Improving flood damage assessments by retrieving building characteristics through automated UAV image processing

Lucas Wouters
Msc. Hydrology
Objective: create flood damage model based on the automated image processing of UAV imagery

- Generate flood susceptibility information on object (building) level
- Compare flood damage with a land-use (pixel) model
Object-based Image Analysis

Segmentation
• Mean-shift

Classification
• Support Vector Machine
• Based on spectral properties and height

Drone imagery collected by the Netherlands Red Cross/510
Damage curves

Census data building stock:
- Permanent
- Semi-permanent
- Traditional
Flood hazard & damage assessment

\[ \text{Damage} \ [\$] = \sum_{i=1}^{3} \text{damage}(i) \times \text{ba}(i) \times \text{rc}(i) \ [\$] \]

Where:
- \( i \) = the building typology as determined by the classification
- \( \text{Damage}(i) \) is the damage represented through the damage curve, using as input the water depth [m]
- \( \text{ba}(i) \) is the area of the building in m\(^2\)
- \( \text{rc}(i) \) is the replacement costs per m\(^2\) based on the typology (i)
Performance statistics

Confusion matrix

<table>
<thead>
<tr>
<th></th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>TP</td>
<td>FN</td>
</tr>
<tr>
<td>Negative</td>
<td>FP</td>
<td>TN</td>
</tr>
</tbody>
</table>

Prediction outcome

Accuracy: 
\[ A = \frac{TP + TN}{TP + FP + TN + FN} \]

F1-score:
\[ F1 - Score = 2 \times \frac{P \times R}{P + R} \]

Precision:
\[ P = \frac{TP}{TP + FP} \]

Recall:
\[ R = \frac{TP}{TP + FN} \]

Cohen Kappa:
\[ \kappa = \frac{A - Pa}{1 - A} \]

\[ Pa = \frac{1}{n^2} \sum_{i=1}^{c} (pi + p_{+i}) \]

Value of K | Strength of agreement
--- | ---
< 0.20 | Poor
0.21 - 0.40 | Fair
0.41 - 0.60 | Moderate
0.61 - 0.80 | Good
0.81 - 1.00 | Very good

TP = predicted + manual
FP = predicted x manual
TN = manual x predicted
FN = not detected
Results & discussion

Flood damage

<table>
<thead>
<tr>
<th>Category</th>
<th>Object</th>
<th>Pixel</th>
<th>OSM</th>
</tr>
</thead>
<tbody>
<tr>
<td># of buildings</td>
<td>1466</td>
<td>1514</td>
<td>1352</td>
</tr>
<tr>
<td># flooded</td>
<td>84</td>
<td>90</td>
<td>97</td>
</tr>
<tr>
<td>Damage (€)</td>
<td>10,140.-</td>
<td>15,728.-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Difference in exposure (#, and size)
- Approach specific damage curves

OBIA performance

<table>
<thead>
<tr>
<th>Category</th>
<th>F1-score</th>
<th>F1-score (height)</th>
<th>Accuracy</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>0.91</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Metal roof</td>
<td>0.89</td>
<td>0.90</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Thatch roof</td>
<td>0.53</td>
<td>0.75</td>
<td>0.77</td>
<td>0.71</td>
</tr>
<tr>
<td>bare ground</td>
<td>0.49</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>shadow</td>
<td>0.90</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions & Recommendations

Object-based approach using UAV imagery to calculate flood damage

Flood damage: Object < Pixel

Accuracy results vary among categories due to spectral similarities

Justify assumptions of roof and wall material with more samples

Combine results of OBIA with homogenous pixels maps scale up
Questions