Electoral Redistricting with Moment of Inertia and Diminishing Halves Models

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Summary

We propose and evaluate two methods for determining congressional districts. The models contain explicit criteria only for population equality and compactness, but we show that other fairness criteria such as contiguity and city integrity are present, too.

The Moment of Inertia Method creates districts whose populations are within 2% of the mean district size, minimizing the sum of the squares of distances between the district's centroid and each census tract (weighted by population size). We prove that this model gives convex districts.

In the Diminishing Halves Method, the state is recursively halved by lines perpendicular to best-fit lines through the centers of census tracts.

From U.S. Census 2000 data, we extract the latitude, longitude, and population count of each census tract. By parsing data at the tract level instead of the county level, we model with high precision. We run our algorithms on data from New York as well as Arizona (small), Illinois (medium), and Texas (large).

We compare the results to current districts. Our algorithms return districts that are not only contiguous but also convex, aside from borders where the state itself is nonconvex. We superimpose city locations on district maps to check for community integrity. We evaluate our proposed districts with various quantitative measures of compactness.

The initial conditions do not greatly affect the Moment of Inertia Method. We run variants of the Diminishing Halves Method and find that they do not improve over the original. Based on our results, district shapes should be convex, and city boundaries and contiguity can be emergent properties, not explicit considerations. We recommend our Moment of Inertia Method, as it consistently performed the best.

The text of this paper appears on pp. 281–299.