Geospatial Imagery Analysis: Application - Change Detection.

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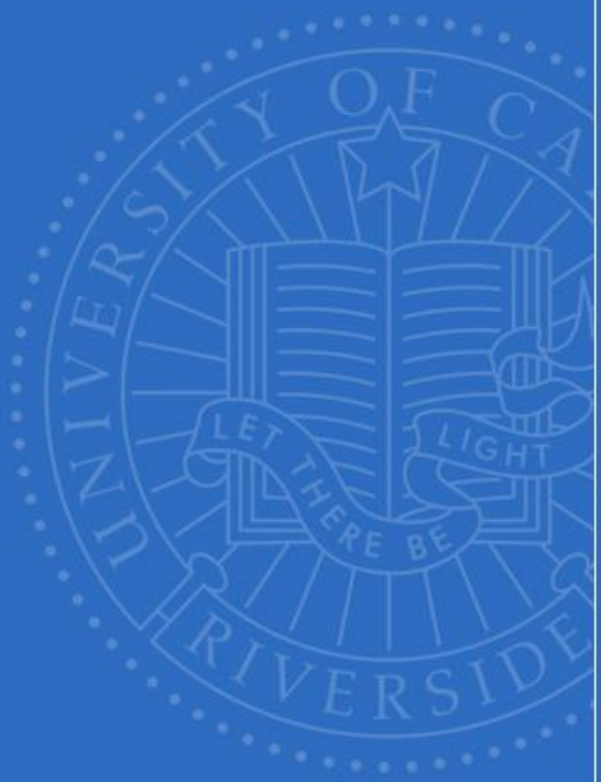


Outline

1. Introduction
2. Methods
3. Experiment & Analysis
4. Discussion
5. Conclusion

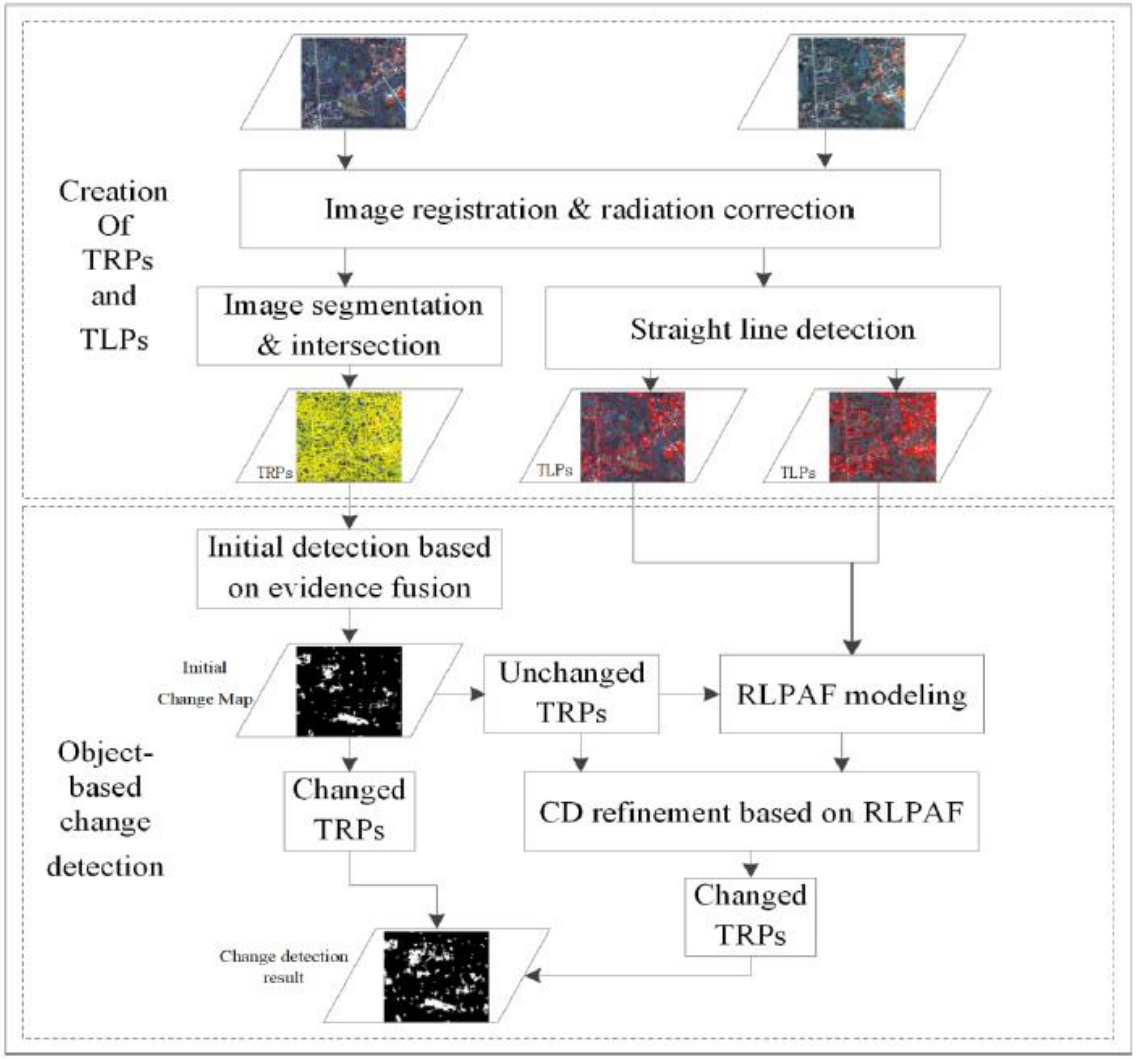
Introduction

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

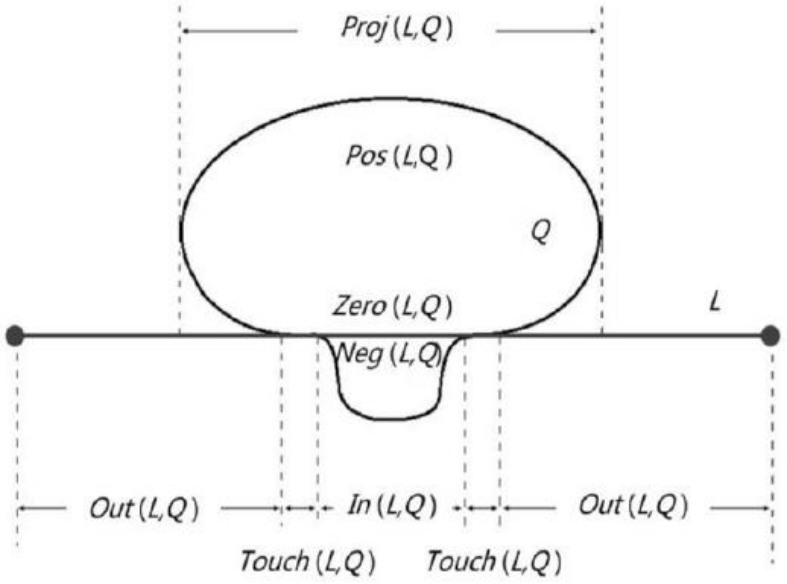
$$\mathrm{SSIM}(X,Y) = \frac{(2\mu_X\mu_Y + C1)(2\sigma_{XY} + C2)}{\left(\mu_X^2 + \mu_Y^2 + C1\right)\left(\sigma_X^2 + \sigma_Y^2 + C2\right)},$$

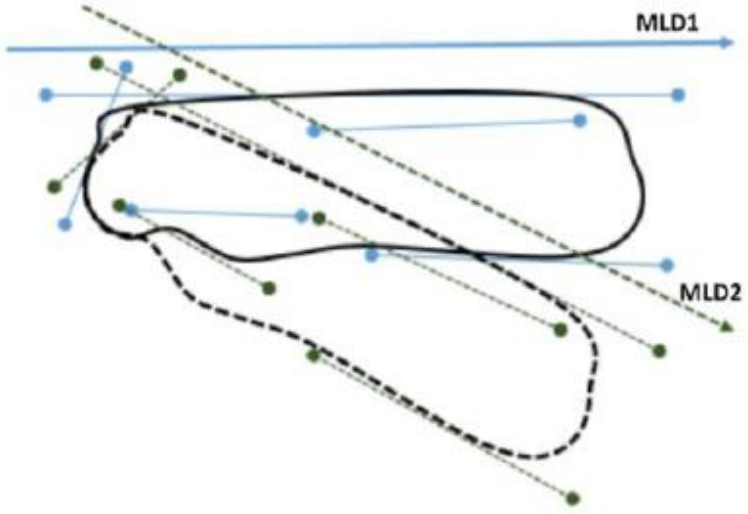
- Evidence Fusion
  - Basic probability assignment function(BPAF)

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

Methodology

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





Methodology

- Evidence Fusion then Refinement

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 $\{P\}$\{
Calculate its spectral BPAF, gradient BPAF, and edge BPAF and fuse them to obtain B_N
If P's $B_N < T$, put P to $\{P_C\}$
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

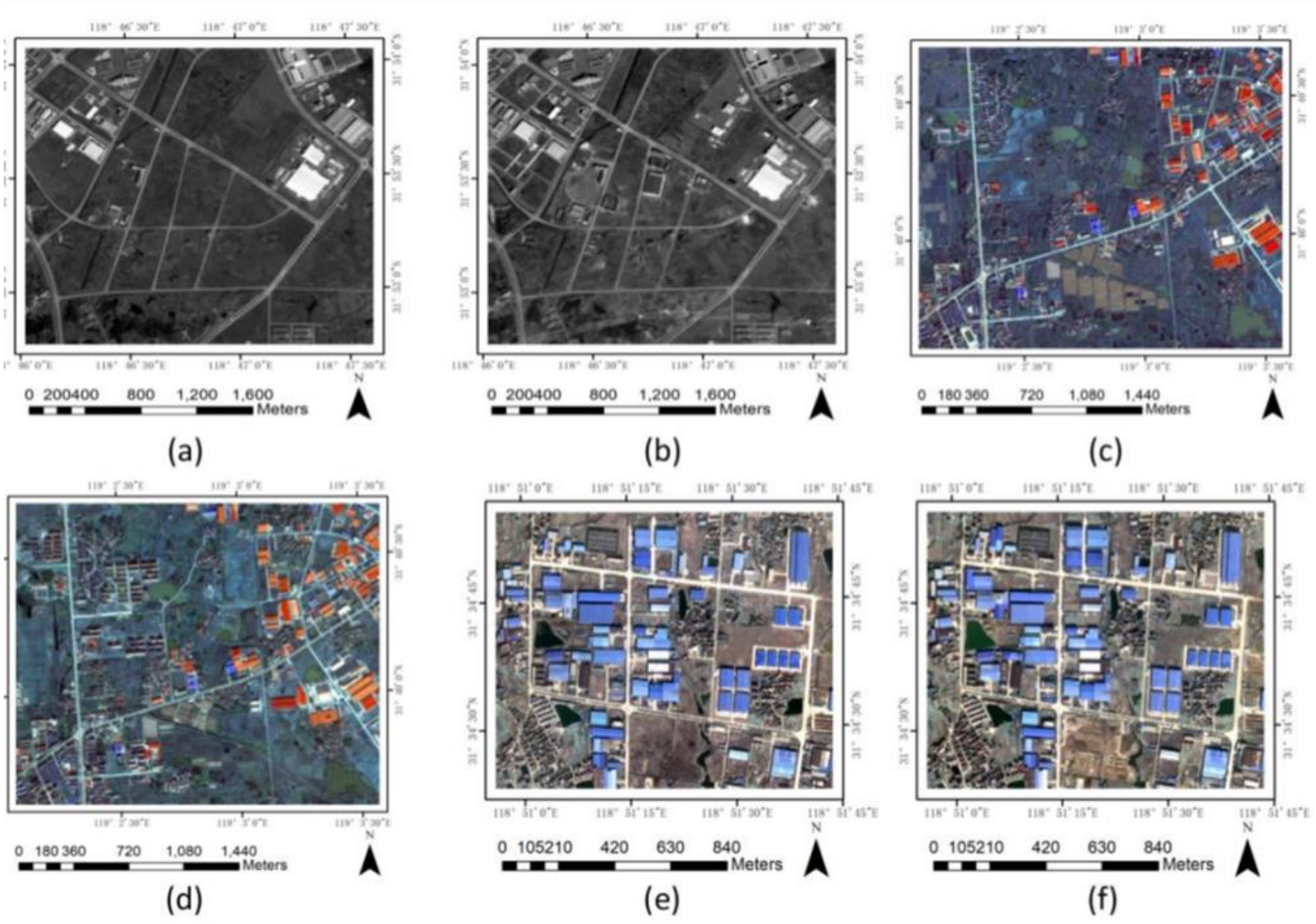


Figure 4. Three experimental areas. (**a**,**b**) Original bitemporal images of area 1. (**c**,**d**) Original bitemporal images of area 2. (**e**,**f**) Original bitemporal images of area 3.

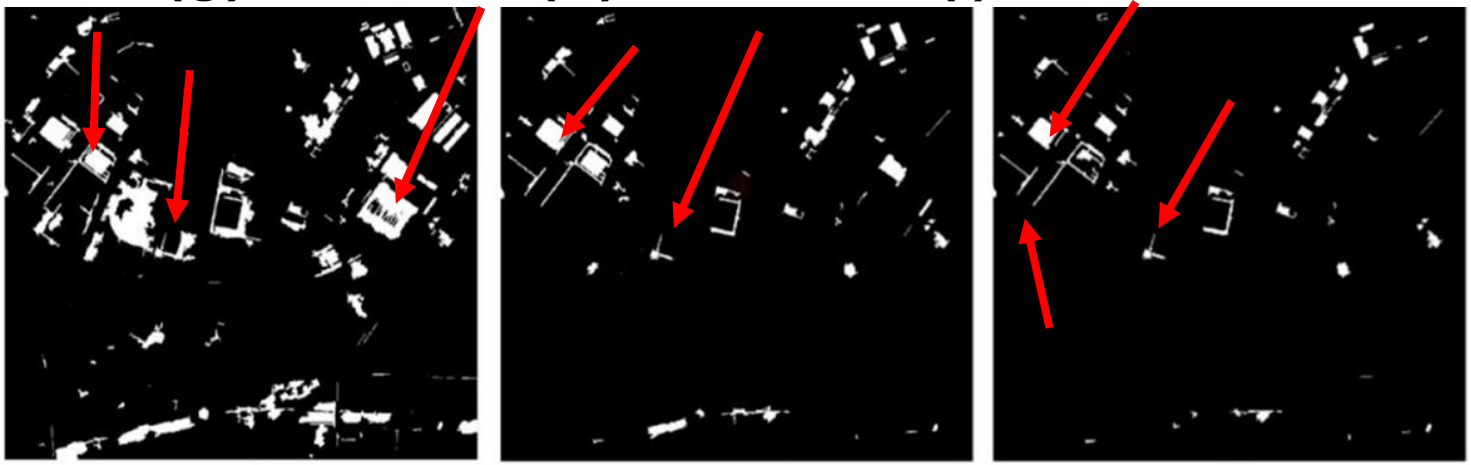
Area 1

(a)

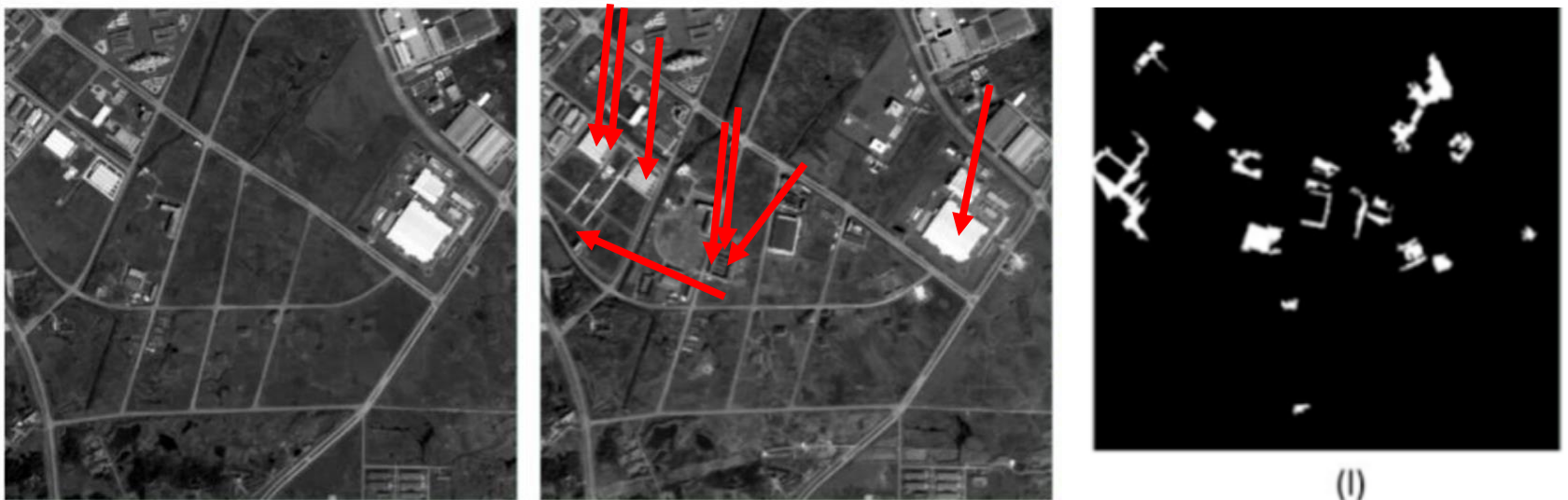
(b)

Area 1

- CVA(g), PCA-k(h), IRMAD(i)



(g) (h) (i)



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Area 1 Result

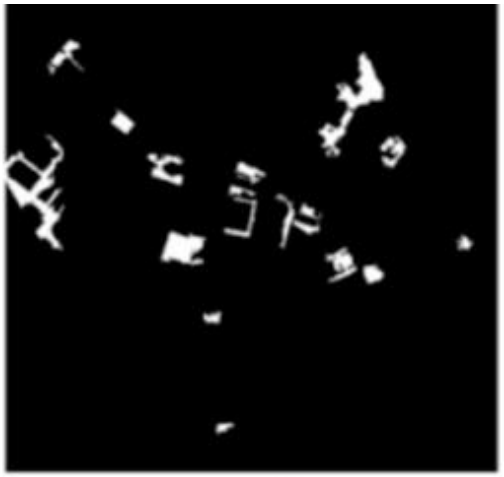

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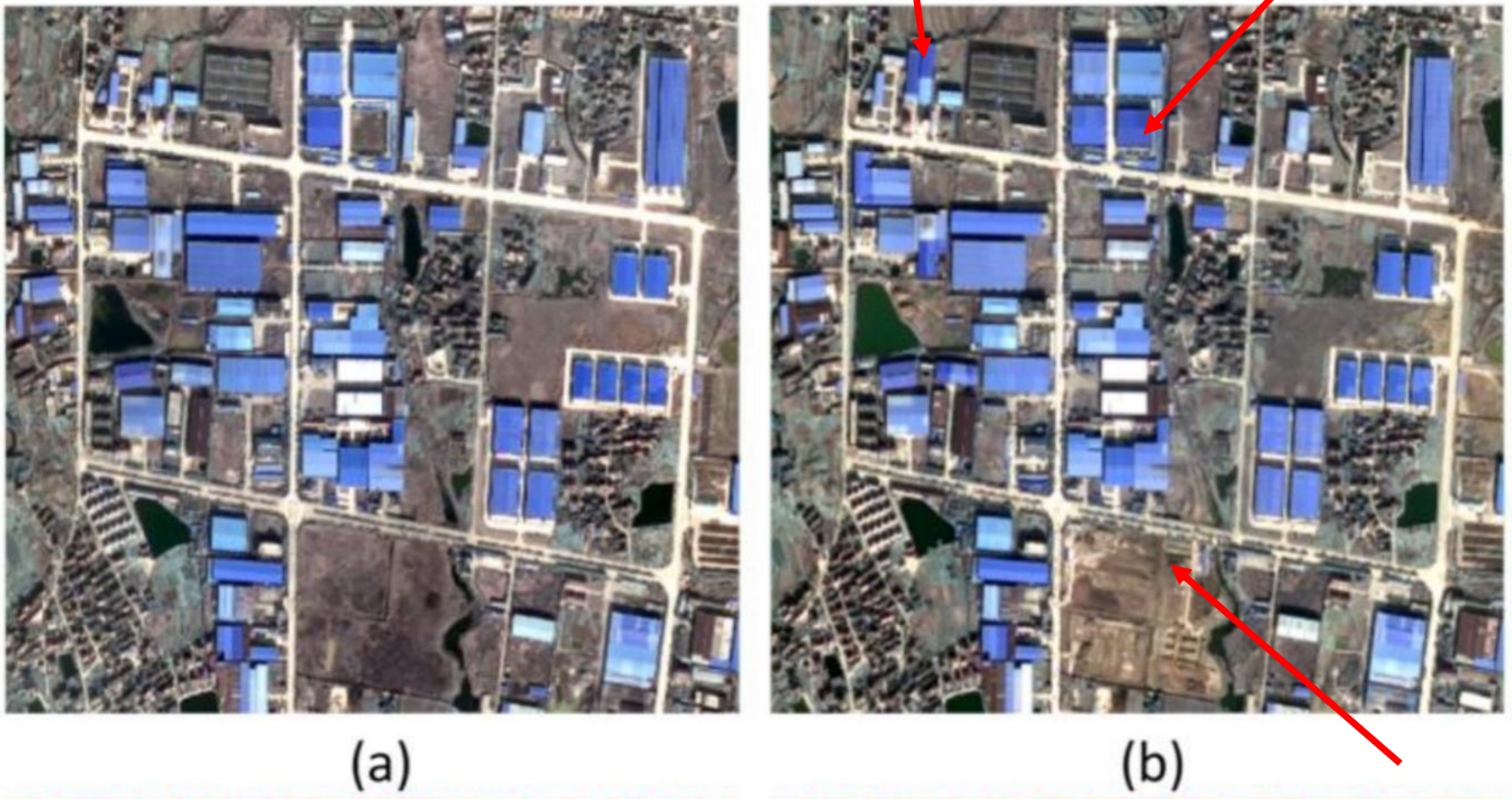
Table 2. Precision in area 1. TP: the number of change image objects correctly detected, FP: the number of unchanged image objects incorrectly detected as changed ones, FN: the number of changed image objects incorrectly detected as unchanged ones, TN: the number of unchanged image objects correctly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

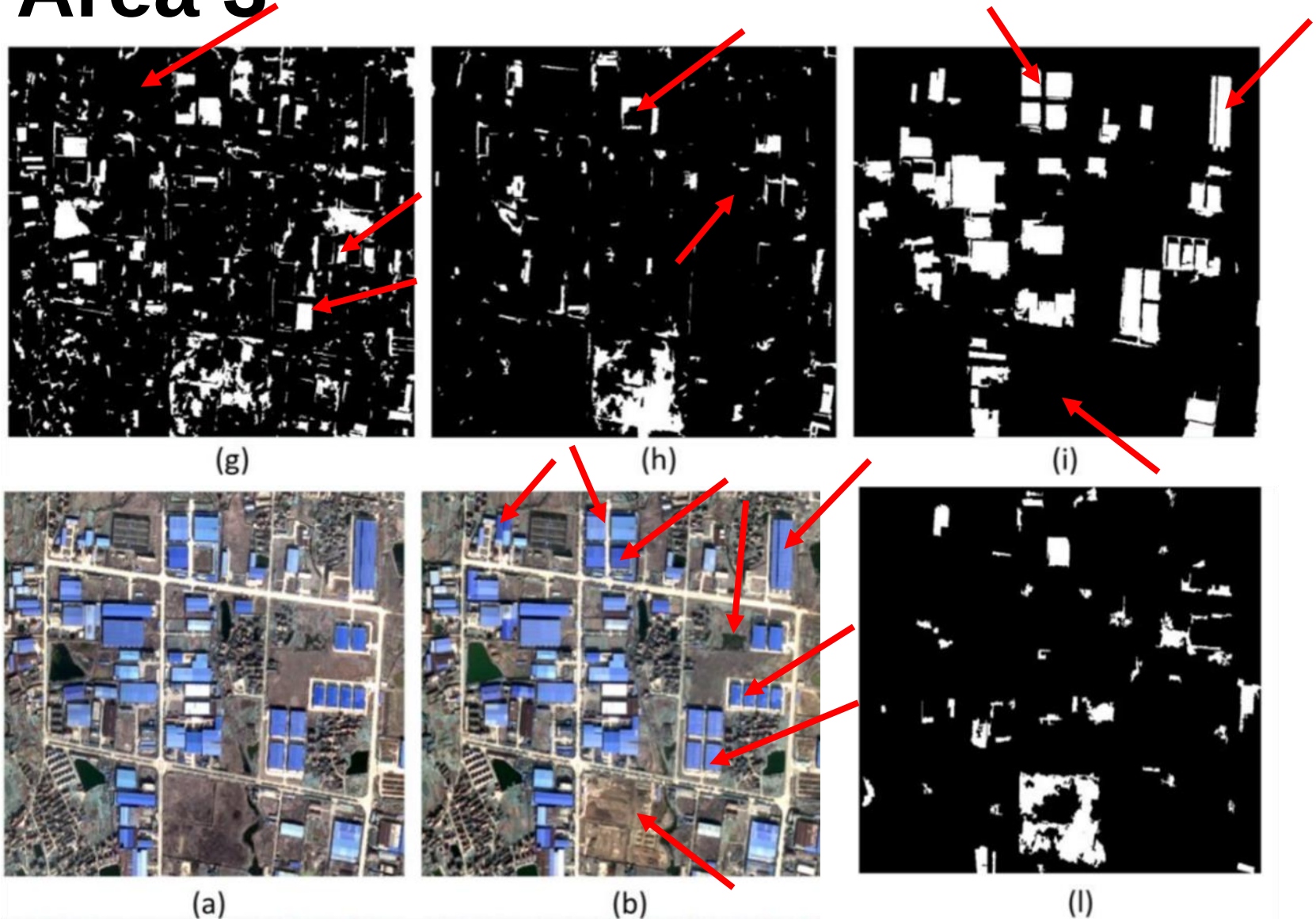
Type	Method	*TP*	*FP*	*FN*	*TN*	*OA (%)*	*MA (%)*	*FA (%)*	*Kappa*
Segment-based	CVA	52	219	21	1000	81.42%	28.77%	20.82%	0.23
	IRMAD	41	50	32	1169	93.65%	43.84%	4.13%	0.47
	PCA-K-means	44	78	29	1141	91.72%	39.73%	6.58%	0.41
	Initial detection	49	8	24	1211	97.52%	32.88%	0.63%	0.74
	Direct threshold relaxation	54	19	19	1200	97.06%	26.03%	1.52%	0.72
	Refined detection	54	11	19	1208	97.68%	26.03%	0.87%	0.77

Area 3



(a) (b)

Area 3



Area 3 Result

Table 4. Detection precision in area 3.

Type	Method	*TP*	*FP*	*FN*	*TN*	*OA (%)*	*MA (%)*	*FA (%)*	*Kappa*
Segment-based	CVA	123	1018	154	2710	70.74%	55.60%	35.93%	0.07
	IRMAD	16	419	261	3309	83.02%	94.22%	12.60%	-0.04
	PCA-K-means	145	342	132	3386	88.16%	47.65%	9.69%	0.32
	Initial detection	138	65	139	3663	94.91%	50.18%	1.71%	0.55
	Direct threshold relaxation	221	289	56	3439	91.39%	20.22%	7.90%	0.52
	Refined detection	199	139	78	3589	94.58%	28.16%	3.67%	0.62

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

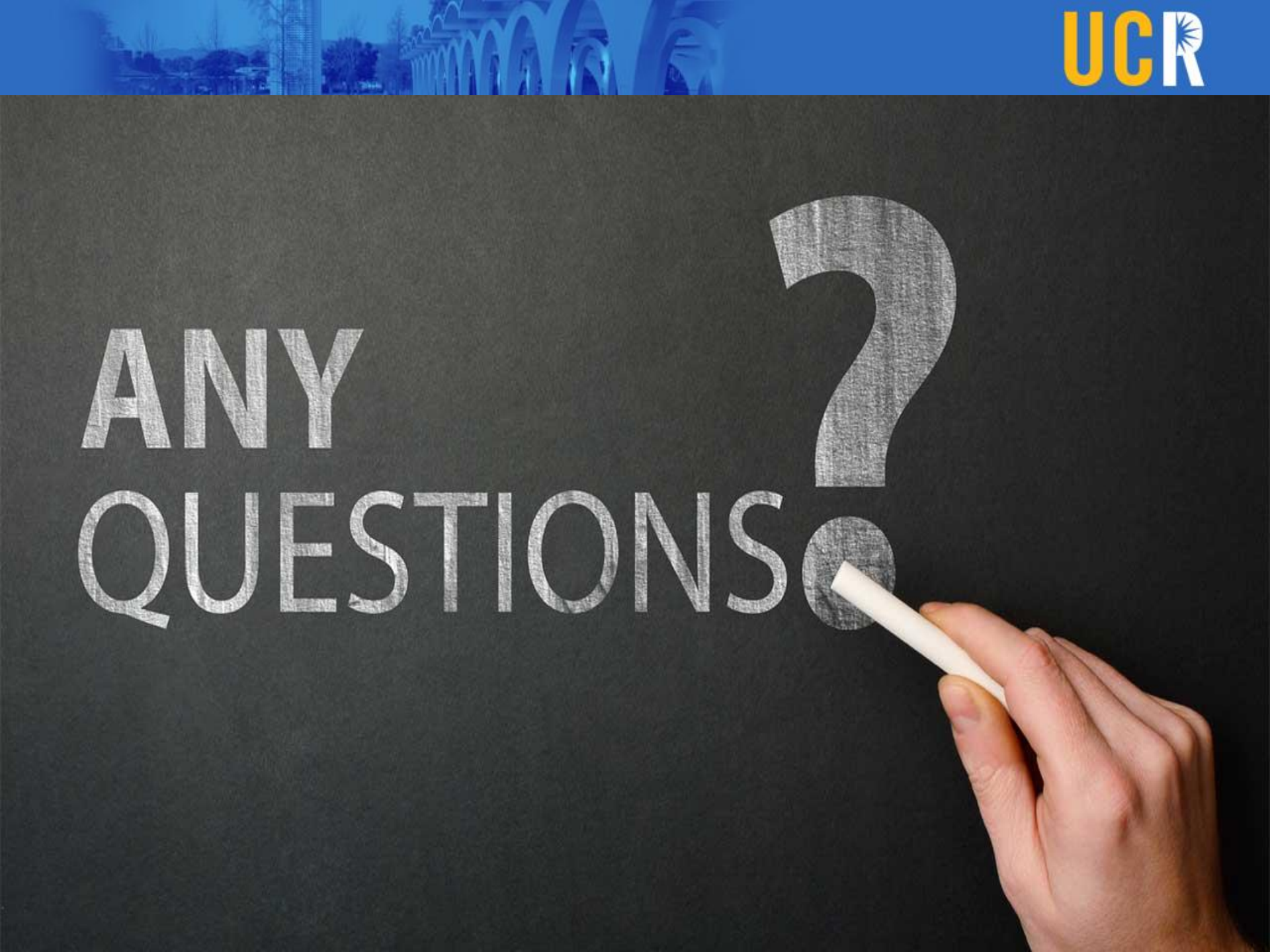
- bitemporal images needed to be segmented separately and straight lines were detected twice
- Area 3 CD refinement longer than others, because the TLPs in area 3 were more densely distributed

Table 5. Method efficiency (unit: seconds).

Area	TRP and TLP Creation	Feature similarity Calculation	CD by Evidence Fusion	CD Refinement Using RLPAF
Area 1	84.78	7.7	1.06	13.99
Area 2	89.84	23.27	1.19	24.25
Area 3	138.09	29.56	1.49	117.93

Conclusion

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