Analysing Satellite Image Time Series by means of Pattern Mining

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Outline

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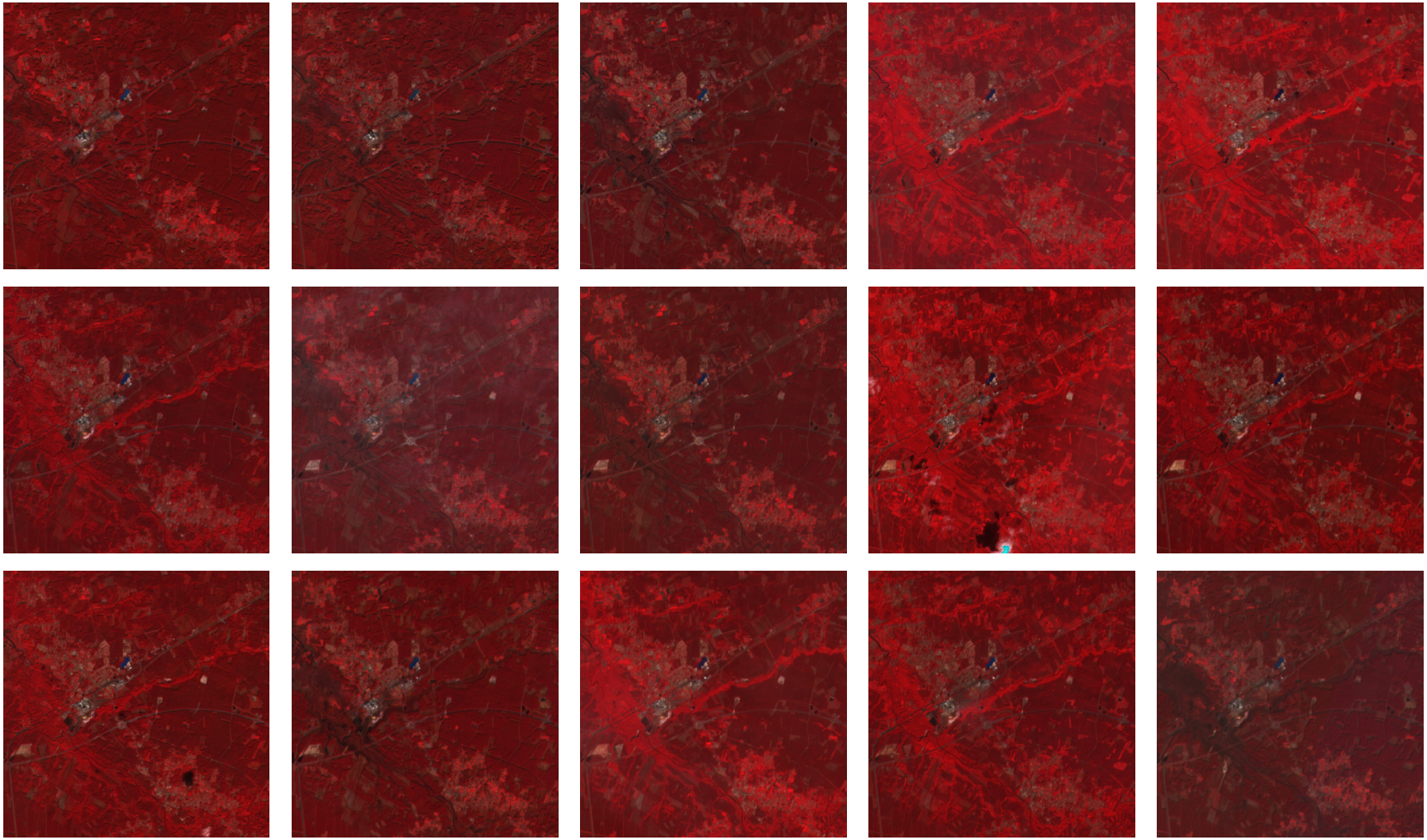
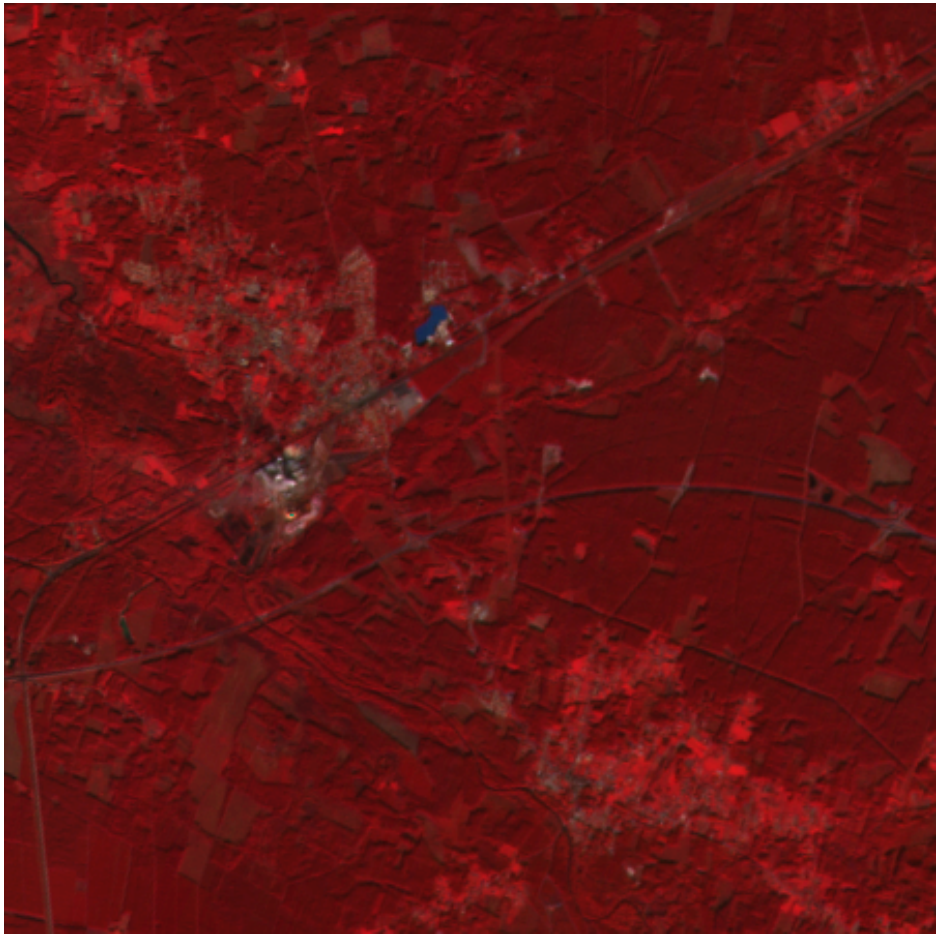
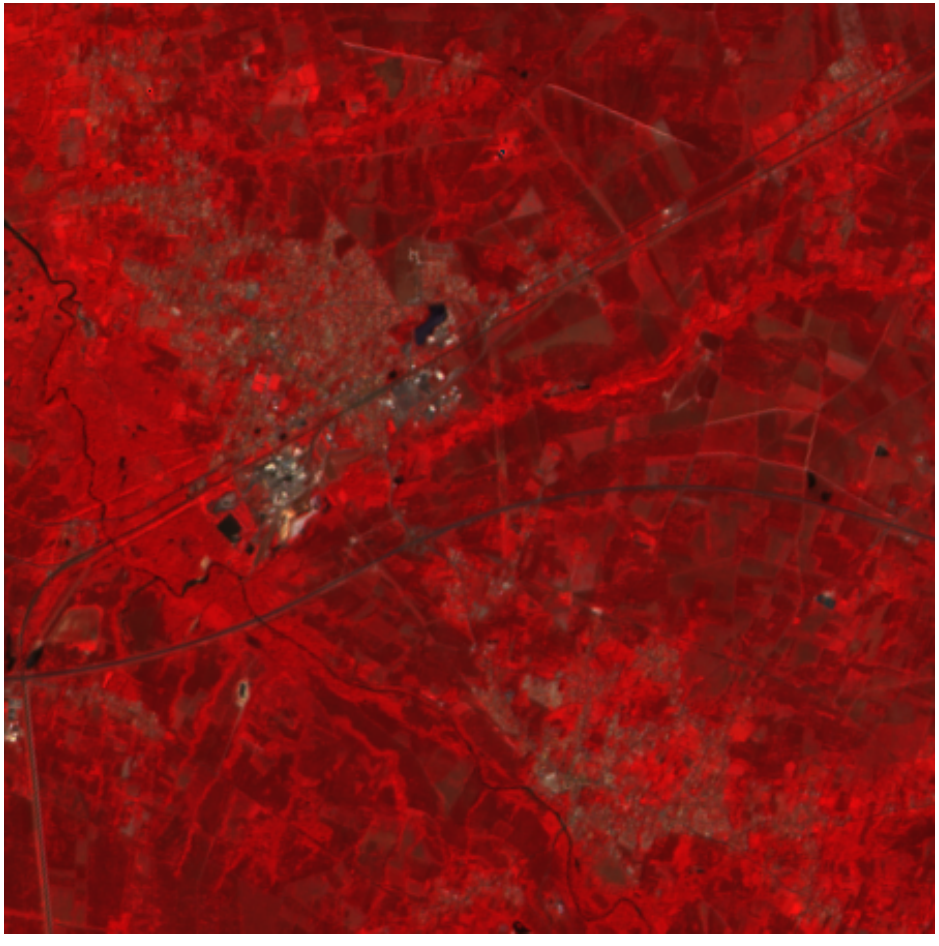
Satellite Image Time Series



Which change ?

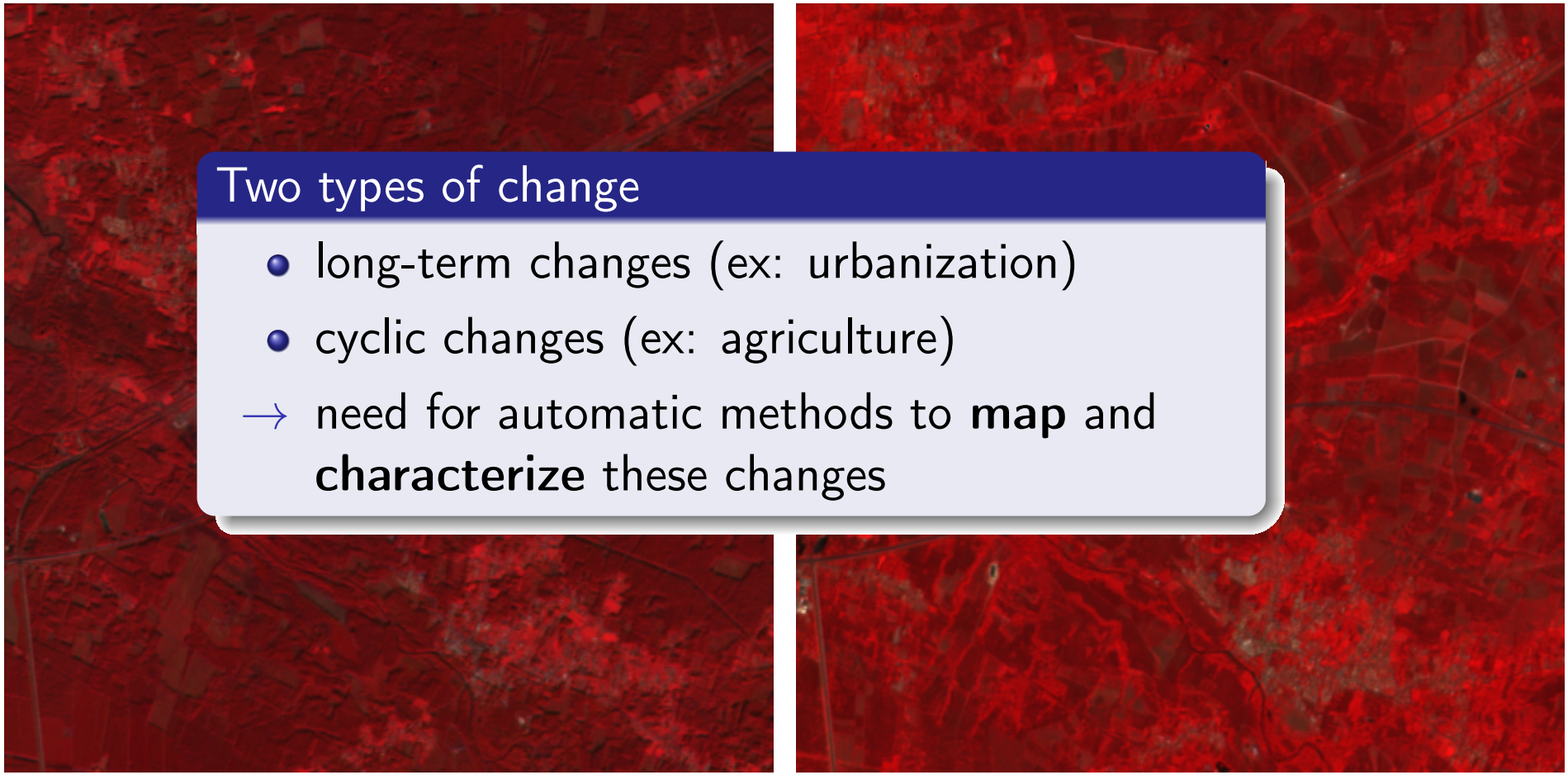


1986



2006

Which change ?



Two types of change

- long-term changes (ex: urbanization)
- cyclic changes (ex: agriculture)

→ need for automatic methods to **map** and **characterize** these changes

1986 2006

Outline

Bi-temporal methods

Principle

- Methods using only 2 images.
- Simple methods ; cannot capture complex changes.
- Mostly used to **map** change areas.

Examples

- Univariate Image Differencing [Bruzzone and Prieto, 2000]
- Image ratioing [Todd, 1977]
- Change vector analysis [Johnson and Kasischke, 1998]

Multi-temporal methods

Principle

- Methods using the whole image time series.
- Able to capture complex changes.
- Able and to **map** and **characterize** change areas.

Examples

- Post-classification fusion [Foody, 2001]
- Linear data transformation [Nielsen et al., 1998]
- Frequency analysis [Andres et al., 1994]
- Frequent pattern mining [Julea et al., 2008]

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Review

Bi-temporal methods

- By definition, these methods do not use the whole dataset.
- So they are unable to capture complex changes (long-term changes, cyclic changes, time shifts, etc.)
- Mostly used for the mapping of abrupt changes (earthquake, etc.)

Multi-temporal methods

- Have the possibility to capture complex changes.
- But generally deal with time dimension as another, except for:
  - **Fourrier** analysis, which don't tolerate **irregular** sampling.
  - **Frequent pattern mining**, which was only applied to the search of **majority** behaviours in **monoband** (gray image).

Aim of the paper

Objectives

Design a method with following characteristics:

- → multi-temporal
- → able to extract long-term or seasonal changes
- → (changes over small areas)
- → applicable to multi-band images
- → robust to meteorological noise (clouds)

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Mining Frequent Sequential Patterns

Frequent sequential Pattern Mining

- Frequent sequential Pattern Mining consists in finding frequent common subsequences.
- This type of methods fits several characteristics:
  - ✓ multitemporal by definition
  - ✓ able to extract different kind of changes by finding representing key states
  - ✓ applicable to multi-band images by extracting sequence of itemsets
  - ✓ robust to meteorological noise by being able to "skip" values
  - × able to extract minority behaviours → critical growth of the search space
- Our approach is based on PSP [Masseglia et al., 1998]

The pattern extraction algorithm

Pattern extraction algorithm

Composed of 2 steps:

1. Generate a set of candidate patterns (sequences).
2. Prune phase: discard from this set, sequences not satisfying the minimum support.

Extracting minority behaviours

- Problem: a lot (!) of non-evolution patterns (*e.g.* tree $\rightarrow$ tree)
- Solution:
  1. Add a maximum support (avoid hyper-frequent values)
  2. Remove candidates with two consecutive identical values

Outline

Area of study

Area of study

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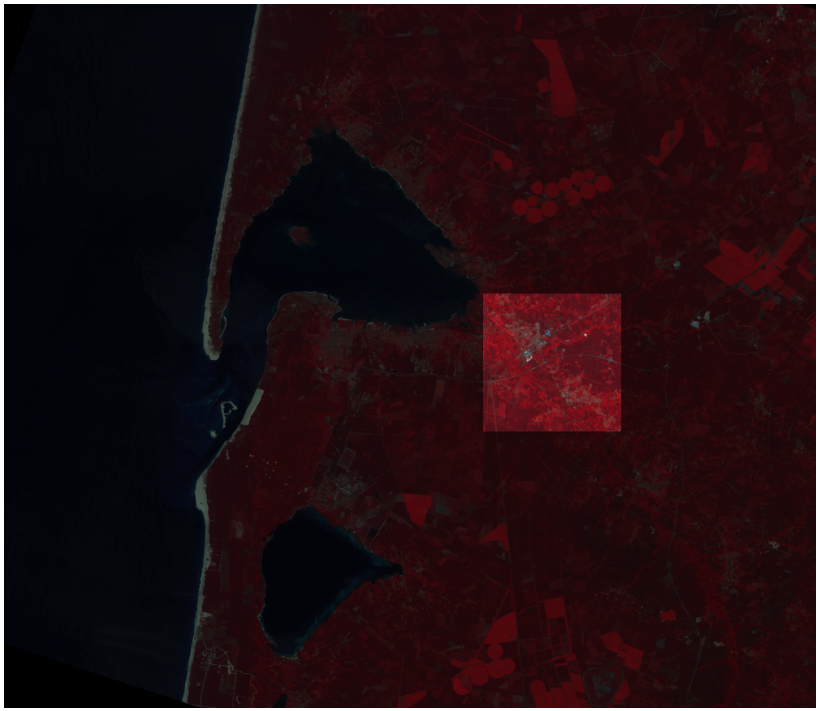
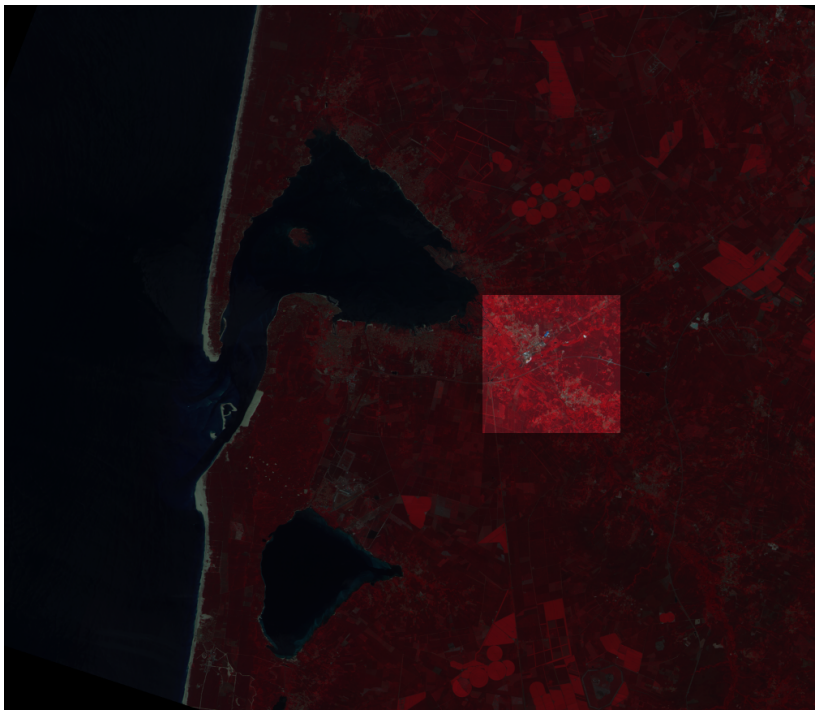
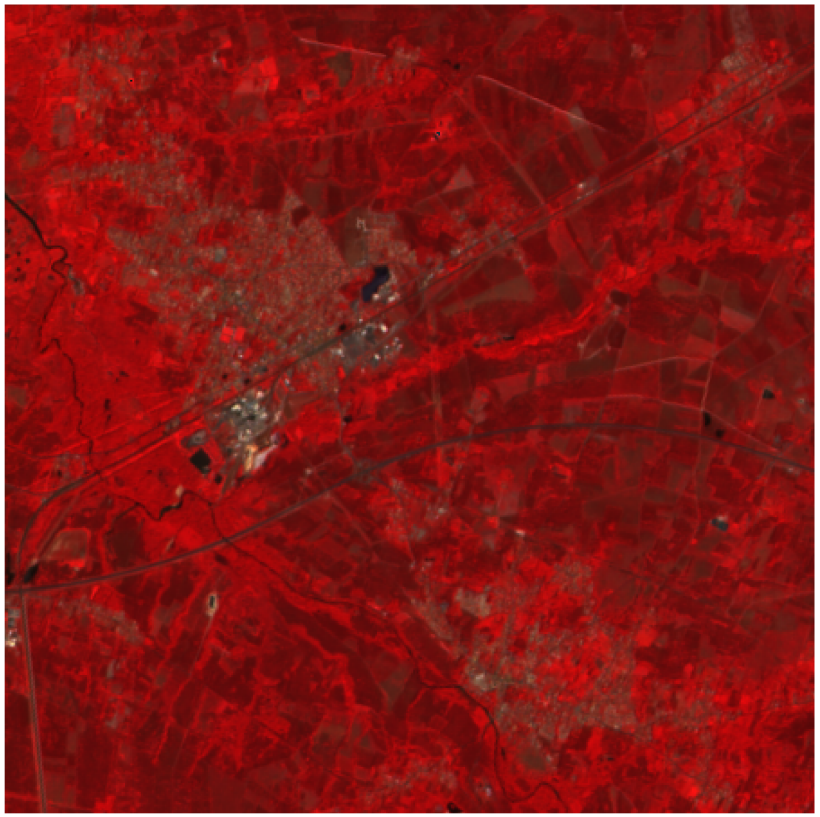
Area of study

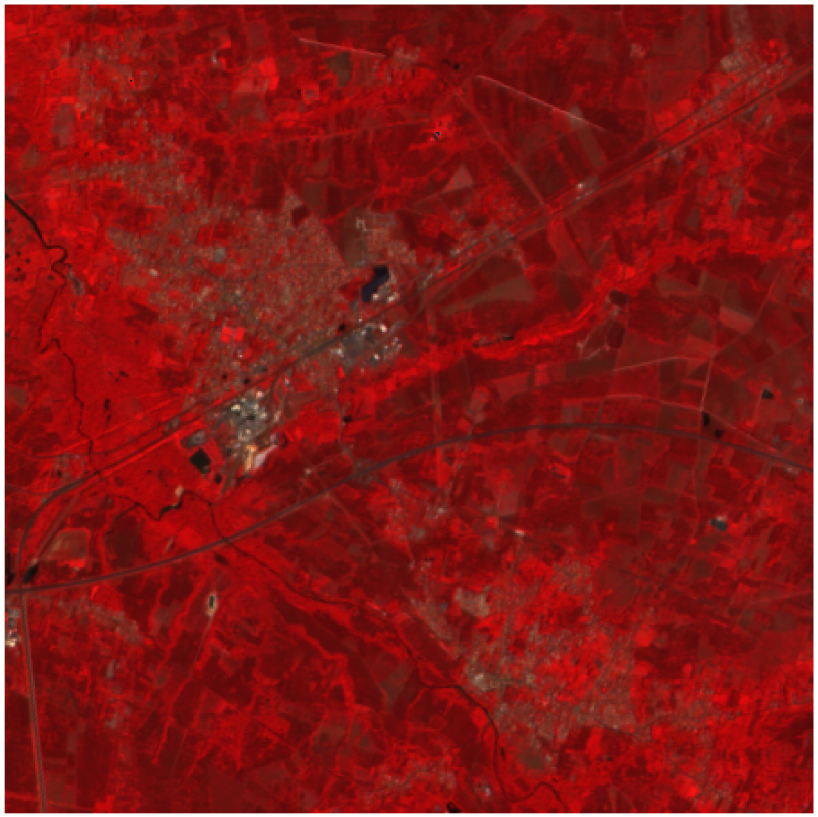


Area of study





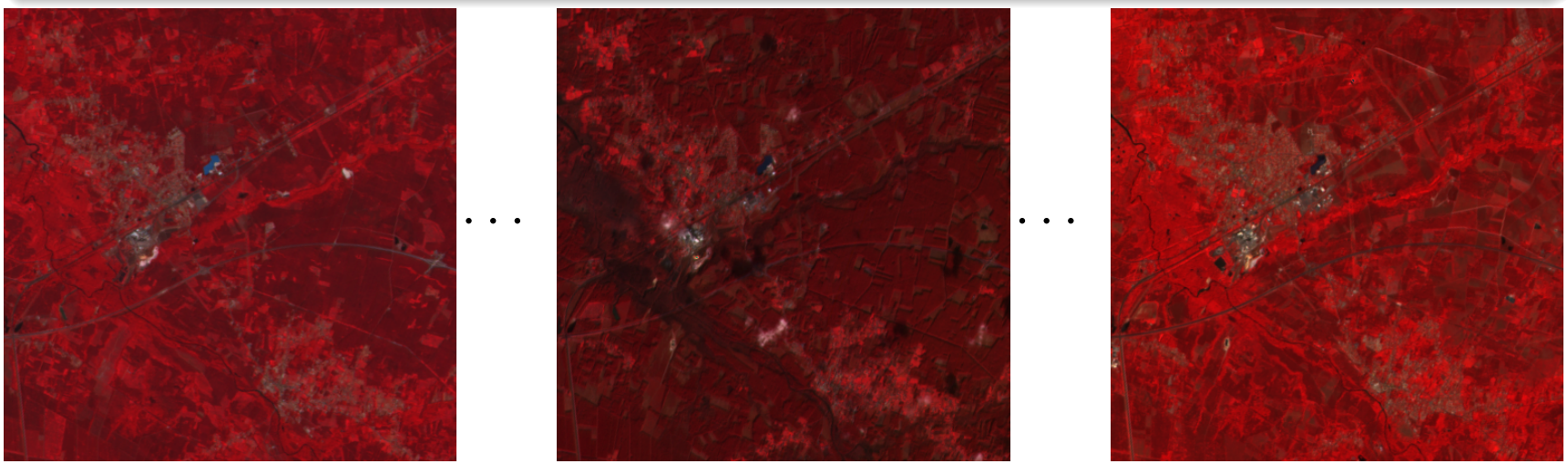
Area of study



Satellite Image Time Series

Description

- Satellite image database: Kalideos © CNES 2010 (`http://kalideos.cnes.fr`)
- Spot 1, Spot 2 & Spot 4
- 35 images over 20 years (1986 to 2006)
- Total number of pixel values: 28 millions



1986-07-16 ... 1994-01-29 ... 2006-06-03

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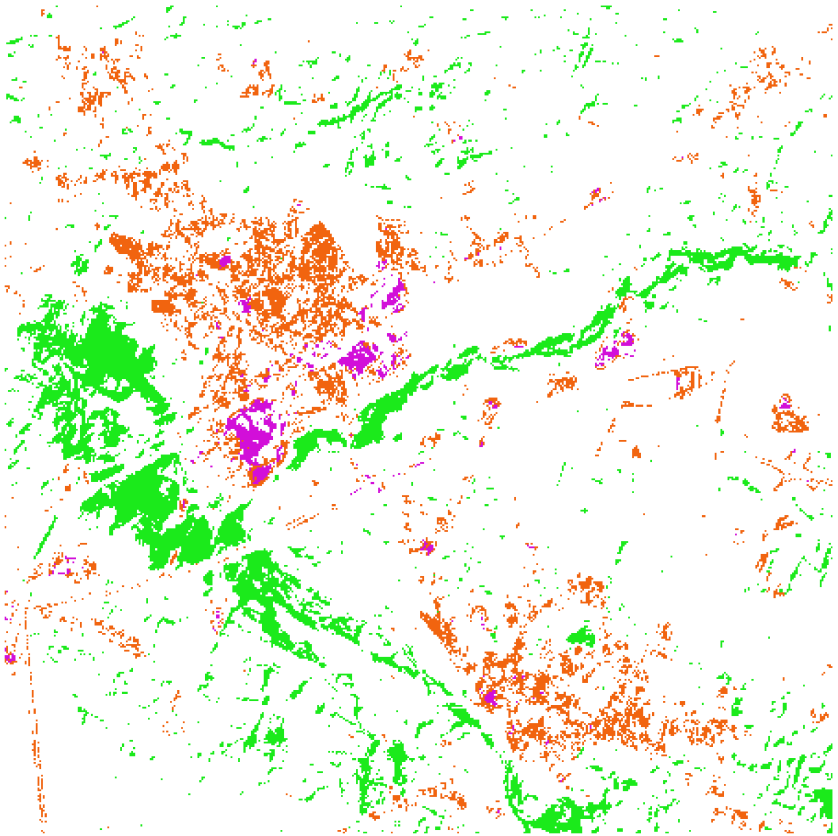
Visualising frequent patterns

How to visualise extracted patterns?

- Each sequence corresponds to a series of pixels' values at coordinates (x, y).
  - $\rightarrow$ each sequence s corresponds to a unique couple (x, y)
- Thus, all sequences supported by a pattern can be highlighted on a map as white pixels.
  - $\rightarrow$ a map can be drawn for each extracted pattern

Presentation of three patterns



Visualisation of three selected patterns (one color per pattern)

$< (IR, 1)\ (NDVI, 20) >$
swamps

$< (R, 17)\ (R, 18;\ NDVI, 3) >$
urbanisation

$< (NDVI, 2)\ (G, 20)\ (NDVI, 1) >$
industrialisation

Conclusion

Summary

- Adaptation and validation of sequential patterns extraction to remote sensing.
- Extraction of minority behaviours.
- Visualisation of sequential patterns.

Future work

- Visualising a set of patterns.
- Application to an other application domain (*e.g.* agronomical)

Questions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