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
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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
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 $Sim(A_l, A_m) = \sum P_i W_i$

• $P = \{P_{topo}, P_{dir}, P_{dist}, P_{attr}\}$
Calculation of similarity degrees(I)

- $P_{\text{topo}}$: to know the difference of the topological relations between the two road networks at different scales.
- $P_{\text{dir}}$: roads are seldom moved before and after map generalization, so their similarity in direction relations can be viewed as equal to 1.
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)
Fig. 2 An ordinary road network at different map scales.
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 the curve.

- \( y = 1.0022x^{-0.439} \)
Construction of the formula (III)

• Resulting formula:

Constructing formulae using the curve fitting method
Discussion and conclusion

• The formula: map scale change $\leftrightarrow$ spatial similarity degree
• Empirical formula: testees, samples
• Domain $[1, +\infty)$; range $[0,1]$. 
• Use of the formula in map generalization.
• Future: a general formula considering all map features.
Thanks for your attendance