An Algorithm to Extract Building Patterns from Topographic Databases

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Abstract. Pattern, in a general way, can be described as a distinguishable harmonious system based on the intended interrelationships of component parts. Buildings can compose patterns on maps/databases with their properties such as geometric positions, semantics, shape, orientation. Cartographic generalization process is not only a simple reduction of geographic objects (micro level) to satisfy the legibility specification of a map (i.e. graphic limits) with respect to target scale, but also is supposed to preserve spatial patterns and structures (meso and macro levels), because they are the main characteristics of spatial phenomena (i.e. geographic meaning). In our approach, first, we divided the region into blocks which is bounded by the objects such as roads, rivers and railways. Then, we clustered the buildings. Later we constructed MST by using nearest distance values in the clusters. After that we constructed Delaunay Triangles (DT) between every two neighbor buildings using building vertices. Finally we analyzed the incident triangles to detect building alignments.

Keywords: Building alignments, Generalization, Constrained Delaunay Triangulation

1. Introduction

Rapidly developing information technology requires up-to-date data. Considering the different scales, it is not easy to instantly update spatial data. Generalization is the critical issue to create data/map at smaller scales. Although significant amount of research has been conducted on generalization, there are still a lot of problems to be researched for its full automation.

While automated generalization of individual map objects such as building and road has been developed for decades, studies on generalization of group objects such as building alignment are relatively new.

There are not so much studies on finding building structures. Regnauld (2001) uses minimum spanning tree (MST) and homogeneity measures in a dynamic way to determine building alignments. Ruas and Plazanet (2002) propose a method to find linear building alignments using gradually increased lines. The center of gravity of each building is projected to these lines and then identified alignments according to a distance threshold. Burghardt and Steineger (2005) use nearest road segments to obtain the linear building alignments. For every group the standardised deviation of all measures is calculated to quantify alignments. Weiping Yang (2008) works on z-shape building patterns. Zhang et al (2011) present a method that travels MST routes and checks angle thresholds to identify building alignments. They also propose an algorithm for curvilinear alignments. They use Constrained Delaunay Triangulation (CDT) and Minimum Spanning Tree (MST) as data structures.

These methods use some structural properties of buildings such as orientation, size, proximity, shape derived from topographic data to characterize building alignments. Based on these properties, homogeneity tests are also done. Higher homogeneity values mean good alignments.

Using these measures especially orientation and shape measures, one cannot strongly characterize building properties. Thereby, it is difficult to get building alignments with poorly characterized buildings.

This study attempts to detect building alignments in three steps without using these measures. At the first step, buildings in a building block are clustered as building groups. Second step includes MST execution to obtain neighboring relations between buildings in building groups. Finally in third step, constrained Delaunay triangles are constructed and then analyzed to determine an alignment. By avoiding disadvantages of traditional geometrical measures (shape, orientation etc), this study proposes an alternative approach on identifying linear building alignment on maps/databases.

2. Methods

We explain our approach in two steps. At the first step, we show how building groups are obtained. Building alignment typology is introduced and alignments are characterized to determine them based on constrained Delaunay triangulation at the second step.

2.1. Obtaining Building Groups

Hydrographic (e.g. river) and transportation (e.g. road) objects create logical boundaries around buildings and built-up areas. To prevent topological and logical inconsistency, buildings must not move to the other side of these objects. So, map space is partitioned into blocks using these kinds of surrounding objects (Basaraner and Selcuk, 2008). We first created the blocks accordingly (Figure 1a). After that building groups were detected in the blocks using DBSCAN algorithm (Figure 1b).

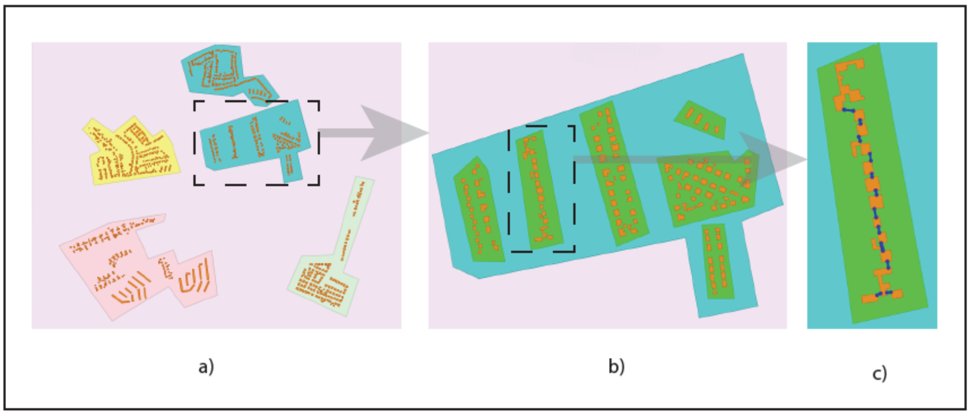

Figure 1. From building blocks to building groups that connected MST edges. a) blocks, b) groups and c) groups with MST.

DBSCAN algorithm is superior to the MST and Chameleon algorithms on finding building clusters (Cetinkaya and Basaraner 2012). DBSCAN is a density based clustering algorithm because it finds a number of clusters starting from the estimated density distribution of corresponding nodes. It is proposed by Ester (1996). This requires two parameters: ε (eps) and the minimum number of points required to form a cluster ($minPts$). MST was constructed to each building groups to determine the sequence and flow of the constrained Delaunay triangulation (Figure 1c).

2.2. Characterizing and Determining Linear Building Alignments

2.2.1 Typology

Building alignments were classified based on intersection angle and homogeneity. We just handle linear alignments. Totally we differentiate four kinds of linear alignments (Figure 3 and Figure 4).

Based on intersection angle between baseline and buildings (Figure 2)

- Right angle linear alignment

- Oblique angle linear alignment

Based on similarities between member (i.e. building) of alignment

- Homogenous
- Heterogeneous

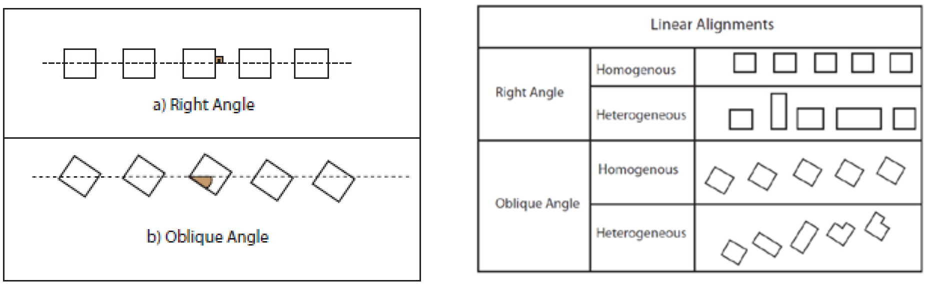

Figure 2. Relation between baseline and buildings (Left). Classification of linear alignments (Right).

2.2.2. Constrained Delaunay Triangulation (CDT)

According to MST structure, one (or odd number) MST edged building was selected as a start building. CDT was obtained between buildings which connected by MST edge, using building vertices. If shape of building is not rectangle, minimum bounding rectangle (MBR) of building is used. It is assigned as a constraint that none of triangles cut any building edge. Incident triangles whose vertices do not only belong to one building were used. From first building to last building of MST, for each building pair, four measures - number of triangles, homogeneity of inter-distance, number of identical triangles and number of right triangles – were calculated (Table 1). According to Table 1, a decision tree was created manually (Figure 5).

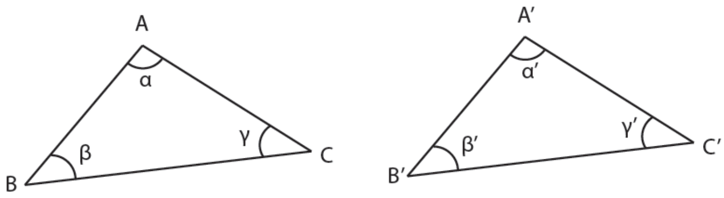

Figure 3. Identical Triangles.

The measures are described below:

Identical Triangle: (See Figure 3)

If Abs(α-α')+Abs(β-β')+Abs(γ-γ') < 10^{o} and 0.95<|BC|/|B'C'| <1.05 then these two triangles are assumed identical.

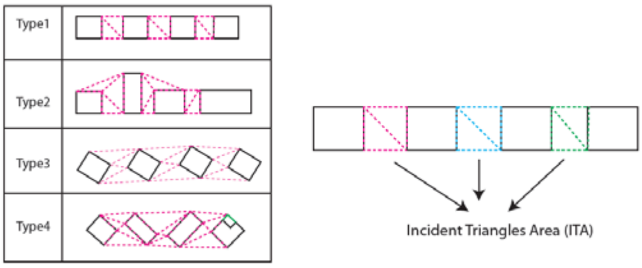

Figure 4. Incident triangles between successive (MST-based) buildings

Right angle: If any triangle has an angle between 85^{o} and 95^{o}, this triangle assumed as right triangle.

Incident Triangles Area (ITA): total incident triangles area between two successive buildings.

Number of triangles: indicate number of triangles between building pairs.

Homogeneity of inter-distance: ratio of standard deviation of area of ITAs to mean area of ITAs belong to an alignment.

Number of identical triangles: number of approximately identical triangles between building pairs.

Number of right triangle: number of approximately right triangles between building pairs.

	Number of triangles	Homogeneity of inter-distance	Number of identical triangles	Number of right triangle
Type1	2	0.05	1 Pair	2
	2		1 Pair	2
	2		1 Pair	2
Type2	3	0.39	None	1
	2		None	2
	3		None	1
Type3	4	0.07	1 Pair	0
	4		1 Pair	0
	4		1 Pair	0
Type4	4	0.32	None	0
	4		None	0
	4		None	2

Table 1. The values of measures for alignment types.

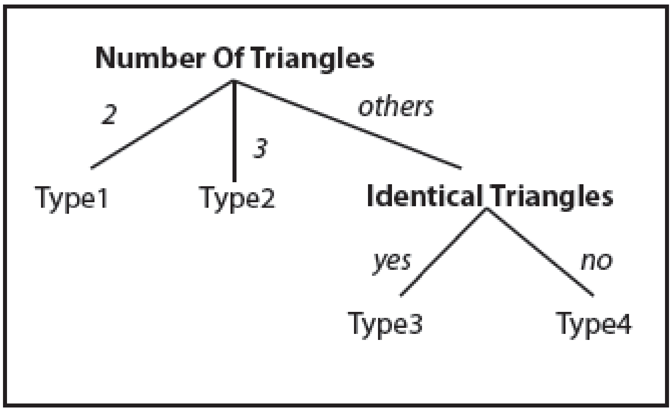

Figure 5. Decision tree

3. Results and Discussion

Using just two simple measure (number of triangles and number of identical triangles), linear alignment types can easily be determined. In the first decision step, approach can discriminate not only between right angle type and oblique angle type but also between homogeneous and heterogeneous types. Homogeneity of inter-distances values reflects homogeneity quality of an alignment. Less value means good homogeneity. There is a strong correlation between number of buildings and number of right triangles.

Number of right triangle can be used in further works for example when determine curvilinear alignments. We only used synthetic data in this study. For elaborated evaluation of the approach, real data must be used. When real data are used, our approach will need tracking algorithm.

4. Conclusion

In this study we proposed a new approach to determine the linear building alignments. Main advantage of this approach is that it does not need complex/well defined measures such as shape index, orientation etc. Measures of this approach are very simple and strong to characterize linear building alignments. This study is ongoing but results are encouraging. We will add curvilinear alignments to our typology and will test with real data in further works.

Acknowledgements

The authors would like to thank TÜBİTAK (The Scientific and Technological Research Council of Turkey) for financial supports.

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