Estimation of the lidar height offset in coastal vegetated areas
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Motivation

- Airborne laser scanning → accurate, reliable, area-wide height information

- Interaction between laser beam and vegetation:
  - Mixed signal from ground and vegetation
  - Multiple echoes
Motivation

- Filter algorithms for the elimination of vegetation points

Problems
- Inappropriate ratio of ground and vegetation points
- Vegetation in valleys
- DTM height shift

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Study Area

Dunes
- Beach grass, creeping willow
- Sea buckthorn, Japanese rose

Salt meadow/transition zone
- Common reed
- Sand couch grass
Study Area

Langeoog

Juist
Study Area

Japanese rose (Rosa rugosa)  Common reed (Phragmites australis)
Workflow

- Initial investigation: comparison of lidar data and terrestrial measurements

- Identification of problematic areas depending on the vegetation type, vegetation height and density

- Extraction of typical features for different vegetation types (height and intensity values, multispectral data, texture analysis)

- Classification of lidar data into different accuracy intervals using these features
Vegetation analysis

- Dependencies between the accuracy of lidar data and different vegetation attributes:
  a) vegetation type
  b) vegetation height
  c) vegetation density

- Analysis using combinations of the attributes
Accuracy of the lidar data

a) Vegetation type (LMS Q560 Riegl)
Accuracy of the lidar data

b) Vegetation height

Beach Grass
(LMS Q560 Riegl)

Mixed shrubbery
(Japanese Rose, Sea Buckthorn)
(ALTM 2050 Optech)
Accuracy of the lidar data

c) Vegetation density

Analysis of Fisheye Photos

- Calculation of the canopy closure
- Investigation of the dependencies between lidar accuracy and the canopy closure (vegetation density)
Accuracy of the lidar data

Relationship between vegetation attributes and remote sensing data

- Vegetation type $\rightarrow$ biotope mapping

- Vegetation height $\rightarrow$ height contrast, features from multiple echoes (difference first-last-pulse), residuals from surface fitting

- Vegetation density $\rightarrow$ intensity values of the echoes, multispectral data, features from multiple echoes (density)
Accuracy of the lidar data

Relationship between vegetation attributes and remote sensing data

Japanese rose (ALTM 2050 Optech)
Accuracy of the lidar data

Relationship between vegetation attributes and remote sensing data

- Requirements for multiple echoes: certain vegetation density and height

Increasing shift →
Classification methods

1. Based on segments

- Training areas from control measurements (Difference Model)
- Segmentation using watershed transformation
- Feature extraction (raster data)
- Classification
Classification methods

2. Based on 3D points

- Calculation of the height shift
- Feature extraction (point cloud)
- Connection between features and height shift using functions
- Estimation of the parameters
- Calculation of the shift from weighted average
## Results

### Segment based classification

<table>
<thead>
<tr>
<th>Feature</th>
<th>Training Area</th>
<th>Class (Lidar DSM minus Reference up to)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>40cm</td>
</tr>
<tr>
<td>Mean Intensity</td>
<td>left</td>
<td>86.5</td>
</tr>
<tr>
<td></td>
<td>right</td>
<td>83.3</td>
</tr>
</tbody>
</table>

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[Images showing segmentation and classification results]
Results

Segment based classification

- Evaluation of the classification: Comparison of the classification result with reference pixel by pixel

<table>
<thead>
<tr>
<th>Features</th>
<th>Classified Area</th>
<th>Correct [%]</th>
<th>1 class too low [%]</th>
<th>1 class too high [%]</th>
<th>Sum [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>left</td>
<td>74,9</td>
<td>7,6</td>
<td>11,0</td>
<td>93,5</td>
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<td></td>
<td>right</td>
<td>64,7</td>
<td>11,7</td>
<td>15,4</td>
<td>91,8</td>
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<tr>
<td>right</td>
<td>left</td>
<td>75,3</td>
<td>8,0</td>
<td>11,1</td>
<td>94,4</td>
</tr>
<tr>
<td></td>
<td>right</td>
<td>64,0</td>
<td>11,9</td>
<td>16,4</td>
<td>92,3</td>
</tr>
</tbody>
</table>
Results

Classification based on 3D points

![Image of classification results]
Summary

- Identification of ALS accuracy intervals using terrestrial control measurements

- Link the vegetation attributes to remote sensing features

- Classification of the data using the extracted features and different methods
Summary

- Continuous characteristic of lidar accuracy $\rightarrow$ no clusters in the feature space

- Classification using estimated function

- Filter algorithm using a-priori information from the classification

- Metadata concerning the accuracy of the lidar data
Thank you for your attention!