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Distance Matters: a more than euclidean approach to visualizing gerrymandering

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Abstract:

Gerrymandering is the practice of deliberately drawing electoral districts in a way that provides unfair advantage to one group over another, typically with respect to political parties or particular social or ethnic groups (Bunge 1966; Horn 1999). The term itself was coined in 1812, after a Massachusetts Governor, Elbridge Gerry, signed into law a political reapportionment bill with long, sinuous districts that one political cartoonist aptly compared to a winged salamander (Morrill 1973). While this practice was by no means new, the particularly grievous instance had given it a name; because, of the profound impact that voting district boundaries can have on the outcome of single-candidate elections, the practice lives on some two centuries later. Since then, several important legislative and judicial standards have emerged at the level of US Federal Government that were intended to stymie this practice. These include the Voting Rights Act of 1965, which stipulated that US Congressional districts be comprised of contiguous territory in "as compact form as practicable" (Bunge 1966). And yet despite these laws and legal standards, the US Supreme Court has been "reluctant to overturn even fairly blatant partisan gerrymandering," (Horn 1999), in part due to the inherent complexity of ascribing arbitrary boundaries on complex social and geographic landscapes, but also due to the onerous (and sometimes conflicting) legal standards that have been established. As Bill Bunge (1966) put it, "the problem sounds geographically simple—merely construct regions of 'compact form'! But the grouping of locations into an antigerrymandered state touches on some of the deepest and most fundamental problems in regional geography."

In the United States, the upcoming 2020 Census, and the resulting redistricting process, has brought gerrymandering back into focus. Specifically, algorithmically conducted geospatial analysis and the resulting cartographic visualizations produced have emerged as a central battleground on which various practices of redistricting are discussed. However, most spatial analysis and cartographic visualization of gerrymandering to date has relied almost exclusively on Euclidean, absolute representations of space (O'Sullivan *et al*. 2018). In this paper, we demonstrate how strictly Euclidean perspectives may fail to account for the quotidian experiences of space. Further, we argue towards a relational understanding of space that takes into account how individuals move through space in their day-to-day lives. To do so, we first return to a set of complex mathematical approaches first espoused during the quantitative revolution of the 1970s (Forer 1978; Morrill 1976; Morrill 1973; Tobler 1961; and others). Using new and improved computational tools, we improve upon these efforts, providing a process for generating new visualizations that explore relational spaces within congressional districts. Specifically, we use Multidimensional Scaling (MDS) within a graph network to bend and fold congressional districts in accordance with the travel-time it takes to move through them. We conclude by discussing the limitations of this approach and areas for further research.

Though quantitative methods in the field of geography seem presently dominated by narrow views of absolute, Euclidean spaces, early efforts at defining quantitative geographic approaches were focused largely on finding new ways to define and visualize space (Janelle 2015; Kitchin 2006; O'Sullivan *et al.* 2018). Tobler (1961) proposed that much distortion of space by transportation can be understood through the transformation of coordinates. Bunge's transformation of the "real" travel time for commuters is one of the more famous visualization of this type of isochronic transformation (O'Sullivan et al. 2018). Forer (1978) expands upon this idea with a discussion of an all-points-to-all-points reorganization, rather than the bending of adjacent points of interest based on a singular, central anchor point. Such an approach is necessarily computationally intensive as points must be moved over many iterations as the relative location of adjacent points is also in flux, and there exists the possibility of complex inversions in cases where the interior of the geographic space is not navigable (O'Sullivan *et al.* 2018). Simply put, this type of computationally intensive visualization was extremely difficult in the 1970s and, additionally, newer techniques such as MDS and bidimensional regression not developed or relatively unknown at that time (Ahmed and Miller 2017).

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While the practical and mathematical execution of these approached failed to overcome the technical barriers of their time, deeper philosophical currents present in such were were carried on through discourse in both feminist and human geography. Much of this work has engaged with Marx's concept of the "annihilation of space by time" particularly as articulated through Harvey's (1990) explication of "time-space compression." Despite academic interest in the relational experiences of space in daily life and a recognition that distance alone is an insufficient means of characterizing the spaces and places in which human interaction takes place, there has been little engagement with these ideas with respect to the creation of representational voting districts where an emphasis on purportedly "neutral" algorithms and their resulting visualizations has dominated the public discourse.

We present an approach for the visualization of congressional districts within the United States that is based upon the estimated travel time between points according to Bing Maps API. Such an approach is informed by the relational, lived experiences of individuals as they attempt to traverse space, but also requires significant computational complexity. The approach follows Forer's (1978) conceptual model of continuous spatial transformations between all points. To create a visualization that maintains some similarity to the types seen by traditional maps, points will be assigned as an evenly spaced grid at sufficient density to roughly approximate the full shape of traditional congressional district polygons. In our test case, we demonstrate significant distortion of districts when travel-time is taken into account that reveals otherwise cartographically hidden experiences of lived space. We select three districts in Washington state for this demonstration, although the open-source code can be readily applied to any district for which the user has information.

In brief, the process involves the transformation of a congressional district to a set of coordinate points (Figure 1). A distance matrix of travel times between all-points-to-all-points is then constructed. MDS, a process for arranging points based on their dissimilarity (Bouts et al. 2016; Shimizu & Inoue 2009; VanderPlas 2016), allows for the rearranging of these points within a graph network such that the average travel time between all points in the graph is minimized. This follows Morrill's (1973; 1976) approach to the construction of congressional districts.

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