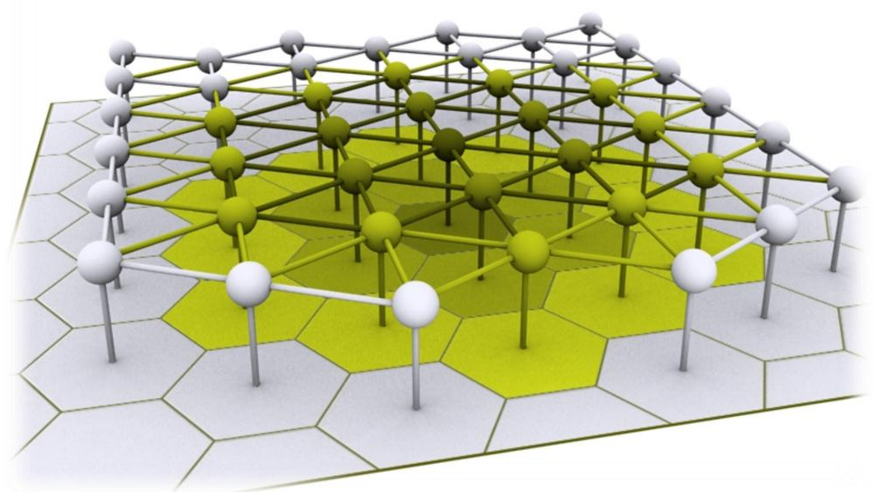
1 We apply Markov Random Fields (MRF) for the classification, using a simple appearance – based model in combination with a probabilistic model of the co-occurrence of class labels at neighbouring image sites. The parameters of these models are learnt from training data. **2** We use multiple overlap aerial images to derive a digital surface model and a true orthophoto without dynamic objects like moving cars. **3** From the DSM and the orthophoto we derive feature vectors that are used in the classification. One of the features is a car confidence value that is supposed to support the classification when the road surface is occluded by static cars. **4** Our approach is evaluated on a dataset of airborne photos of an urban area by a comparison of the results to reference data. Whereas the method has problems in distinguishing classes having a similar appearance, it is shown to produce promising results, yielding an overall classification accuracy of 74.8%.

1 Markov Random Fields

- MRF are undirected graphical models
- Assume the data at image site to depend on class label at that site
- The class label is modelled to be statistically dependent on the class labels of its neighbouring image sites
- As a consequence, the individual sites can no longer be labelled independently from each other

1D and 2D graphical model for MRF:

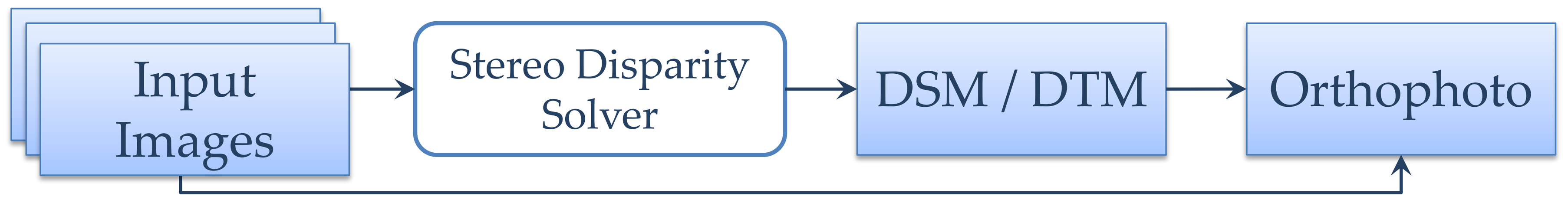




2 Preprocessing

- Input data for one crossroad:
  - At least 4 airborne images with infra-red channel;
  - Image overlapping at least 60%;
  - Ground sampling distance: ~15 cm.
- Derived data for one crossroad:
  - Digital Surface / Terrain Model (DSM / DTM);
  - Orthophoto.
- Reasoning of "No Data" regions in DSM

Preprocessing pipeline:

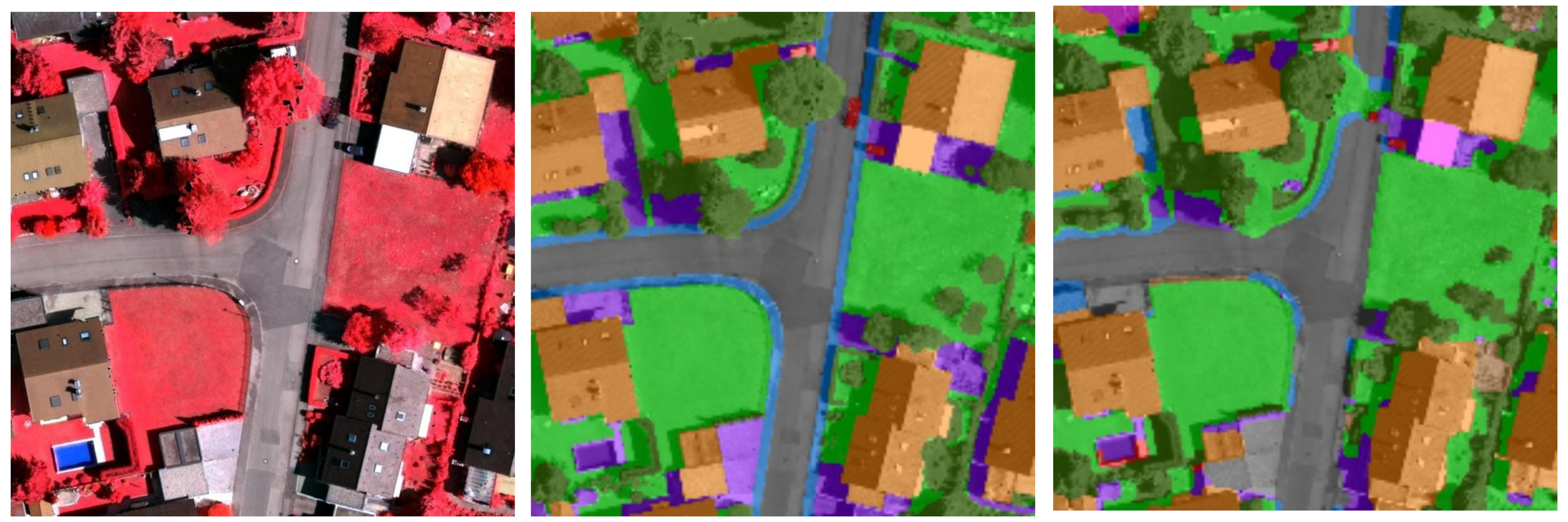


3 Data Features

- Image features: NDVI, saturation, intensity, variance of saturation and intensity, distance map, main gradient orientation
- DSM feature: DSM - DTM
- Car confidence feature: output of the car detection algorithm

4 Experimental Results

An original orthophoto, ground truth superimposed to the intensity mage and classification results achieved with 14 classes and the car feature superimposed to the intensity image:



● *asphalt;* ● *building;* ● *grass;* ● *sidewalk;* ● *sealed;* ● *tree;* ● *car;* ● *bridge*

Confusion matrix. All values are given in [%]. Overall accuracy: 74.39%

Ref. \ Class	Asph.	Build.	Grass	Agr.	Beach	Tree	Car	Bridge	Comp.
Asph.	24.63	1.28	1.60	0.72	0.01	0.56	0.88	0.03	**82.90**
Build.	1.53	13.26	0.44	0.11	--	0.16	0.40	0.13	**82.70**
Grass	1.30	0.62	14.21	1.60	0.41	4.87	0.17	--	**61.30**
Agr.	0.96	0.27	0.68	7.38		3.25	0.07	--	**58.53**
Beach	0.10	--	--	--	0.00	--	--	--	--
Tree	0.10	0.12	2.36	0.27	--	14.58	0.02	--	**83.48**
Car	0.25	0.02	0.03	0.02	--	0.01	0.32	--	**49.33**
Bridge	0.12	0.07	--	--	--	--	0.03	0.00	--
Corr.	**84.95**	**84.79**	**73.49**	**72.99**	--	**62.24**	**17.01**	--	