Quantitative Spatial Similarity Relations for Automated Map Generalization

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SUMMARY

Automated map generalization is a necessary technique for the construction of multi-scale vector map databases that are crucial components in spatial data infrastructure of cities, provinces, and countries. Nevertheless, this is still an unrealized dream because many algorithms for map feature generalization are not truly automatic and therefore need human's interference. One of the major reasons is that map generalization is a process of spatial similarity transformation in multi-scale map spaces; however, existing theory are not capable to support such transformation.

This study focuses on the theory of spatial similarity relations in multi-scale map spaces, proposing a series of approaches and models that can be used to automate relevant algorithms in map generalization, and achieves the following innovative contributions.

First, the fundamental issues of spatial similarity relations are explored, i.e. (1) a classification system is proposed that classifies the objects processed by map generalization algorithms into ten categories; (2) the Set Theory-based definitions of similarity, spatial similarity, and spatial similarity relation in multi-scale map spaces are given; (3) mathematical language-based descriptions of the features of spatial similarity relations in multi-scale map spaces are addressed; (4) the factors that affect human's judgments of spatial similarity relations are proposed, and their weights are also obtained by psychological experiments; and (5) a classification system for spatial similarity relations in multi-scale map spaces is proposed.

Second, the models that can calculate spatial similarity degrees for the ten types of objects in multi-scale map spaces are proposed, and their validity is tested by psychological experiments. If a map (or an individual object, or an object group) and its generalized counterpart are given, the models can be used to calculate the spatial similarity degrees between them.

Third, the proposed models are used to solve problems in map generalization: (1) ten formulae are constructed that can calculate spatial similarity degrees by map scale changes in map generalization; (2) an approach based on spatial similarity degree is proposed that can determine when to terminate a map generalization system or an algorithm when it is used to generalize objects on maps; and (3) an approach is proposed to calculate the distance tolerance of the Douglas-Peucker Algorithm so that the Douglas-Peucker Algorithm may become fully automatic.