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%.

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.

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:

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

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:

<table>
<thead>
<tr>
<th>Class</th>
<th>Ref.</th>
<th>Asphalt</th>
<th>Building</th>
<th>Grass</th>
<th>Air</th>
<th>Beach</th>
<th>Tree</th>
<th>Car</th>
<th>Bridge</th>
<th>Corp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asph.</td>
<td>24.85</td>
<td>1.28</td>
<td>1.00</td>
<td>0.72</td>
<td>0.01</td>
<td>0.56</td>
<td>0.88</td>
<td>0.03</td>
<td>82.39</td>
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<tr>
<td>Build.</td>
<td>1.53</td>
<td>83.26</td>
<td>0.44</td>
<td>0.11</td>
<td>0.16</td>
<td>0.40</td>
<td>0.13</td>
<td>82.70</td>
<td></td>
<td></td>
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<tr>
<td>Grass</td>
<td>1.30</td>
<td>0.92</td>
<td>1.21</td>
<td>1.00</td>
<td>0.41</td>
<td>4.87</td>
<td>0.17</td>
<td>0.00</td>
<td>61.30</td>
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<tr>
<td>Air</td>
<td>0.96</td>
<td>0.27</td>
<td>0.68</td>
<td>1.58</td>
<td>3.25</td>
<td>0.87</td>
<td>0.00</td>
<td>58.43</td>
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<td></td>
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<tr>
<td>Beach</td>
<td>0.10</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>Tree</td>
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<td>0.12</td>
<td>0.56</td>
<td>0.27</td>
<td>14.58</td>
<td>0.02</td>
<td>83.48</td>
<td>49.53</td>
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<tr>
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<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>49.53</td>
<td>49.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridge</td>
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<td>0.07</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>84.95</td>
<td></td>
</tr>
</tbody>
</table>

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