# Cartographic Generalization Applied to Social Networks Maps in the City of Curitiba in Brazil

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## 1. Introduction

Social network is a form of representation of affective or professional relationships between themselves or between groups of mutual interests. Generally, social networks are understood as a set of social actors (individuals, groups and institutions), called nodes, which are interconnected when these are relations between them, incorporating a social system (Delazari, Sluter and Kauchakje, 2007).

However, the representations used by analysts in social network, ie graphs and matrices of relationships are not georeferenced, and it does not allow to perform analysis about the network structure in relation to their spatial distribution and other phenomena that may affect this distribution.

In this research we intend to produce maps of social network in small-scale representations and digital media in order to allow user interaction with the map and to make handling easier and to be effective. Thus we used the cartographic generalization automatically of the elements that form the network, which was performed using the aggregation and displacement operators. Therefore we gained readable representations of all social actors together with their respective links in a map on a smaller scale.

The automation of the cartographic generalization process aims to represent the maps at smaller scales and to transmit efficiently the information. Today, maps are viewed even on mobile phone screens. Therefore several decisions should be modeled and implemented by algorithms. This research discusses, specifically, the problem of automation of aggregation and displacement operators applied to point features.

Maps are important to explore the influence of the geographic localization in the social networks. We can see where there is more actors, places with no organizations acting. And then the analysts can make your decisions about the position of a next actor or relocate them. The cartographic generalization allows users to use maps on digital screens in any scale through your operators.

## 2. Social network

The network analysis emphasizes the relationships between actors, which means that they usually are not sampled independently, as in other types of conventional data focusing on the actors and attributes. The study of complex networks was initiated by mathematicians and then used in sociology from the perspective of structural analysis of social networks ( Tomael and Marteleto, 2006).

Social networks associated with cartography gained support to expand the knowledge of their analysts through a spatial component originated from the georeferencing of social actors and their relationships (Delazari et al, 2007). In the graph without reference we can move an actor to avoid overlaps without any compromise with its geographical location. Network analysis can still show their degree of dependence between nodes and how this can be complex or not.

## 3. Procedures

This research aims to automate two existing cartographic generalization operators. Here we will focus on procedures needed to automate the aggregation and displacement operators applied on the reduction of scale of the representations of social networks.

In this study we used the same data survey of Marchis (2008) and Pombo (2009) that refer to the social actors of the social networks that guarantee the right to social assistance in the city of Curitiba. The data were collected through research on Internet search sites to issues concerning health, labor, dwelling, nutrition, education and social assistence.

The maps were produced using the software ArcGIS, which allows variation of the scale of representation and hiding of certain types of features on the map. In addition to allowing the variation of the symbology. For the organization of data in tables are used Microsoft Excel.

The main goal was to achieve that automated process of generalization results similar to manual work performed in Pombo (2009). In both studies was applied the aggregation to the overlaps involving point symbols with the same classification - with the same symbology. Otherwise, if there is conflict between different symbols will be used the displacement operator.

The work began with a file with the coordinates of the points (network nodes), the developed software calculates and stores the distances between all points of the network. To perform the aggregation procedure, the program determines which is the minimum distance to avoid the conflict in the symbology. This distance is defined as the product between the radius of the symbol in the representation and the value of the scale. Then the algorithm checks which the distances are shorter than the minimum allowed value and stores the involved points.

Then there is a classification of points. If the points have the same classification, are assembled in one whose coordinates are obtained by averaging the coordinates of the points in which it originated. The radius of this new symbol is determined by the aggregate amount of symbols.

If the symbols were different, the software would randomly selects one of the points involved and their coordinates were added or subtracted from the value of the radius multiplied by the scale until there is no more overlap between the symbols. If this displacement cause new conflicts, the procedure is repeated, but with the point that had not been drafted first. If there is still conflict, moves the third point that does not allow the separation of the symbols and so on until there are no more congestion. Finally, a new file is organized with the generalized points.

## 4. Results

With the developed software, several tests were performed by varying representation of the input parameters. An analysis with respect to the results obtained by changing the size of the minimum point symbol and the variation of the scale. The figures presented in this section refer to tests based on network social health data of Curitiba in the scale of 1:75,000. The goal is to produce representations on the scale of 1:250,000, which allows visualization of the whole base map of the city of Curitiba on computer screen of 15 ". But tests were made with intermediate stops to realize that if and when problems occur as in the representation. FIGURE 1 shows the scale of the original part of the social network of health, more specifically, in the central region (Downtown Regional), which has the largest concentration of social actors with a minimum radius of 1 mm.

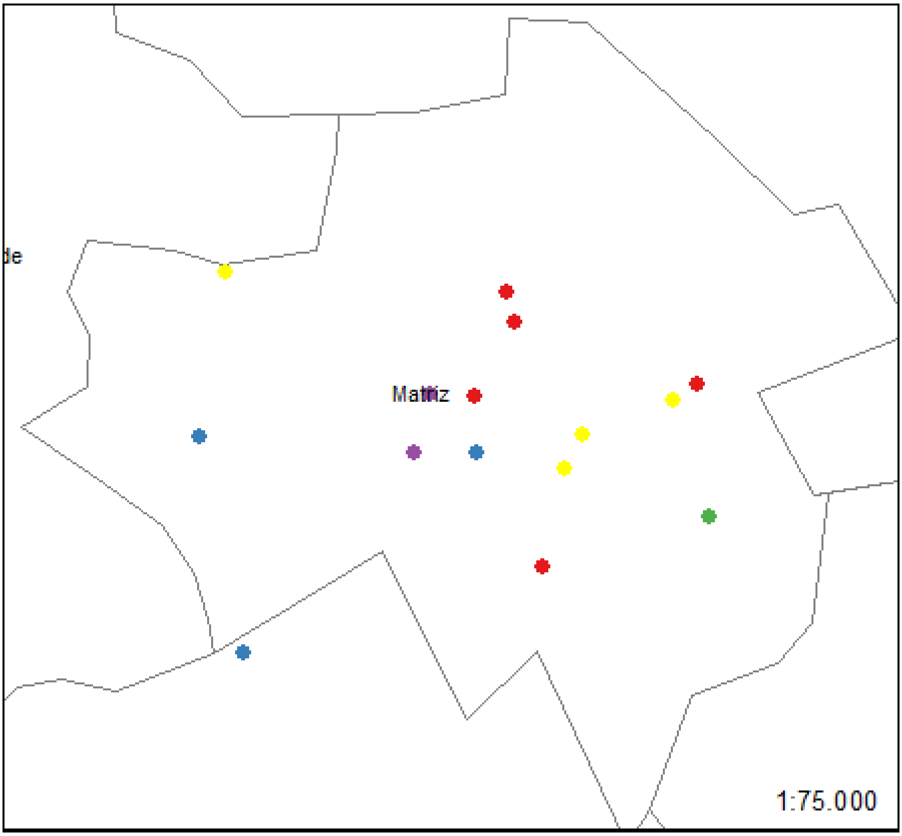


Fig. 1. Original data with 1:75.000 scale for regional division

The three intermediate scales adopted in the tests were 1:100,000, 1:150,000, 1:200,000. On a scale of 1:100,000 (Figure 2) there were no changes in the positions of the actors, because there is no problems in the representation.

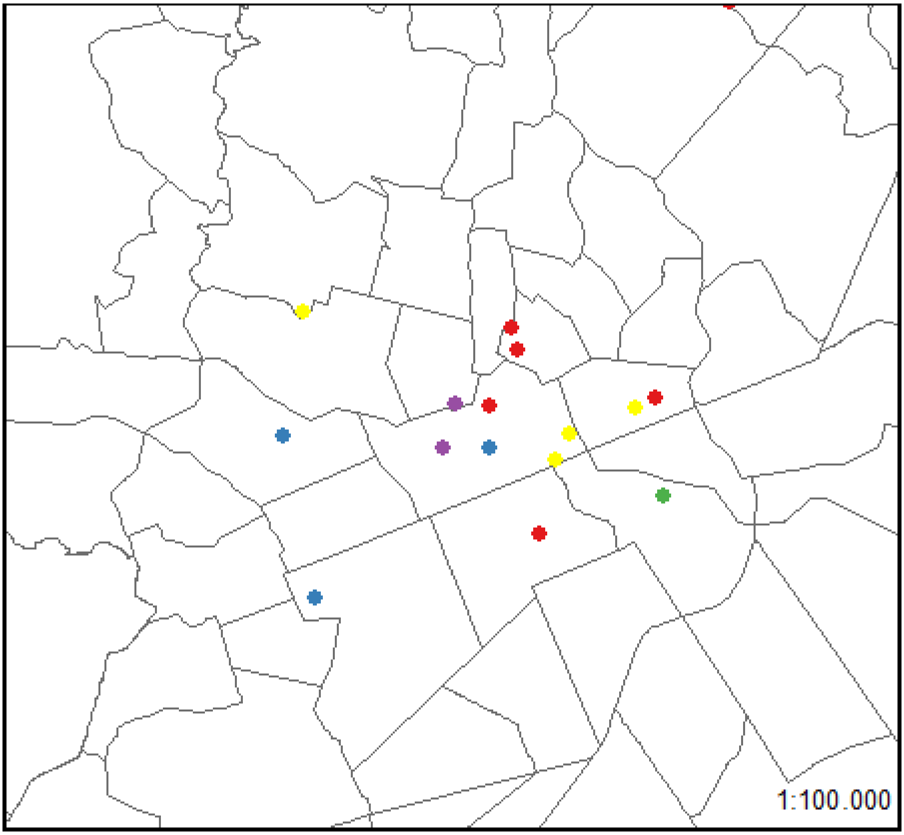


Fig. 2. Generalized data for 1:100.000 scale

On a scale of 1:150,000 (Figure 3) we have the first generalization, in which the actors are separated by the displacement operator. It appears that the symbol red circle was moved north to not collapse as in Figure 4 - highlighted - the operator was applied so that, even after the displacement, the actors keep in their positions of origin.

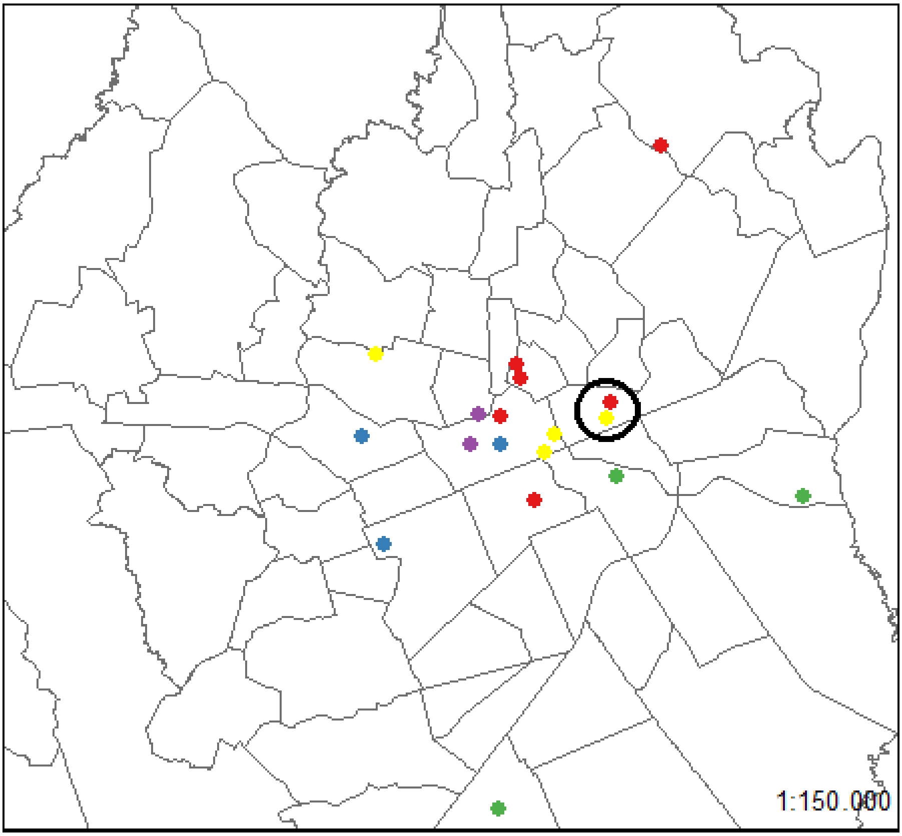


Fig. 3. Generalized data for 1:150.000 scale

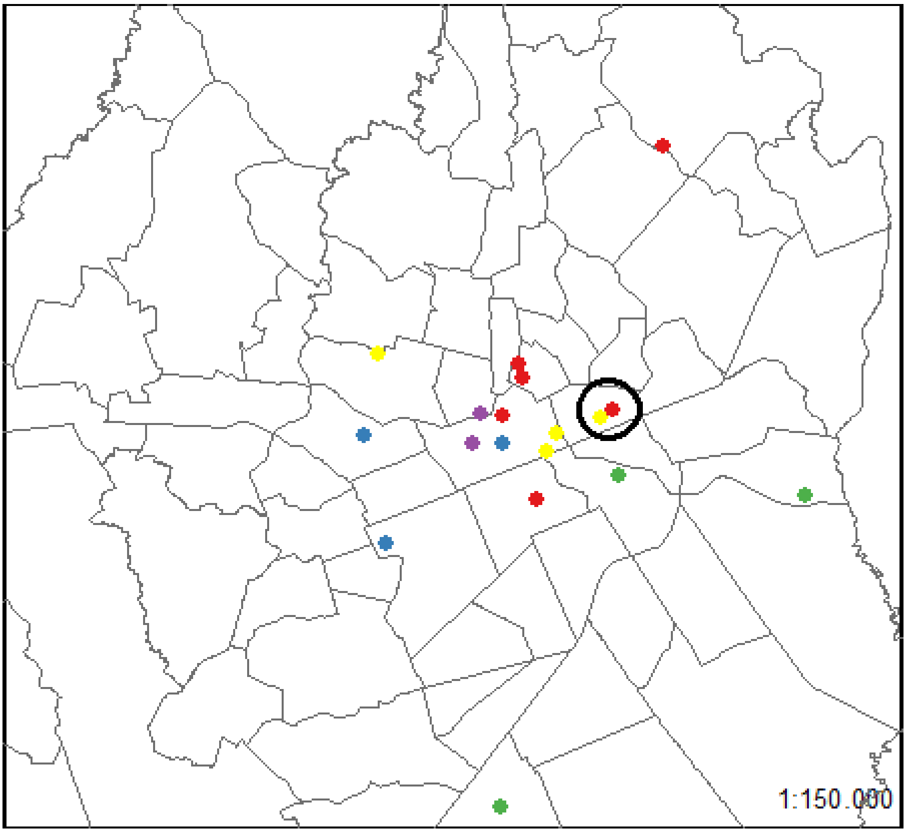


Fig. 4. No generalized data for 1:150.000 scale

Although the new symbols are represented with circles of radius bigger than 1 mm it causes problems at the division representation by districts, because they could be represented in two city district on the same time. But with the regional division (Figure 5), this type of conflict does not exist.

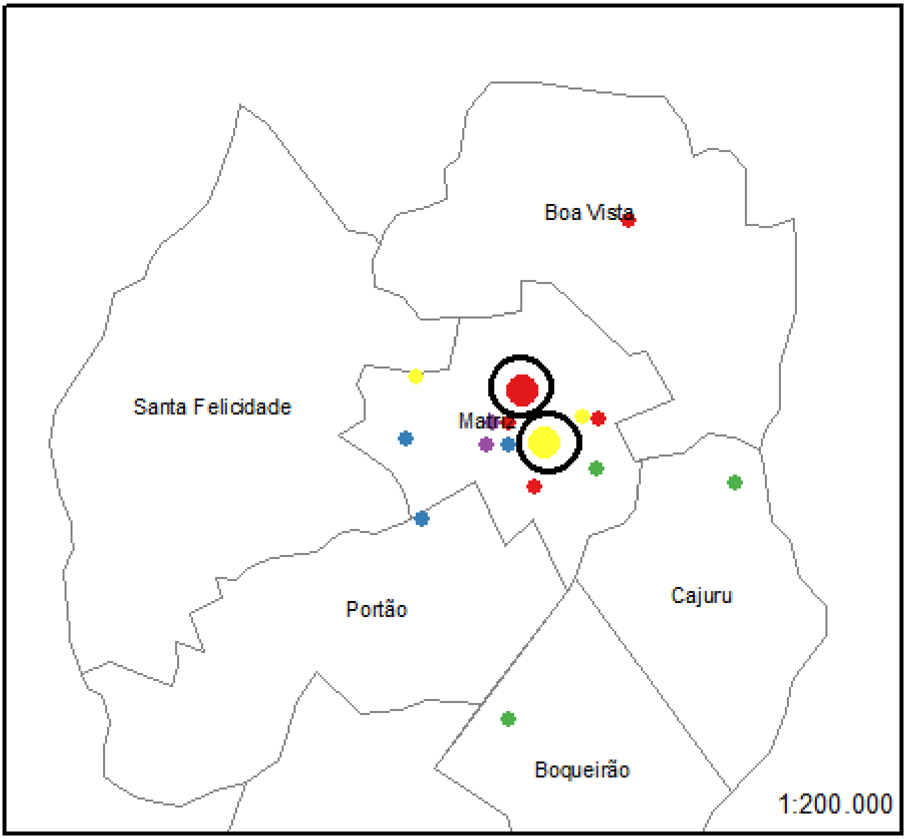


Fig. 5. Generalized data for the regional division for 1:200.000 scale

The reduction of scale gives an increase in quantity of symbols, conflicts that can be seen in Figure 6, that is in the scale of 1:250,000.

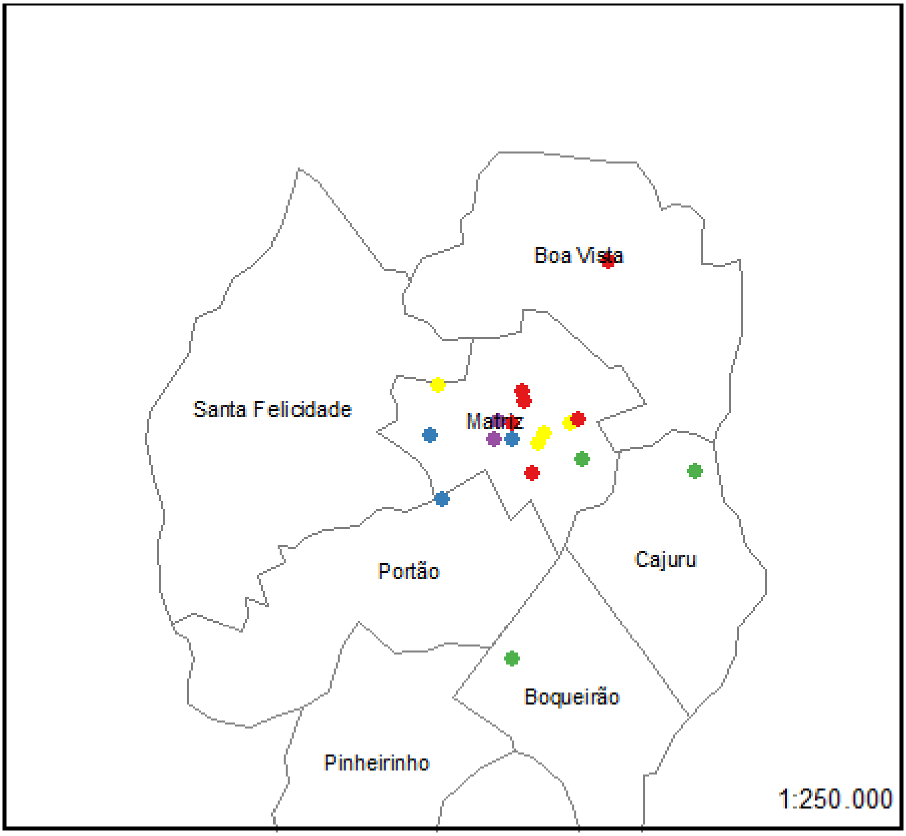


Fig. 6. No generalized data for 1:250.000 scale

The result of generalization of the program shows that new displacements were implemented and applied to the circles (2 purple, 1 red and 1 blue) in the center of the illustration. The generalized representation can be seen in Figure 7. The actors who once seemed to represent the four points of a rectangle, were reconfigured to form a diagonal line.

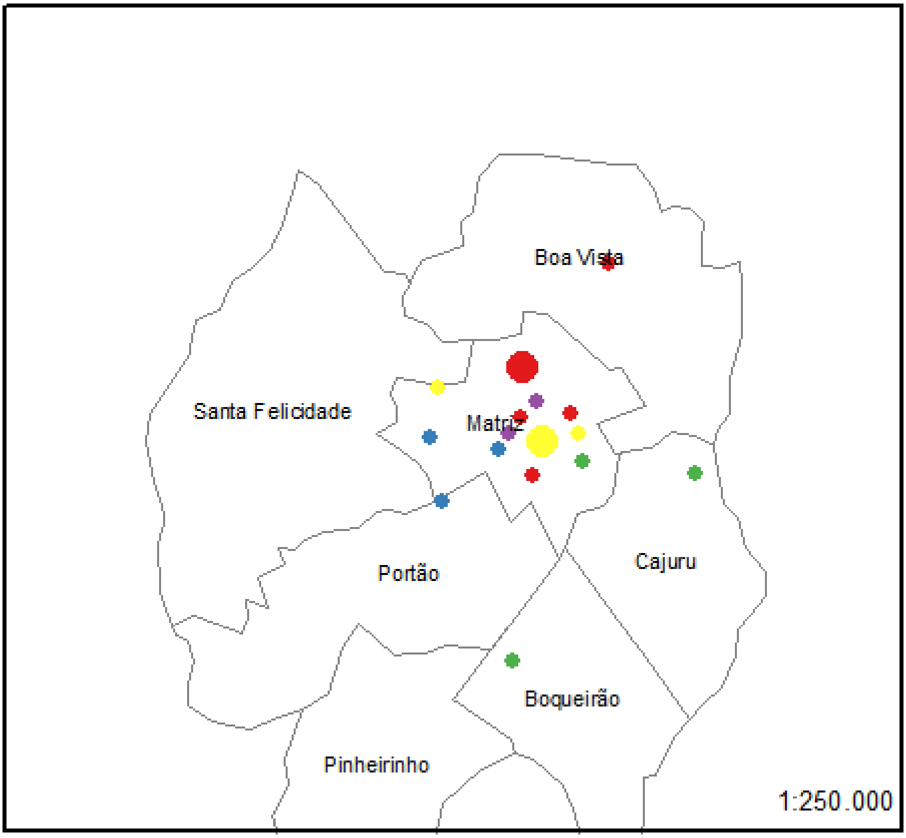


Fig. 7. Generalized data for 1:250.000 scale

In Figure 8 presents the results obtained by the generalization made in the manual work of Pombo(2009). This process also ran avoiding overlaps with place names and sought a greater spread between the symbols for the addition of place names to social actors. The author was concerned with the relative orientation of the features specific to each other and it can be seen in Figure 7 that this was maintained in most situations. The biggest difference is between the two generalizations involving circles in purple. In automatic generalization between them there was a displacement because there were other symbols that preserved the position of the features. In the manual there was aggregation of these symbols in order to maintain the relative orientation between them.

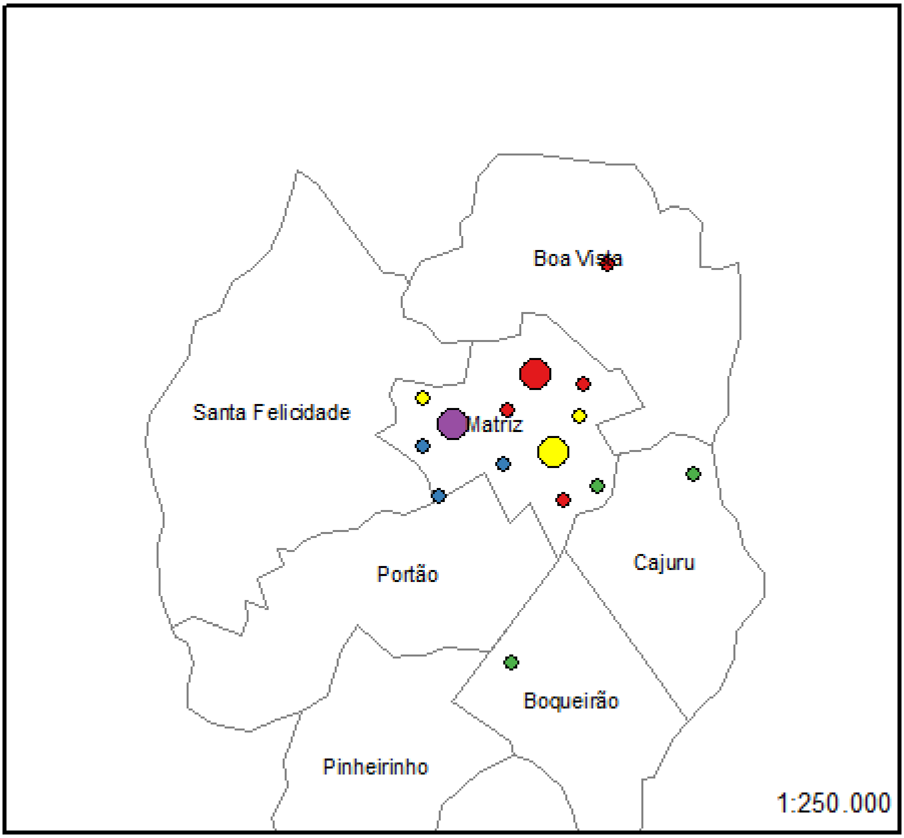


Fig. 8. Manual generalized data for 1:250.000 scale

In the next figures 9, 10 11, 12,13 and 14, after the generalization, we can see how the generalized maps are applied to the city of Curitiba. On the left is the map with scale reduction without generalization and on the right the results of this research. In Figure 15 we have the result for the Parana state. And, finally, in the illustration in the Figure 16, we have the result for Brazil. These last two results are about the social network for social assistance, because is the only network in Curitiba that has relationship with institutions, that are not located in the same city.

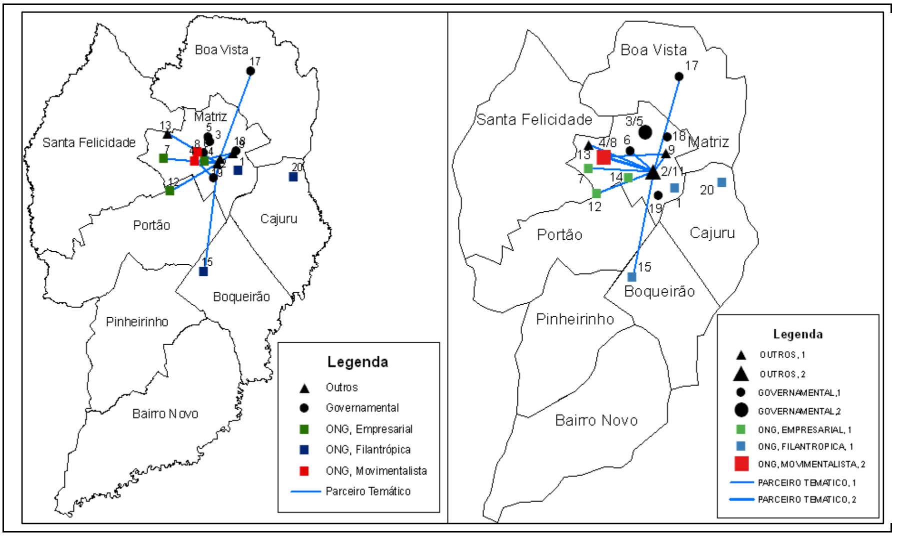


Fig. 9. Social Network for health

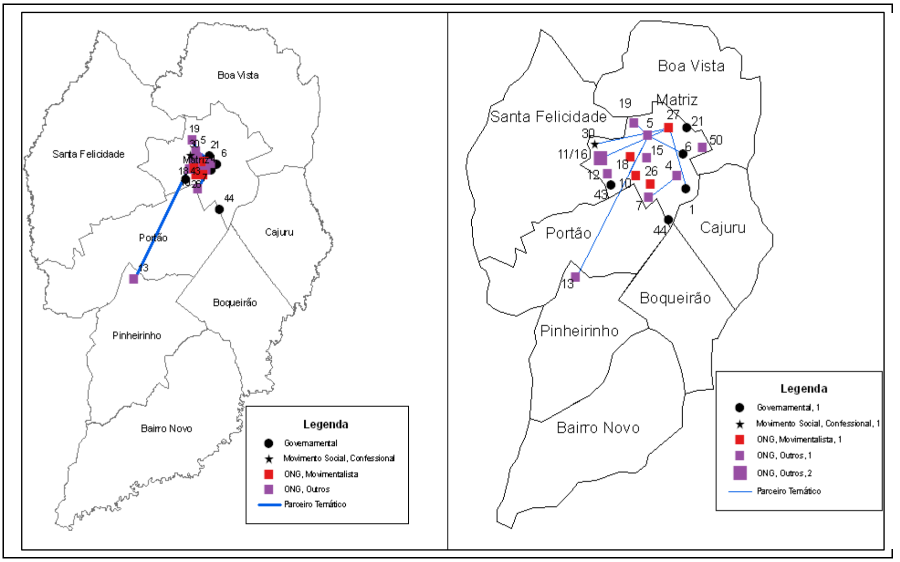


Fig. 10. Social Network for labor

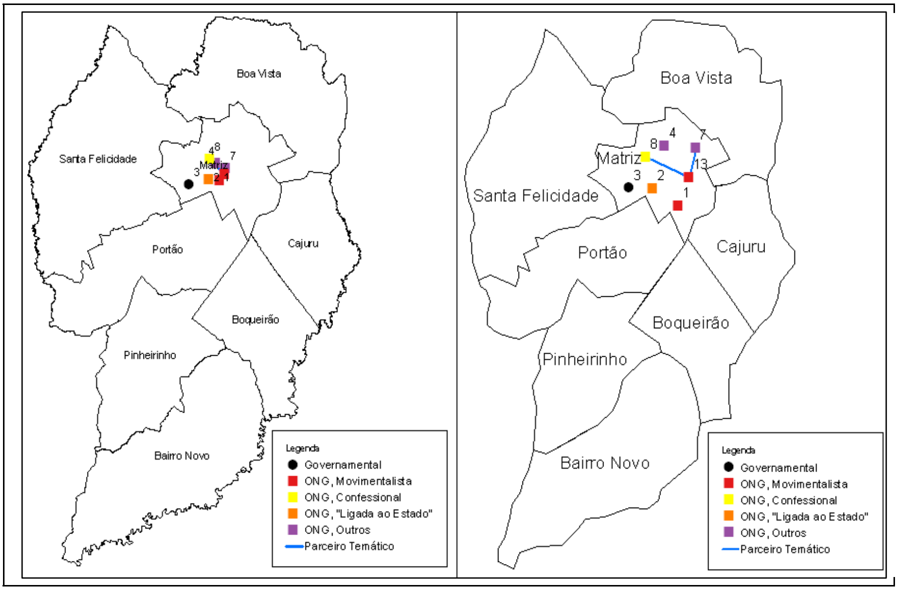


Fig. 11. Social Network for dwellling

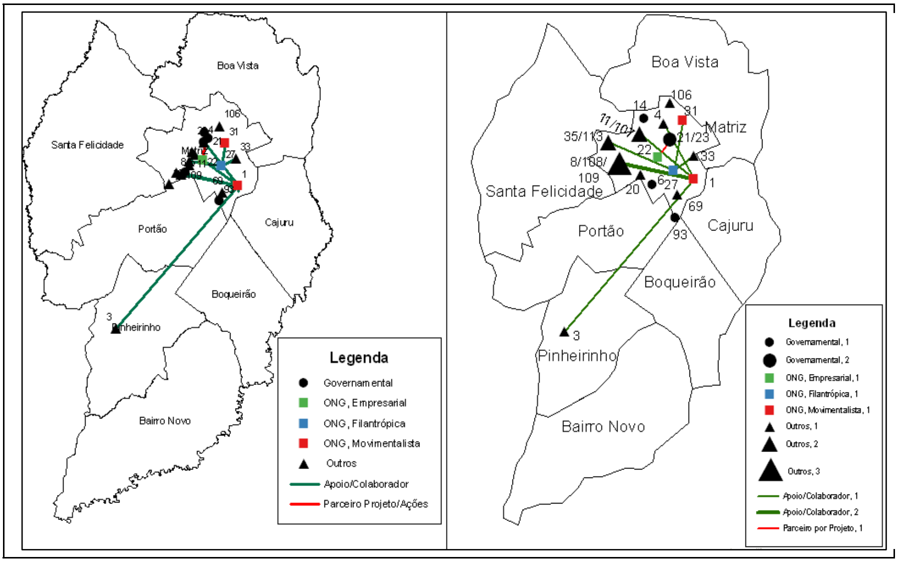


Fig. 12. Social Network for education

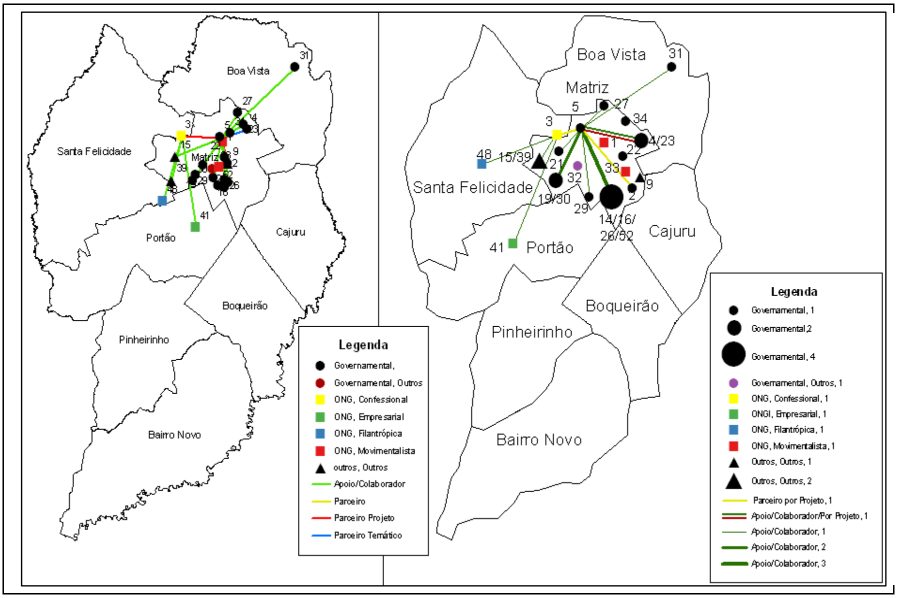


Fig. 13. Social Network for nutrition

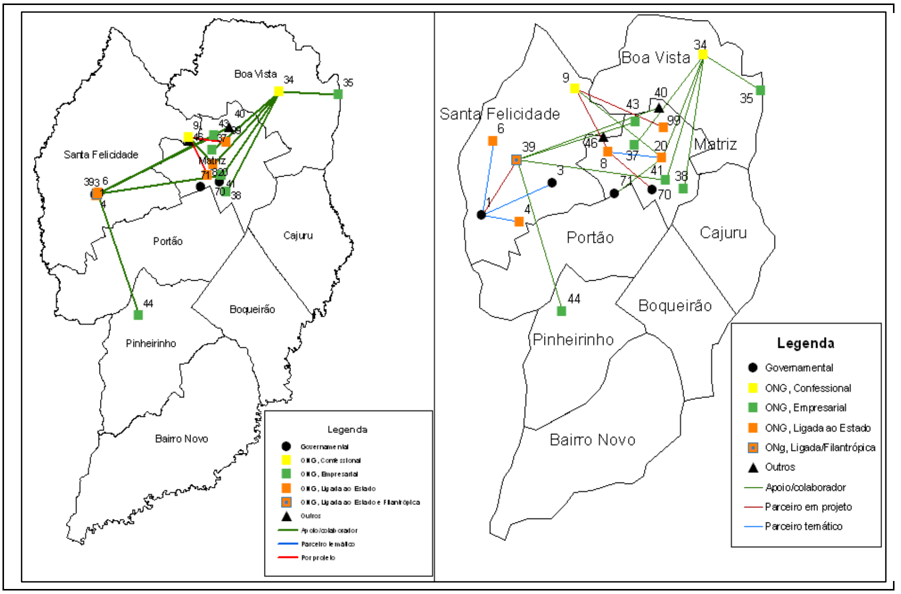


Fig. 14. Social Network for social assistence

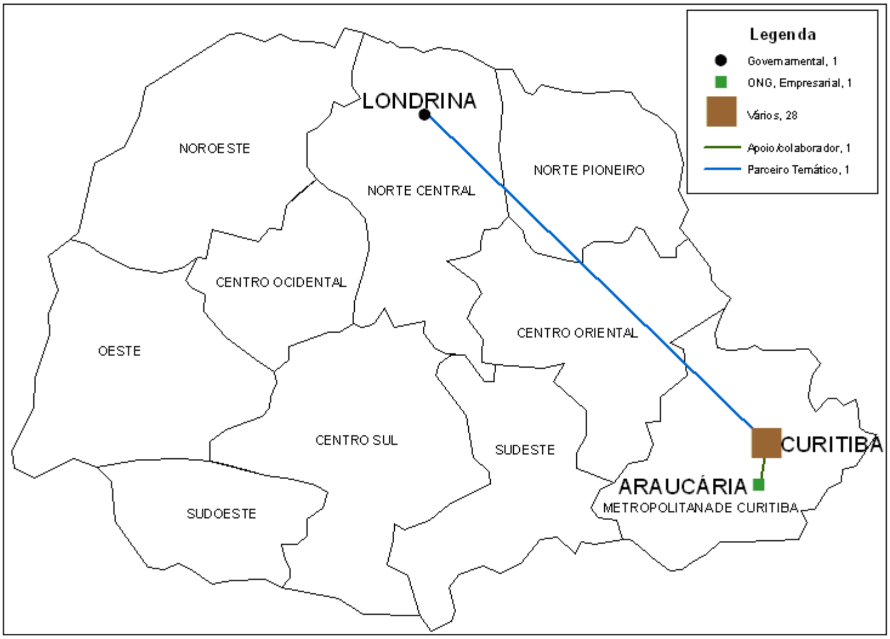


Fig. 15. Social Network for social assistence in Parana

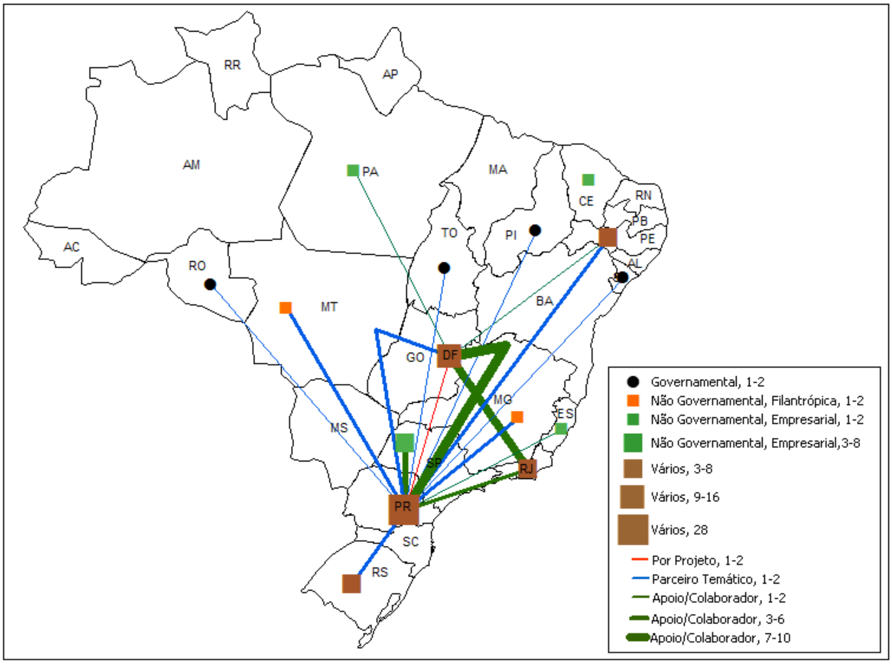


Fig. 16. Social Network for social assistence in Brazil

## 5. Conclusion

This work aimed to contribute to the stdy of the process of cartographic generalization by automating the aggregation and displacement operators applied to specific features. This is the continuation of research that has as main objective to evaluate the contributions of cartography for the representation of social networks.

When symbols were used with radii of 1 mm, the generalized representations were effective, because even after geometric transformations, the nodes have not lost their spatial reference, or even when displaced, remained in their original neighborhoods. This result exceeded original expectations, because the level of analysis takes place by regional (group of districts) would not be considered a problem if the actors change their position in the new neighborhoods, while still belonging to the same region.

The symbols aggregates, formed by two or more social actors, were represented by a variation in size. Therefore, we have to aplly displacement and make aggregations with the symbols because of the new conflicts caused by the bigger size of circles.

There is no single solution when the displacement operator is applied due to its random nature not always resulting generalizations have the same results. This is because in each use of the software, the algorithm picks which actor will be moved and its direction. However for the purposes of analysis, the conclusions are independent of small movements, provided there are no sudden changes in spatial reference. Compared to the manual generalization, results were quite similar.

To improve the software, it is recommended to implement restrictions on the location of the symbols, for example, create barriers for the displaced points do not exceed certain limits in order to preserve the spatial reference.

This work contribute to make easier the geografic analysis about social networks and the position of their actors. The cartographic generalization supports many scales of visualization of the social phenomena. Finally, when we have this processes in a automatic way, the analysts can make your own maps without a cartographer.

## 6. References

Delazari, L., Sluter, C., Kauchakje, S. *Visualização Cartográfica Aplicada à Análise de Redes Sociais*. V Colóquio Brasileiro de Ciências Geodésicas, p 538-542, 2007.Li, B.; Xu, Y. & Choi, J. (1996). Applying

Firkowski, H. *Generalização Cartográfica de Grades Retangulares Regulares Baseada na Teoria Matemática da Comunicação.* Curitiba, 2002.Tese (Doutorado em Ciências Geodésicas) - Universidade Federal do Paraná.

Granovetter, M. *The strength of weak ties: a network theory revisited*. In: MARSDEN, Peter V.; LIN, Nan (Eds.). Social structure and network analysis. Beverly Hills: Sage, 1982. Cap.5, p.105-130.

Hanneman, R. Riddle M. *Introduction to social network methods*. Sociology Departament. 2001. < http://faculty.ucr.edu/~hanneman/ >.

Hardy, P. *Map Production From An Active Object Database, Using Dynamic Representation and Automated Generalization*. Laser-Scan Ltd, Science Park, Milton Road, Cambridge, CB4 4FY, UK, 1999.

Marchis, C. *Proposição de projeto cartográfico para representação de redes sociais*. Curitiba, 2008. Dissertação de Mestrado – Universidade Federal do Paraná.

Matheus, R. F.; Silva, A. B. O. *Análise de rede social como método para a ciência da informação*. Revista de Ciência da Informação, vol. 7, n. 2, 2006. <http://www.netic.com.br/redeci/images/stories/docs/ars.pdf>

Pombo, R. M. *Generalização Cartográfica Aplicada à Representação e Análise das Redes Sociais*. Curitiba, 2009. Dissertação de Mestrado – Universidade Federal do Paraná.

Tomaél, M. I.; Marteleto, R. M. *Redes Sociais: posições dos atores no fluxo da informação*. Encontros Bibli., Florianópolis, n.esp., 1. sem. 2006.UCINET. Disponível em <http://www.analytictech.com/downloaduc6.htm>.