Automated assignment of building representations between different scales for the calculation of preservation constraints

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Cartographic constraints are a formal way of specifying cartographic requirements on generalised topographic maps. Several typologies for the categorisation of cartographic constraints are proposed in the literature, typically with a distinction of two main categories - legibility constraints and preservation of appearance constraints. Legibility constraints are used to specify cartographic requirements of map readability considering limits of visual perception. Preservation constraints are introduced for the conservation of properties such as topology, position, orientation, shape, pattern, distribution/statistic of individual and groups of map objects during the generalisation process.

While legibility constraints can be defined through the introduction of minimal size and distance thresholds, only a part of the preservation constraints can be modelled easily with fixed values for examples constraints on keeping the position or orientation during generalisation. More often preservation constraints have to be specified by considering the property evolution of objects which are presented at different scales. Object properties might be preserved during generalisation for example the width-length ratio of a building or they can change for example the shape complexity described by fractal dimension. In both cases a relationship between generalised and original map object has to be modelled to access the different property values. In this paper a algorithm for the unique assignment of *n:m*-relations between objects is presented.

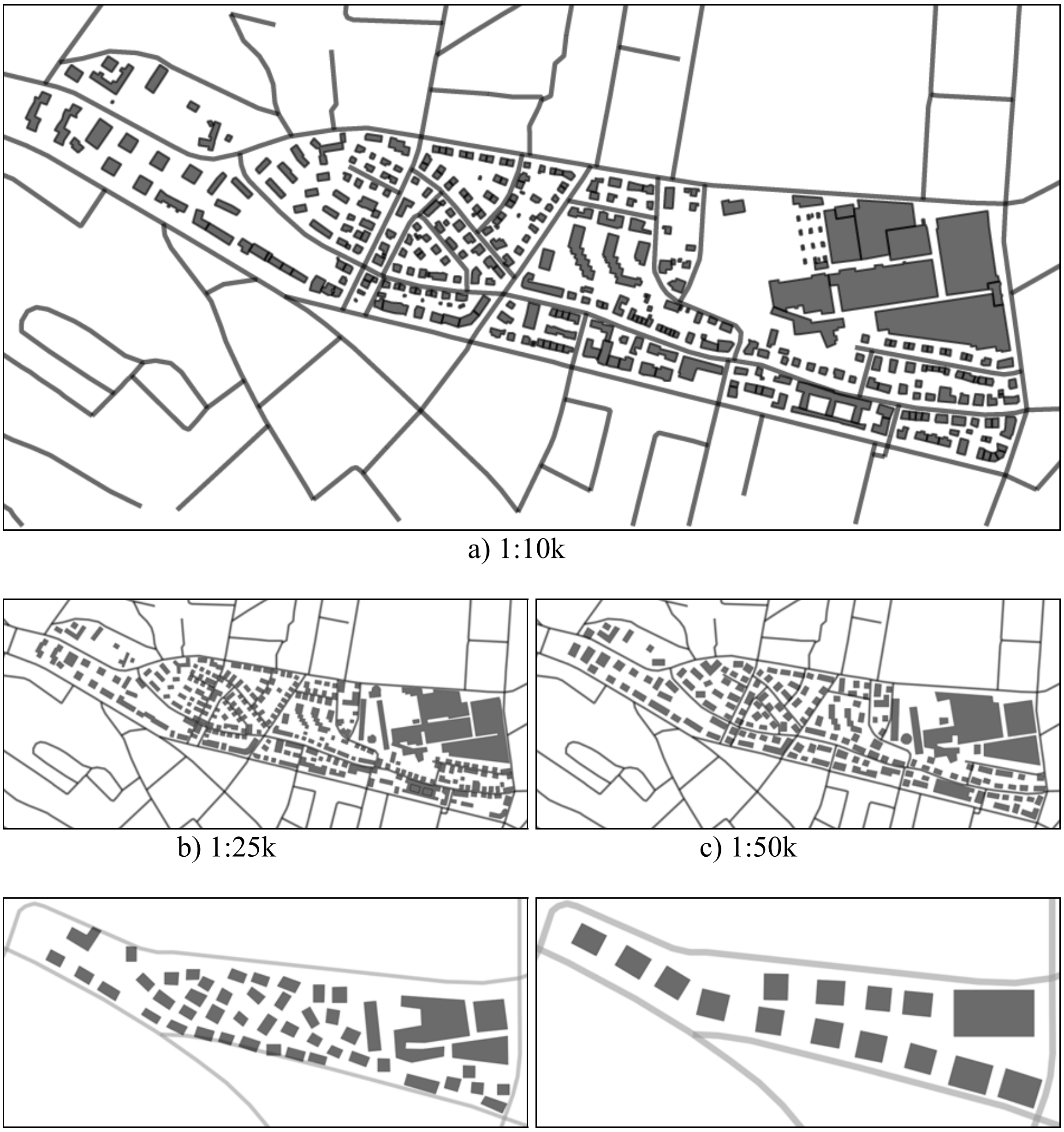
Introduction

There are several typologies proposed to categorise cartographic constraints within map generalisation (Beard, 1991; Ruas and Plazanet, 1996, AGENT, 1998). The typology used here are presented in Burghardt et al. (2007), with a subdivision of constraint type, geometry type, number of involved map objects and thematic class. The two main categories within the typology are legibility constraints and preservation constraints. The difference is that preservation constraints at the beginning of the generalisation process are completely satisfied, while legibility constraints are violated through the scale changes and the applied symbolisation. Harrie (2001) argues further legibility constraints aim at changing the data, while the preservation constraints strive to maintain them. A second major difference is that the violation of legibility constraints at the target data set can be investigated independent from the source data set. In contrast the preservation constraints have often to be calculated in dependence of the source data.

The assignment between map objects of different scales can be carried out during the generalisation process. Therefore the generalisation algorithm has to return the modified map objects but also the reference to the original ones. In case the generalisation software is not able to provide these references or in case of manual generalisation the references have to be determined afterwards. Within this paper an approach is presented for the derivation of these references through calculation of intersections. A flexible parameterisation allows the configuration of the matching procedure.

Automated assignment of building representations

The assignment of map objects between different scales requires the modelling of n:m-relations with n, $m \geq 0$. In the case of building objects often several objects of the original scale are represented by one building in smaller, derived scale, as it can be seen in Fig. 1.



a) 1:10k

b) 1:25k

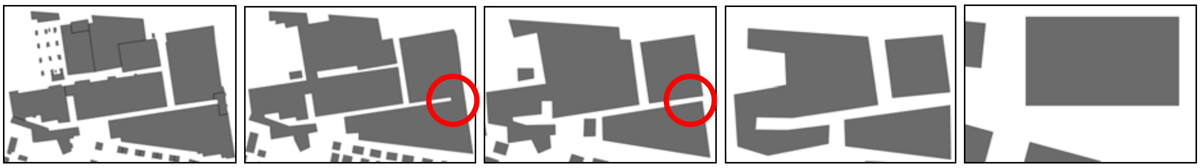
c) 1:50k

d) 1:100k

e) 1:200k

Fig. 1: Manual generalised building objects at different scales.

But also the reverse case might be possible, whereby one building of the original scale will be assigned to more than one building in the derived scale. Although this case occurs less frequent, because generalisation tries to remove less important, small buildings, there are plausible reasons for the “appearance“ of building objects. One example is shown in Fig. 2 with the split of a building in the derived scale caused by suppression of a small connection. Further reasons are the different update cycles for maps of different scales.



a) 1:10k b) 1:25k c) 1:50k d) 1:100k e) 1:200k

Fig. 2: Special case of 1:2-relation between buildings of original (1:25k) and derived scale (1:50k) caused by a split. The circle shows the small connection in the original scale, which gets suppressed in the derived scale.

The assignment algorithm is based on intersection and distance. Thus objects from different scales get an "intersection assignment" in case of overlapping or connecting. A "distance assignment" is detected if they are closer than a distance threshold. If an object has no associate in the other scale a 1:0 respective 0:1 relation gets assigned. More common are 1:0 relations describing small objects which gets deleted in the derived scale. If a 0:1 relation is identified the matched data sets must have different update cycles or an error is detected.

The concept of groups is used to model the different relation types by keeping information about the intersection respective distance assignment of all involved object pairs. An object pair contains one object from the original scale and one from the derived scale. Thus a group consist of one object pair in case of 1:1 relation, of n pairs in case of n:1 relation. In case of n:m relation with $n > 1$ and $m > 1$ the group contains at least $n+m-1$ pairs and in maximum n x m pairs. Second reason for introducing groups is to investigate and assign cartographic constraints on them.

Assignment algorithm

1. Pre steps
    a. Create partitions based on linear network, e.g. transportation, hydrography
    b. Identify protected buildings within the original scale, which should treated separately e.g. because of special shape or semantics (church, public buildings)
2. Identify the intersection relations between original and derived buildings
    a. add pair to group (*n:1* relation),
    b. if no group exist create a new one (*1:1* relation),
    c. mark the intersection flag for the pair
3. Search further, if buildings of the derived scale are situated within the distance threshold of the original building and proceed like 2a) and 2b)
    a. mark distance flag for the pair
4. If no assignment is created, thus the original building has no corresponding object in the derived scale (*1:0* relation)
    a. create a new group, with one pair, containing only the original building
5. Analyse if there is a derived building contained in different groups
    a. combine groups by assigning all pairs to one group (*1:n* relation and *m:n* relation)
6. Analyse if there are derived buildings without assignments (*0:1* relation) and proceed in analogy of 4a)
7. Calculate new group properties like aggregate area size, average shape index

The assignment algorithm creates identical results independent if the original scale gets assigned to the derived scale or vice versa. Fig. 3 shows a matching result, whereby buildings coloured according to their relation type. Green colour represents the unique *1:1* relation. Blue colour shows *n:1* relation. In case of deletion for example of small, less important buildings a *1:0* relation is applied. The less frequent cases of *1:n* or *0:1* are shown in black. The non unique *n:m* relation are highlighted with red colour.

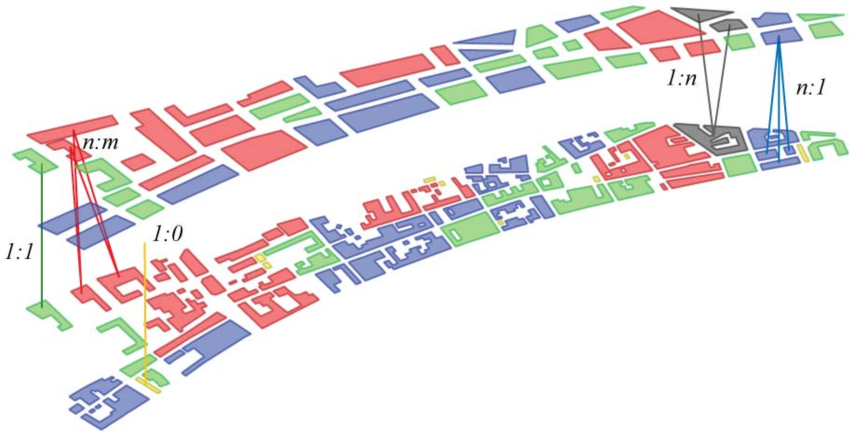
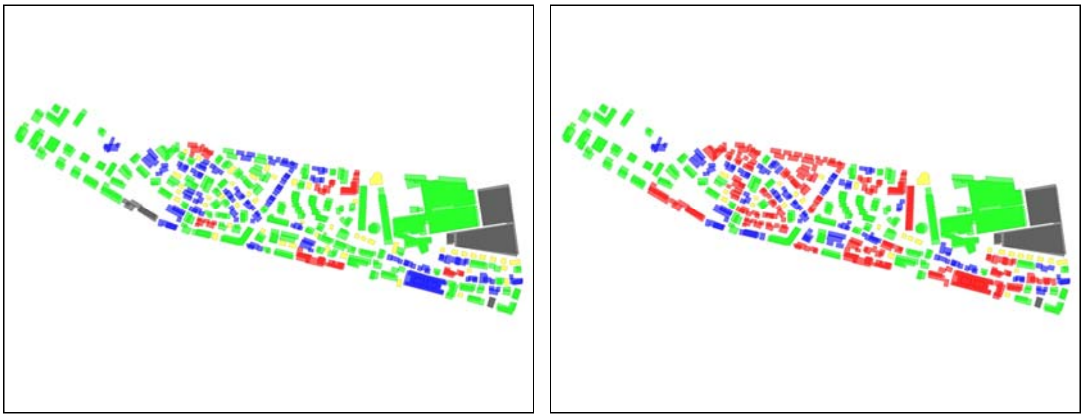
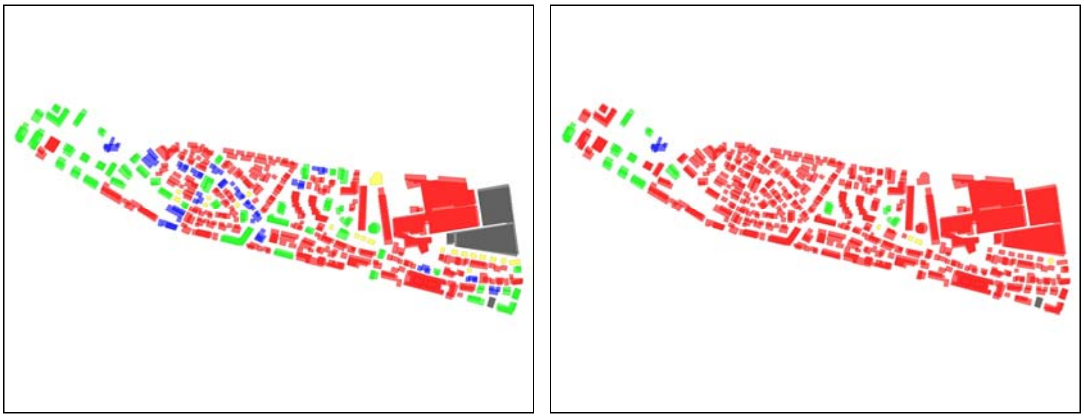


Fig. 3: Assignment result of overlapping or connecting buildings (with distance threshold zero), 1:1 green, n:1 blue, 1:0 yellow, 0:1 black, 1:n grey, m:n red; ICC data set

Depending on a distance threshold also objects of the surrounding will be matched and associated with a "distance assignment". The distance threshold should be parameterised in dependence of the scale change. Fig. 4 shows different assignment results by enlargement of the distance threshold. The spreading of *m:n* relations as in Fig. 4d) illustrated can be limited by considering partitions derived from a network.

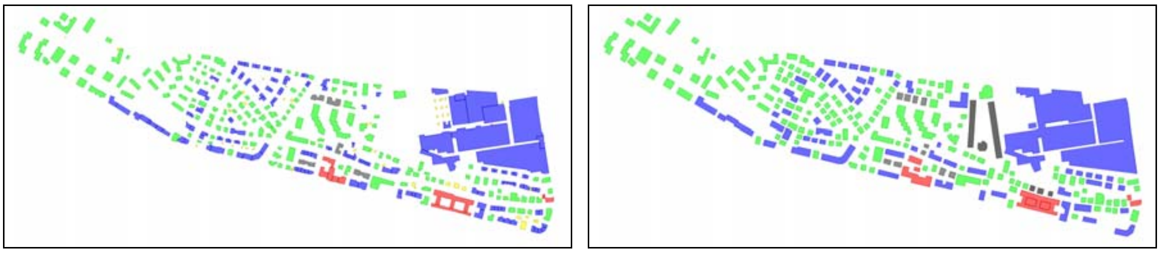


a) 198 groups, distThreshold = 0.0 b) 148 groups, distThreshold = 3.0

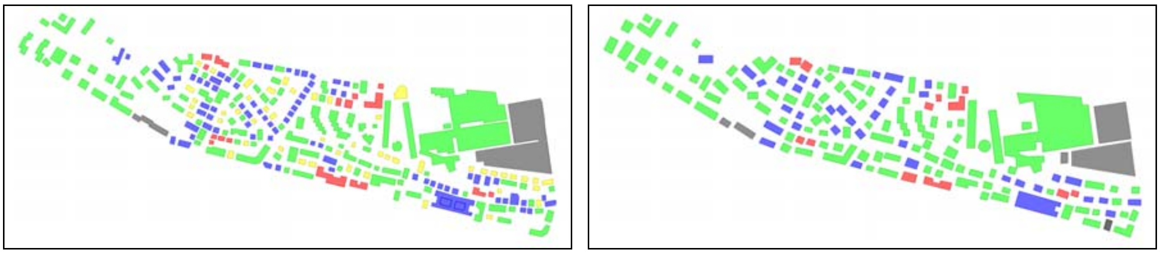


c) 117 groups, distThreshold = 5.0 d) 21 groups, distThreshold = 10.0

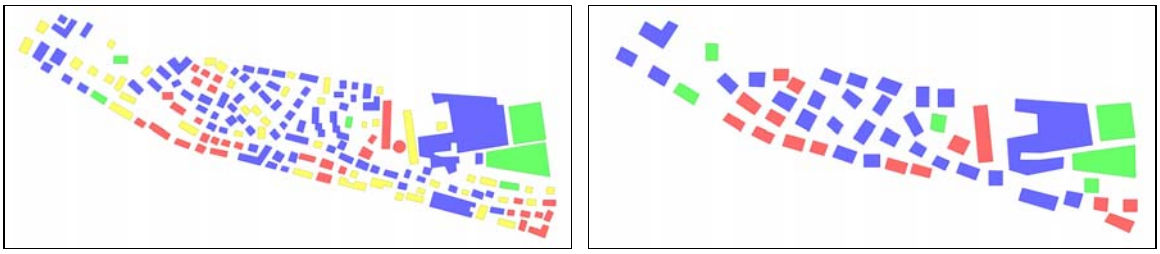
Fig. 4: Variation of distance threshold for scale change from 1:25k to 1:50k; source and target scale are shown in every picture (1:1 green, n:1 blue, 1:0 yellow, 0:1 black, 1:n grey, m:n red).



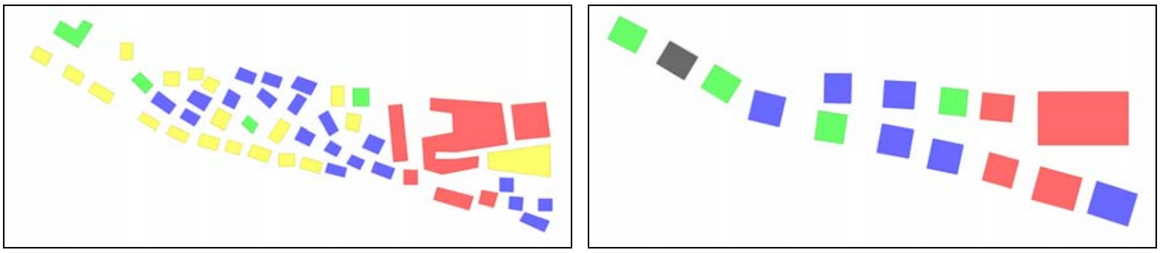
a) **1:10k to 1:25k**, 285 groups, 162 (1:1), 61 (m:1), 48 (1:0), 6 (0:1), 5 (1:n), 3 (m:n)



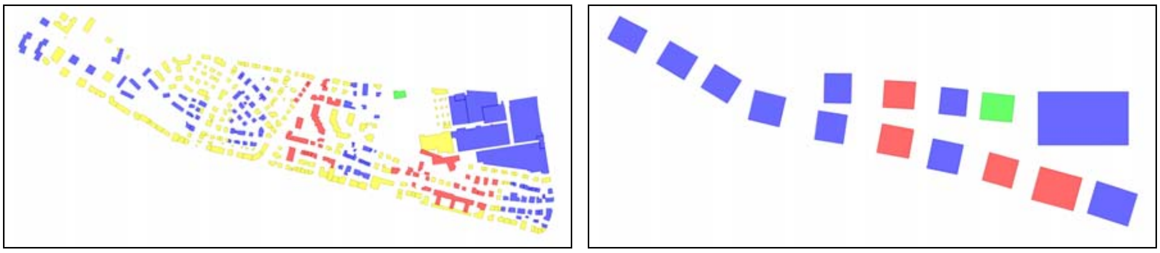
b) **1:25k to 1:50k**, 198 groups, 103 (1:1), 38 (m:1), 48 (1:0), 1 (0:1), 2 (1:n), 6 (m:n)



c) **1:50k to 1:100k**, 87 groups, 6 (1:1), 28 (m:1), 46 (1:0), 0 (0:1), 0 (1:n), 7 (m:n)



d) **1:100k to 1:200k**, 31 groups, 4 (1:1), 6 (m:1), 19 (1:0), 1 (0:1), 0 (1:n), 1 (m:n)



e) **1:10k to 1:200k**, 238 groups, 1 (1:1), 10 (m:1), 225 (1:0), 0 (0:1), 0 (1:n), 2 (m:n)

Fig. 5: Assignment results for different scale changes with distance threshold zero; source scale (left) and target scale (right); assignment type - 1:1 green, n:1 blue, 1:0 yellow, 0:1 black, 1:n grey, m:n red.

Conclusion

An approach is presented for the unique assignment of building representations between different scales. Unique refers to the fact that source and target scale can be switch resulting in corresponding relations, e.g. 1:0-relation changes to 0:1-relation. The influence of distance threshold parameter is illustrated through several examples. Larger threshold values result in more *n:m*-relations, thus everything is related to each other. Smaller threshold values have the disadvantage that a lot of 1:0-relations gets assigned, especially for large scale transitions. Consequently a careful selection of the distance threshold parameter values has to be carried out in dependence of the spatial configuration and the corresponding scale transition.

Literature

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