Multi-scale methodology to map urban structures: classification of Pléiades images combined with existing geographic data

Léo VETILLARD
Jean NABUCET
Laurence HUBERT-MOY
LETG-Rennes COSTEL
UMR CNRS 6554, Université Rennes 2

Emilie HANSON
Omar BENARCHID
Eléonore WOLFF
IGEAT
Université Libre de Bruxelles

Julien DENIAU
Simon ROUGIER
Anne PUISSANT
LIVE UMR CNRS 7362, Université de Strasbourg
Objectives

- A survey of users’ needs:
  - a detailed land use/land cover map is useful to manage the city, its urban fabrics and green network.

- Lack of consolidated and reproducible methodology

→ to define a multi-scale methodology based on Pléiades images and existing ancillary data
  - to map built-up and vegetation surfaces in urban and suburban areas of Western Europe
  - to characterize urban fabrics and green infrastructure
3 North-western European cities

Localization of the study areas

<table>
<thead>
<tr>
<th>City</th>
<th>Pop Adm</th>
<th>S Adm</th>
<th>S Pleaides</th>
<th>Date Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brussels Region</td>
<td>1,169,065 hab. (2014)</td>
<td>161 km²</td>
<td>800 km²</td>
<td>29/08/2012</td>
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<tr>
<td>Rennes Métropole</td>
<td>415,000 hab. (2013)</td>
<td>705 km²</td>
<td>400 km²</td>
<td>4/10/2012, 22/04/2011 (WVII)</td>
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<tr>
<td>Strasbourg - CUS</td>
<td>473,187 hab. (2013)</td>
<td>316 km²</td>
<td>551 km²</td>
<td>14/08/2012</td>
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</table>
Methodology

1. Preprocessing
   • Geometric and radiometric corrections of image data

2. At a coarse scale: Morphological Urban Area delineation
   • from HR image or ancillary DB (roads and built-up)

3. At a fine scale:
   • detailed land cover classification from Pleiades data
   • Post-classification rules in GIS
   • Aggregation of land cover classes toward land use classes

4. At a meso-scale (urban block):
   • First analysis of grey and green infrastructures
2. MUA

- Reproducible scheme: 2 methods according to existing data:

  - Use of existing ancillary data:
    - Generalisation of the buildings and roads from NGI Topo DB, updated with OpenStreetMap

  - Use of HR images:
    - NDVI threshold
    - NN classification
3. Classification scheme definition

- Definition of a standardized classification hierarchical scheme of (peri)urban areas in Europe
  - User’s needs
  - Existing schemes:
    - CORINE LandCover, Moland (Urban Atlas) for urban classes
    - CORINE Biotope, EUNIS for green classes

Hierarchical legend in 4 levels: Use of the 3rd level with 12 classes

- Water
- Trees
- Schrub
- Herbs
- Crops
- Agricultural bare soils
- Orange surfaces
- Grey surfaces
- White surfaces
- Beige surfaces
- Shadow
- Clouds
3. Semi-automatic training and validation sampling strategy

- Semi-automated strategy:
  - Subdivision with a 500 sqm grid
  - NDVI thresholding in 5 equiprobable classes (imperviousness degree)
  - Random selection of points within each impervious class (1000 for the 2 first classes, 600 for the others)
  - Labelling of each point using existing topographic DB
  - Spatial query to label the polygons according to the class of each point
  - Visual check

- Selection of polygons
  - Number/class proportionnal to the extent of the class
3. OBIA classification

- After the segmentation, features selection:

<table>
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<th>Spectral features</th>
<th>Morphological features</th>
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<tr>
<td>Mean</td>
<td>Area,</td>
</tr>
<tr>
<td>Standard-deviation</td>
<td>Length/width</td>
</tr>
<tr>
<td>Brightness</td>
<td>Asymmetry</td>
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<tr>
<td>NDVI</td>
<td>Compactness</td>
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</table>

  **Haralick textural features:**
  - Entropy
  - Homogeneity

- 3 algorithms (kNN, Support Vector Machine, Random Forest) assessed using script written in the open software R, applied on 10km tiles

- Use of k-fold cross-validation
  - Samples divided in 50 folders,
  - in each folder, 2/3 choosen randomly for training, 1/3 for validation
  - Classifier is tested for each of those folder
  - resulting accuracy = mean of the accuracy in each situation.
3. Classification

- Example of results on Rennes:
  - Kappa increases with the number of features up to 12
  - Better kappa with SVM but computation time 10 times higher for SVM than for Random Forest
  - Computation time increases linearly with the number of features for kNN

- Similar results on Strasbourg and Brussels
SVM - Strasbourg

- Shrubs
- Forest
- Bare soil
- Agricultural land
- Water
- Cloud
- Shadow
- Beige surfaces
- White surfaces
- Grey surfaces
- Herb
- Orange surfaces

K≈80% for 12 classes

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<th>Boisements</th>
<th>Sols nus agricoles</th>
<th>Cultures agricoles</th>
<th>Eau</th>
<th>Nuages</th>
<th>Ombres</th>
<th>Surfaces beiges</th>
<th>Surfaces blanches</th>
<th>Surfaces grises</th>
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</table>
3. Post-classification: Majority vote and use of existing NGI database

- Random Forest
- SVM
- kNN

NGI

If class=water and NGI doesn’t contain water -> class=shadows
3. Post-classification: aggregation of LC classes and integration of vector DB

- Building
- Agricultural parcels
- Forest
- Herbaceous
- Other surfaces
- Water
- Railway

Legend:
- Shrub
- Forest
- Bare soil
- Agricultural land
- Water
- Cloud
- Shadow
- Beige surfaces
- White surfaces
- Grey surfaces
- Herb
- Orange surfaces
4. Analysis of green and grey infrastructures

At a meso-scale: block analysis

- Urban blocks delineation based on the updated vector DB (linear)
- Using a GIS model
- Metrics analysis
- Mapping of green and grey infrastructure

Strasbourg
Percentage of landscape
Building
Network
Tree

Rennes
Percentage of landscape
Building
Network
Tree

Legend:
- Dense Urban Fabrics (UF)
- UF with individual houses
- UF with housing blocks
- Specialized areas (activities)
- Other surfaces
Conclusions

- Ability of Pleiades images to cover large urban areas (e.g. Brussels)
- The landcover/landuse map is derived with the same methodology on three cities differing in terms of size and morphology
- Hierarchical method with use of available ancillary data at each scale
- Application of post-classification rules to improve results
- Difficulties with large file resolved through tiling process
Thank you for your attention!

QUESTIONS?

Info : ewolff@ulb.ac.be