Detection of Temporary Objects in Mobile Lidar Point Clouds

Xinwei Fang
Guorui Li
Kourosh Khoshelham
Sander Oude Elberink
BACKGROUND

- Mobile laser scanning provides an accurate recording of road environments useful for many applications;
- Usually only **permanent objects** are of interest;
- **Temporary objects** can hamper the analysis of permanent ones;
- Example: change detection using multi-epoch data where temporary objects appear as (false) change signals.
APPROACH

- Temporary objects: \{ Static, Moving \}

- Static temporary objects:
  \( \rightarrow \) segmentation + classification based on shape features

- Moving temporary objects:
  \( \rightarrow \) segmentation + closest point analysis in two sensor data
STATIC TEMPORARY OBJECTS

- Classification based on shape features:

  - Linear & short
  - Linear & tall
  - Volumetric & tall
  - Planar
  - Volumetric & short
MOVING TEMPORARY OBJECTS

- Detection based on closest point analysis with two sensor data
1. Ground removal
2. Connected-component segmentation
3. Static temporary objects:
   → feature extraction + classification
4. Moving temporary objects:
   → closest point analysis + classification
GROUND REMOVAL

- Plane-based segmentation
- Ground = large & low segment
CONNECTED COMPONENT SEGMENTATION

- Points that are closer than a certain distance (e.g. 30 cm) belong to one connected component;
FEATURE EXTRACTION

- **Shape features**
  - Size (number of points)
  - Area on horizontal plane
  - Mean density
  - Height of the lowest point
  - Height

- **Contextual feature**
  - Distance to trajectory

- **Eigen-based features**
  - Anisotropy
  - Planarity
  - Sphericity
  - Linearity
CLASSIFICATION

- Ground truth for training and evaluation: manual labeling (115 samples)
- Feature selection
  - Forward Selection (FS)
  - Backward Elimination (BE)
- Classification
  - Linear Discriminant Classifier (LDC)
  - Support Vector Machine (SVM)
CLOSEST POINT ANALYSIS

Number of pairs:
- Static objects: 45
- Moving objects: 24
EXPERIMENTS

- Study area
  → Enschede, urban

- Data
  → TopScan MLS
  → One strip: ~20 mio points
RESULTS

- Detection results for static temporary objects (test set):

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Completeness</th>
<th>Correctness</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDC - all features</td>
<td>0.90</td>
<td>0.86</td>
</tr>
<tr>
<td>LDC - FS (8 features)</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>LDC - BE (8 features)</td>
<td>0.95</td>
<td>0.91</td>
</tr>
<tr>
<td>SVM - all features</td>
<td>1.00</td>
<td>0.91</td>
</tr>
<tr>
<td>SVM - FS (9 features)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>SVM - BE (11 features)</td>
<td>1.00</td>
<td>0.95</td>
</tr>
</tbody>
</table>
RESULTS

- Classification results for the whole strip:
RESULTS

- Detection results for moving objects:
  - Total 64 samples
  - 4 false positives
  - 6 false negatives

<table>
<thead>
<tr>
<th></th>
<th>Sensor 1</th>
<th>Sensor 2</th>
<th>Sensor1 + Sensor2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness</td>
<td>0.93</td>
<td>0.86</td>
<td>0.90</td>
</tr>
<tr>
<td>Correctness</td>
<td>0.90</td>
<td>0.96</td>
<td>0.93</td>
</tr>
<tr>
<td>Overall Accuracy</td>
<td>0.84</td>
<td>0.83</td>
<td>0.84</td>
</tr>
</tbody>
</table>
LIMITATIONS

- Occlusion;
- Overgrown and undergrown segments;
- Shrunk or elongated shapes due to movement.
- Variable shape and size of vehicles.
SUMMARY

- Object-based approach: obvious choice as we are dealing with objects not points;
- Connected component segmentation of objects works well (but not perfect!);
- Shape features are suitable for classification of static temporary objects; Accuracy > 90%.
- Distance between closest points is a useful measure for detecting moving objects; Accuracy > 80%.
- Occlusion: objects seen by one sensor but not the other = problem for moving objects.
THANK YOU!