Multi-scale Representation of Building Feature in Urban GIS

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1 Introduction

Two kinds of generalization methods can be used to conduct multi-scale representation. One is to store different scale version maps in the database and then to extract different layer data to display according to the scale change. The data layers describe the same geographic area but with varied resolution. This method requires huge memory space to store redundant map data and additional preparation work to organize the various scale map layers. Furthermore, the representation can only carry out limited discrete layers in scale change, so it is not a really continuous scale change. The advantage of this method exists in quick running.

The another method is based on special generalization model which automatically compute and determine whether objects are displayed or not and how detailed graphics is displayed in the process of zoom-in. This method needs hierarchical data structure and abstraction algorithm to support. The research associated with it is active in the field of map generalization.

Multi-scale representation and map generalization has to take into account spatial object properties in geometrical, semantic and topological aspects. The objects with the same geometrical type but different geographic meaning should be executed with different generalization models and algorithms. In recent years, the study of geo-oriented generalization is active[1-3]. The research on urban building abstraction and multi-scale representation is an example. As the polygon object with human culture characteristics, the building has different properties in spatial distribution, shape structure and Gestalt nature compared with natural features such as soil parcel, vegetable, lake etc. Disjoint cluster distribution and orthogonal shape properties require to
be considered specially in building generalization.

Building cluster generalization includes multiple level analysis and operation. Grouping is the first decision-making based on conflict detection, distribution pattern recognition and Gestalt nature cognition. The second displacement involves distance and direction identification. Thirdly, the geometrical combination and simplification has to maintain orthogonal geometric nature. Three-level processes require special models to derive distribution density, distribution pattern, adjacency distance, adjacency direction and so on. Independent building simplification is active in this field and some methods and algorithms are achieved. More details are given in References[3-7].

2 Constrains of building multi-scale representation

On the basis of geometric, topological and semantic analysis, the constraints of building generalization involve position accuracy maintenance, short space distance avoidance, the whole area balance maintenance, and square shape retainment, etc. The main purpose of building generalization is to remove spatial conflict and during the procedure to respect the above constraints as much as possible.

From the point of readable view, when distance between buildings is shorter than cognition tolerance, we may think the spatial conflict generating. To resolve conflict, the candidate operations include deletion, displacement, aggregation. Deleting some buildings needs to take into account semantic importance and spatial characteristic, such as area size. Generally, through SQL conditional selection can delete some categories of building, and remnant buildings are equally of importance requiring other operation to solve conflicts. Displacement is valid just within relative large space. When scale changes largely, in limited space one displacement may result in new conflicts and it is very hard to find an appropriate position for each building. Combination makes the conflict between original buildings disappear but increases the building size. Furthermore, the conflict between new combined results still exist, unless all buildings having conflict to each other are combined to one big block. Single operation does not work for building cluster generalization. The valid strategy is executing both displacement and aggregation. (The independent simplification is necessary, however, it is not considered for building cluster.) When two or more buildings move together and aggregate into one, the conflict between them exists no longer. On the other hand, movement gives the contrary direction more room and the conflict between the just generated new building and context neighbors may also be resolved.

Some of constraints contradict to each other in building generalization. The compromise strategy is to sacrifice each constraint partly, without respecting anyone completely. Spatial conflict removal is one of constraints and for its solution the maintenance of position accuracy, the whole area balance and Gestalt nature have to be taken into account. The largest offset distance of displacement should be restricted within position accuracy. Generally, displacement can not guarantee two neighbor buildings seamlessly sharing one common boundary, but still with gap fragment. So the aggregation result has the trend to increase area. The following independent simplification needs to consider this fact and perform operation preferring area reduction.

The Gestalt nature is hard to maintain because of the difficulties of formally describing these cognition principles. We can psychologically feel some buildings with the same size, direction and shape and other similar visual characteristics should be assigned to one group, but until now we can not find a model to represent spatial distribution pattern to identify the group. It depends on complex spatial relationship representation considering context environment, such as similarity relationship. For building cluster, when the difference of gap distance is distinct to each other, the grouping decision can be made on only distance computation. Otherwise there may be the case that all buildings within one street block have the same conflict distance to each other and need to be classified as one group. In this case, it is Gestalt nature rather than geometric distance that distinguishes building group in clus-