**Modeling the Generalization of Topographic Database Using the Extraction and Integration of Constraints**

**Abstract**

The necessity of preparing and applying maps in different scales is clear to all users of data and spatial information. In addition, increasing the need of different specialists in different science to spatial information has made it necessary to produce maps at various scales through generalization. The map generalization is a complex process for producing small-scale maps from large-scale maps that preserves the main structures and characteristics of features and lead to the transformation of features in a legible way on the target scale. One of the most important classes in the topographic data base is building polygons. Building polygon generalization is a major step in the generalization of topographic maps, which is very difficult due to the complexity of the spatial distribution of buildings. The purpose of this research is to model the building polygon generalization.

The presented model consists of three main models: (1) grouping the building polygons; (2) extraction of linear patterns within each group; and (3) constraint-based generalization of building polygons. In the first model, in order to solve the problem of density-based algorithms, a new spatial clustering algorithm, LA-DBSCAN, which can cluster polygonal buildings in urban blocks with noise and non-uniform density, is developed. In the second model, firstly by introducing a new index called the similarity index and using the difference in direction criterion, straight and perpendicular patterns are extracted and secondly, the extracted patterns are refined using a novel definition of pattern interaction index. In the third model, after the geometric transformation of building polygons, a new constraint-based model, combining displacement and a new area reduction model, is proposed. In this model, two new constraints for preserving the area and shape of building polygons have been added to the existing constraint-based model. In order to achieve this, firstly the area preservation constraint with the goal of minimizing the change in the area of polygons is added to the objective function of the IGA algorithm for implementing the displacement. Secondly, the shape preservation constraint is modeled by presenting a new area reduction model and the area of conflicting polygons is reduced while maintaining their main shapes.

To evaluate the performance of the proposed model, the complete building polygon generalization process is implemented using two data sets with different distributions located in Isfahan province at 1:25k scale and finally, the generalized map of building polygons at 1:50k scale was produced. The evaluation of the presented models was carried out by using the cluster assessment circles method, the homogeneity of the patterns, harmony assessment of map before and after the generalization process and comparing the produced map with the existing map through the correctness and completeness indicators.

An evaluation of the results in the first model allowed us to conclude that the LA-DBSCAN algorithm results in the extraction of more homogeneous and dense groups compared to the DBSCAN algorithm. The extraction of the groups based on the LA-DBSCAN algorithm compared to the DBSCAN algorithm results in the improvement of correctness (1.79% and 6.54% for dataset 1 and 2, respectively) and completeness (2.67% and 5.54% for dataset 1 and 2, respectively) indicators. The evaluation of the results of the second model showed that the proposed pattern extraction model meets the requirements of the generalization in the pattern extraction step (extraction of homogeneous and regular patterns). Also, by assessing the harmony of the produced map based on the proposed pattern extraction model with respect to the base map and the comparison with the existing map, it was determined that the map obtained based on the proposed model, by reducing the amount of deviation to the base map has more ability in preserving the characteristics of the base map than the map produced by a cartographer. Finally, the comparison of the results of the third model with results obtained by a cartographer showed that adding area and shape preservation constraints to the existing constraint-based generalization model in the form of a new area reduction model has led to an increase in the correctness and completeness indicators. The increase of the correctness is 3.09% and 4.72% for dataset 1 and 2, respectively and the increase for the completeness is 2.41% and 6.69% for dataset 1 and 2, respectively. Therefore, it can be concluded that the proposed constrain-based model led to the closer similarity of the generalization model to the manual process of cartography.

In general, the proposed model is a semi-automatic solution for modelling the generalization process which is done by a cartographer for generalizing the building polygons. It has the best use of existing data while avoiding arbitrary assumptions. Therefore, the results of this research are beneficial for application in the field of topographic database generalization.

**Key words**: Map generalization, generalization constraints, polygon grouping, spatial patterns, spatial conflicts, optimization methods.