From Image - Objects to Maps:
Cartographic Requirements for GEOBIA

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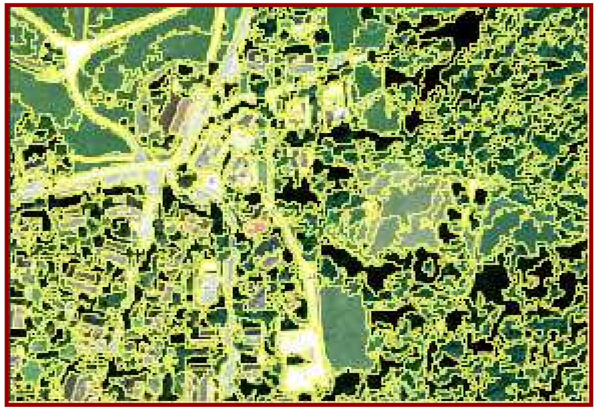
SNF Project: PAGEVIS-LD

Outline

from image-objects to maps



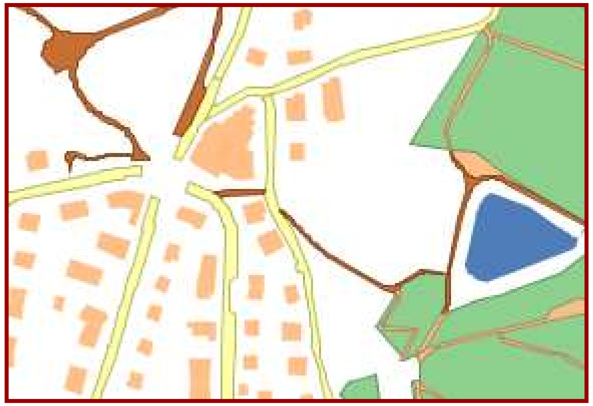


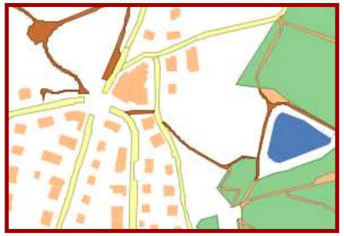
image (0.50m) → **objects** → **Map**

(map data 1:5k, City of Zurich)

Objective: simplify GEOBIA results to ensure cartographic standards

Discuss: cartographic requirements imposed on data and their visualization

2. Requirements on Image Data



- a map, as raster/vector graphics, has a defined map scale (e.g. 1:25 000)
- the map scale imposes
  1. a minimal object size that can be displayed in [m],
  2. a positional accuracy

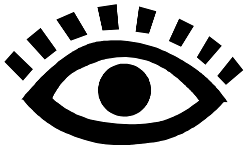
- imagery needs a certain spatial resolution to fit the maps accuracy requirements!

<u>or conversely:</u>

- the image resolution defines the finest derivable map scale

How to establish the relationship between image resolution and map scale? »

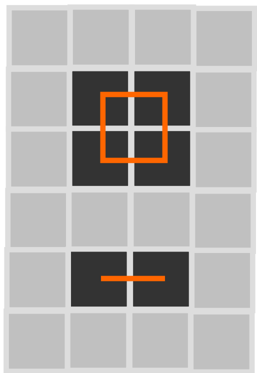
2. Requirements on Image Data



. **Map**: human eye acuity:

~ 0.2mm for reading distance of 30cm (SSC 2005, p.26)

. smallest map object that can be displayed: 0.2mm



. **Image**: Nyquist-Shannon Sampling theorem:

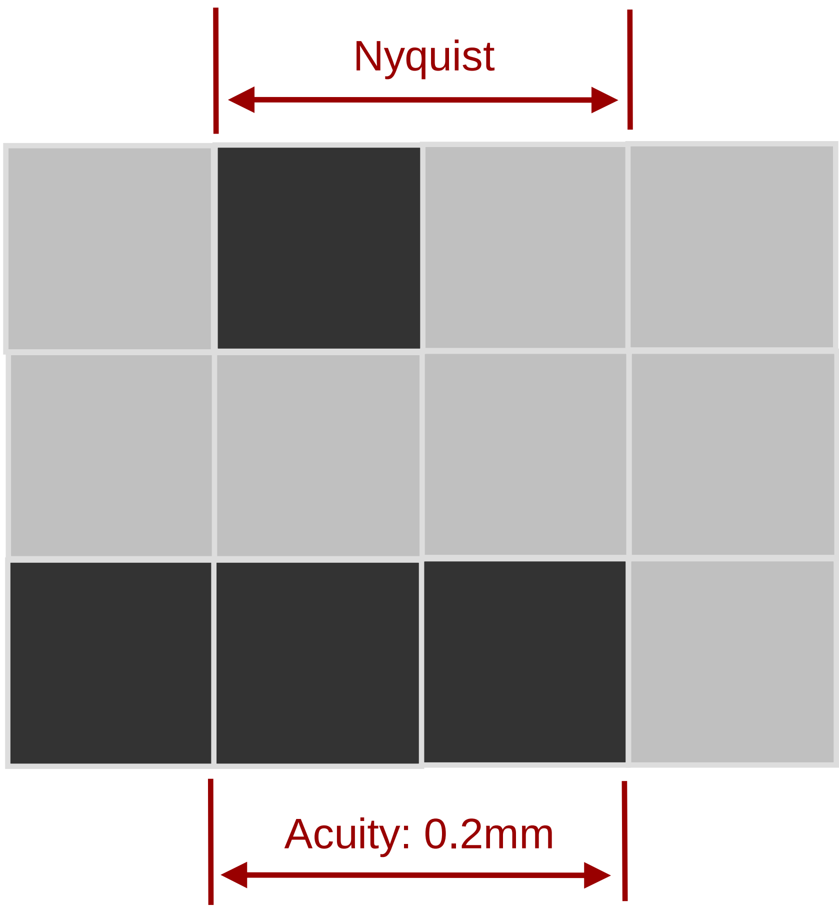
need of at least 2 samples to re-construct a signal

(signal = an object in the image)

. we need (min): 4px for a house & 2 px for a road

bringing things together »

2. Requirements on Image Data



Example 1:

. required map scale: 1:25 000

0.2mm (acuity) = 2px (NS)

0.2mm*25000 = 5m

5m = 2px

. needed resolution at least 2.5m/px

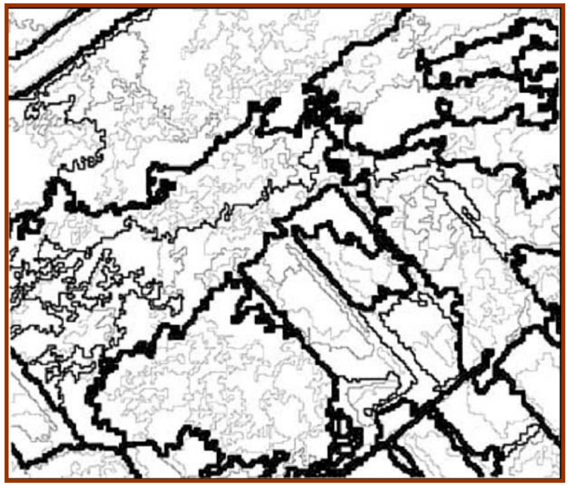
Example 2:

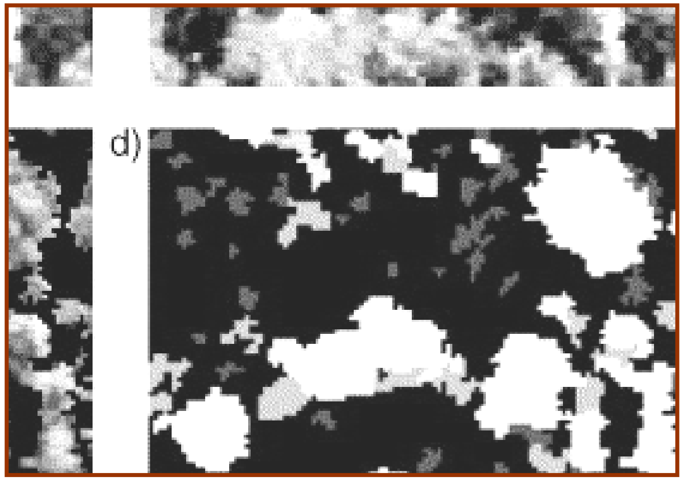
. image resolution: 0.5m/px

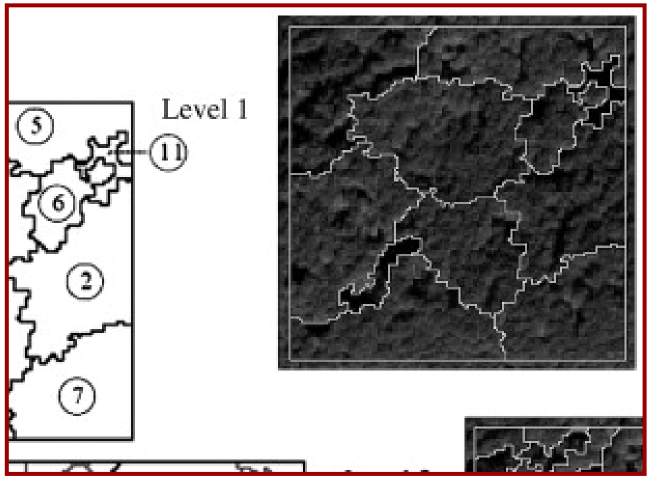
. 2px = 1m = 0.2mm (map)

. scale = 1.0m / 0.2mm = 1:5000+

. three images taken from journal publications







. jagged outlines : an artifact from change of representation (R to V)

. side-effects:

- . introducing a pseudo accuracy (psychological; metadata?)
- . doesn’t look nice

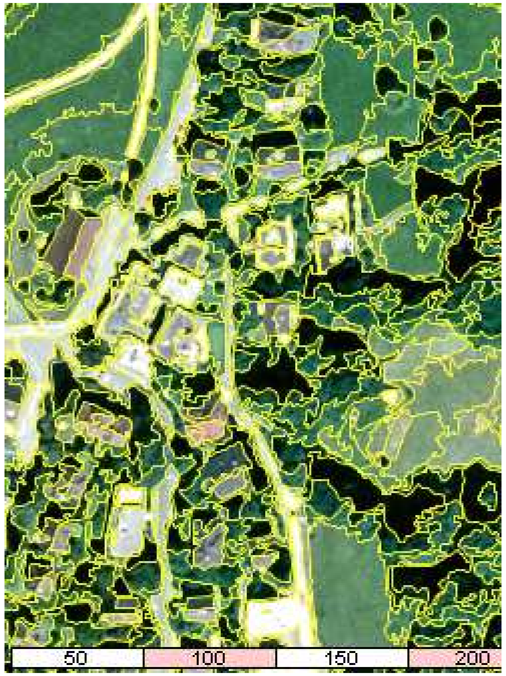
➡ let’s remove jagged lines! (e.g. simplification and/or smoothing)

3. Removing Representational Artifacts

Example:

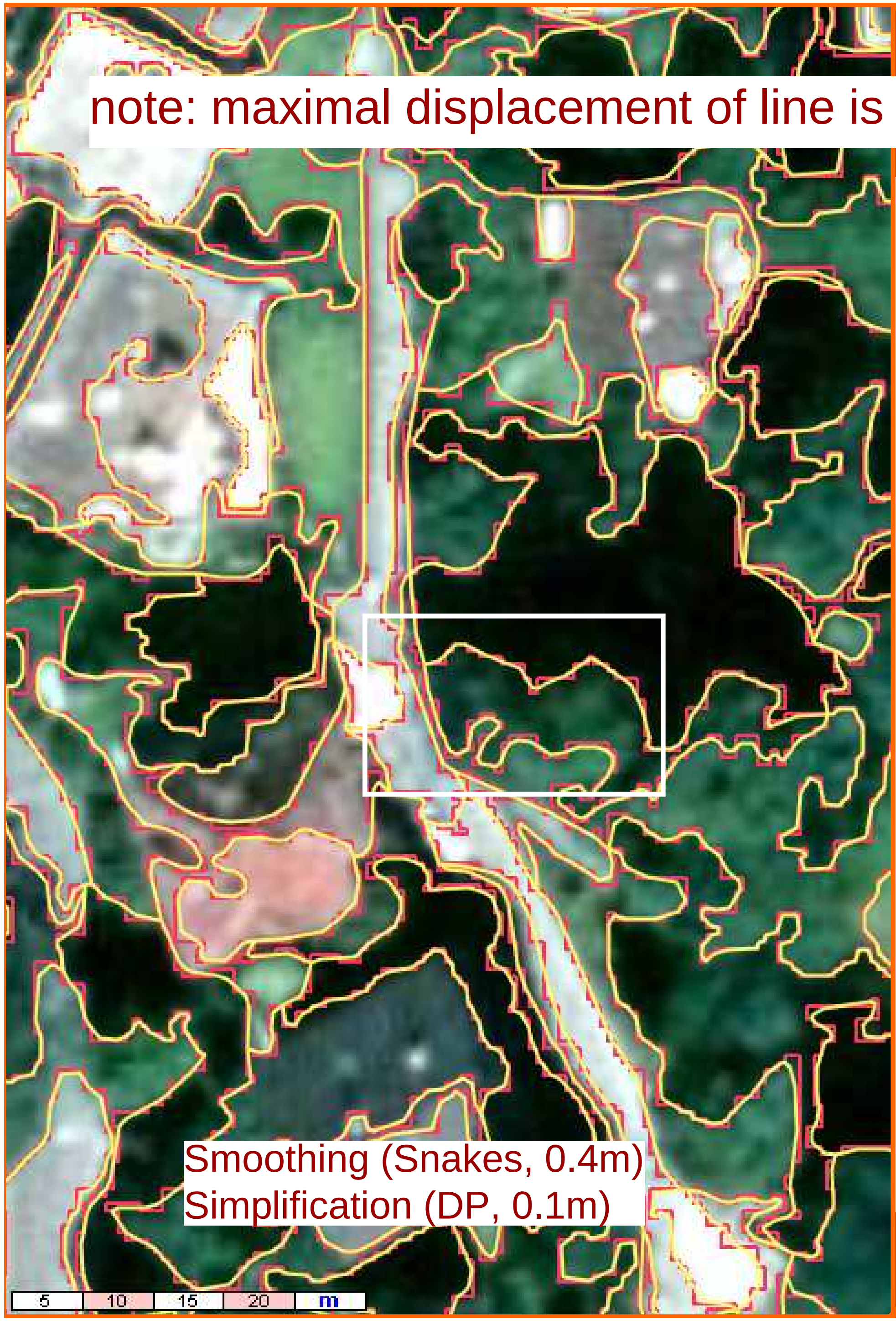
0.5 m/px

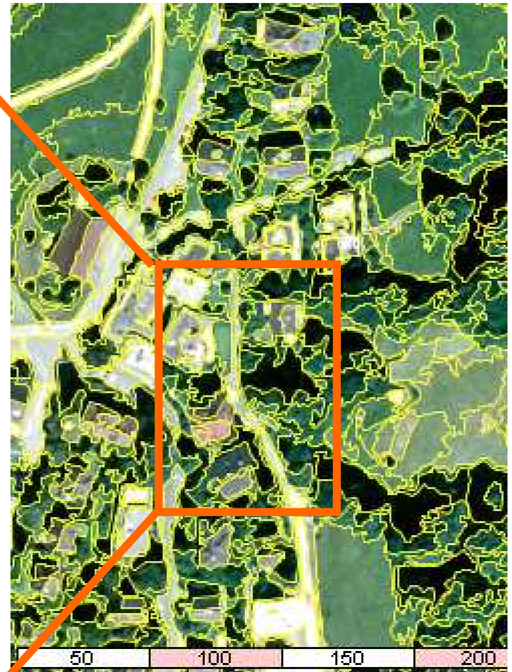
Segmentation with Definiens
(scale factor: 50)



Smoothing (Snakes, 0.4m)
Simplification (DP, 0.1m)

note: maximal displacement of line is adjustable: 0.4m+0.1m = 0.5m = 1px





Smoothing (Snakes, 0.4m)
Simplification (DP, 0.1m)


Smoothing (Snakes, 0.4m)
Simplification (DP, 0.1m)
5 10 15 20 m
Smoothing (Snakes, 0.8m)
Simplification (DP, 0.2m)
5 10 15 20 m

4. Introducing Scale: Cartographic Constraints

Background:

. automated map generalization: "constraint-based" modeling (Beard 1991)

. constraint: condition to which the map should adhere (Weibel and Dutton 1998)

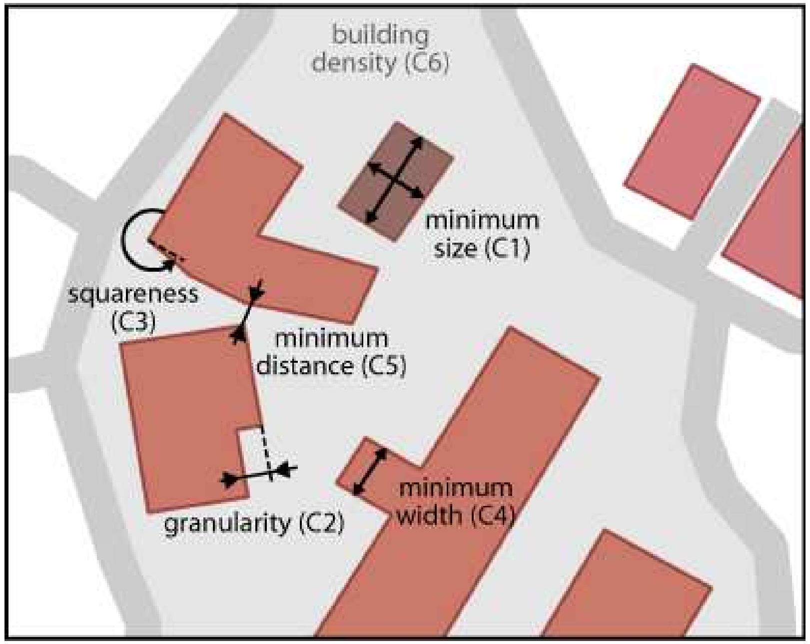


Fig.: constraints on buildings

. several types of constraints:
  - . geometrical
  - . topological
  - . contextual
  - . cultural
  - . procedural

. with different objectives:
  - . ensure legibility (active)
  - . preserve shape + location

4. Introducing Scale: Cartographic Constraints

. Galanda (2003): constraints on polygonal subdivisions

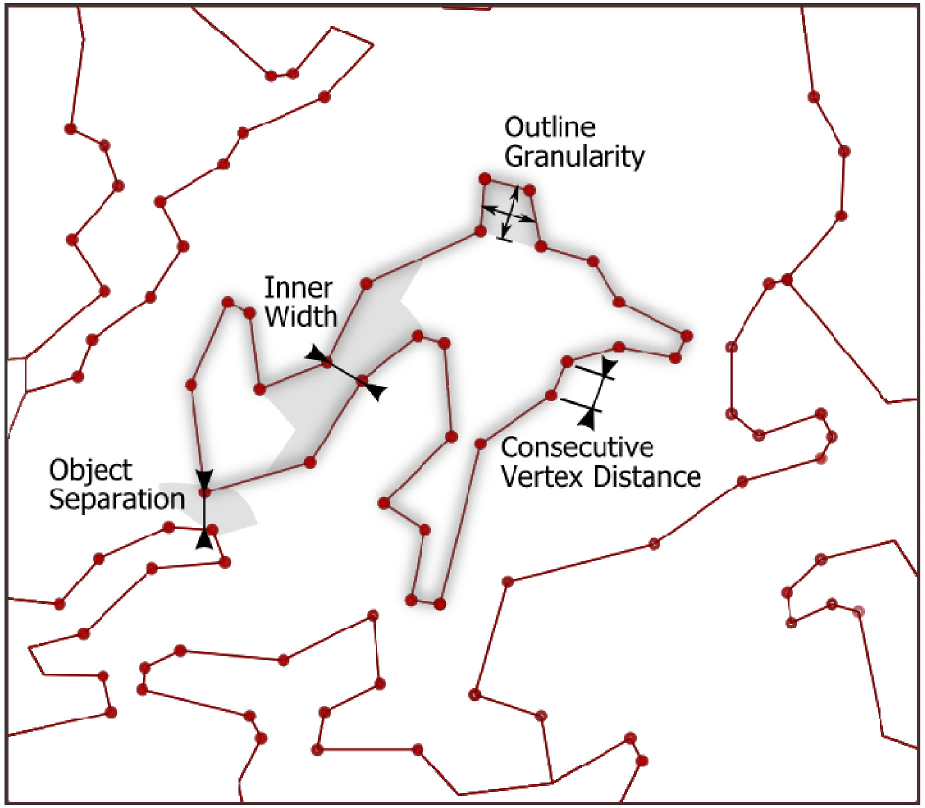
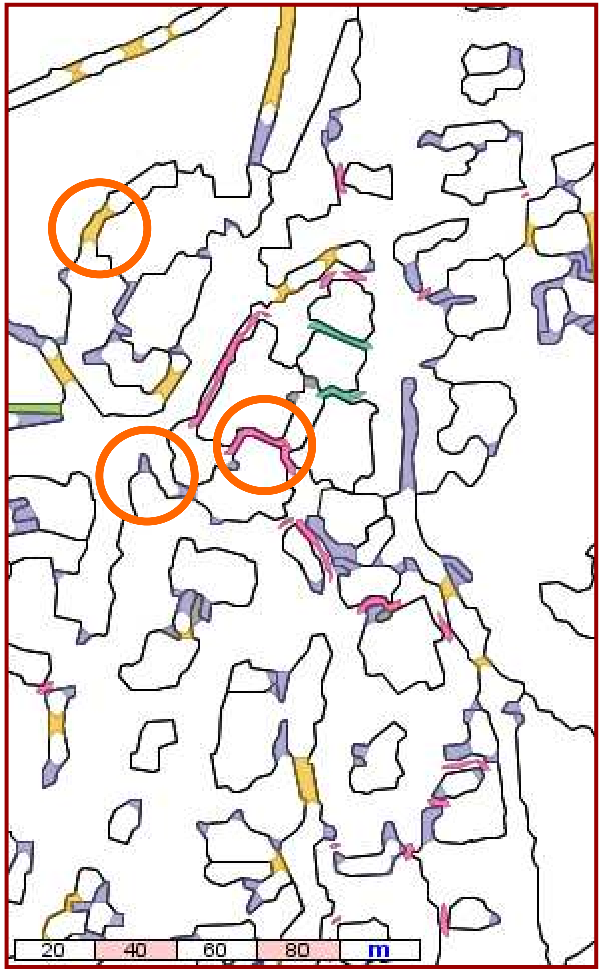


Fig.: geometric constraints on polygons

1. geometrical constraints (active):
   . minimal area
   . object separation (e.g. holes)
   . consecutive vertex distance*
   . inner-width
   . outline granularity
2. procedural constraints
   . redundant points (*)
3. and other (preserving) constraints
   . e.g. structure preservation [area & class ratios]
   . e.g. modeling related
   . e.g. topological [self-intersection]

4. Introducing Scale: Cartographic Constraints

polygons from segmentation



result of constraint evaluation

Example:

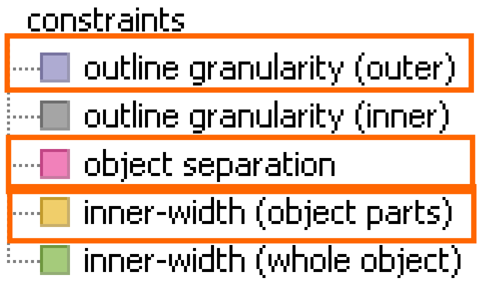
. image 0.5m/px

. segmented with SCRM (Castilla et al. 2008)

. simplified (DP) & merged

. target map scale: **1:5.000**

. **Result**: polygon-parts that do not fulfill the constraints (min-dimension SSC 2005: 0.4mm = 2m)



5. Conclusions and Outlook

Conclusions

To create maps from image objects we need to simplify these to ensure cartographic standards!

This requires to be aware of:

1. the image resolution that constraints spatial accuracy
2. jagged lines that should be removed
3. cartographic constraints that account for human vision

Benefits:

1. further the cartographic utility of GEOBIA results
2. implicit data reduction facilitates further GIS analysis

5. Conclusions and Outlook

Outlook

build an automated system that

1. implements relevant cartographic constraints
2. offers map generalization algorithms to fulfill these constraints
3. detects patterns (based on spectral and geometric information) to enable a meaningful aggregation of polygon patches (segments)

Thank you for your attention!

Acknowledgments:

Swiss National Science Foundation: Project PAGEVIS-LD

References:

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