Geospatial Imagery Analysis: Application - Change Detection.

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Introduction

- Change Detection of High Spatial Resolution Images (HSR)
- Using Region-Line Primitive Association Analysis and Evidence Fusion
- HSRs can have spectral confusion and image noise
  - A solution is proposed by combining multiple detection methods that are primarily from Object-based Change Detections (OBCD)
Methodology Overview

- Create temporal region primitives (TRP) and temporal line primitives (TLP)
- OBCD - Object-based Change Detection
  - Feature similarity measure
  - Evidence Fusion
  - Refinement
Methodology
Methodology

- Feature similarity measure
  - obtains the mean, variance and covariance from two different TRPs, and finds the similarity measure (SSIM) with the following equation.

\[
SSIM(X, Y) = \frac{(2\mu_X\mu_Y + C1)(2\sigma_{XY} + C2)}{(\mu_X^2 + \mu_Y^2 + C1)(\sigma_X^2 + \sigma_Y^2 + C2)},
\]

- Evidence Fusion
  - Basic probability assignment function (BPAF)

\[
m_i(\{Y\}) = (1.0 - S_i) \times \alpha_i, m_i(\{N\}) = S_i \times \alpha_i, m_i(\{Y, N\}) = 1.0 - \alpha_i, \ i = 1, 2, 3,
\]
Methodology

• Region-line primitive association framework (RLPAF)
  • changes with low BPAF values will might get ignored in evidence fusion
Methodology

- Evidence Fusion then Refinement

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Algorithm 1. Two-stage change detection

**Input:** TRPs \( \{P\} \), TLPs \( \{L_1\} \), and \( \{L_2\} \), Change threshold \( T \), Scaling factor \( S \)

**Output:** Changed TRPs \( \{P_C\} \)

For each \( P \) within \( \{P\} \):

1. Calculate its spectral BPAF, gradient BPAF, and edge BPAF and fuse them to obtain \( B_N \)
2. If \( P \)'s \( B_N < T \), put \( P \) to \( \{P_C\} \)
3. Else

   Obtain \( P \)'s bitemporal \( MLD_1 \) and \( MLD_2 \) using its contacted lines extracted from \( \{L_1\} \) and \( \{L_2\} \)

   If \( MLD_1 \) is not equal to \( MLD_2 \)

      Relax threshold \( T \) to \( T_1 (T \times S) \)

   If \( B_N < T_1 \), put \( P \) to \( \{P_C\} \)

Return \( \{P_C\} \)
Experimental & Analysis

Figure 4. Three experimental areas. (a,b) Original bitemporal images of area 1. (c,d) Original bitemporal images of area 2. (e,f) Original bitemporal images of area 3.
Area 1
Area 1

- CVA(g), PCA-k(h), IRMAD(i)
Area 1 Result

Table 2. Precision in area 1. TP: the number of change image objects correctly detected, FP: the number of unchanged image objects incorrectly detected as changed ones, FN: the number of changed image objects incorrectly detected as unchanged ones, TN: the number of unchanged image objects correctly detected, FA: false alarm, MA: missed alarm, OA: overall accuracy.

<table>
<thead>
<tr>
<th>Type</th>
<th>Method</th>
<th>TP</th>
<th>FP</th>
<th>FN</th>
<th>TN</th>
<th>OA (%)</th>
<th>MA (%)</th>
<th>FA (%)</th>
<th>Kappa</th>
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<td>21</td>
<td>1000</td>
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<td>28.77%</td>
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<td>Initial detection</td>
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<td>Direct threshold relaxation</td>
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<td>19</td>
<td>19</td>
<td>1200</td>
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<td>26.03%</td>
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<td></td>
<td>Refined detection</td>
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<td>26.03%</td>
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Area 3
Area 3
## Area 3 Result

![Image](image_url)

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<th>Type</th>
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<th>FP</th>
<th>FN</th>
<th>TN</th>
<th>OA (%)</th>
<th>MA (%)</th>
<th>FA (%)</th>
<th>Kappa</th>
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Table 4. Detection precision in area 3.
Discussion

• Main Steps
  1. TRP and TLP creation
  2. feature similarity calculation
  3. CD by evidence fusion
  4. CD refinement using RLPAF

• System Environment: Windows 7 64-bit OS with a CPU (Intel Core i7-4790, 3.60 GHz), RAM (8 GB), and a GPU (NVIDIA GT 630, 2 GB)
Discussion

- bitemporal images needed to be segmented separately and straight lines were detected twice
- Area 3 CD refinement longer than others, because the TLPs in area 3 were more densely distributed

Table 5. Method efficiency (unit: seconds).

<table>
<thead>
<tr>
<th>Area</th>
<th>TRP and TLP Creation</th>
<th>Feature similarity Calculation</th>
<th>CD by Evidence Fusion</th>
<th>CD Refinement Using RLPAF</th>
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<td>Area 2</td>
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<td>23.27</td>
<td>1.19</td>
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<td>Area 3</td>
<td>138.09</td>
<td>29.56</td>
<td>1.49</td>
<td>117.93</td>
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Conclusion

- Multifeature fusion in the initial CD stage obtains fair method accuracy.
- RLPAP feature subsets of line and region–line association offers effective information for OBCD.
- CD is limited within the areas with distinctive MLD changes.
ANY QUESTIONS?