Spatial information extraction for urban areas based on hyperspectral data

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CASI-SWIR WORKSHOP

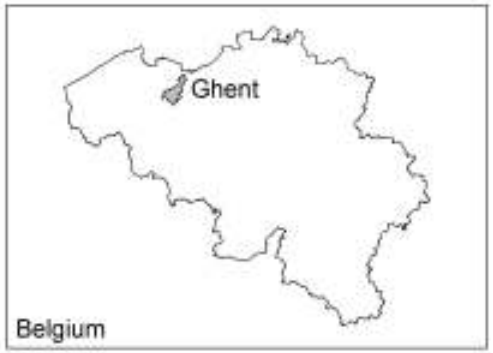
Spatial information extraction for urban areas based on hyperspectral data

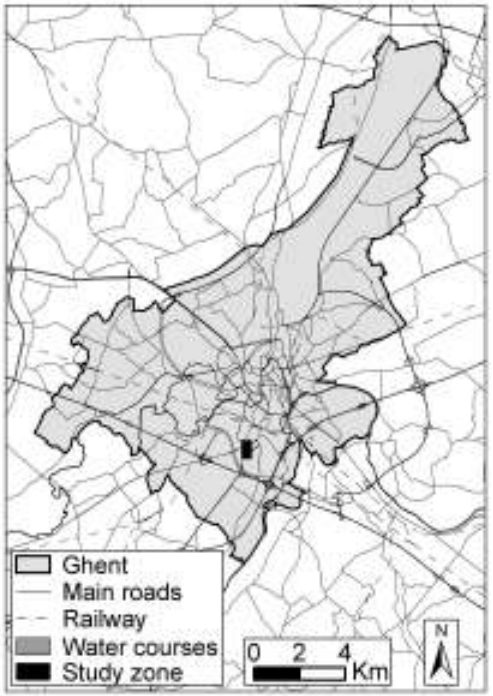
- aim : to extract all different kinds of information over urban and peri-urban environment using hyperspectral data.
- 2 kinds of information : geometric and thematic
- in conjunction with the Stereo-project “Improving spatial information extraction for local and regional authorities using very-high-resolution data”. SPIDER

Flight Planning

- 3 images
  - 2 in “metric” mode
    - Altitude 440 m
    - Resolution 0.52 m
    - 10 bands
  - 80 % overlap between 2 metric images
  - 1 in hyperspectral
    - Altitude 970 m
    - Resolution 1.34 m
    - 48 bands

Flight Planning





Ghent

1000 x 200 m

Field Campaign

movie http:\\allserv.rug.ac.be\~dedvrien\casi

Data Handling

- Radiometric Correction
- Geometrical Correction :
  - Metrical mode : not for terrain
  - Hyperspectral mode : terrain (DSM aerial photo)
- Atmospheric Correction

Goals – geometrical aspects

- Digital Surface Model
- Orthophoto

Photogrammetrical processing

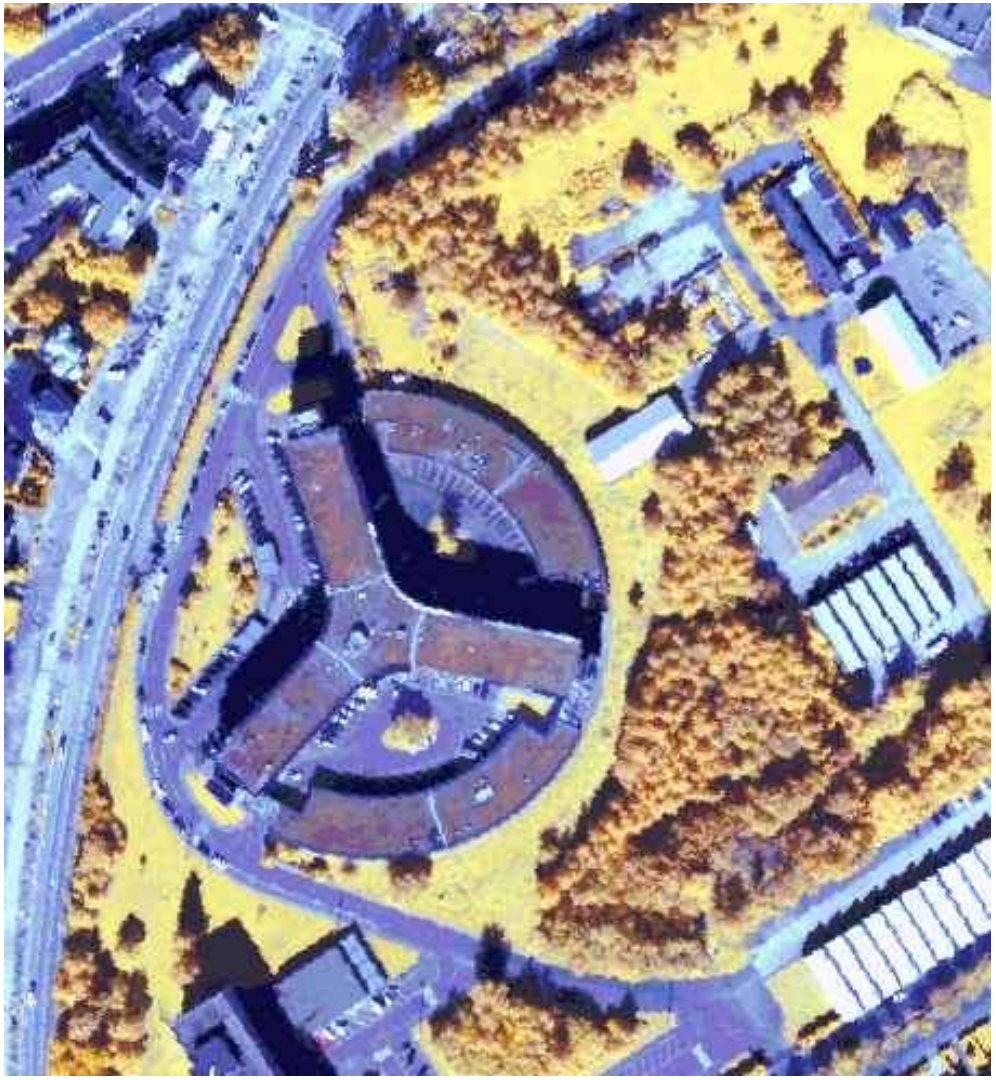
- Reducing 10 bands to 3 bands
- 2 methods :
  - Grouping bands
  - FCC with individual bands <=
  - 3 bands that react best to the matching algorithm

band	interval		no points
1	467.4nm+/- 17.9nm		74
2	502.9nm+/- 16.1nm		71
3	540.5nm+/- 19.9nm		60
4	581.1nm+/- 19.1nm		78
5	639.0nm+/- 10.6nm		49
6	670.4nm+/- 19.2nm		68
7	725.9nm+/- 34.6nm		86
8	795.9nm+/- 33.8nm		101
9	866.2nm+/- 34.8nm		96
10	926.0nm+/- 23.3nm		106
	RMS	= 1/5 pixel	

Photogrammetrical processing

- FCC

- band 8 – R
- band 9 – G
- band 10 – B



Photogrammetrical processing

- Relative orientation
  - Δt between images : shadows have moved
    15 min = 1.3 m for 20 m building
  - manual : 70 points
- Absolute orientation
  - Ground level : 9 points
    AO with only these points resulted in no Z results in stereomodel
  - Rooftop Level : 4 points
  - Problem : B/H = 0.1 to 0.2
- Automatic parallax matching, DEM extraction and orthophotogeneration

Geography
DEPARTMENT

SURFACES

UNIVERSITÉ
DE LIÈGE

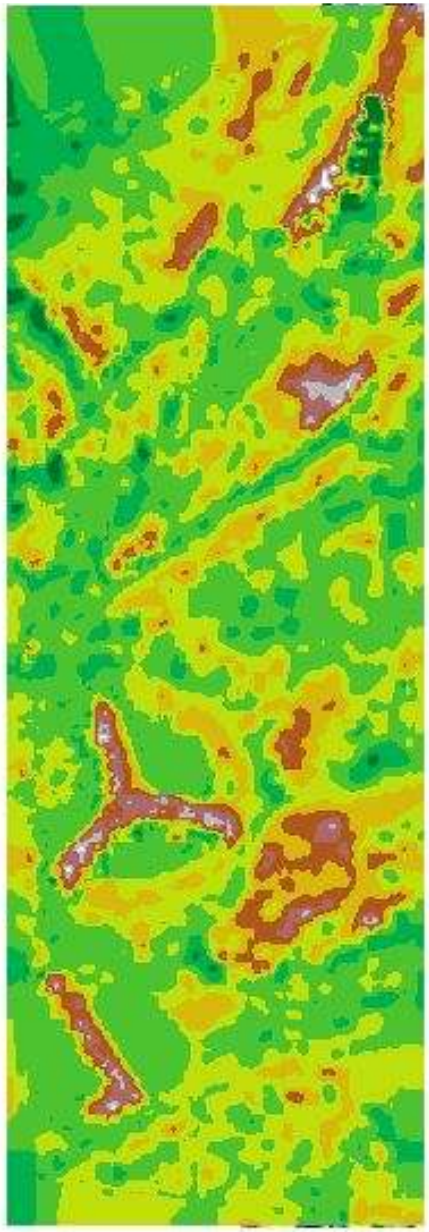
ULB
Ideas

CCG
Centre for Cartography and GIS

VITO

0 - 4
4 - 8
8 - 12
12 - 16
16 - 20
20 - 24
24 - 28
28 - 32
32 - 36
No Data

N
W
E
S



80 0 80 160 Meters

Conclusion

- better spatial resolution, better result
- larger area
- cross-track stereo overlap with 2 nadir images not ideal for good stereomodel
- suggestion : nadir image + backward image
  nadir image + forward image
  ...

Classification of hyperspectral data

- Objective:
  - Extract detailed thematic information from hyperspectral data for urban areas
- Topics:
  - Band reduction
  - Different classification strategies
    - Pixel-based
    - Region-based methods
  - Postclassification

Land-cover legend

	LAND COVER CLASS
grey surface	grey slate and tile roofing light roofing dark roofing grey gravel concrete asphalt road light road material
red surface	red tile exposed red tile not exposed red tile red gravel

	LAND COVER CLASS
reflecting surface	metal light metal dark metal
vegetation	grass shrub and tree moss
shadow	shadow vegetation shadow non vegetation

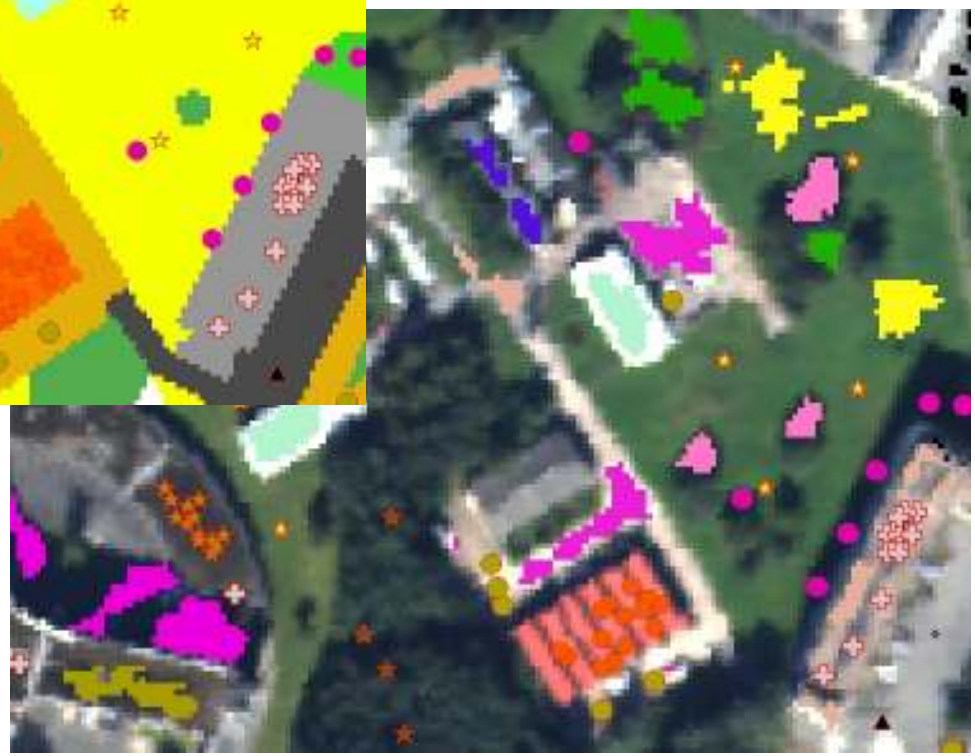
Collection of training data

- Sampling blocks on aerial photos
- Terrain verification
- Add shadow classes
- Ecognition segments as training blocks

concrete

Collection of validation data

- CAPI based on aerial photo and terrain verification
- random sampling in CAPI
- removal of points too close to training sites



Band reduction

- Feature selection
  - Visually from signature profiles
  - Best combination of bands (Bhattacharryya distance)

- Feature extraction
  - Principal Components Analysis (PCA)
  - Discriminant Analysis Feature Extraction (DAFE)
  - Decision Boundary Feature Extraction (DBFE)

Land-cover classification approach

- Comparison of results obtained with:
  - Different classifiers
    - Pixel-based approach
      - Minimum distance classification (MD)
      - Maximum-likelihood classification (ML)
    - Region-based classification
      - ECHO classifier (ML)
      - eCognition (MD)
  - Different band reduction techniques
  - Results:
    - Kappa's between 0.47 and 0.73

Pixel-based classification

True-color composite (17, 10, 2)

ML DBFE (7 features): Kappa 0.73

Region-based classification

- red gravel
- grey slate and tile
- red tile
- concrete
- grey gravel
- metal
- grass
- shrub&tree
- moss
- shadow_nv
- shadow_v
- asphalt road
- light road material
- roofing

True-color composite (17, 10, 2)

ECHO DBFE (7 features): Kappa 0.70

Conclusions classification results

- Band reduction
  - Best results DBFE (7 bands)
- Classification
  - Kappa's are high considering the number of classes (0.73 for 14 classes)
  - Best results for maximum-likelihood
  - Region-based groups too many pixels together
- Problems
  - Clutter in pixel-based classifications
  - Shadows

Postclassification

- Two-step approach:
  - Rule-based classification or grouping of land-cover regions
    - Using:
      - Region-based metrics (area, shape,...)
      - Properties of neighbouring regions
      - Ancillary data, e.g. DSMs, vector maps
  - Post-classification filtering
    - Class specific rules

Post-classification based on DSM

red gravel
grey slate and tile
red tile
concrete
grey gravel
metal
grass
shrub&tree
moss
shadow_nv
shadow_v
asphalt road
light road material
roofing

ML classification, DBFE (7 features)

< 12 m
> 12 m

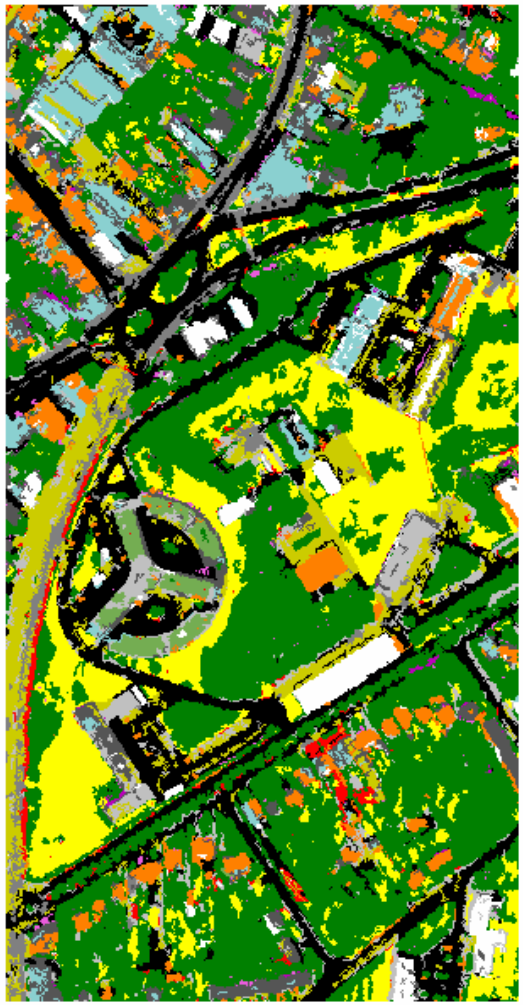
DSM threshold (12 m)

Post-classification based on DSM

Intersection ML – DSM threshold

Postclassification (2 levels)

Post-classification based on DSM



Postclassification (1 level) Kappa: 0.78

ML classification DBFE Kappa: 0.73

Post-classification based on DSM

- Advantages
  - Higher accuracy, Kappa = 0.78
  - Strong reduction of clutter, better structure
  - Strong reduction in amount of shadow
  - Better performance than region-based (ECHO)

- Problems
  - Quality of DSM
  - DSM threshold
  - Additional rules are needed (shape, context larger than neighbourhood)

General Conclusions

- Geometrical issues:
  - Low B/H ratio
  - Nadir + backwards/forwards
- Thematic issues:
  - Thematically very detailed land-cover maps
  - High accuracy
  - Maximum likelihood + Band reduction
    - Pixel based + DBFE
  - Postclassification
    - Increases accuracy
    - Improves structure
    - Removal of shadow