# Using cartograms to explore temporal data: Do they work?

Rehmat Ullah, Menno-Jan Kraak, Corné P.J.M. van Elzakker
Faculty of Geo-Information Science and Earth Observation, University of Twente, the Netherlands
{ullah29176, kraak, elzakker}@itc.nl

Currently, a great amount of multivariable geographical data is available. Interactive visual analytical representations need to be designed in order to analyze and synthesize these data to produce useful insights about phenomena and systems represented by the data (Guo, Chen et al. 2006). Of the available geographical data, a large share has a temporal component as well. Temporal data are often related to movement. This could be along fixed networks such as rail or road networks or free movement by animals or birds.

Many diagrams and map-like representations exist to visualize geographical data. Most of these deal very well with the locational and attribute components of data, whereas options that also deal with the data's temporal component have not been sufficiently developed (Andrienko, Andrienko et al. 2010). At the same time, representations specifically designed to visualize the temporal component, such as cartographic animations, space-time cubes, and flow maps only function well for a certain type of data and only answer certain types of queries. In this paper, cartograms are introduced as an alternative tool to represent temporal data. We investigate whether cartograms improve insight into temporal data and help to explore temporal characteristics, temporal relationships, and temporal regularities or patterns.

A cartogram is a map transformation that distorts or displaces elements of the map such as areas, lines, or points according to a thematic variable (e.g., election results, population, or travel-time). Based on the distortion of the main map elements, three types of cartograms can be identified: area, line, and point cartograms. In our research we do not work with area cartograms, but with line and point cartograms. A line cartogram resizes the length of line segments according to the thematic variable being mapped. An example could be replacing geographic distance with other measures like travelling-times or travelling-costs and scaling the line segments accordingly (see e.g., Figure 1). A point cartogram displaces points or locations and shows travelling-times or travelling-costs from a single starting location to other locations in the region. Concentric circles are drawn from the starting location, and the geography is distorted accordingly by moving other locations either away or closer to the starting location. An example is shown in Figure 2.


**Figure 1:** A line cartogram showing time-distances of Japan's railways network in 1965 (Shimizu and Inoue 2009).


**Figure 2:** A point cartogram example showing travelling-time (in minutes) by train from the city of Enschede to other parts of the Netherlands (Ramaer 2011).

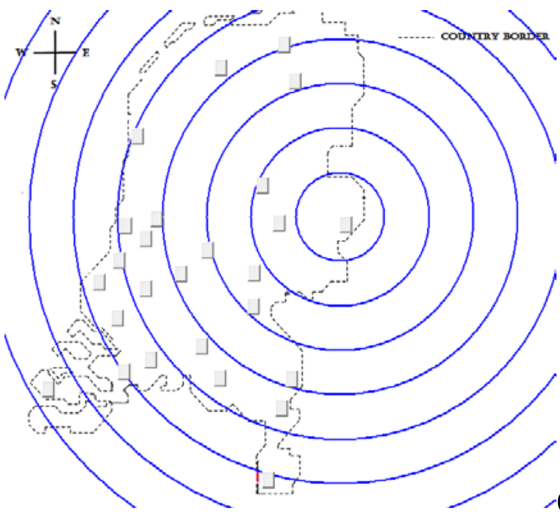
Cartograms have become an increasingly popular tool due to their captivating design (Bhatt 2006), and also due to the availability of tools to create them automatically. Despite many positive claims (Dent 1975; Kocmoud and House 1998; Shimizu and Inoue 2009; Sun and Li 2010; Wu and Hung 2010; Dodge, Kitchin et al. 2011) , very little is known about the usability of cartograms – i.e., whether they are effective, efficient, readable, understandable, and acceptable to users (Kaspar, Fabrikant et al. 2011) .

Line and point cartograms are well-suited to visualize temporal data related to movement along paths with stations or stops. Both line and point cartograms could be integrated to create strong visual impacts. In the literature, we find some examples of point and line cartograms applied mainly to network based movement (e.g., Shimizu and Inoue 2009; Chen 2011; Bies and van Kreveld 2012). Limited research has been done on cartograms to represent temporal data associated with free movement. Although in our research we will pay attention to free movement, this paper focuses on network based movement.

In this study, we created cartogram (in fact several cartograms depending upon starting location) to answer temporal questions related to the Dutch railways network. Possible temporal questions could be “Does the train trip from station X to station Y take longer than the train trip from station X to station Z?”, “What is the travelling-time from station X to station Y?”, “Which stations are closer to station X in time?”, “Which station is the farthest (remote in time) from station X?”, “Which places are reachable within X minutes?”, and “How did the accessibility of station X change over time?” A major part of this study is to test the usability of cartograms to find out how they perform and whether it makes sense to work on cartograms to visualize temporal data. For this purpose, we set up a test where we evaluate cartograms against a geographic map and a schematic map to find out whether they can answer some temporal questions better than the geographic and schematic map (Figure 3). An online survey is used to perform the evaluation. Test persons or users in our study are people who use the Dutch trains. The users are asked to work with the three types of maps to answer temporal questions, and report whether cartograms do indeed provide an efficient and effective visual representation of temporal data and satisfy their requirements better than the other solutions. Our hypothesis is that cartograms perform better than the other mapping methods concerning the temporal aspects. The test results will be presented during the conference.

**(3a.)**

(3b.)




(3c.)

**Figure 3:** (3a.) Geographic map, (3b.) Schematic map and (3c.) Cartogram map of the Dutch railways network.

## References

Andrienko, G., Andrienko, N., Dykes, J., Kraak, M.-J. and Schumann, H. (2010). GeoVA(t) – Geospatial visual analytics: focus on time. International Journal of Geographical Information Science **24**(10): 1453-1457.

Bhatt, L. M. (2006). Investigating the Appropriateness of Gastner-Newman's Cartogram Versus Conventional Maps in Visual Representation and Modeling of Health Data. Southern Illinois University Carbondale.

Bies, S. and van Kreveld, M. (2012). Time-Space Maps from Triangulations. 20th International Symposium on Graph Drawing. Redmond, Washington, USA.

Chen, X. (2011). Seeing Differently : Cartography for Subjective Maps Based on Dynamic Urban Data. Department of Architecture, Massachusetts Institute of Technology.

Dent, B. D. (1975). Communication Aspects of Value-by-Area Cartograms. Cartography and Geographic Information Science **2**(2): 154-168.

Dodge, M., Kitchin, R. and Perkins, C. (2011). The Map Reader: Theories of Mapping Practice and Cartographic Representation. Wiley.

Guo, D., Chen, J., MacEachren, A. M. and Liao, K. (2006). A Visualization System for Space-Time and Multivariate Patterns (VIS-STAMP). IEEE Transactions on Visualization and Computer Graphics **12**(6): 1461-1474.

Kaspar, S., Fabrikant, S. I. and Freckmann, P. (2011). Empirical Study of Cartograms. 25th International Cartographic Conference, Paris, France.

Kocmoud, C. J. and House, D. H. (1998). A constraint-based approach to constructing continuous cartograms. 8th international symposium on Spatial Data Handling **1**: 236-246.

Ramaer, L. (2011). De vervaardiging van temporele kartogrammen. 100 Jaar veranderingen in de reistijd per trein in beeld. Geo-Info: 11-13.

Shimizu, E. and Inoue, R. (2009). A new algorithm for distance cartogram construction. International Journal of Geographical Information Science **23**(11): 1453-1470.

Sun, H. and Li, Z. (2010). Effectiveness of Cartogram for the Representation of Spatial Data. The Cartographic Journal **47**(1): 12-21.

Wu, Y.-H. and Hung, M.-C. (2010). Non-Connective Linear Cartograms for Mapping Traffic Conditions. Cartographic Perspectives **65**: 33-50.