Change detection using multiscale segmentation and Kullback-Leibler divergence: Application on road damage extraction

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Outline

- ☞ Introduction
- ☞ Problematic and objectives
- ☞ Proposed methodology
- ☞ Experimentations
- ☞ Conclusion and perspectives

Introduction

Introduction

➪ Change detection occupies an important role in the extraction of useful information in remote sensing images:

Figure 1: Land use: The Niagara escarpment

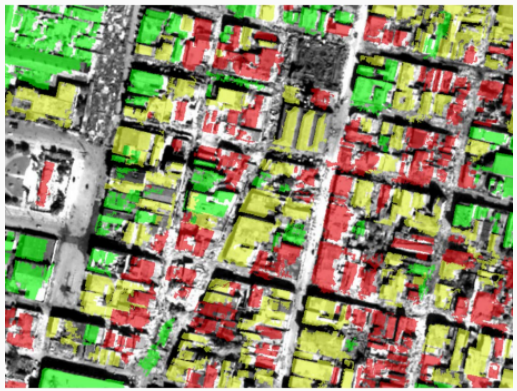


Figure 2: Damage detection and assessment

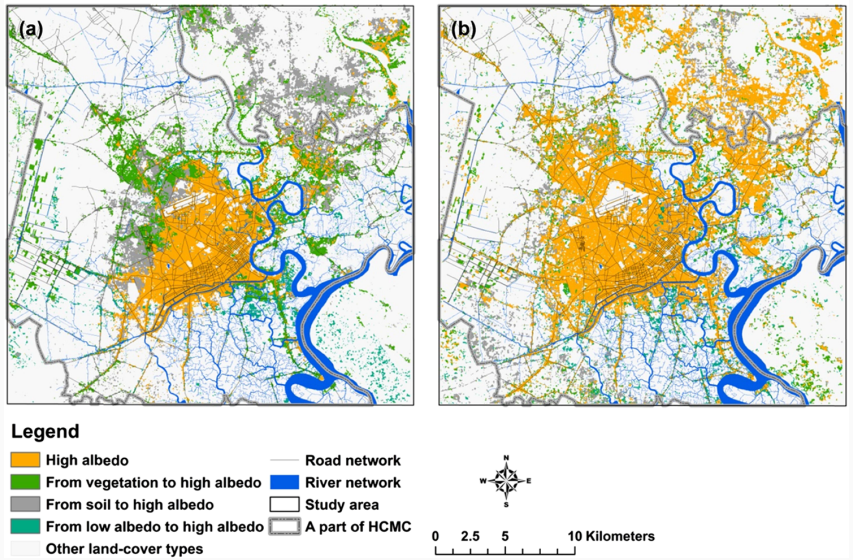


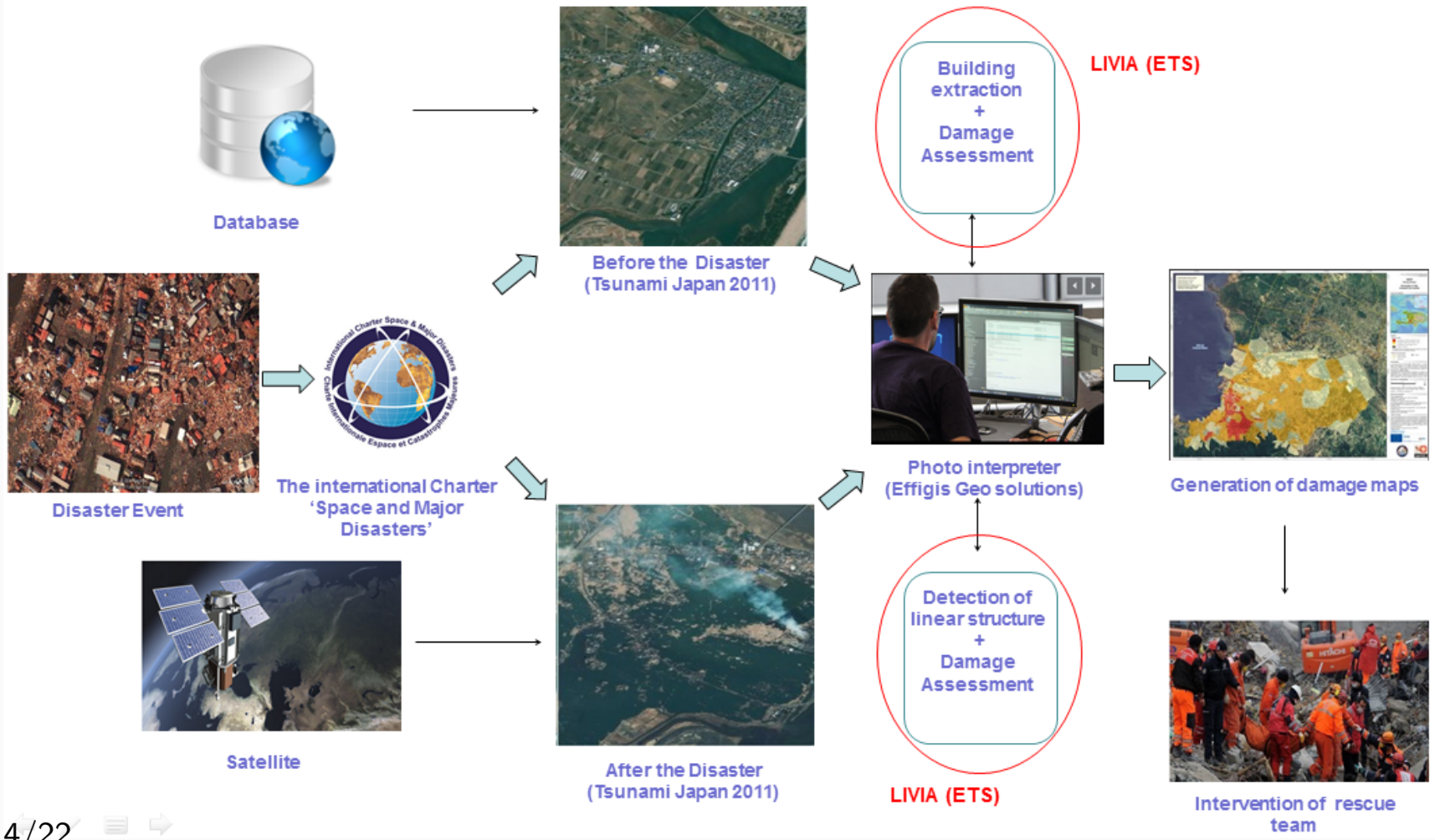
Figure 3: Urban expansion

Intervention cycle in case of major disasters

Le génie pour l'industrie

Remote Sensing For Major Disasters

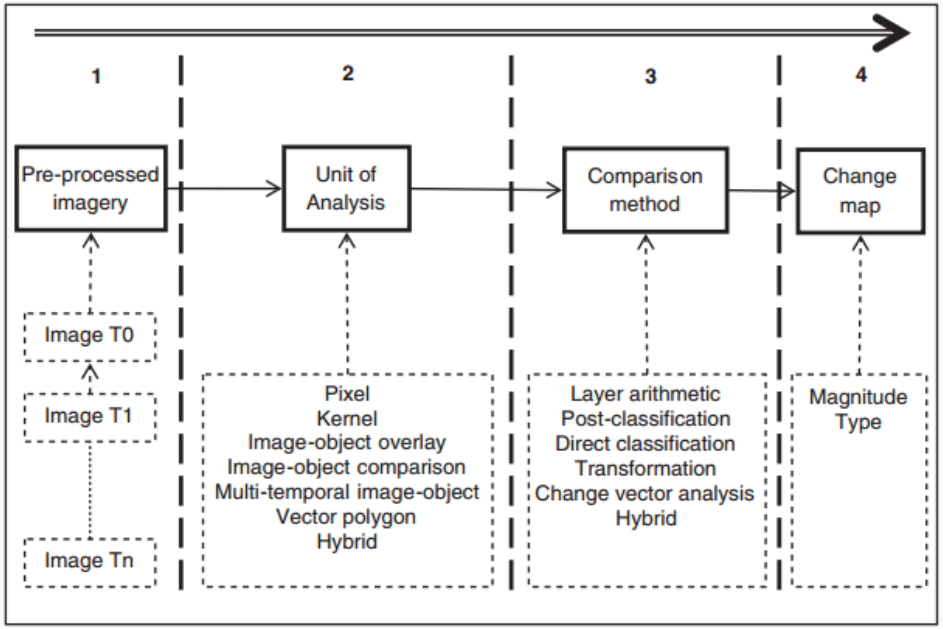
GEO SOLUTIONS



Problematic and Objectives

Problematic

- Problems related to the change detection techniques:



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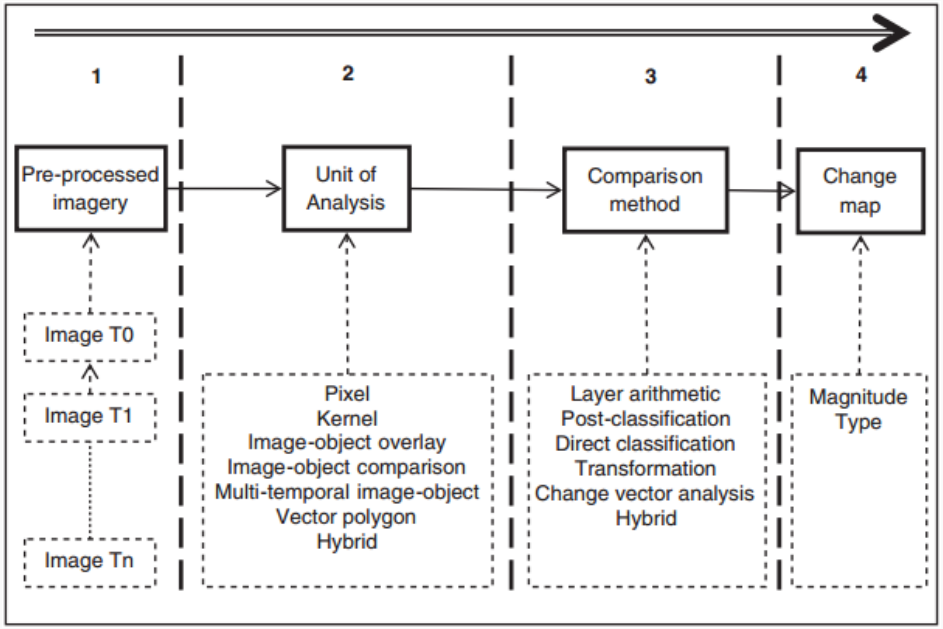
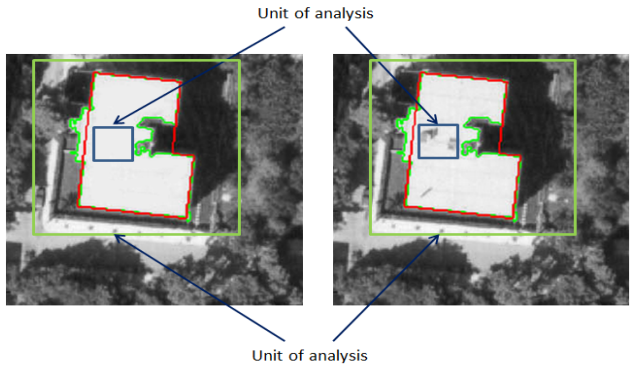


1. How to choose the unit of analysis ?



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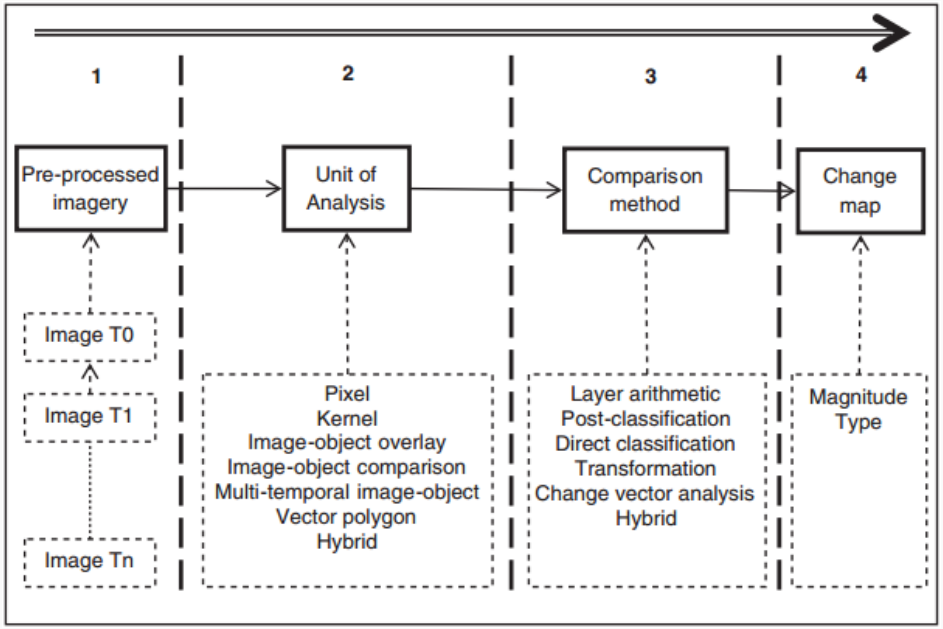

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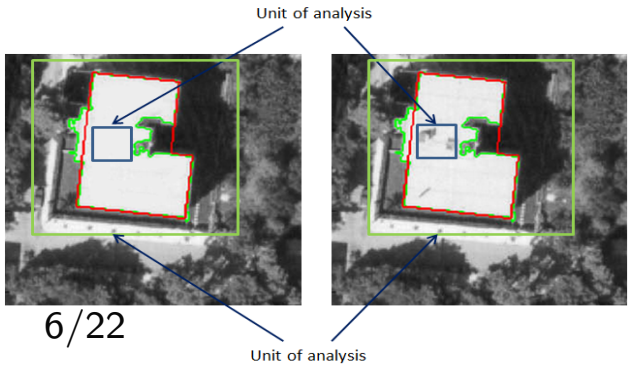

2. How to choose the comparaison method ?

Objectives

1. Achieve an optimal segmentation of the image as it influences on the change detection results.

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2. Perform a comparison method robust to noise.

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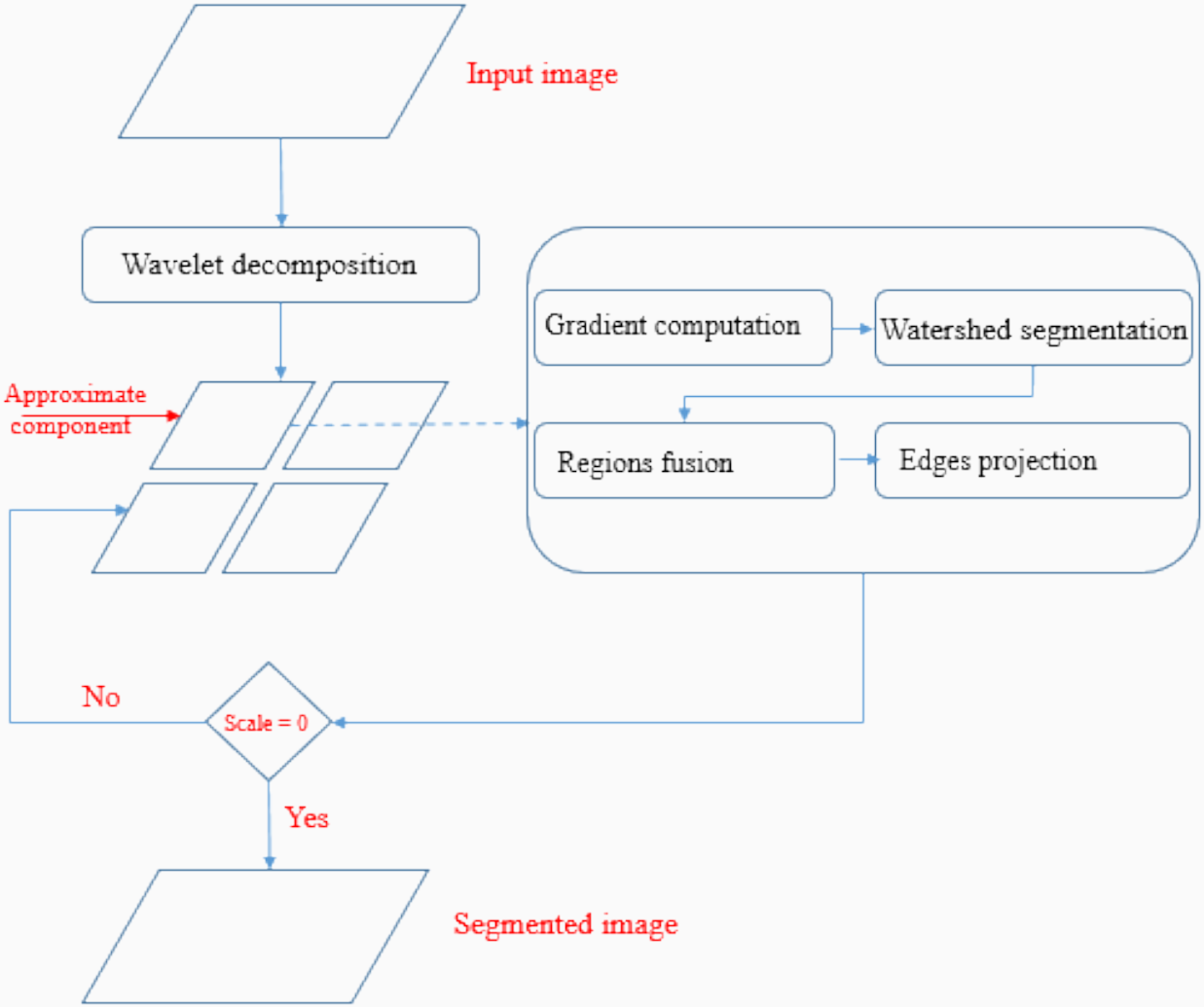
2. Perform a comparison method robust to noise.

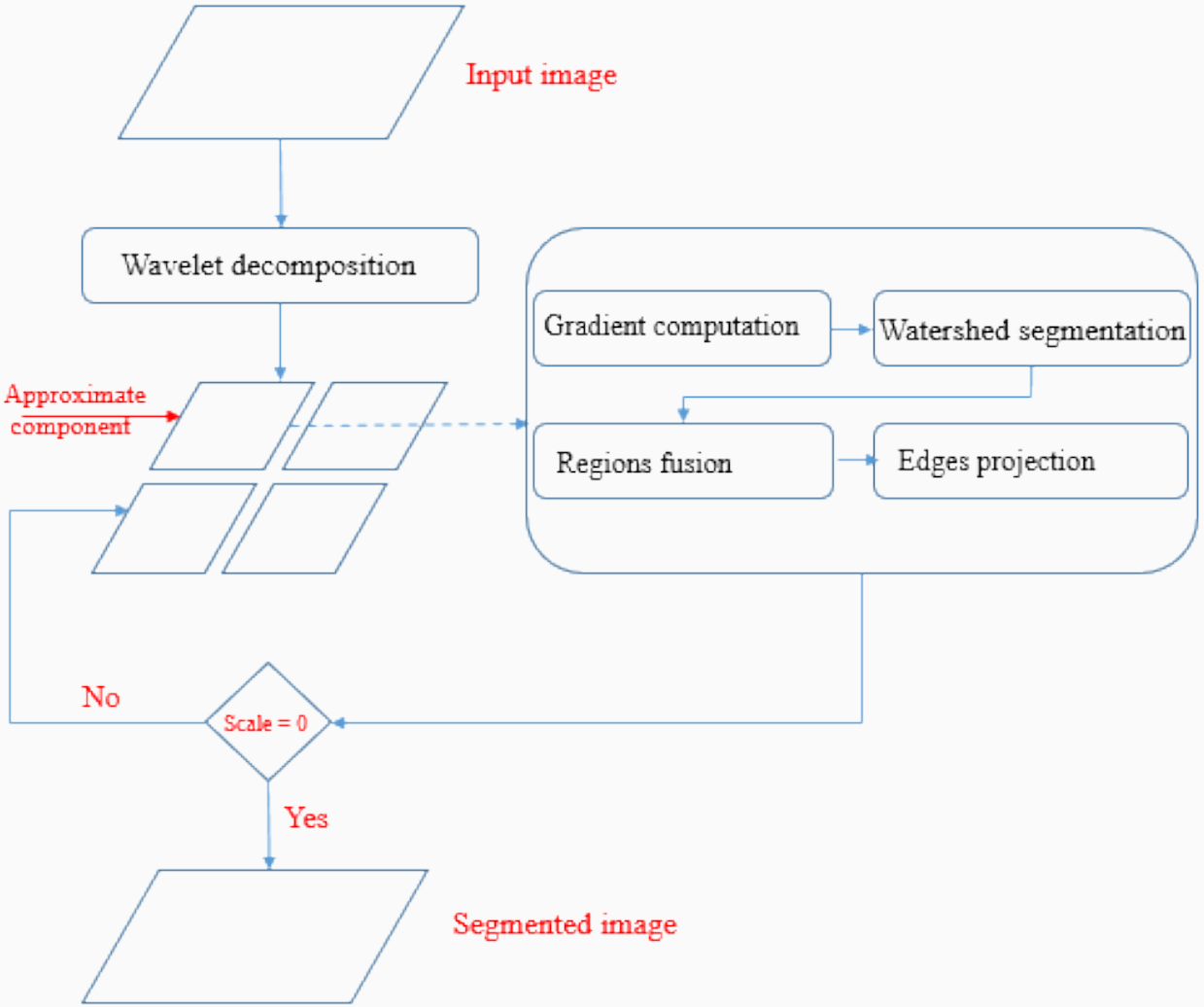
3. Apply the proposed method on road damage detection.

Proposed methodology

Multiscale segmentation



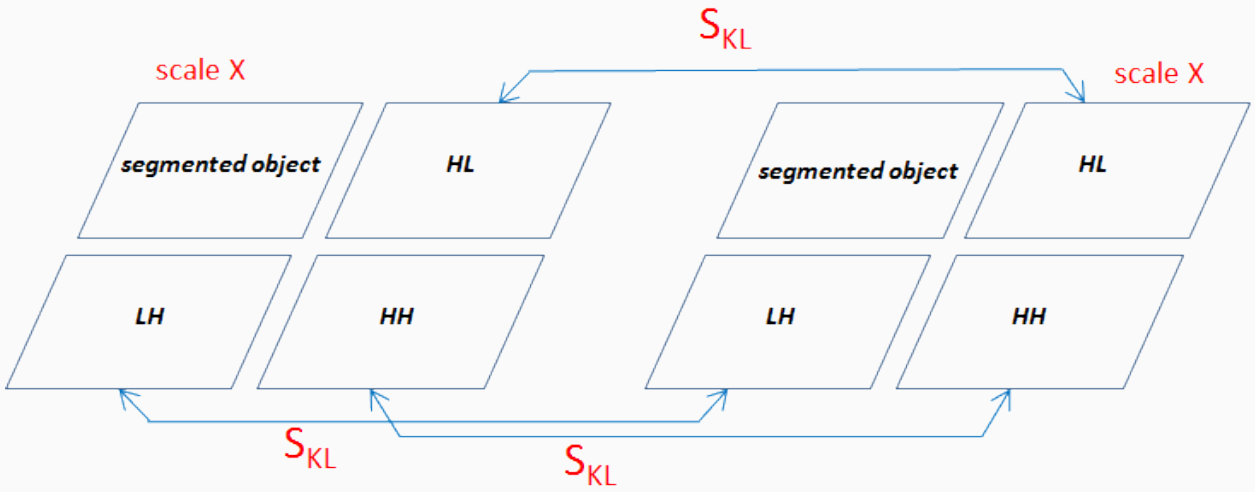
Multiscale segmentation



1. Texture measurements are used in the fusion process:

$$\begin{cases} | \, Texture_i - Texture_j \, | \leq \epsilon \\ Texture_i = Shade_i + Energy_i + SumVar_i + Mean_i \end{cases}$$

Change detection using the KLD



- The regions supporting the same object from the two images are compared using the Kullback-Leibler divergence.

Change detection using the KLD

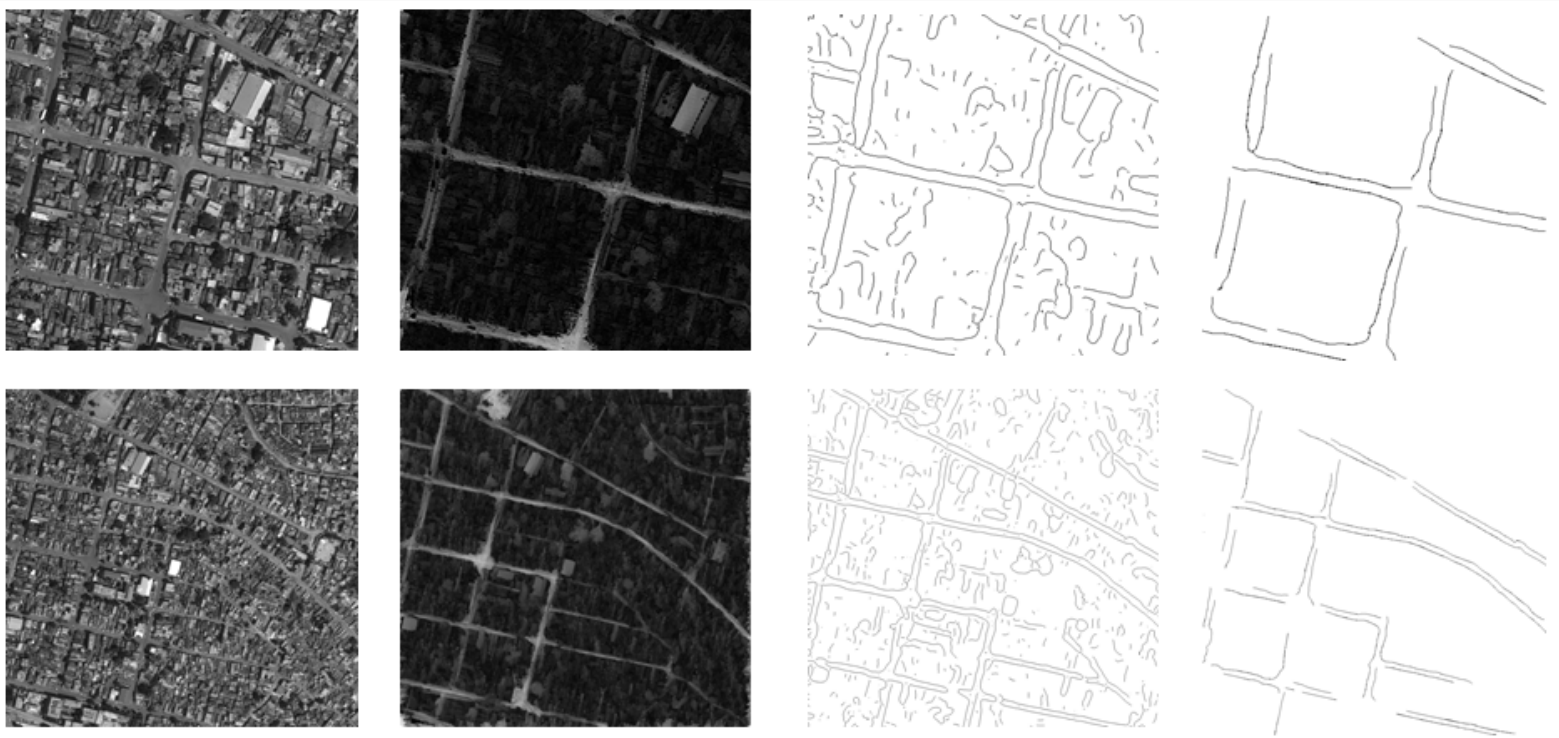
$$D_{KL}(P||Q) = \sum_i P(i) ln \frac{P(i)}{Q(i)} \quad (1)$$

$$S_{KL}(P||Q) = \frac{1}{2}(D_{KL}(P||Q) + D_{KL}(Q||P)) \quad (2)$$

- The regions supporting the same object from the two images are compared using the Kullback-Leibler divergence.
- A symmetric version of the KLD is obtained by taking the mean value of both directions.

IV. Application on road damage extraction

- Preprocessing: (Selection of Area of Interest)



Road extraction results (Igarss 2014, Jstars 2014)

- Introduction to the Dempster-Shafer theory:
  - Frame of discernment:
    $\Omega = \{w_1, w_2, ..., w_c\}$
  - Power set: $2^{\Omega} = \{\emptyset, w_1, w_2, \{w_1, w_2\}, w_3, \{w_1, w_3\}, \{w_1, w_2, w_3\}, ..., w_c\}$
  - A mass function m(.) is defined from 2^{Ω} to $[0, 1]$ as:

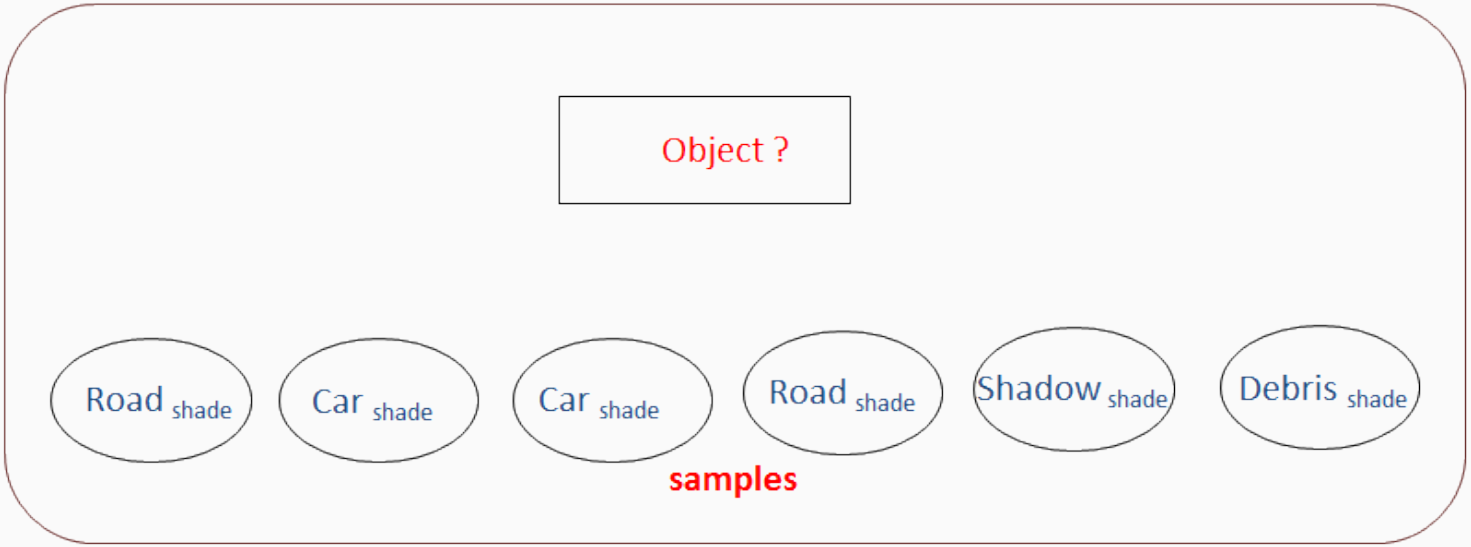
$$\sum_{A \subseteq 2^{\Omega}} m(A) = 1 \qquad m(\emptyset) = 0 \tag{3}$$

  - Two mass functions m_1 and m_2 can be combined using the Dempster's rule of combination:

$$m_{1 \textcircled{\cap} 2}(A) = \sum_{B \cap C = A} m_1(B) m_2(C), \qquad \forall A \subseteq \Omega \tag{4}$$

$$m_{1 \oplus 2}(A) = \begin{cases} 0 & \text{if } A = \emptyset \\ \frac{m_{1 \textcircled{\cap} 2}(A)}{1 - m_{1 \textcircled{\cap} 2}(\emptyset)} & \text{else} \end{cases}$$

IV. Application on road damage extraction



- Images classification using the Evidential K-nearest neighbor method (Denoeux, T 1995).

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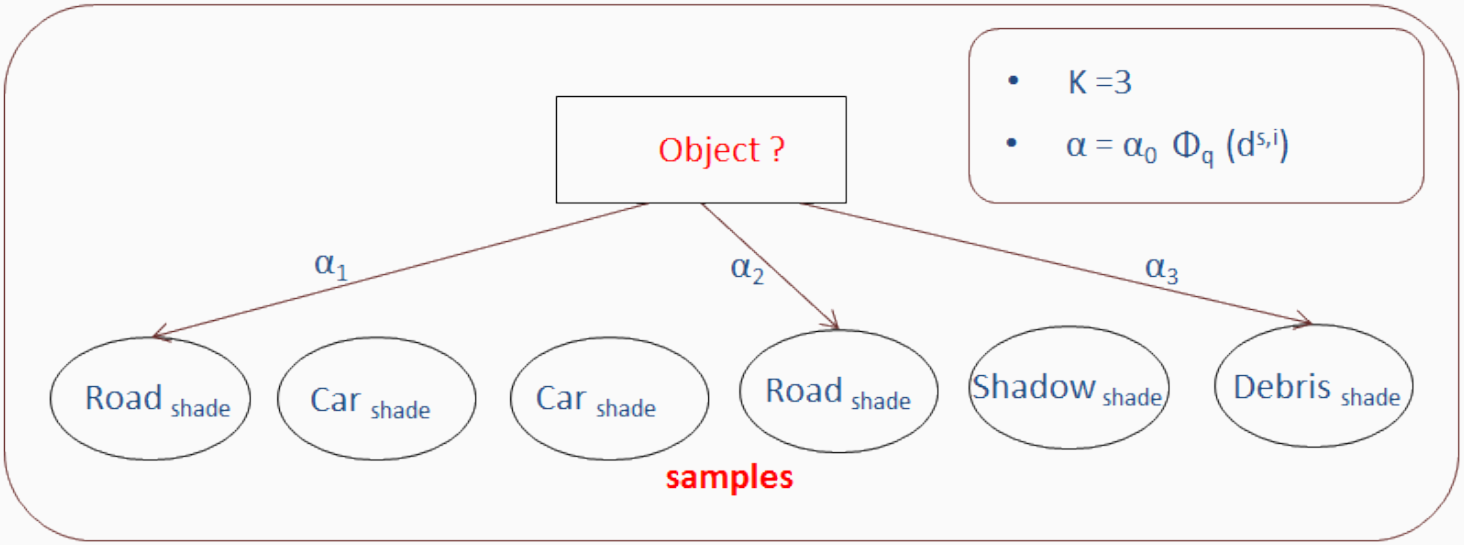

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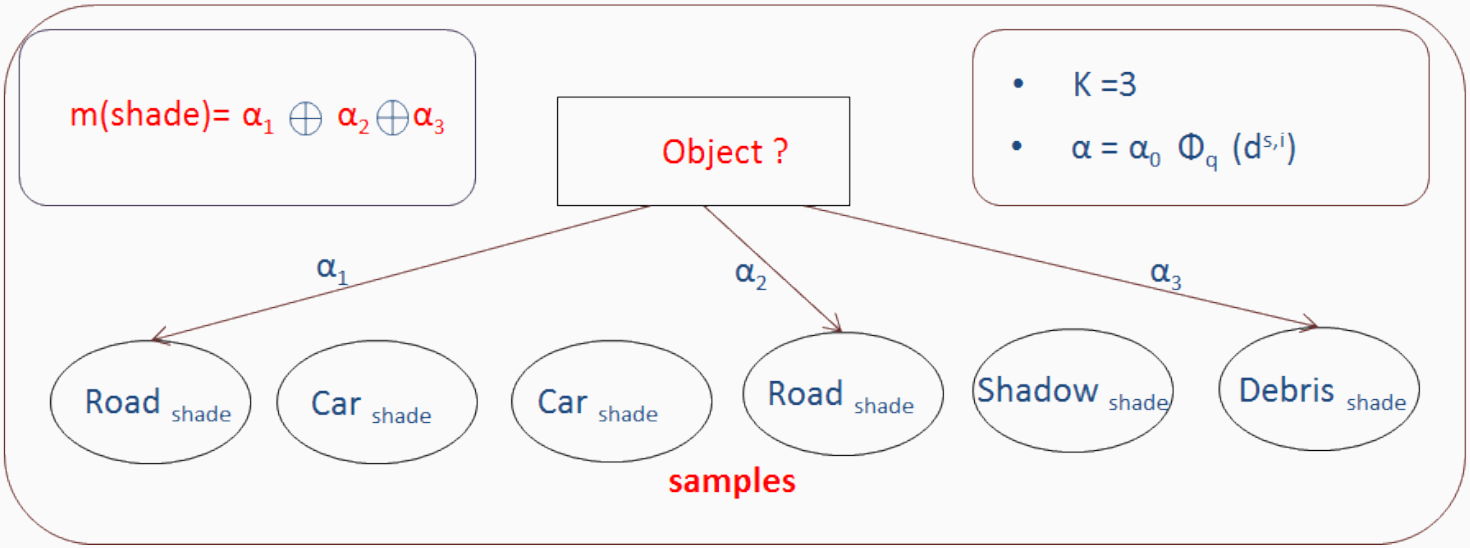

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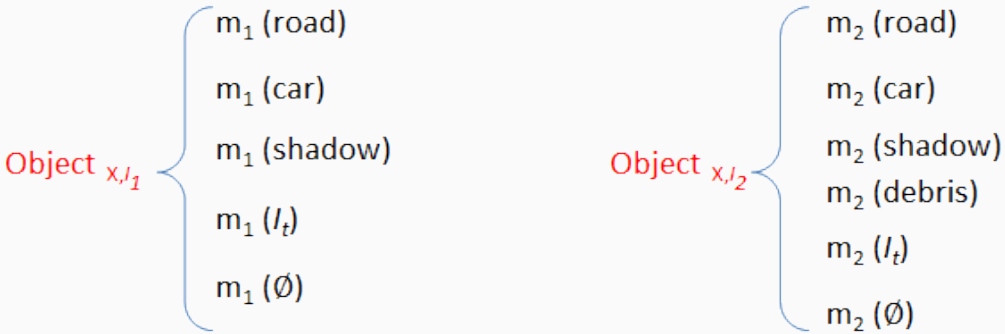
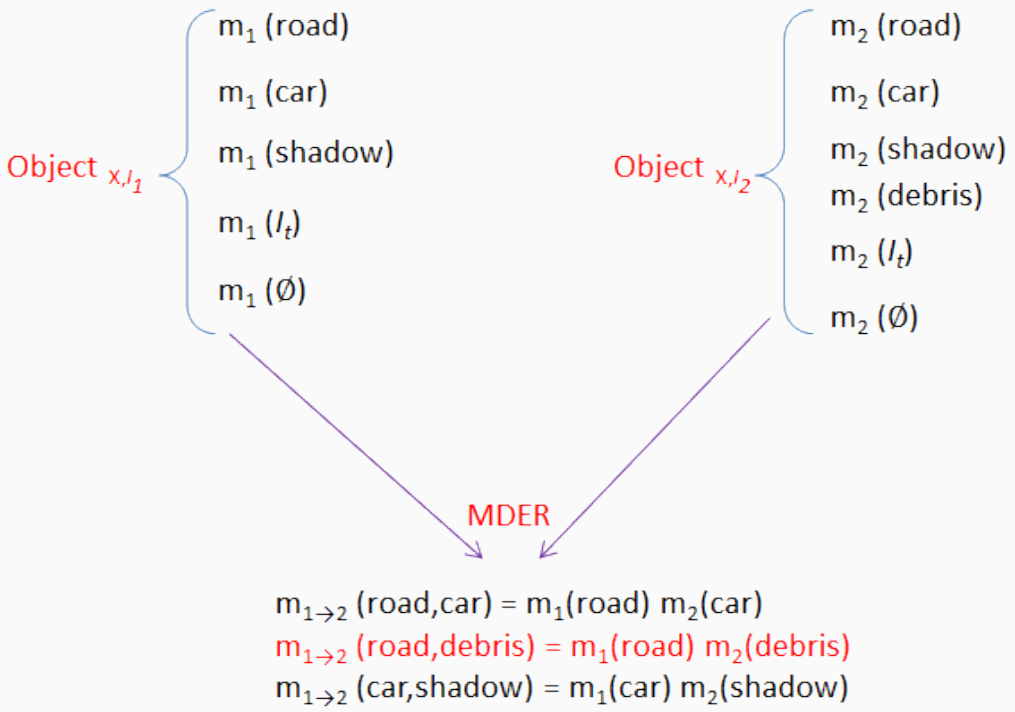


- Images classification using the Evidential K-nearest neighbor method (Denoeux, T 1995).
- Fuse mass functions from the two images using the Multidimensional Evidential Reasoning MDER (Zung-ga 2014).

IV. Application on road damage extraction



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IV. Application on road damage extraction

$$BetP(A) = \sum_{B \in 2^{\Omega}, B \neq \emptyset} \frac{|B \cap A|}{|B|} m(B)$$

- Images classification using the Evidential K-nearest neighbor method (Denoeux, T 1995).
- Fuse mass functions from the two images using the Multidimensional Evidential Reasoning MDER (Zung-ga 2014).
- Keep the most likely change using the maximum of the pignistic probability.

Experimentations

Experimentations

- Benchmark:

	Port-au-Prince (Haiti)	**Boumerdes (Algeria)**
Event	earthquake	earthquake
Date	12 January 2010	21 May 2003
Satellite	Geoeye-1	Quickbird
Dimension	14000×14000	28488×9732
Resolution	46 cm/1.84 m	60 cm/2.4 m
Bands	Panchromatic/Multispec.	Panchromatic/Multispec.

- Port-au-Prince site:

Figure 4: (a) Pre-disaster image

Figure 5: (b) Post-disaster image

Experimentations

- Boumerdes site:

Figure 6: (a) Pre-disaster image

Figure 7: (b) Post-disaster image

Experimentations

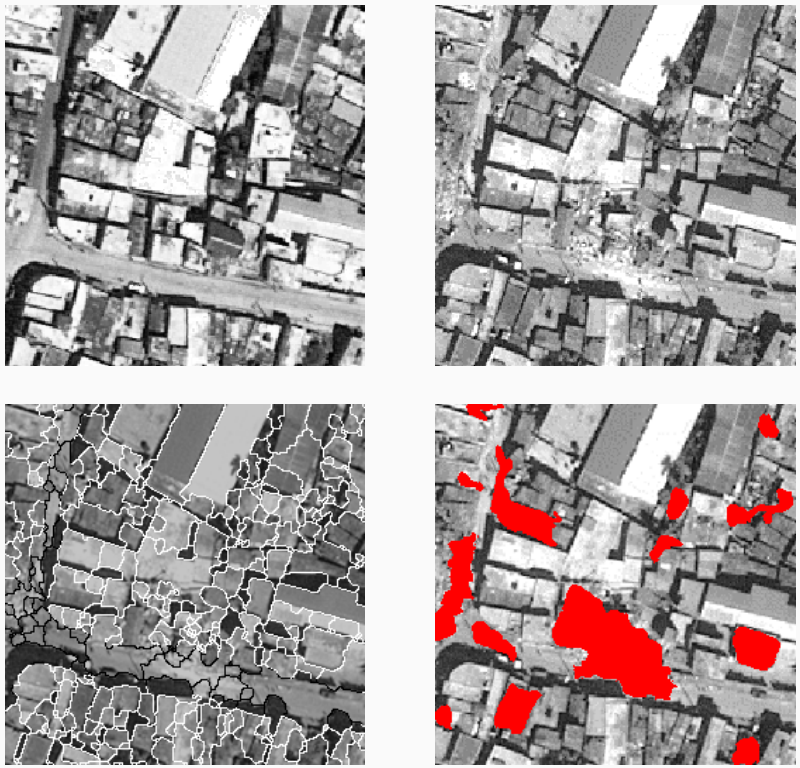

Figure 8: Results on Port-au-Prince site

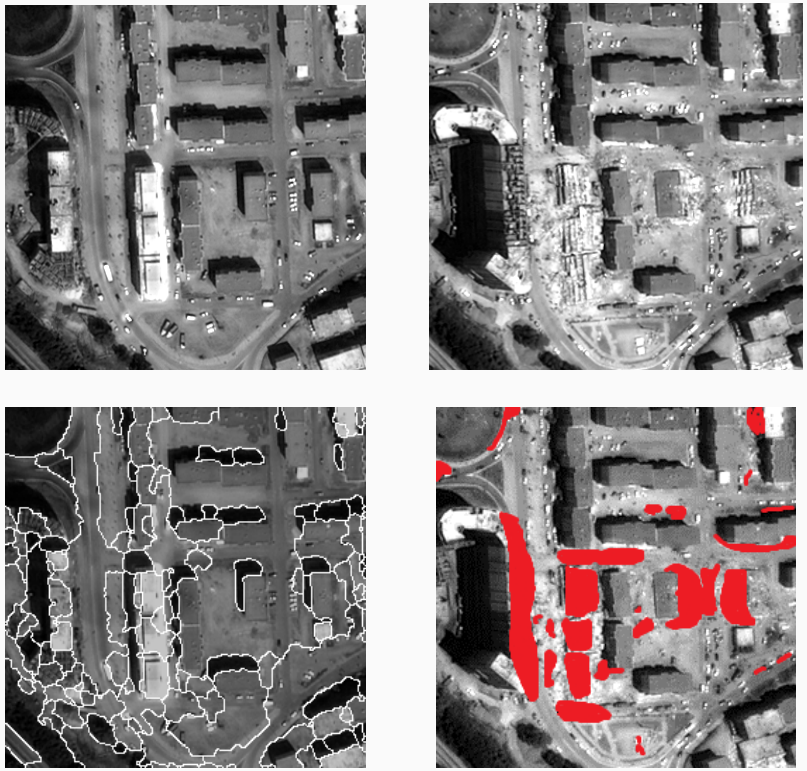

Figure 9: Results on Boumerdes site

Experimentations

- Comparison with existing techniques:

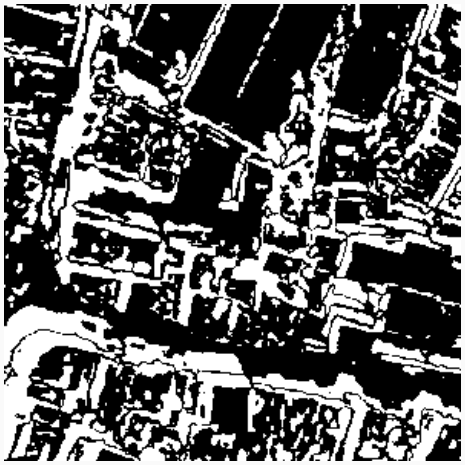

Figure 10: (a) Image differencing

Figure 11: (b) Multivariate alteration detector

	Detected Changes	False Alarms
Our method	220	20
Image differencing	402	103
MAD	395	78

Experimentations

Figure 10: (a) Input image

Figure 11: (b) Road damage detection

- Roads damage detection results:

Data set	Haiti	Boumerdes
DST-based method	TP = 82 % FP = 18 %	TP = 93 % FP = 7 %
Knn-based method	TP = 78 % FP = 22 %	TP = 87 % FP = 13 %

Conclusion and perspectives

Conclusion and perspectives

❒ Conclusion:

✍ A multiscale change detection technique is proposed.

✍ The wavelet transform is introduced to overcome the watershed segmentation algorithm limitations.

✍ The Dempster-Shafer theory is applied to classify segmented objects and to define the change nature.

❒ Perspectives:

✍ Consider other features in the fusion phase.

✍ Quantify the damage degree and identify passable roads.

Questions?