Approach to calculating spatial similarity degree using map scale change of road networks in multi-scale map spaces

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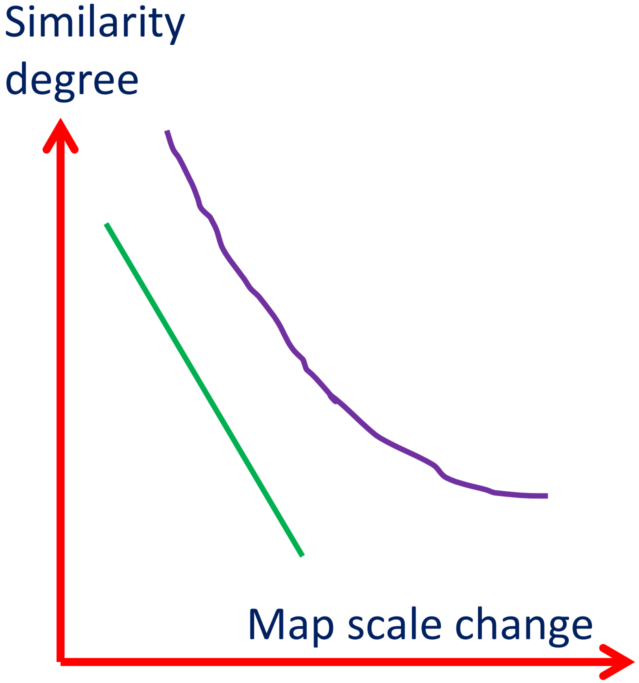
Outline

- Background
- Idea
- Calculation of similarity degree
- Construction of the formula
- Discussion and conclusion

Background: spatial similarity

- Why automated map generalization (AMG)?
- Similarity-related problems in AMG
- when to terminate a map generalization procedure?
- how to assess the quality of generalized maps?
- how to calculate threshold values of the algorithms in AMG?



Background: Significance

- Theory of spatial relations
- Spatial description, reasoning, retrieval…
- Spatial cognition
- Automated map generalization

Background: the Problem

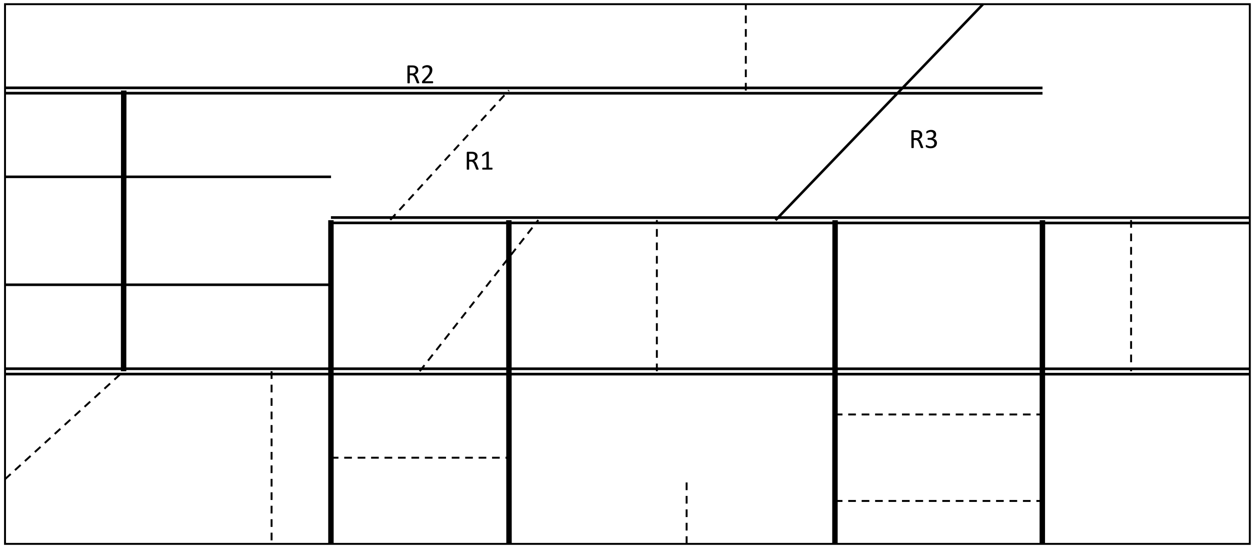
- Supposed that an object (or group) is represented as A_m and A_k respectively at scales m and k. Previous study has revealed that spatial similarity relation and map scale change in multi-scale map spaces depend on each other. Topological, directional, distance relations, and attributes are major factors taking effects in spatial similarity judgments. Their weights have been got by experiments.
- The formulae for calculating spatial similarity degrees among individual linear feature and among river basin networks on multi-scale maps have been proposed.
- Aim of this study: formula for calculating similarity degree among rivers in multi-scale map spaces.

Idea

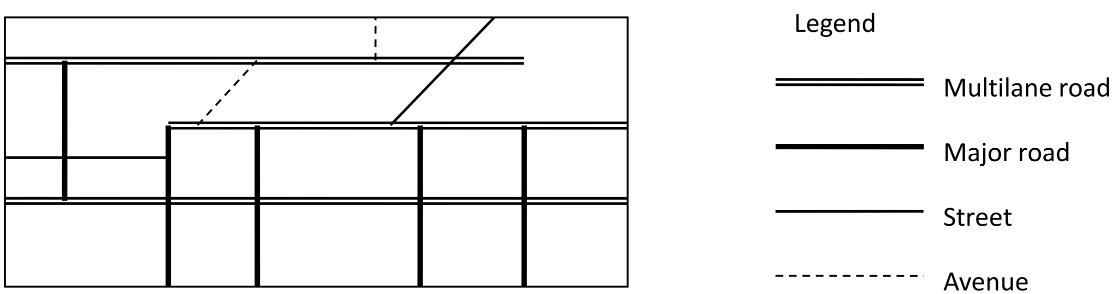
- Suppose that A_l is a road network consisting of N_l roads on the map at scale l, A_m is a generalized road network of A_l consisting of N_m roads at scale m.Their properties and their weights are $P = \{P_{topo}, P_{dir}, P_{dist}, P_{attr}\}$ and $W = \{W_{topo}, W_{dir}, W_{dist}, W_{attr}\}$.
- $\because W_i \in W \ is\ known$
- $\therefore to\ know\ Sim(A_l, A_m) = \sum P_i W_i$
- $\boldsymbol{P = \{P_{topo}, P_{dir}, P_{dist}, P_{attr}\}}$ **???**

Calculation of similarity degrees(I)

- P_{topo} : to know the difference of the topological relations between the two road networks at different scales.
- P_{dir}: roads are seldom moved before and after map generalization, so their similarity in direction relations can be viewed as equal to 1.



(a) Original city road map at scale .



(b) Generalized city map at scale .

Fig.1 A road network and its generalized version.

Calculation of similarity degrees(II)

- P_{dist}: similarity of road networks in distance relations is evaluated using road density.

- P_{attr}: similarity in attributes of road networks depends on a number of attributes such as road type, road class, road condition, etc. To simplify the problem, road class is used to represent the differences of road attributes.

Construction of the formula (I)

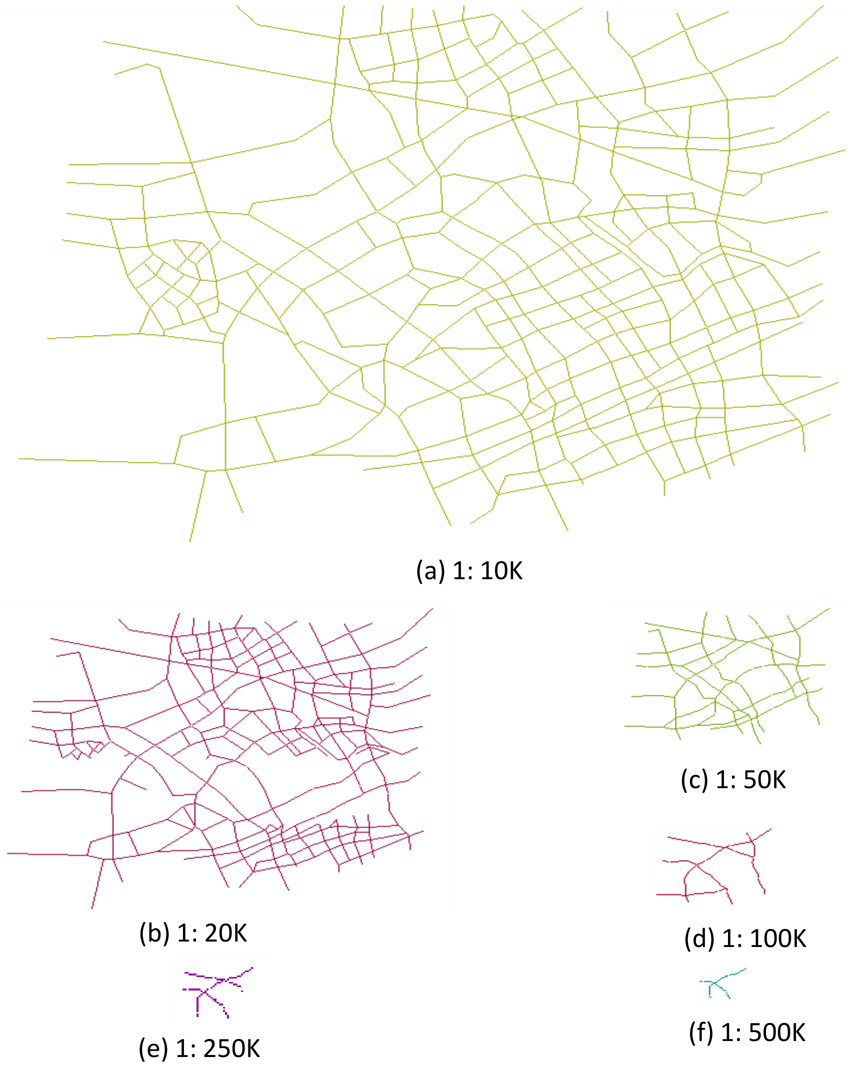
- Experiments: 50 subjects, 3 road networks and their generalized counterparts .
- 16 points (map scale change, similarity degree)

(2, 0.77), (5, 0.52), (10, 0.31), (25, 0.22), (50, 0.18),

(2, 0.75), (5, 0.55), (10, 0.37), (25, 0.28), (50, 0.19),

(2, 0.68), (5, 0.49), (10, 0.34), (25, 0.28), (50, 0.16).

(1, 1.00)



(a) 1: 10K

(b) 1: 20K

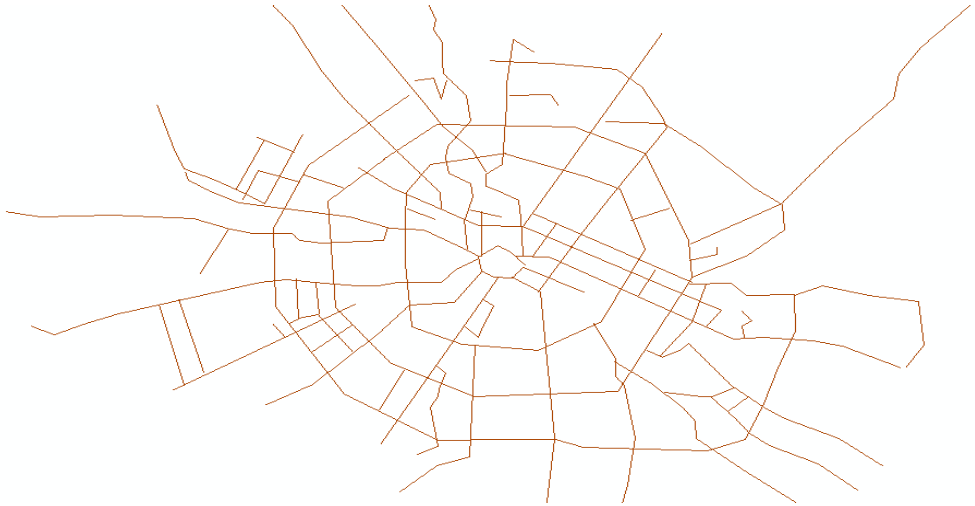
(c) 1: 50K

(d) 1: 100K

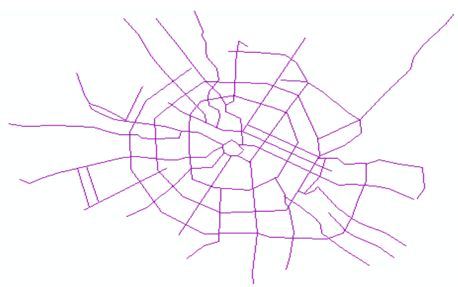
(e) 1: 250K

(f) 1: 500K

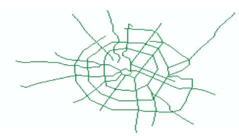
Fig.2 An ordinary road network at different map scales.



(a) 1: 10K



(b) 1: 20K



(c) 1: 50K

(d) 1: 100K

(e) 1: 250K

(f) 1: 500K

Fig.3 A road network with ring roads at different map scales.

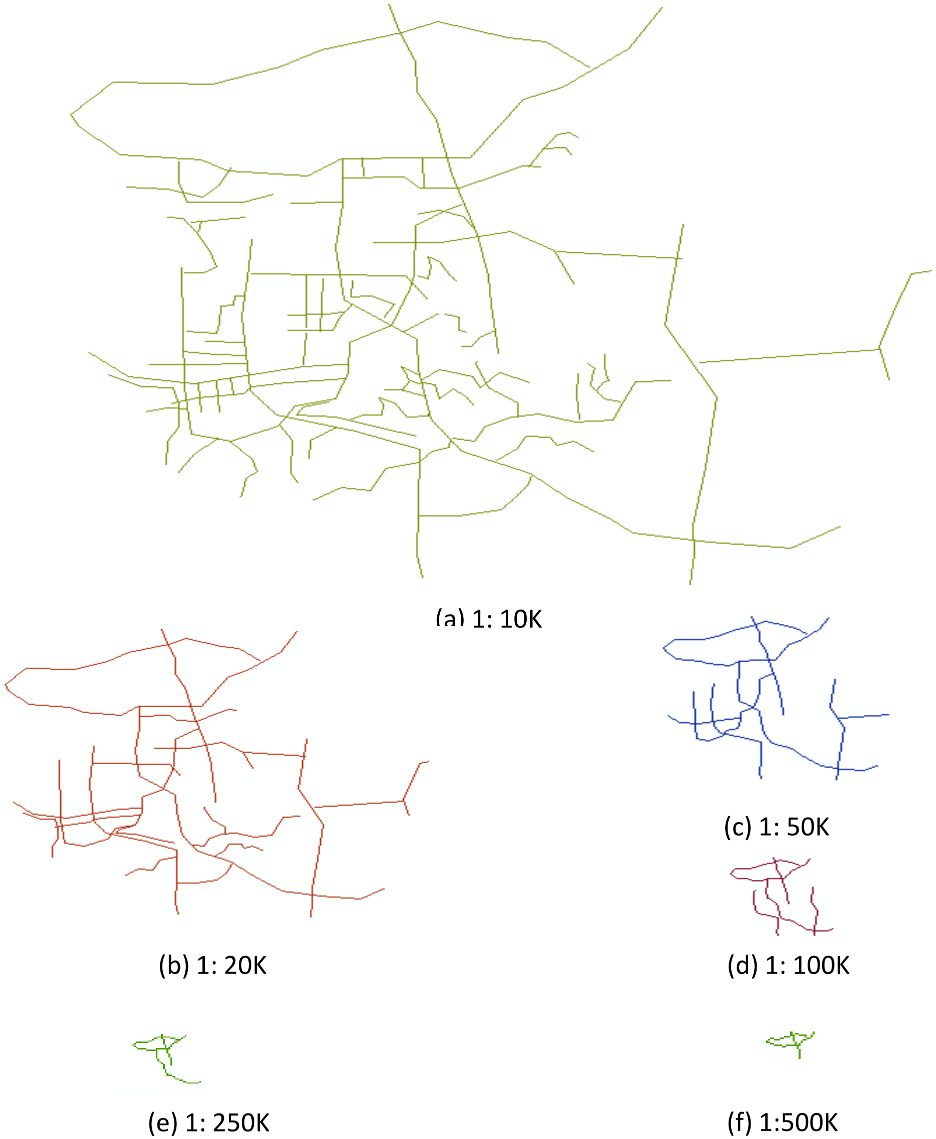


Fig.4 A road network with zigzag roads at different map scales.

Table 1 Calculated spatial similarity degrees and the subjects' responses

Fig.2	0.77, 0.52, 0.31, 0.22, 0.18	2, 5, 10, 25, 50	50, 0, 0
Fig.3	0.75, 0.55, 0.37, 0.28, 0.19	2, 5, 10, 25, 50	49, 0, 1
Fig.4	0.68, 0.49, 0.34, 0.28, 0.16	2, 5, 10, 25, 50	48, 0, 2

Construction of the formula (II)

- **Candidate formulae for curve fitting:**

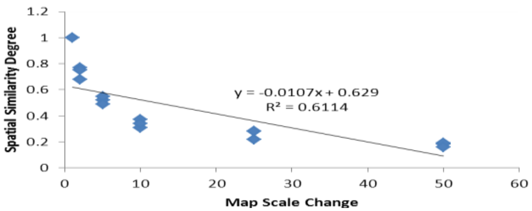
$$y = a_1 x + a_0$$
$$y = a_2 x^2 + a_1 x + a_0$$
$$y = a_2 e^{a_1 x} + a_0$$
$$y = a_1 ln(x) + a_0$$
$$y = x^a$$

The greater the R^2, the better the curve.

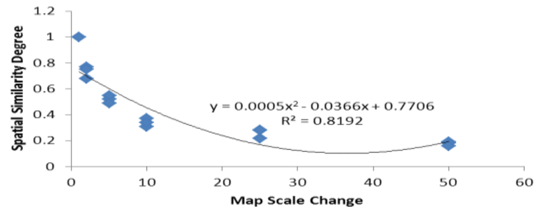
- $y = 1.0022x^{-0.439}$

Construction of the formula (III)

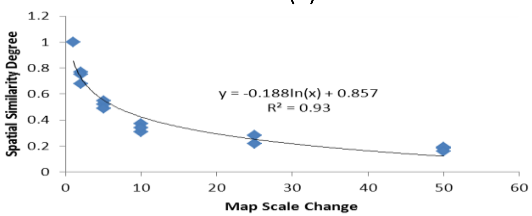
- Resulting formula:



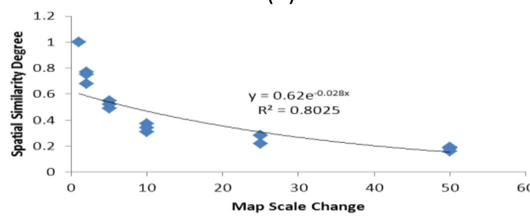
(a)



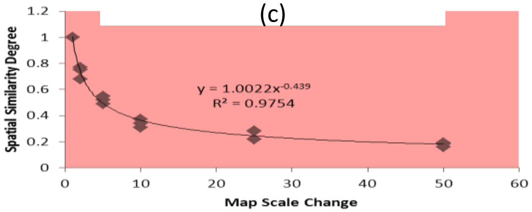
(b)



(c)



(d)



(e)

Constructing formulae using the curve fitting method

Discussion and conclusion

- The formula: map scale change ←→ spatial similarity degree
- Empirical formula: testees, samples
- Domain [1, +∞); range [0,1].
- Use of the formula in map generalization.
- **Future: a general formula considering all map features.**

Thanks for your attendance