Consortium Meeting
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The constrained tGAP for progressive vector data transfer

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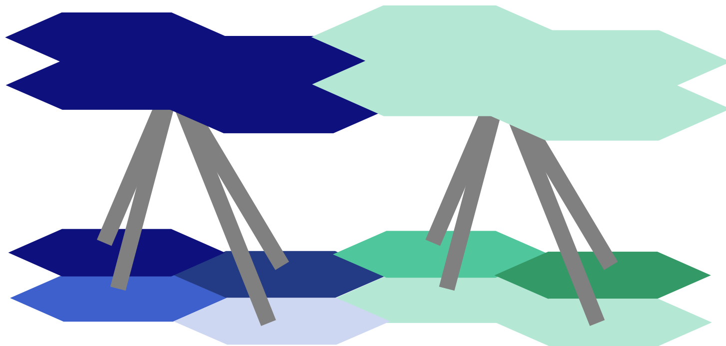
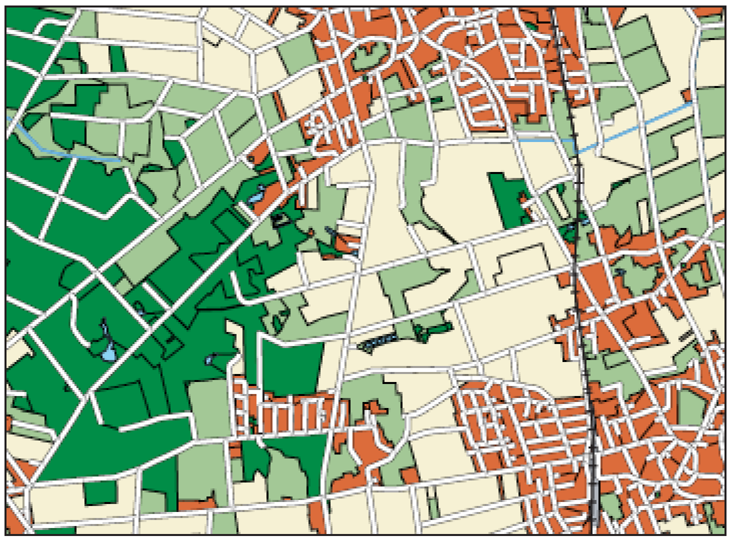
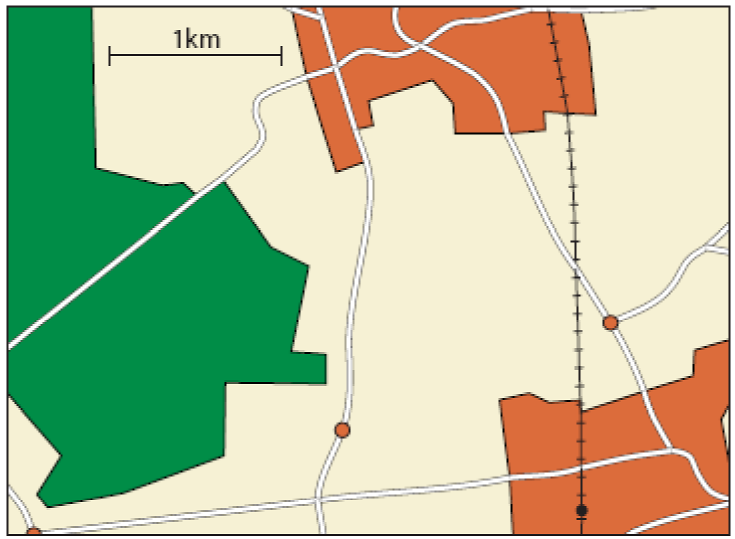


Context of this work

- German NMAs provide digital landscape models (DLM) at four different scales:
  - ATKIS Basis-DLM (1:25.000)
  - ATKIS DLM 50 (1:50.000)
  - ATKIS DLM 250 (1:250.000)
  - ATKIS DLM 1000 (1:1.000.000)



ATKIS Basis-DLM

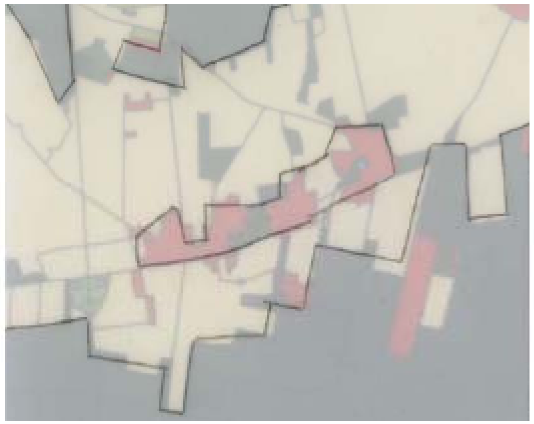


ATKIS DLM 250

Context of this work

- Data sets contain faces of different land cover classes that constitute planar subdivisions.
- Map generalization requires aggregation of faces.

Faces from ATKIS DLM 50



A manually generalized map (1:250.000)

- To enable “smooth” zooming and progressive data submission in mobile applications a single output scale is not enough.
- The classical algorithm for the GAP-tree set-up can be applied, but does it provide data sets of sufficient quality?

Outline

- Classical set-up of the GAP tree (from a given data set at large scale)
- Optimization approach to aggregation of faces
- Constrained set-up of the GAP tree (from two given data sets of different scales)

Classical GAP-tree set-up

- Aggregation by iterative merging of faces:

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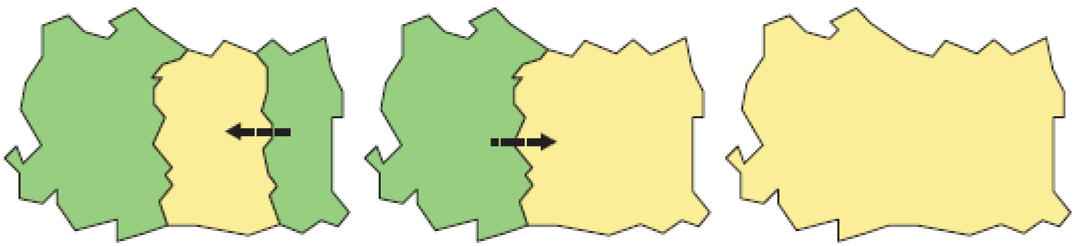
a = least important face (e.g. smallest face)

while number of faces > 1 **do**

    merge a to most compatible neighbor

    a = least important face

end while



Step 0   Step 1   Step 2

Classical GAP-tree set-up

- Aggregation by iterative merging of faces:

---

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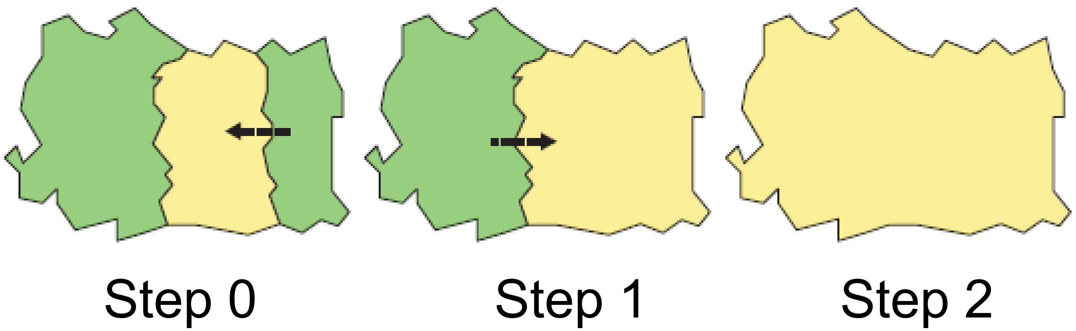


+ The algorithm defines intermediate scales (can be stored in the GAP-tree structure)

– Results can be poor (large areas change classes)

Optimization approach to aggregation of faces

- Spatial data quality is commonly defined by several elements, including **logical consistency** and **semantic accuracy**.

  "A spatial data set is said to be **logically consistent** when it complies with the structural characteristics of the selected data model and when it is compatible with the attribute constraints defined for the set." (Kainz 1995)

→ Properties of a planar subdivision must be preserved, hard size constraints defined in ATKIS specifications must be satisfied.

Wald, Forst	
„Fläche, die mit Forstpflanzen (Waldbäume und Waldsträucher) bestockt ist.“	
scale	selection criterion
1:25k	area ≥ 0,1 ha
1:50k	area ≥ 1 ha
1:250k	area ≥ 40 ha
1:1000k	area ≥ 500 ha

Optimization approach to aggregation of faces

- Spatial data quality is commonly defined by several elements, including **logical consistency** and **semantic accuracy**.

  “The purpose of **Semantic Accuracy** is to describe the semantic distance between geographical objects and the perceived reality.” (Salgé 1995)

→ A semantic distance between classes is defined.

	Settlement	Grassland	Farmland	Forest
Settlement	0	1	1	1
Grassland	1	0	0.2	0.3
Farmland	1	0.2	0	0.3
Forest	1	0.3	0.3	0

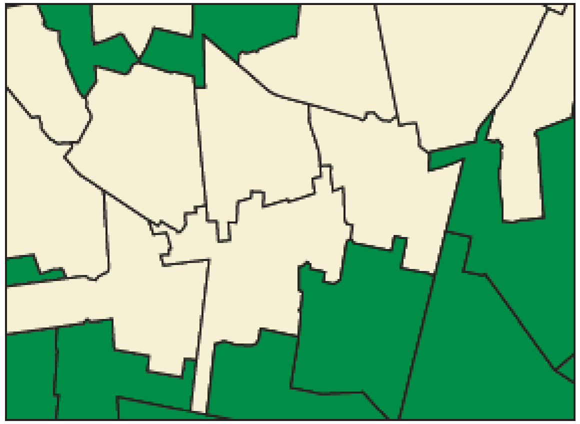
Optimization approach to aggregation of faces

- Basically, the logically consistent map for the target scale of highest semantic accuracy is searched.
- In addition to class similarity, geometrical compactness of shapes should be aimed.

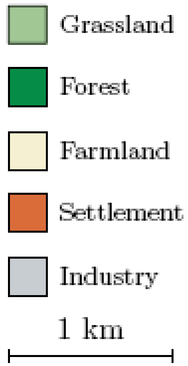
- The problem is a constrained combinatorial optimization problem.
- It is extremely complex, i.e., it is NP-hard (Haunert & Wolff 2006).
- However, small instances can be solved exactly by mixed-integer programming.
- Heuristics have been developed to reduce the complexity of the problem (Haunert 2007). A complete sheet of the topographic map 1:50.000 was generalized in 80 minutes to meet specifications for the scale 1:250.000. Samples from this test will be shown…

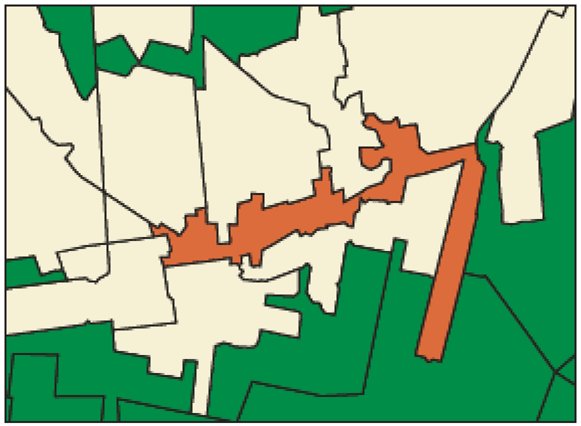
Optimization approach to aggregation of faces

(a) Original map (DLM50).

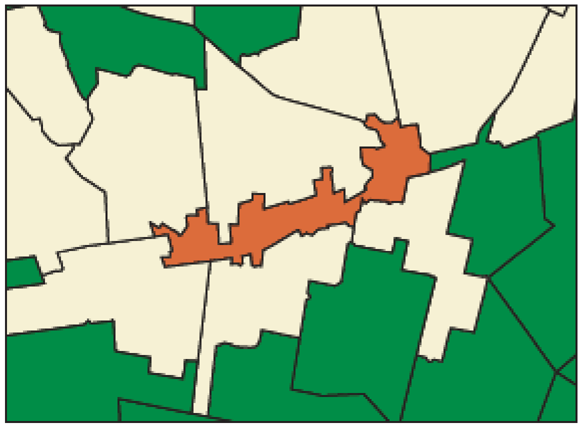


(b) Result of Algorithm 1, applying specifications for scale 1:250.000.





(d) Result with minimal class change.



(e) Considering class change and compactness.

Optimization approach to aggregation of faces

Input

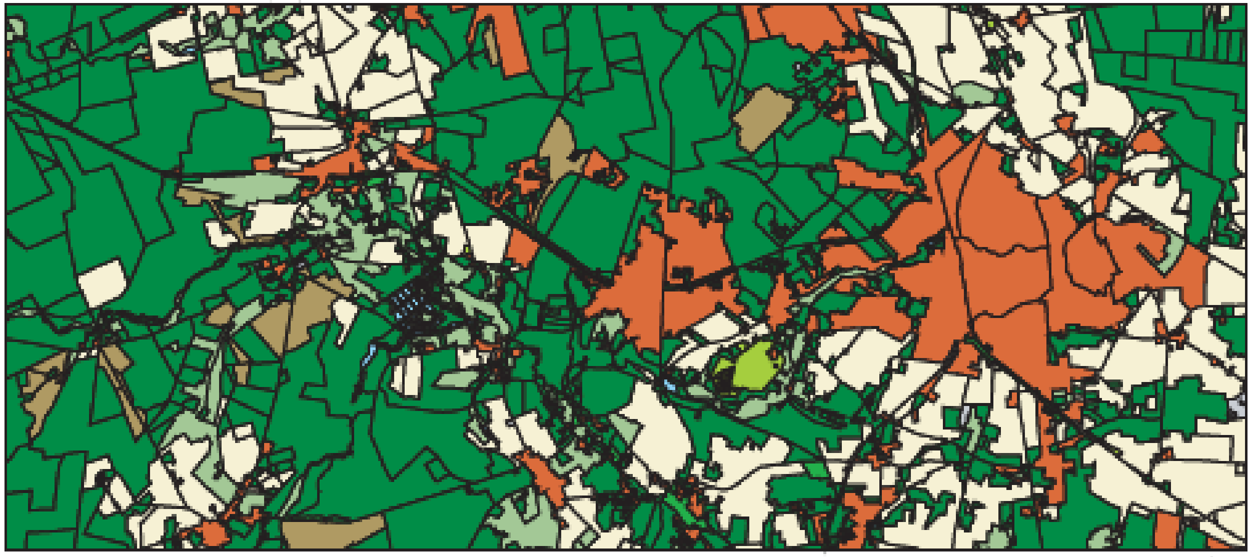
Output (iterative Alg.)

Output (Minimizing class change)

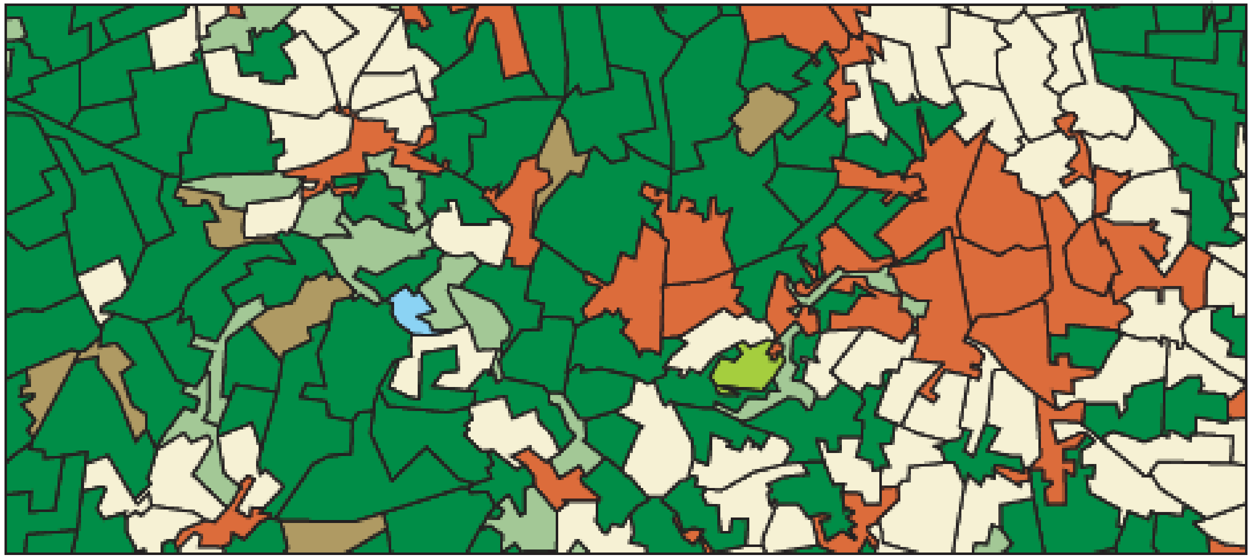
Output (Optimizing class change & compactness)

Optimization approach to aggregation of faces

DLM50



DLM250



Optimization approach to aggregation of faces

- \+ Optimization yields results of higher quality (-20% class change)
- – The optimization approach yields a single output scale, not a sequence of representations that is needed in mobile applications.

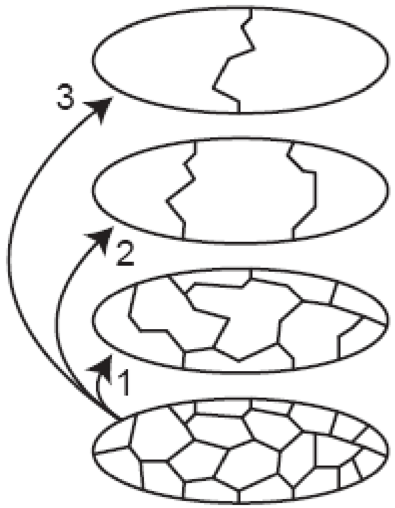
The constrained tGAP

- How to combine the advantages of both approaches?
- How to apply the optimization method to set up a sequence of scales?

The constrained tGAP

- How to combine the advantages of both approaches?
- How to apply the optimization method to set up a sequence of scales?

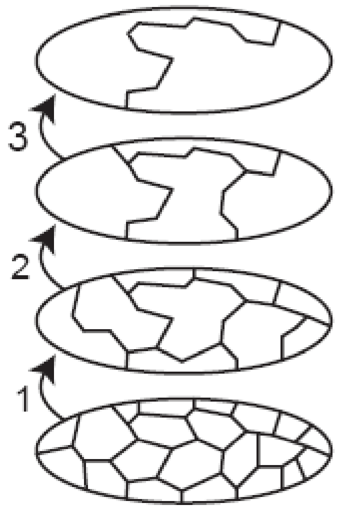
a: Deriving different scales independently from the input scale we do not end up with a sequence of small, incremental changes.



The constrained tGAP

- How to combine the advantages of both approaches?
- How to apply the optimization method to set up a sequence of scales?

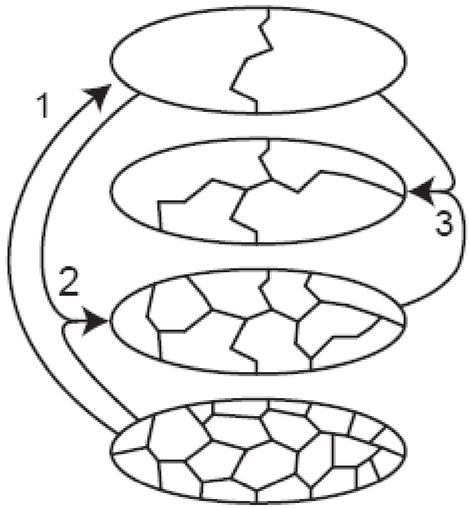
b: Deriving scales in succession in small scale steps is just the same as the iterative approach, thus we can end up with a poor result.



The constrained tGAP

- How to combine the advantages of both approaches?
- How to apply the optimization method to set up a sequence of scales?

c: The idea is to produce a small scale map first and then to apply the iterative algorithm such that it will end up with the defined result.



The constrained tGAP

- Algorithm:

Define a face of unchanged class in each region of the given target data set as a ***center***.

while there is an area that is not a center **do**

a = least important area

if a is not a center **then**

merge a to the neighbor in the same region, such that the cost of this step is minimal

else

merge a neighbor of the same region to a, such that the cost of this step is minimal

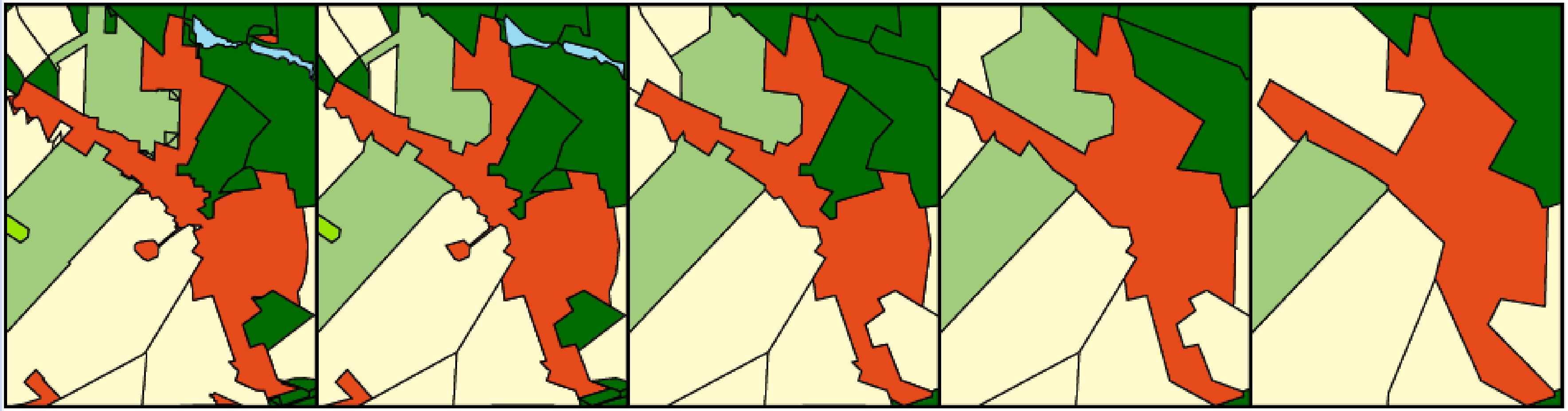
end if

end while

The constrained tGAP

- Results

DLM50 DLM250



Conclusion

- The constrained GAP-tree approaches ensures generalization results of high quality.
- It can be interpreted as an interpolation of scales between a given large scale map and an optimally generalized small scale map.
- The interpolation approach is not restricted to any particular optimization method, i.e., it does not matter how the small scale map was generated.
- An interesting problem for future research is to use the interpolation method to derive intermediate representations between data sets from different sources.

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