An AI Approach to Drawing Electoral Maps

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Motivation

"If elections were held at this moment, Democrats would get 54% of the votes, but 47% of house seats..."

Our democracy is built upon the foundation that our elections reflect the will of the people. However, gerrymandering, dividing voting precincts into districts in such a way that the party in power artificially increases their shares in the house, threatens this key ideal. With our project, we hoped to create an AI that can draw "fair" district maps to protect the democratic process.

Figure 1: Simple Gerrymandering Example

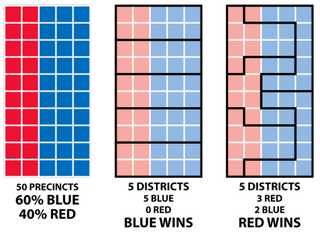
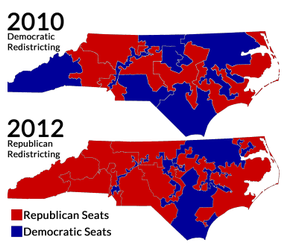


Figure 2: North Carolina 2010 v. 2012



Problem Definition

We will focus on Pennsylvania, a contentious and gerrymandered state.

Constraints:

- Assign the 9256 precincts to 19 districts.
- Districts must be contiguous.
- Populations of districts should be roughly equal.

Goal:

- Efficiency gap (measurement of unfairness) is minimized, given by: $\frac{|D-R|}{P}$
- Where D is the number of wasted Democratic votes, R is the number of wasted Republican votes, and P is the total number of votes.

Approach

- Variable-based - assigning 9256 precincts as variables to one of 19 districts
- Local search - initialized to complete assignments and ran local search algorithms
- Evaluation Functions - experimented with and used a combination of efficiency gap and population gap metrics to evaluate assignments
- Initialization - tried initializing to both current district map and random initializations

Algorithms

- Relaxed problem - ran Gibbs Sampling without geographic constraints
- Modified Iterated Conditional Modes (ICM) - limited choices to assignments at least as good as current assignment
- Gibbs Sampling - selected new assignment probabilistically proportional to evaluation scores

Challenges

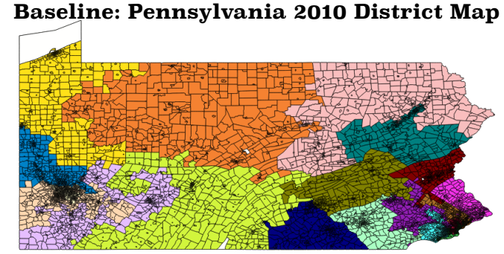
- Working with geospatial (GIS) data
- Algorithmic complexity - we were dealing with 9256 precincts and 19 district assignments, which is over 10^58 possible assignments of precincts to districts without restrictions
- Enforcing contiguity - precincts in the same district must share edges
- Tuning evaluation functions

Analysis

- Overall, we were able to improve the efficiency gap while maintaining legal continuity and population gaps
- Continuity proved to be a difficult problem to solve and even with constraints produced some wild district shapes
- Initializing randomly produced worst results than starting with initial district map
- Gibbs was able to get the best constrained solution

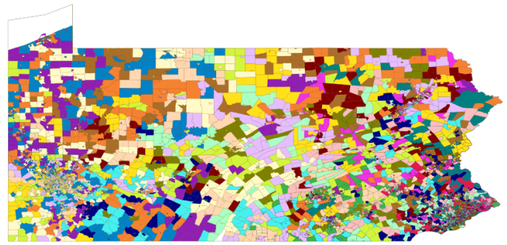
Results

Baseline: Pennsylvania 2010 District Map



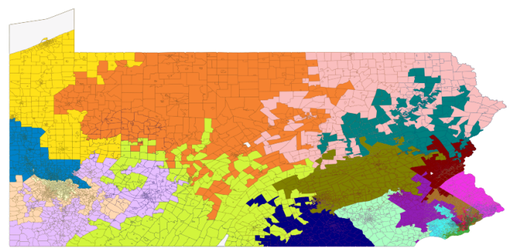
Efficiency: 0.1100 Population: 0.0430

Relaxed Geographic Constraints



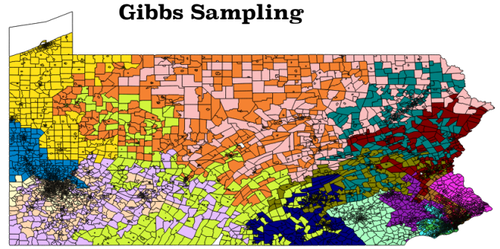
Efficiency: .00002 Population: .0068

Modified Iterated Conditional Modes



Efficiency: 0.0803 Population: 0.0499

Gibbs Sampling



Efficiency: 0.0280 Population: 0.0284