

BUILDING TYPIFICATION AT MEDIUM SCALES

I.Oztug Bildirici, Serdar Aslan

Abstract

Generalization constitutes an inevitable step in map production. Lots of researches have been carried out so far that aim to automate the generalization processes in data and map production lines. Building typification is an important operation that reduces the number of buildings while preserving the properties of the building group that refer to. The aim is to maintain the pattern as far as possible and preserve the similarities and differences between the groups with regard to density, size and orientation of buildings. In this study two newly developed methods, named Length and Angle Methods, are presented that typify buildings having point geometries. Before typification, building groups are detected. Then the methods are applied. In some cases, one method can have some superiority to another. For this reason both methods are applied to the same building groups separately and the method, that produces more selected buildings for the related building groups, is chosen to be implemented in the production. The results of these two methods have been evaluated and seemed to be quite encouraging. Studies for the improvements of these two methods are still ongoing.

Keywords: Map generalization, building generalization, topographic maps

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1. INTRODUCTION

Geographic data and maps at different scales and resolutions have been increasingly used for various application areas such as earth science, natural resource management, environmental protection, urban planning, defence, transportation, tourism, statistics, education, etc. (Başaraner, 2005). For this reason, countries or data providers produce maps having the same standards but different scales. Cost and production time of these maps are always aimed to be minimized. Many researches have been increasingly making research on map generalization.

Geographic features are represented in maps with symbols. The sizes of the symbols on the map are the same for various scale maps. Therefore scale reduction from a source map to a target map leads to a competition for space among map features caused by two cumulative effects: at a reduced scale, less space is available to place symbols representing map features, while at the same time, symbol size increases relative to the ground it covers in order to maintain size relations and legibility. Hence, simply scaling map data to a smaller scale results in unreadable and incorrect information: The sizes of individual map features become too small to be legible, while neighbouring symbols become crowded and hence will no longer be clearly distinguishable or may even overlap (Bader et al., 2005).

Generalization of buildings and built-up area constitute a vital process in medium scale topographic map production (Başaraner and Selçuk, 2008). Most of the buildings are represented with point geometries at medium (1:25000-

1:100000) scale topographic maps, in Turkey, especially in rural areas. Buildings having point geometries at basic (1:25.000) scale data sources, are mostly overlapped when symbolized at smaller scales such as 1:50.000, 1:100.000, etc.

In a digital environment, the generalization process has been decomposed into many operations and several map generalization operators may be applied to resolve these problems (McMaster and Shea 1992). Building groupings will only be related to such generalization operations as aggregation (Figure 1), simplification, elimination, and typification (Figure 2) (Li et al., 2004).

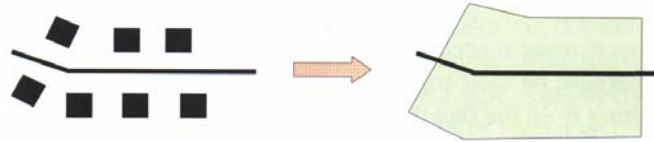


Figure 1. Aggregation of buildings in settlement area.



Figure 2. Typification (Sester, 2004)

The operation of reducing the number of buildings while preserving the properties of the group is referred to as typification (Christophe and Ruas, 2002). Typification constitutes an important process in topographic mapping, especially in the selection of buildings. The aim is to preserve the pattern as far as possible, preserve similarities and differences between the groups with regard to density, size and orientation of buildings (Regnauld, 2001). This paper describes an integrated methodology for the fully automated typification of buildings. The contents include the automated grouping of buildings and the automated execution of the typification process.

2. BUILDING TYPIFICATION

Generalization of building groups is a bit different from the generalization of other geographic features. In building generalization, building groups should be taken into account as well as some relations with other geographic features such as roads, etc. One of the important issues here is to detect the building groups and recognize their structures, because the structures and the patterns that the buildings construct are aimed to be preserved after the generalization process.

The generalization of building clusters includes multiple level analysis and operation. Grouping is the first decision-making step which is based on the conflict detection, the distribution pattern recognition and the Gestalt nature cognition (Ai and Zhang, 2007).

Research on detection of building structures for building typification; Hangouet (1998) detects buildings aligned along roads, Regnauld (1998) detects close buildings organized along a graph using Minimum Spanning Tree (MST), Anders and Sester (2000) put forward a parameter-free cluster detection method used in spatial databases, Boffet and Boffet and Rocca-Serra (2001) detect and aggregate triplets of buildings to constitute building alignment using a bottom-up approach. Christophe and Ruas (2002) detected building alignments using straight-line templates. Building alignments are identified from the templates. The alignments are then characterized by a set of parameters such as proximity and similarity, and only those perceptually regular buildings are retained. Rainsford and Mackaness (2002) have also used the template matching technique for building grouping. Li et al. (2004) combine the urban morphology and Gestalt theory presenting a method to group building cluster. Chaudhry and Mackaness (2005) develop a method to generate the city boundaries by the buffering of building features and the derivation of the single polygon surrounding clusters.

Typification is a generalization operation that replaces a large number of similar objects by a smaller number of representative objects, while ensuring that the typical spatial structure of the object arrangement is preserved (Anders, 2006). Since 1990, various researches have been making research on building typification. Müller and Wang (1992) use mathematical morphology to typify natural areal objects. Their principle is to enhance big objects and reduce small ones – unless they are important. Ruas (1999) groups buildings by means of a network (Delaunay triangulation) and progressively removes the ‘worst building’ by means of a cost function based on size, density and directional proximity (Christophe and Ruas, 2002). Sester and Brenner (2000) describe an approach based on Kohonen Feature Maps. Kohonen Feature Maps are self organizing maps which try to preserve the original structure by moving the remaining objects in the direction of the removed one to minimize a certain error measure (Anders, 2006).

The preservation of spatial patterns and spatial relationships between map objects is an important requirement of any map-generalization procedure (McMaster and Shea 1992, Robinson et al. 1995, Swiss Society of Cartography 2005). Spatial relationships between map objects give important hints to the map reader about the relative positions and arrangement of the real-world objects they represent. Spatial relationships can broadly be classified into topological, proximal, and directional relationships between spatial objects (Jones 1997). On maps, spatial relationships between map objects build complex patterns such as alignments of a row of buildings, circular arrangements, density variations (e.g. clustered vs. sparse) (Bader et al., 2005). The typification algorithm has to find a compromise that preserves the original patterns as far as possible. Therefore many researches have been made on typification algorithms that care alignments of buildings and recognize the geometric structures they construct. Structural knowledge is used in approaches, which try to detect geometrical structures in the object groups which should be preserved by the generalization process. Typification for linear structures is proposed by Regnaud (1996). Based on a minimum spanning tree, clustering groups are detected; then the relevant objects within these groups are replaced by typical exemplars. This approach for building typification is motivated by the phenomenological property of buildings being aligned along streets – thus a one-dimensional approach is feasible. Another approach, which tries to find linear building structures, is described in Christophe and Ruas (2002). In Anders and Sester (2000) an approach to detect two-dimensional irregular structures with homogenous density is described. After clustering, the number of objects within the clusters has to be reduced. The reduction factor can be derived using e.g. the black-and-white ratio, which is to be preserved before and after generalization, or Töpfer’s radical law. Anders made research on grouping of grid structured buildings and typification (Anders, 2006).

3. LENGTH AND ANGLE METHODS AT BUILDING TYPIFICATION

3.1. Detecting Building Groups

Digital data usually have no information about the distribution of the objects: which ones are neighbours, or part of the same town, or which ones are isolated. It is important to identify such additional information in order to generalize buildings in an urban area successfully (Regnaud, 2001). When viewing a map, most people are able to conceptually group entities together. The action of grouping is usually based on some similarity in the criteria. Things that “look the same” can be grouped together. This definition of perceptual groups comes from the Gestalt theory (Wertheimer, 1912) (Christophe and Ruas, 2002). Gestalt principles have been applied for the recognition of spatial distribution patterns for many years (Weibel 1996), in both digital and manual generalization (Li et al., 2004). These principles are proximity (Figure 3), similarity (Figure 4), closure, continuity (Figure 5), and common fate. Three more factors are added to this list later. These are common region (Palmer 1992), element connectedness (Palmer and Rock 1994) and common orientation (Li et al., 2004). Three of them -proximity, similarity and continuity, drawn from Thorisson (1994) - are relevant to the distribution of buildings;

□ Proximity: Proximity is one of the most critical criteria for the visual grouping of objects. In Figure 3 three groups of points can easily be identified. For our purpose this is of great importance because it helps us to identify objects in conflict due to their proximity (Regnaud, 2001).

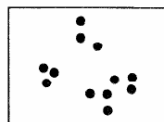


Figure 3. Proximity.

□ Similarity: This criterion relates to our capacity to group objects that look similar. In Figure 4 we can divide the set of objects into two groups: the squared ones and the round ones. Buildings can also be grouped in terms of shape, size and orientation (Regnaud, 2001).

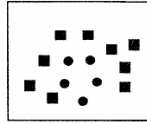


Figure 4. Similarity.

□ Continuity: The last criterion is that of continuity. We can identify groups of objects according to their regular linear disposition, as in Figure 5. This characteristic is important for our purposes because buildings are usually located along roads, often with a strong regularity in their position, especially within small residential areas (Regnaud, 2001).

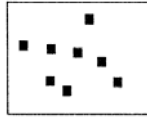


Figure 5. Continuity.

Grouping of buildings comes logically before the application of generalization operators (Başaraner and Selçuk, 2008). Therefore there is a need for methods and criteria to find building groupings in computer environment. A minimum spanning tree (MST) can be used for identifying clusters of buildings, and a Delaunay triangulation can be used for analyzing proximity (Başaraner and Selçuk, 2008).

In this application three principles (proximity, similarity and continuity) of the Gestalt theory, mentioned above, have been used in detecting the building groups. Resource data is only composed of buildings having point geometries (Figure 6.a). Symbol sizes at target scale are used as criterion to detect the building groups. Firstly, polygons are constructed from the symbol sizes of the buildings at the target scale and with the help of coordinates and their rotation angles (Figure 6.b). The polygons that are overlapped are merged. Then, by taking into account the transportation network, building groups are detected (Figure 6.c).

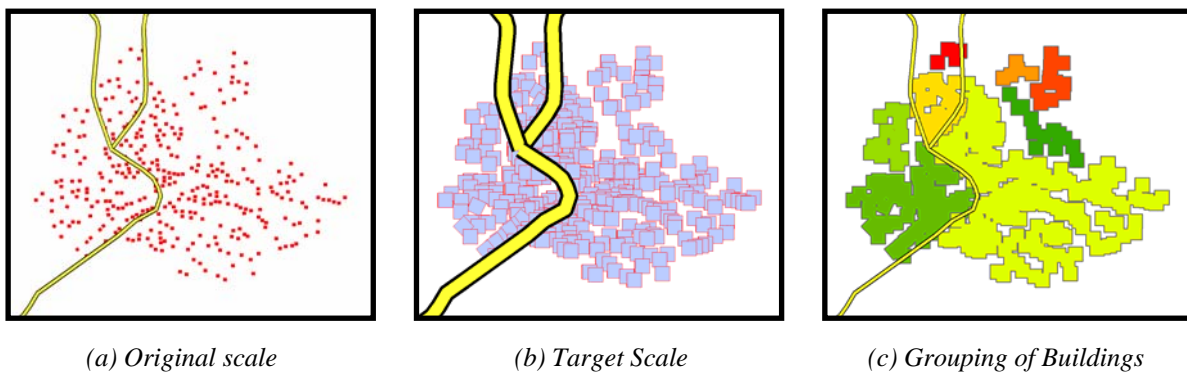


Figure 6. Grouping of buildings by taking into account the transportation network.

3.2. Length And Angle Methods At Building Typification

In this study on building typification, simple exemplars have been taken into consideration at first, for developing the methods. An example of three buildings located side by side is taken as a simple pattern of building distribution and is depicted at Figure 7. These three buildings at original scale (1:25.000) is overlapped at target scale (1:100.000), due to space covered by the symbols increase comparing with the actual area covered by the buildings in real earth.



Figure 7. Appearances of the building objects at original and target scales.

It is apparent that the building in the middle should be eliminated when the typification of these buildings is the case (Figure 8). In similar cases, selecting the buildings farther to building groups' centers which they belong to, and eliminating the buildings whose symbols overlap the symbols of these selected buildings, has given cartographically encouraging results. This method described is called Length Method.



Figure 8. Building typification.

The shapes that the building groups construct on the earth are mostly not simple geometric shapes. But the shapes of the building groups are desired to be preserved at the derived data through typication. At Figure 9, building group of triangle shape is depicted. After the typification process, it is expected that the typified data preserve the triangle shape of building group at target scale. Selecting the buildings at the corners of the building group's shape and deleting the buildings whose symbols overlap the symbols of these selected buildings at target scale, give the desired solution. This method is called Angle Method.

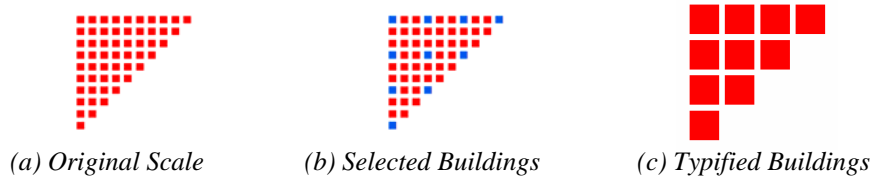


Figure 9. Typification of building group with triangle shape.

Following steps should be pursued to implement the Length Method:

- Detecting the building groups (Figure 10),

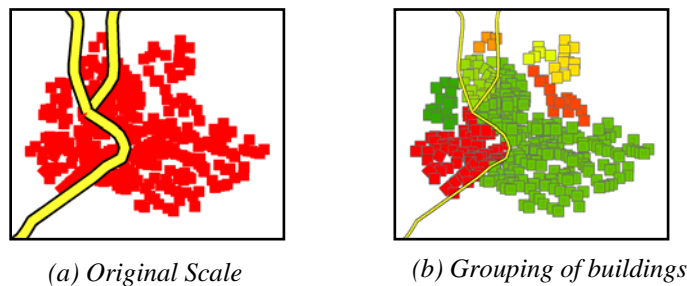


Figure 10. Detecting the building groups.

- Computing the centers of the building groups (Figure 11),

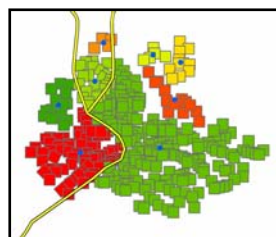
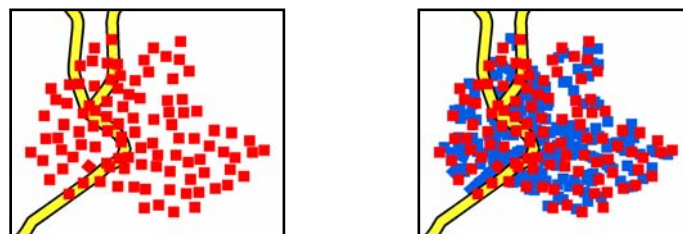


Figure 11. Blue colored points represent the centers of the building groups.

- Calculating the distances between buildings and their corresponding building groups' centers and ordering them decreasingly,
- Selecting the farthest building and eliminating the buildings whose symbol overlap with the symbol of this selected building at the target scale (Figure 12),
- Iteration of the above selection and eliminating processes.



(a) Typication Result (b) Typification result (red) comparing with the original (blue)

Figure 12. Building typification with Length Method.

Figure 12 depicts the selected buildings after the typification process with Length Method. The selected buildings represent the original data quite satisfactorily.

Following steps are required for the typification with Angle Method:

- Constructing polygons from the symbols of the building at target scales,
- Merging the polygons of building groups (Figure 13),



(a) Original Scale (b) Merging building polygons

Figure 13. Constructing the merged polygons.

- Simplification of the outer contour of the merged polygon (Figure 14),

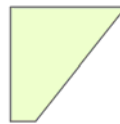


Figure 14. Simplification of the outer contour of the merged polygon.

- Detecting and computing the corner angles of the merged polygon and ordering them increasingly,
- Beginning from the smaller corner angles, selecting the building at the corner angle, eliminating the buildings whose symbols overlap with the symbol of the selected building at the target scale (Figure 15),
- Reconstructing the merged polygons from the remaining polygons,
- Continuing iteration till no building features left that will be handled.



Figure 15. Building typification with Angle Method.

For some buildings groups, similar results have been obtained through these two methods. Sometimes one method may give better results comparing with the other method's. In this study, both methods are implemented to the same data separately and the results are then compared in terms of the number of selected buildings. The result of the method that produces more selected buildings is accepted in the application. Table 1 shows the number of the buildings of dataset on which both methods are applied. Second column named Building Number shows the number of the original buildings before typification. The third and fourth columns, named as Building Number Method 1 and Building Number Method 2, show the number of buildings after the implementation of Length and Angle Methods, respectively.

GrupNo	BinaSayisi	BinaSayisiMes	BinaSayisiAci
20	13	5	6
21	75	20	19
22	14	6	5
24	195	55	50
25	22	7	6
26	5	3	3
27	11	4	4
28	4	2	1

Table 1. The number of buildings after the implementation of Length and Angle Methods.

4. CONCLUSION

1:25.000, 1:50.000, and 1:100.000 scale standard topographic maps, produced in Turkey, bear the same standards. 1:50.000 and 1:100.000 scale topographic maps are produced through generalization workflow using the 1:25.000 scale data. Most of the buildings having polygon geometries are transformed into building features of point geometries in the production of 1:50.000 and 1:100.000 scale topographic maps, due to having areas smaller than criteria. And most of buildings have point geometry types, especially in rural areas. Symbols and their representation sizes are the same in 1:25.000, 1:50.000, and 1:100.000 scale maps. The symbols of building objects are overlapped when depicted at smaller scales. For this reason, typification of buildings is inevitable. In this paper new approaches for the typification of buildings are described. These are Length and Angle Methods.

These typification methods keep the typical pattern of the point feature while removing some points. The results of these methods are evaluated as quite encouraging. These methods also show that they preserve the spatial pattern of building distributions of building groups having regular geometric shapes (Figure 16).

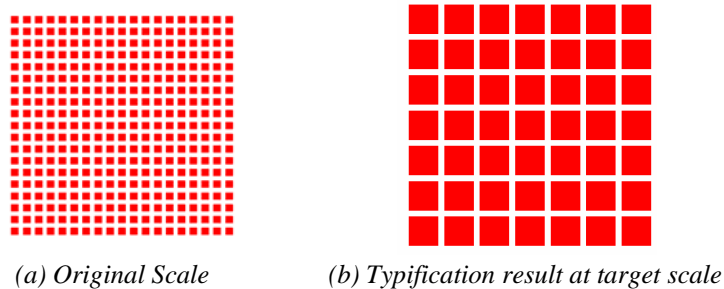


Figure 16. Building typification.

These newly developed methods are applied for the building having the same attributes and having point geometries. The two methods, for the time being, do not take into account the buildings having polygon geometries and having different attributes. Researches are still being kept to cover those points and improve the results.

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BIOGRAPHY



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Serdar Aslan was born in 1971. He finished military academy and completed mapping education program at the School of General Command of Mapping. He completed his MSc at Yildiz Technical University. He is now a PhD student at Selcuk University. He is working at the division of cartography of the General Command of Mapping.