Fighting Gerrymandering by Automating Congressional Redistricting

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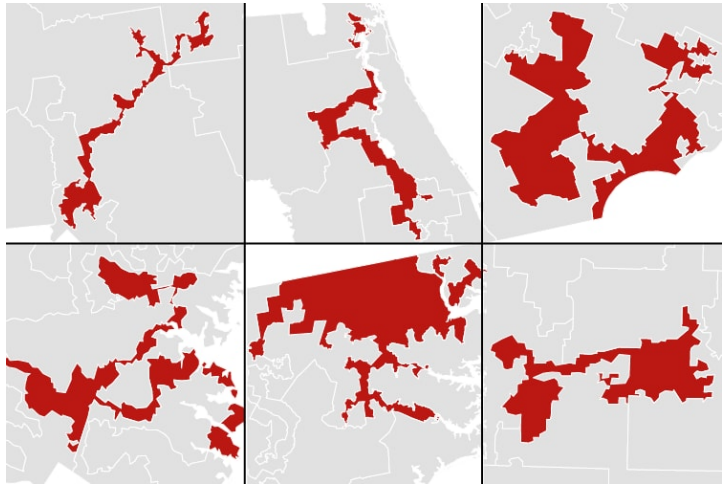
Outline

Outline

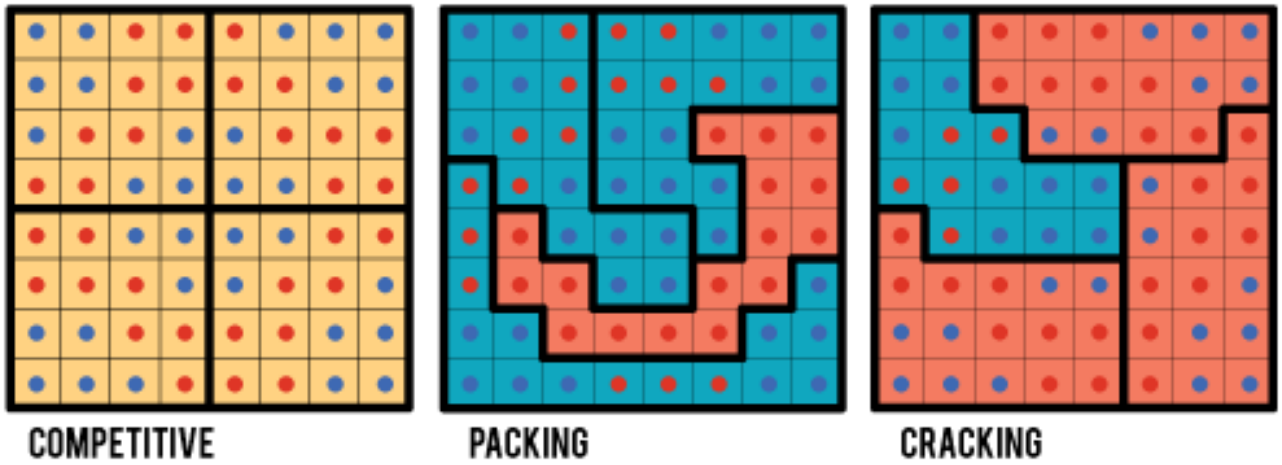
Introduction

- Congressional redistricting takes place every 10 years
- Partisan gerrymandering presents problems
- Algorithms could solve this



Examples of gerrymandered districts [3]

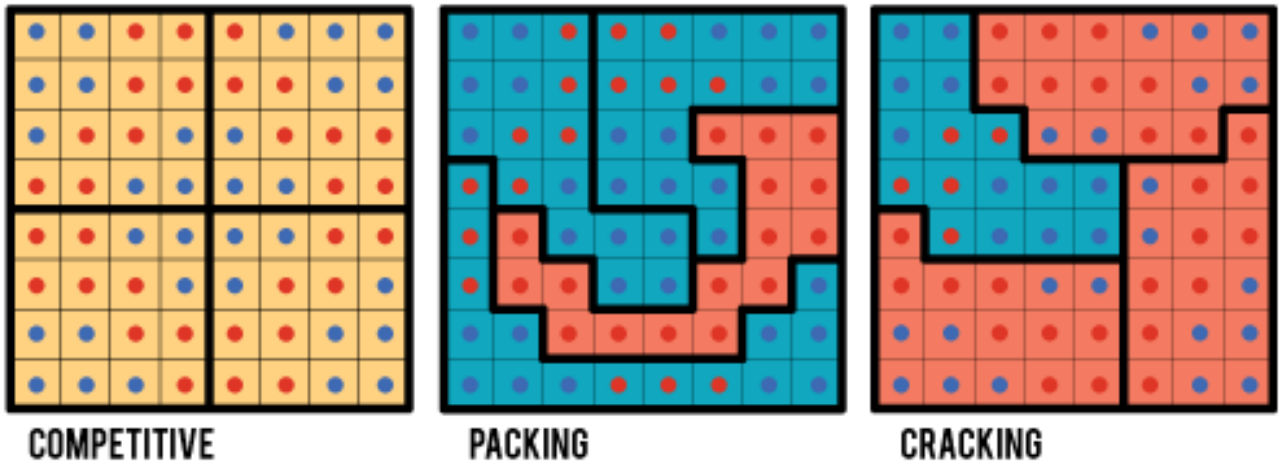
What is Gerrymandering?



A figure of competitive, packed, and cracked districts [5]

- Gerrymandering is when districts are drawn to favor a specific group
- A packed district clumps similar voters together in one district

What is Gerrymandering? Cont.



A figure of competitive, packed, and cracked districts [5]

- A cracked district splits similar voters across districts

How are districts drawn currently?

- Census collects data every 10 years
- Congress apportions representatives to states
- States must drawn district lines
  - Advisory committees
  - Independent committees

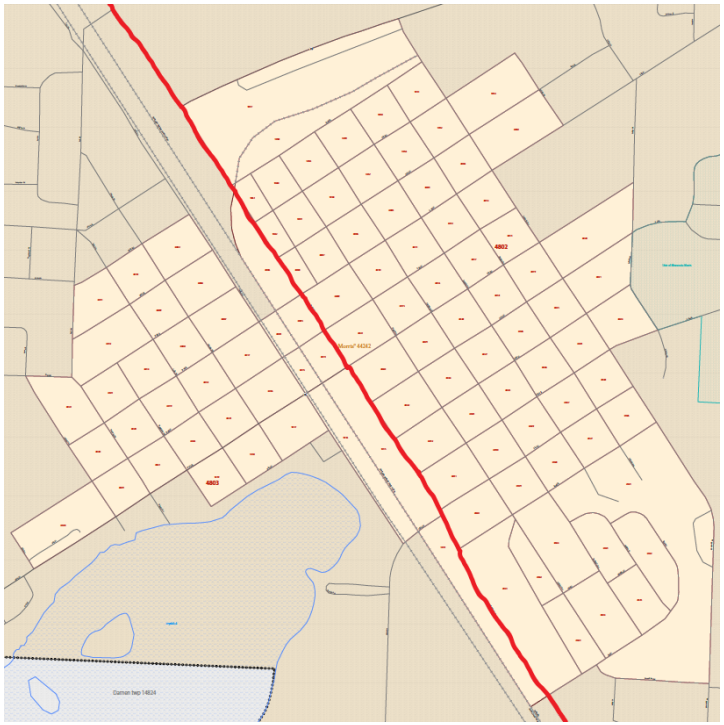
Outline

Different metrics

- There's no consensus on what makes a "good" district
- Different metrics are used to measure different goals
  - Party registration for competitiveness
  - Racial composition for majority-minority districts
  - Various definitions of compactness

Census Data

- Census *blocks* are the smallest population units
- Census *tracts* are made of census blocks
- District lines cannot cut through census blocks



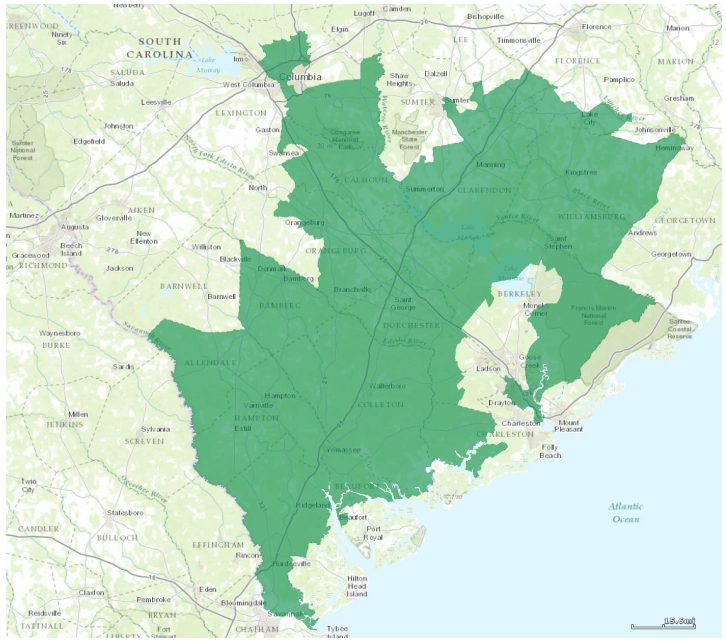
The 2020 census block and tract lines for Morris, MN [1]

Communities of Interest

- Could be demographic, or could be something people share in common
- Very difficult to define reliably
- Nearly impossible to quantify
- Excluded from analysis

Racial Minorities

- Voting Rights Act of 1965
- Majority-Minority districts
- Can be incorporated into the algorithm

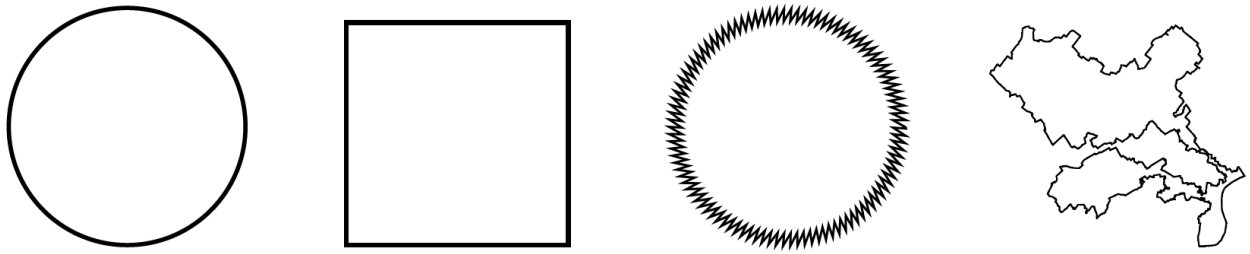


South Carolina District 6 is a majority-minority district that is 57% African-American [2]

Population Deviation

- Measures population differences between districts
- Ideal population deviation is Population(State)/Num. of Districts
- Primary focus of Levin and Friedler [4]
- Must be less than 0.5%
- Lower scores are better

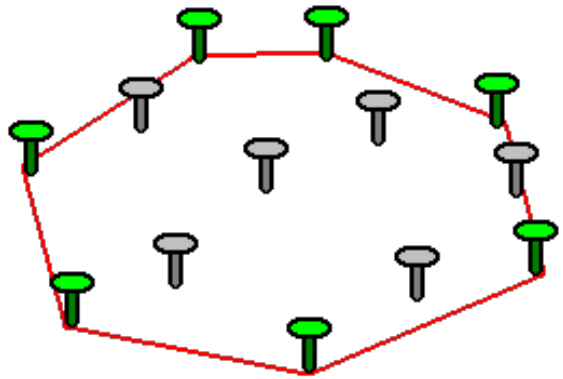
Compactness



Starting from the left, high levels of compactness that decrease with more complexity [6]

- No consensus on definition
- Three kinds used in analysis
- Higher scores are better

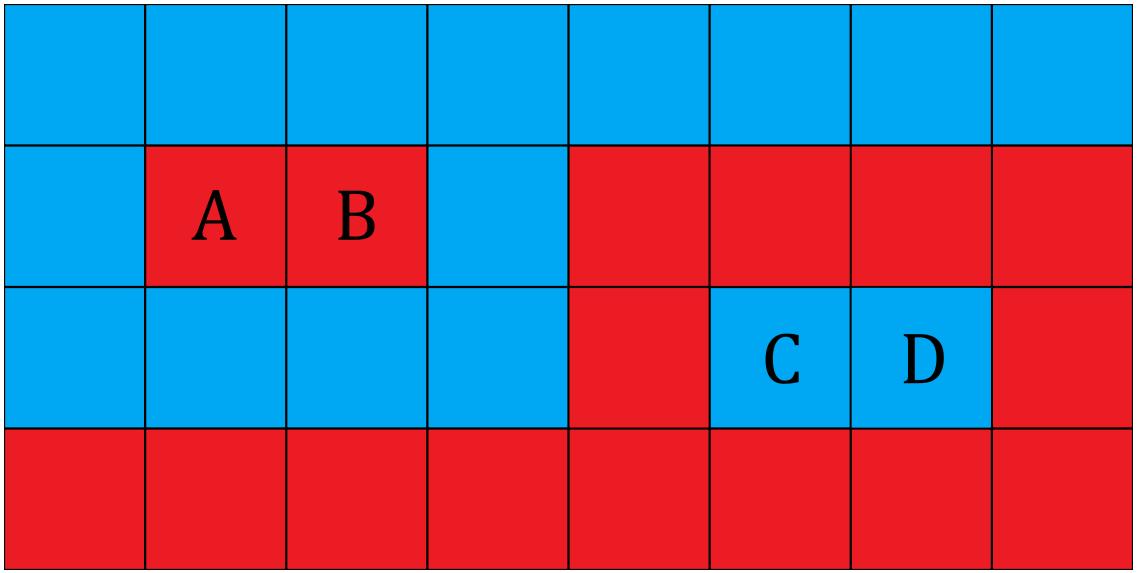
Compactness Cont.



An example of a convex hull. The set of green nails are the vertices of the Convex Hull that surrounds all of the nails

- D stands for District and $p(D)$ stands for perimeter
- Convex Hull: $area(D)/convexHull(D)$
- Polsby-Popper: $(4\pi \cdot area(D))/p(D)^2$
- Modified Schwartzberg: $\left(2\pi\sqrt{area(D)/\pi}\right)/p(D)$

Contiguity



An example of non-contiguous districts. Blocks A,B,C, and D are non-contiguous

- Necessary for all congressional districts
- Every point must connect to every other point without crossing a district line

Outline

Proposed Redistricting Algorithm

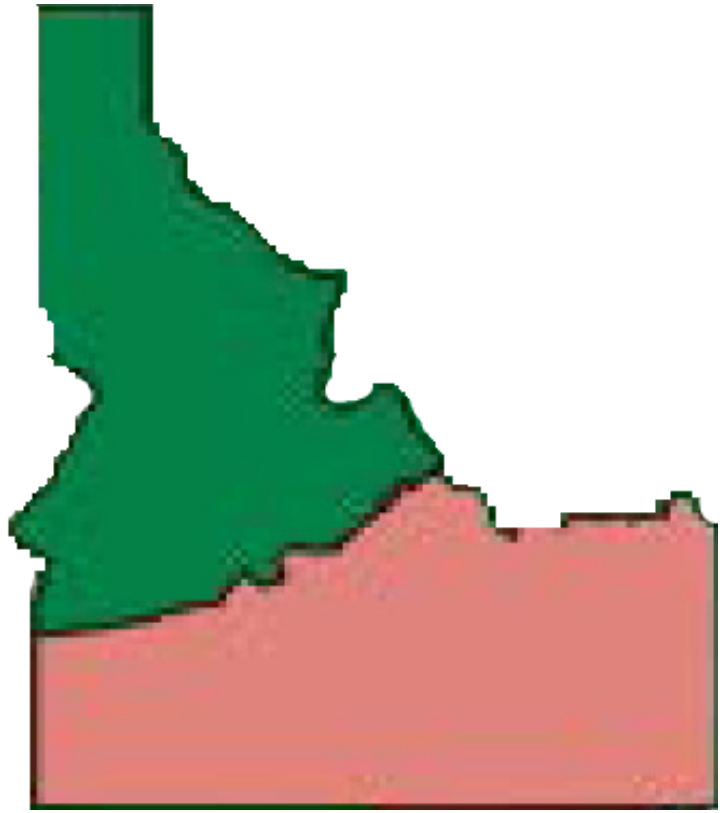
- Recursive Divide and Conquer Redistricting Algorithm, by Harry Levin and Sorelle Friedler [4]
- Utilizes components to show importance of each part

Divide and Conquer

- Main function that calls components
- Starts with a state's geography and population
- Creates a two-district partition
- Recursively sub-divides those two-district partitions

Example 1

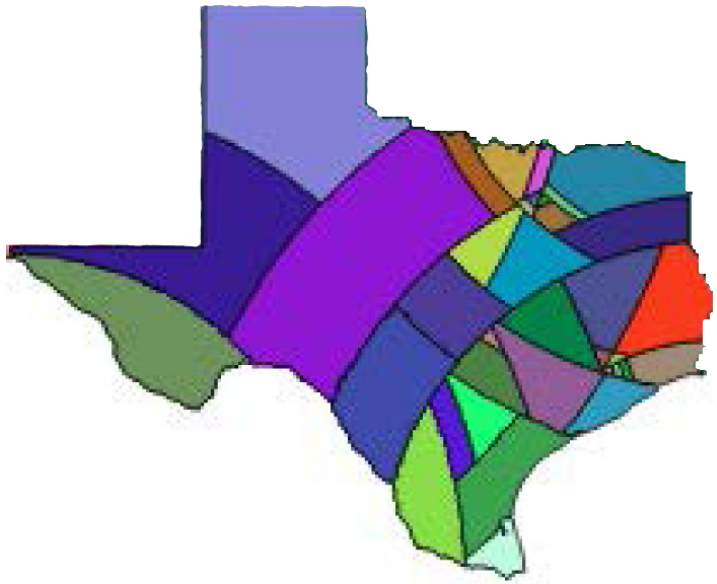
- For a state with two districts, this is easy
- Sub-division is not needed



Idaho, which only has 2 districts [4]

Example 2

- For a state with more districts, this becomes more complicated
- Sub-division happens recursively



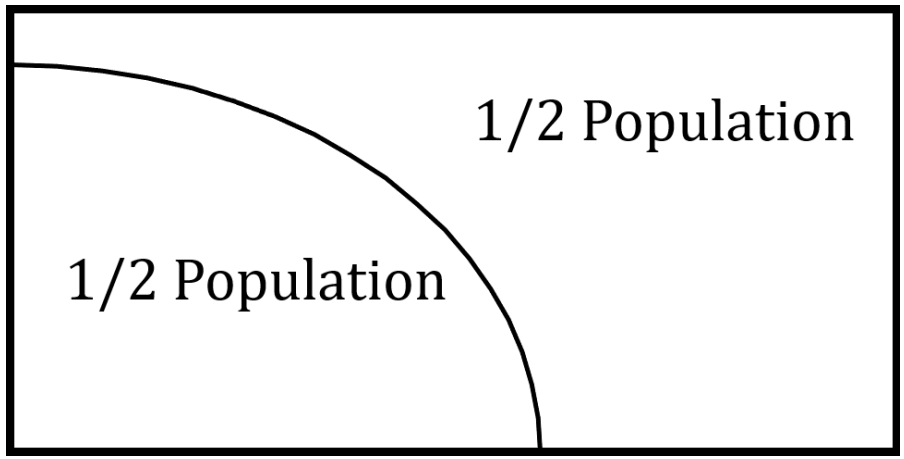
Texas, which has 36 districts in this example [4]

Voronoi Component

- Starts with a rectangle that encompasses the part of the state we want to divide
- This rectangle is called a sub-graph
- Create a two-district partition from this sub-graph
- This process is done for each corner of the rectangle, and is analyzed later

Voronoi Component Cont.

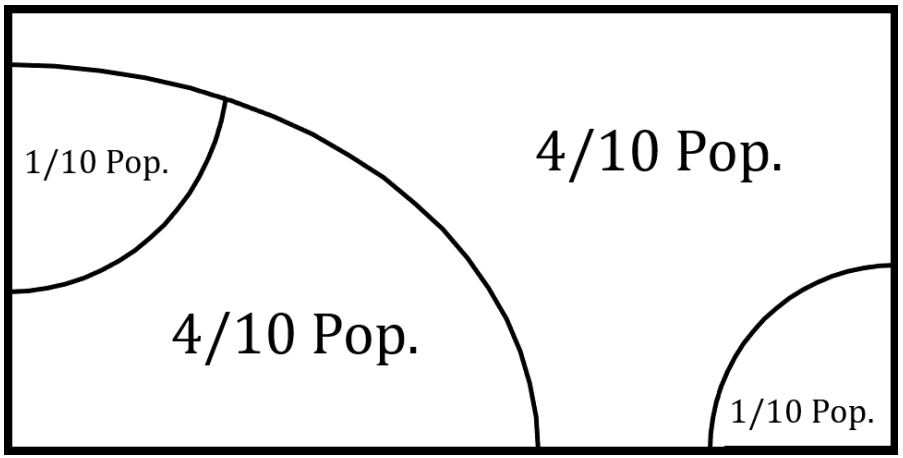
- The diagram on the right shows a state that needs 10 districts being divided
- We start with a district in the corner
- This district will grown until it reaches the desired population
- Because the num. of districts we want is *even*, ideal population is half the sub-graph's population



A two-district partition split into two equal halves

Voronoi Component Cont.

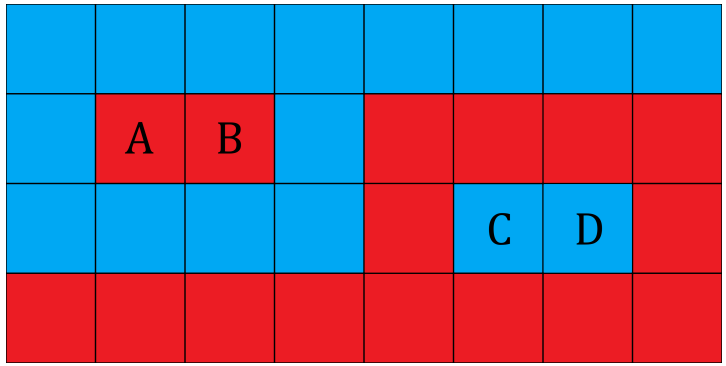
- We still need districts, so both districts become sub-graphs
- The num. of districts needed per sub-graph is 5
- Because 5 is *odd*, ideal population is the population of the sub-graph / num. of districts for the sub-graph
- We will end up with a district that has 1/10th the population of the state, as $1/2 \cdot 1/5 = 1/10$



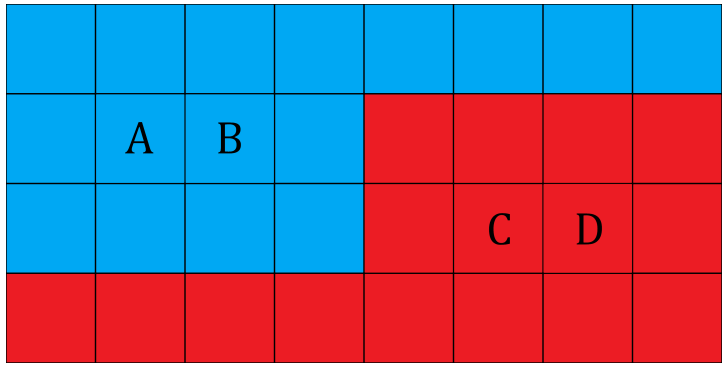
Each sub-graph needs 5 districts, so we create a small district before we cut in half again

Contiguity Swapping

- Both districts must be contiguous
- Find largest collection of contiguous units
- Swap all non-contiguous units to the other district



A,B,C, and D are non-contiguous



A,B,C, and D were swapped, and became contiguous

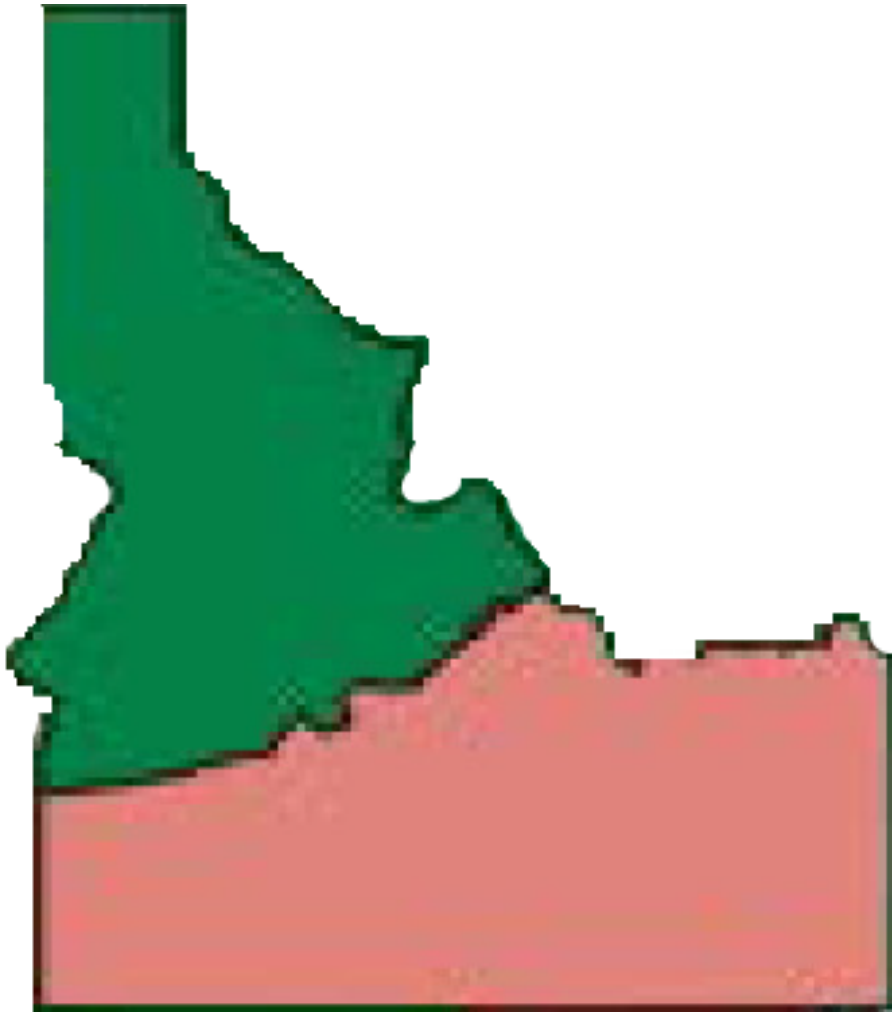
Population Swapping

- Similar to contiguity swapping
- Try and make population deviation as low as possible
- Create a collection of population units (census blocks) that border the edge of the two districts
- Swap population units if it's beneficial

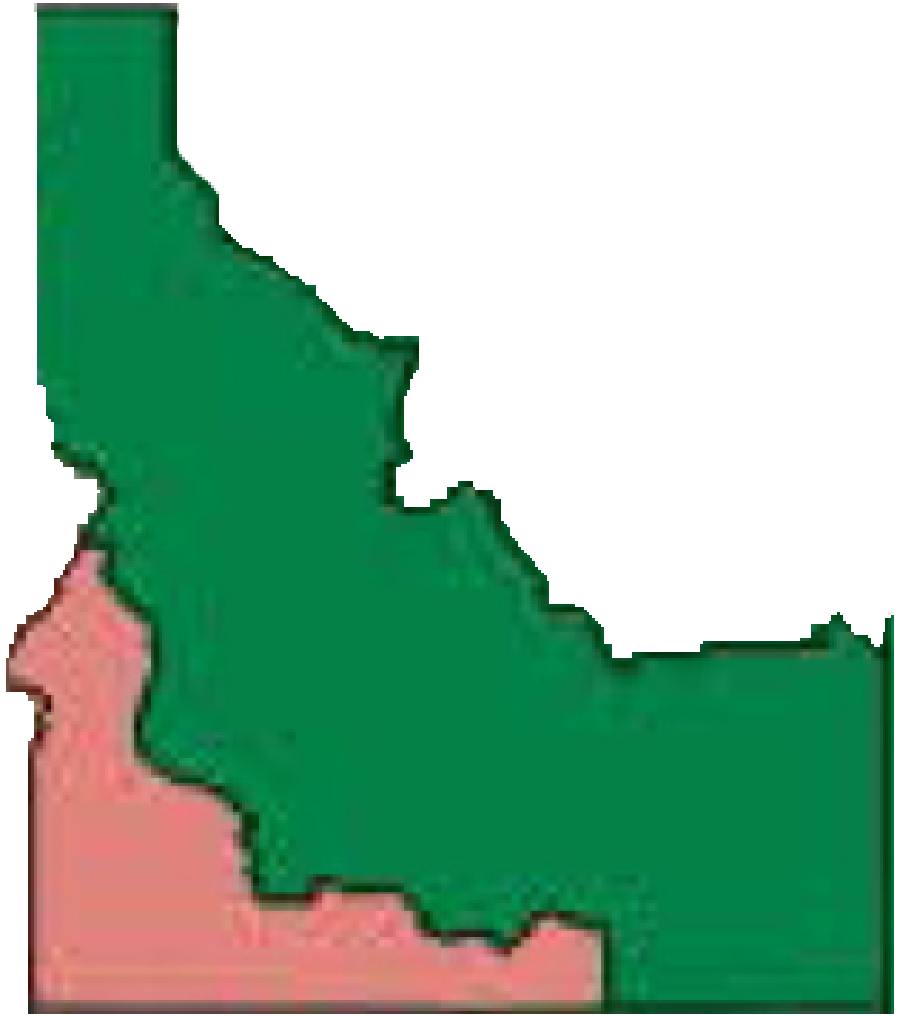
Maximization

- Chooses the best of the four corners in the Voronoi component
- Can do this three ways
  - MinPop: Minimal population deviation
  - MaxCompact: Maximum compactness
  - ValidCompact: Combination of MaxCompact and MinPop (if possible)

Maximization Example



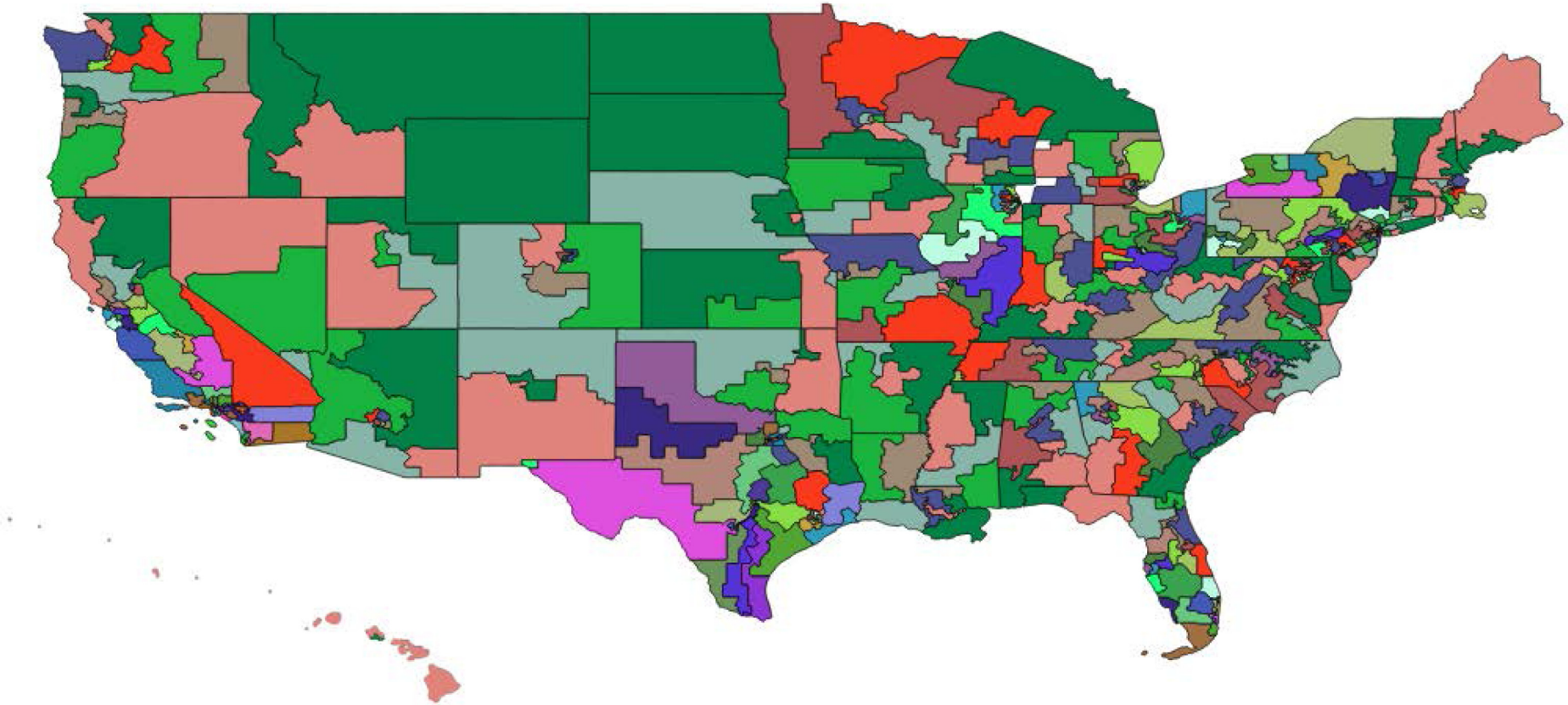
A two-district partition chosen under blocks [4]



The same two-district partition chosen under tracts [4]

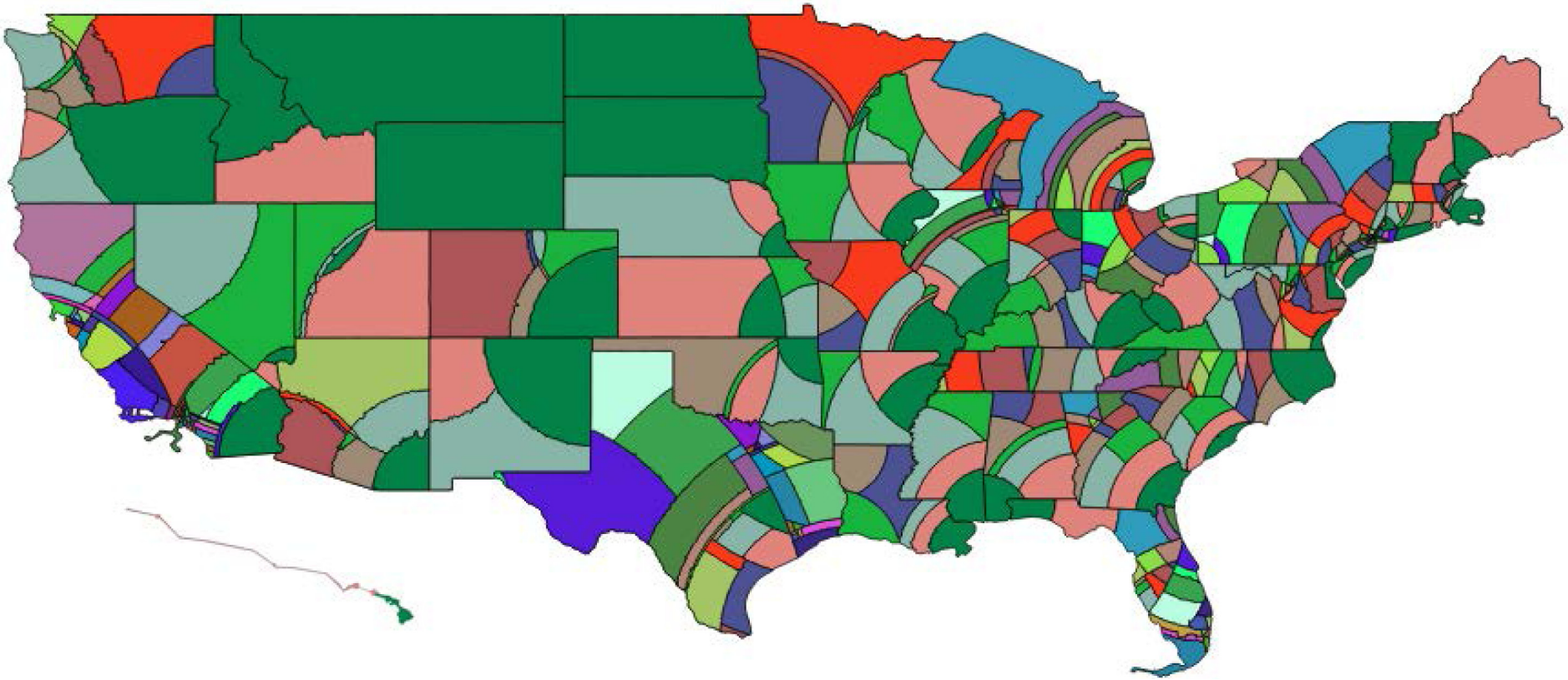
Outline

Actual 2010 Districts



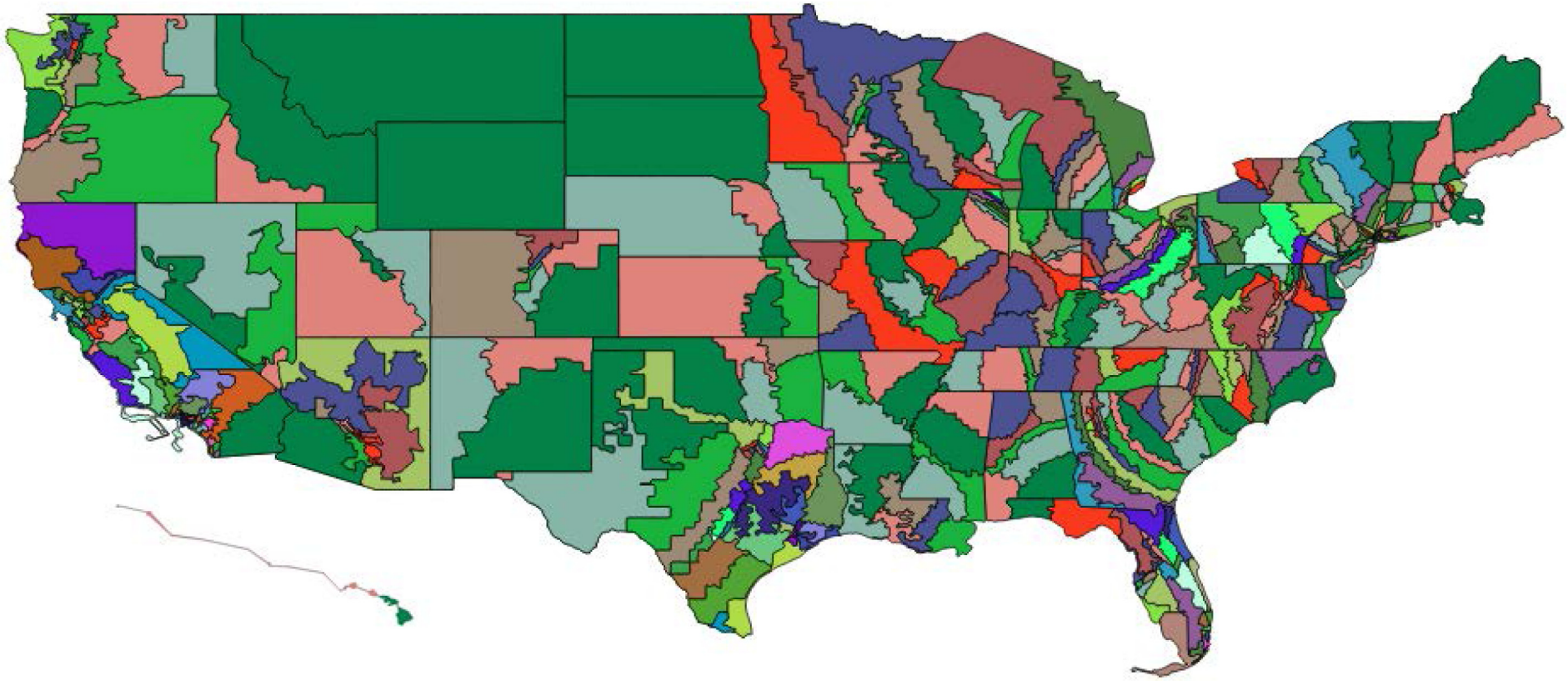
The 113th congressional districts based on the 2010 census data [4]

MinPop run on census blocks



MinPop being run on census blocks [4]

MinPop run on census tracts



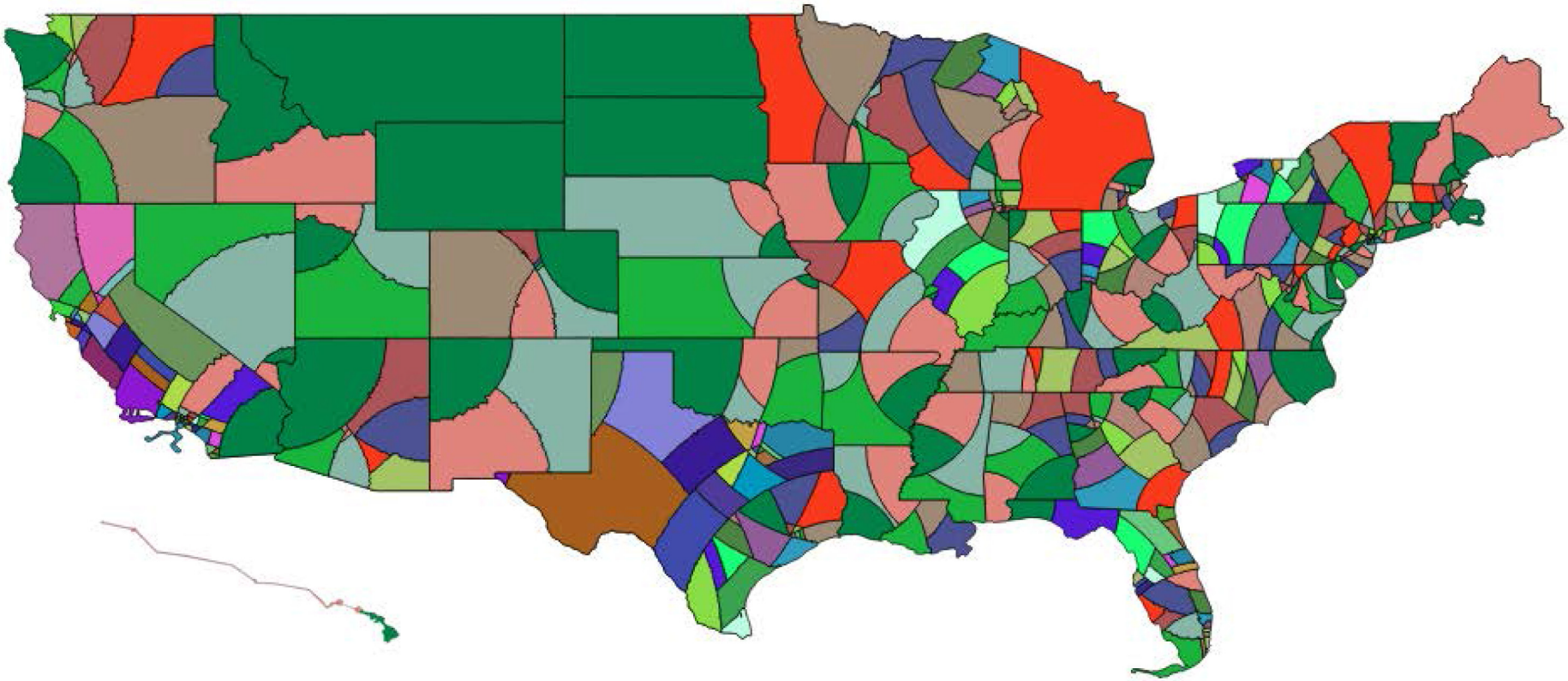
MinPop being run on census tracts [4]

Data Results of MinPop

Measure	Census Blocks Full Alg	Census Tracts No Pop Swap	Census Tracts Full Alg
Valid States (deviation < 0.5%)	42/43	19/43	41/43
Population Deviation Med (%)	0.00%	0.60%	0.02%
Population Deviation Med (people)	1	4,005	127
Convex Hull 25th Percentile	0.76296	0.73297	0.58767
Convex Hull Med	0.81714	0.76072	0.66362
Convex Hull 75th Percentile	0.86209	0.78885	0.73640
Polsby-Popper 25th Percentile	0.20278	0.22542	0.14579
Polsby-Popper Med	0.23686	0.25676	0.20019
Polsby-Popper 75th Percentile	0.27402	0.28161	0.24559
Schwartzberg 25th Percentile	0.44288	0.46605	0.37398
Schwartzberg Med	0.47477	0.50227	0.43874
Schwartzberg 75th Percentile	0.51713	0.52496	0.48407

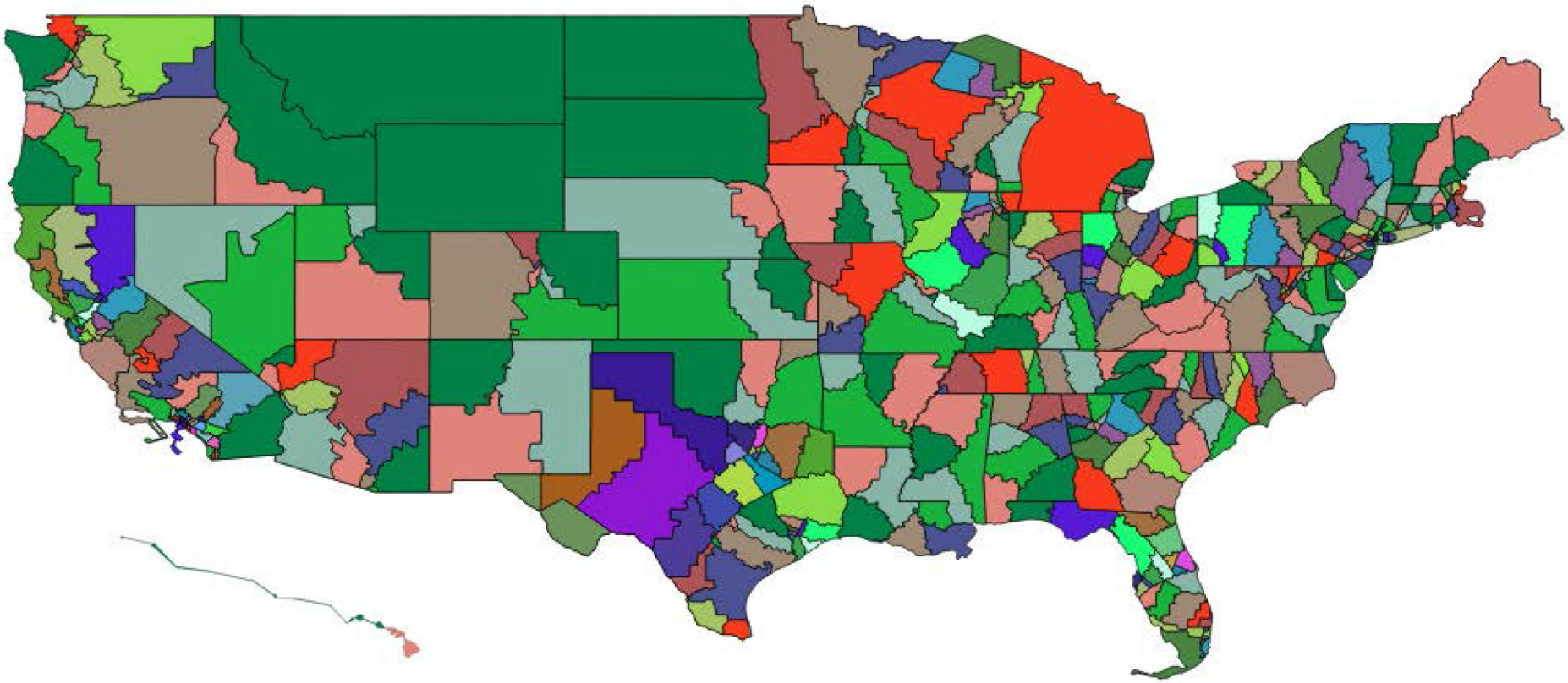
Data Results of MinPop [4]

MaxCompact run on census blocks



MaxCompact being run on census blocks [4]

MaxCompact run on census tracts



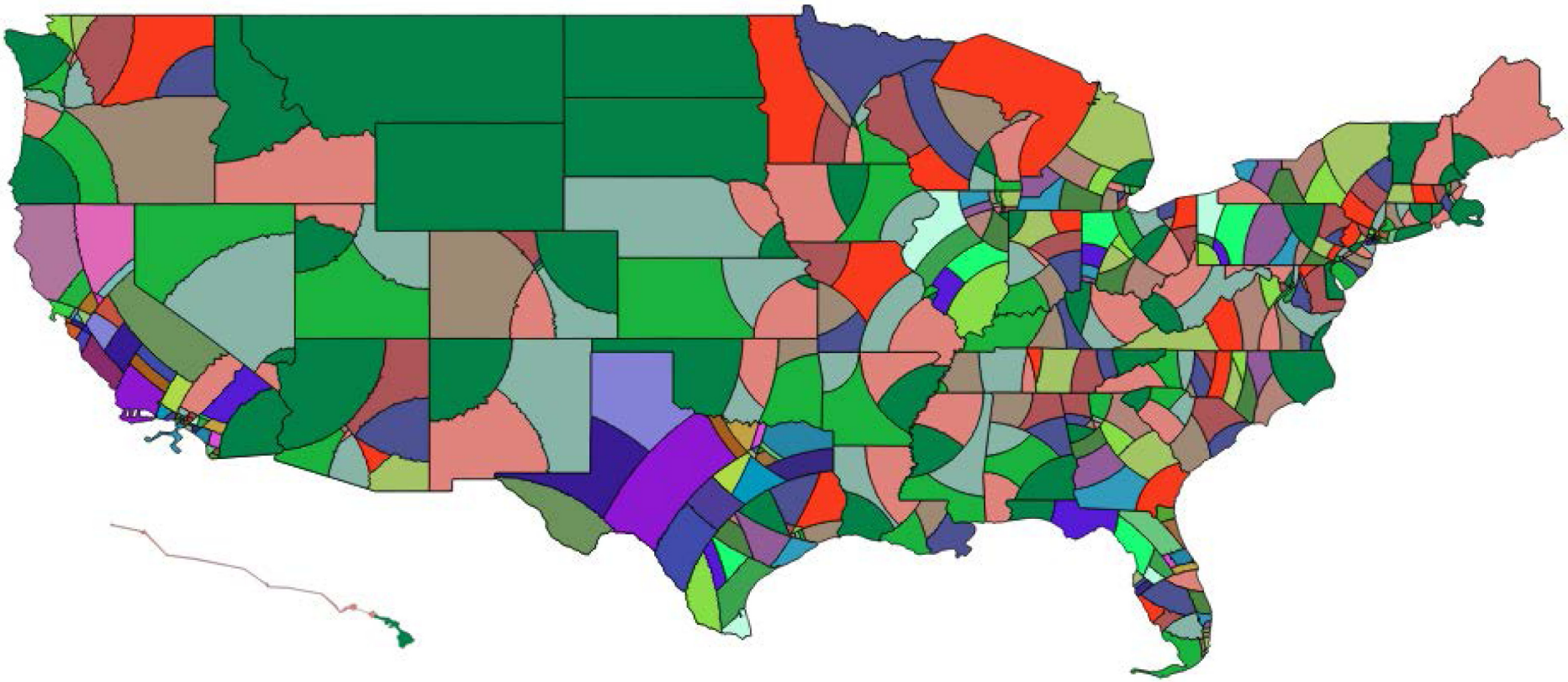
MaxCompact being run on census tracts [4]

Data Results of MaxCompact

Measure	Census Blocks Full Alg	Census Tracts No Pop Swap	Census Tracts Full Alg
Valid States (deviation < 0.5%)	36/43	8/43	36/43
Population Deviation Med (%)	0.00%	1.84%	0.11 %
Population Deviation Med (people)	1	13,775	736
Convex Hull 25th Percentile	0.82189	0.72449	0.73293
Convex Hull Med	0.85537	0.78063	0.77731
Convex Hull 75th Percentile	0.87740	0.82690	0.81376
Polsby-Popper 25th Percentile	0.23476	0.26090	0.24178
Polsby-Popper Med	0.26598	0.30871	0.28837
Polsby-Popper 75 Percentile	0.30701	0.33692	0.32579
Schwartzberg 25th Percentile	0.47934	0.50370	0.48475
Schwartzberg Med	0.51140	0.55189	0.53229
Schwartzberg 75th Percentile	0.54979	0.57534	0.56395

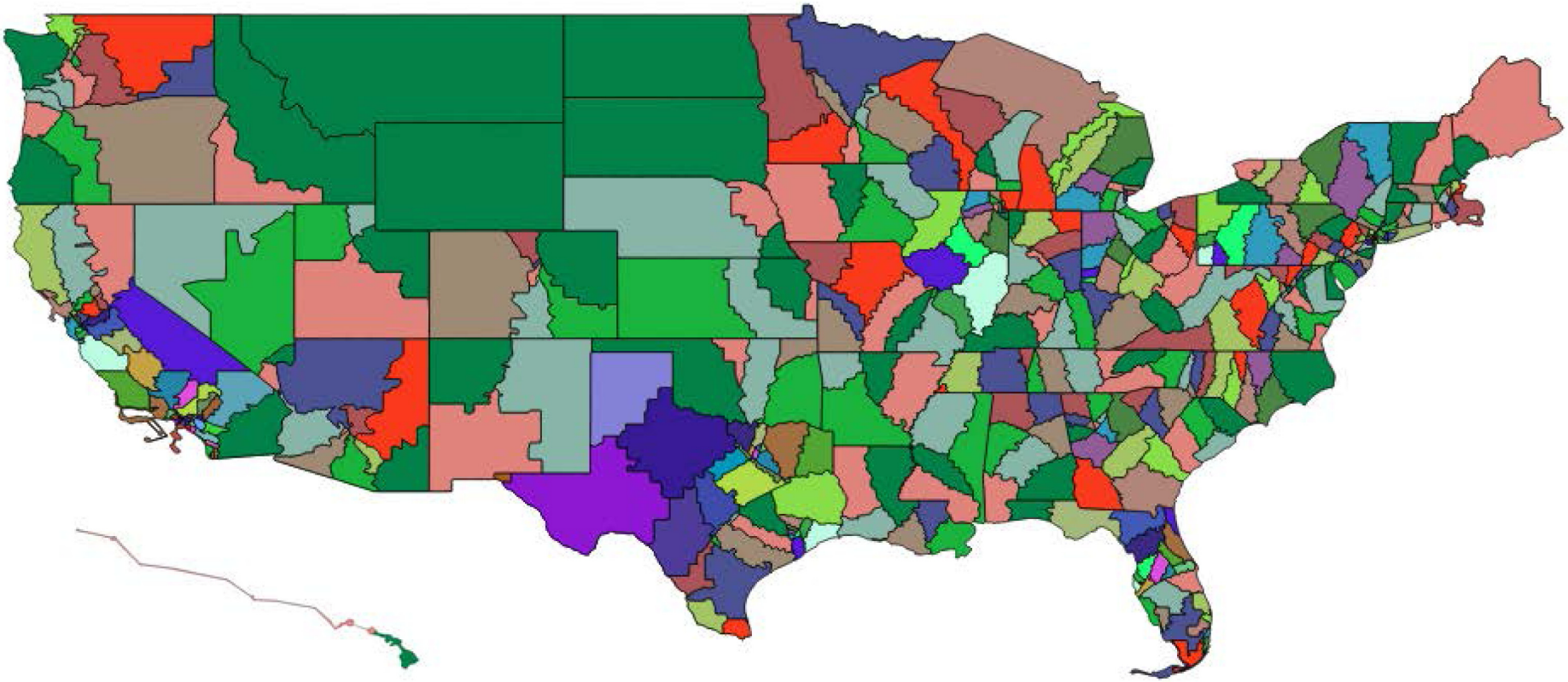
Data Results of MaxCompact [4]

ValidCompact run on census blocks



ValidCompact being run on census blocks [4]

ValidCompact run on census tracts



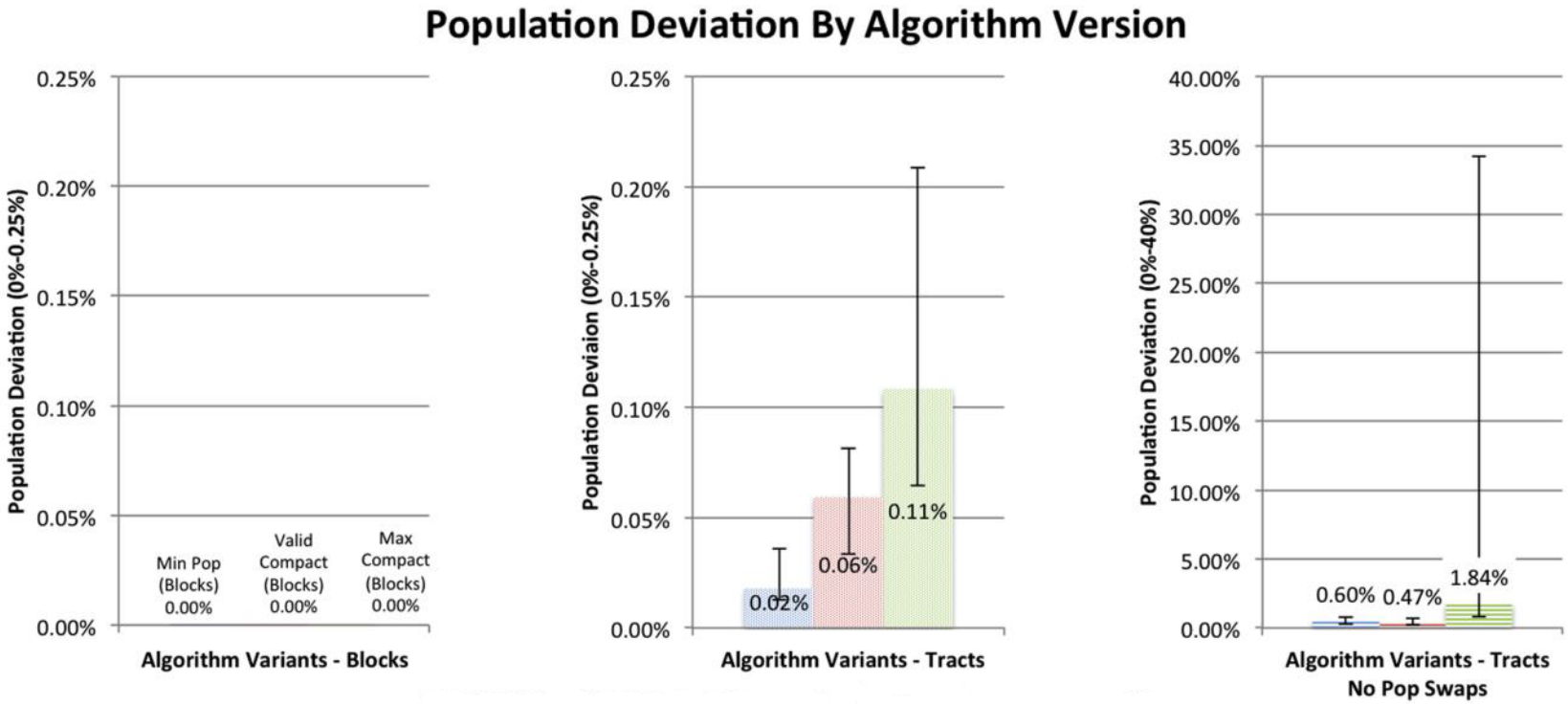
ValidCompact being run on census tracts [4]

Data Results of ValidCompact

Measure	Census Blocks	Census Tracts	
	Full Alg	No Pop Swap	Full Alg
Valid States (deviation < 0.5%)	42/43	23/43	41/43
Population Deviation Med (%)	0.00%	0.47%	0.06%
Population Deviation Med (people)	1	3,291	449
Convex Hull 25th Percentile	0.82489	0.72429	0.72583
Convex Hull Med	0.85929	0.77753	0.76874
Convex Hull 75th Percentile	0.87740	0.80296	0.81066
Polsby-Popper 25th Percentile	0.23476	0.22563	0.23141
Polsby-Popper Med	0.27517	0.27422	0.26915
Polsby-Popper 75th Percentile	0.30701	0.30421	0.31924
Schwartzberg 25th Percentile	0.47934	0.46613	0.47507
Schwartzberg Med	0.51961	0.51365	0.51129
Schwartzberg 75th Percentile	0.54979	0.54638	0.56034

Data Results of ValidCompact [4]

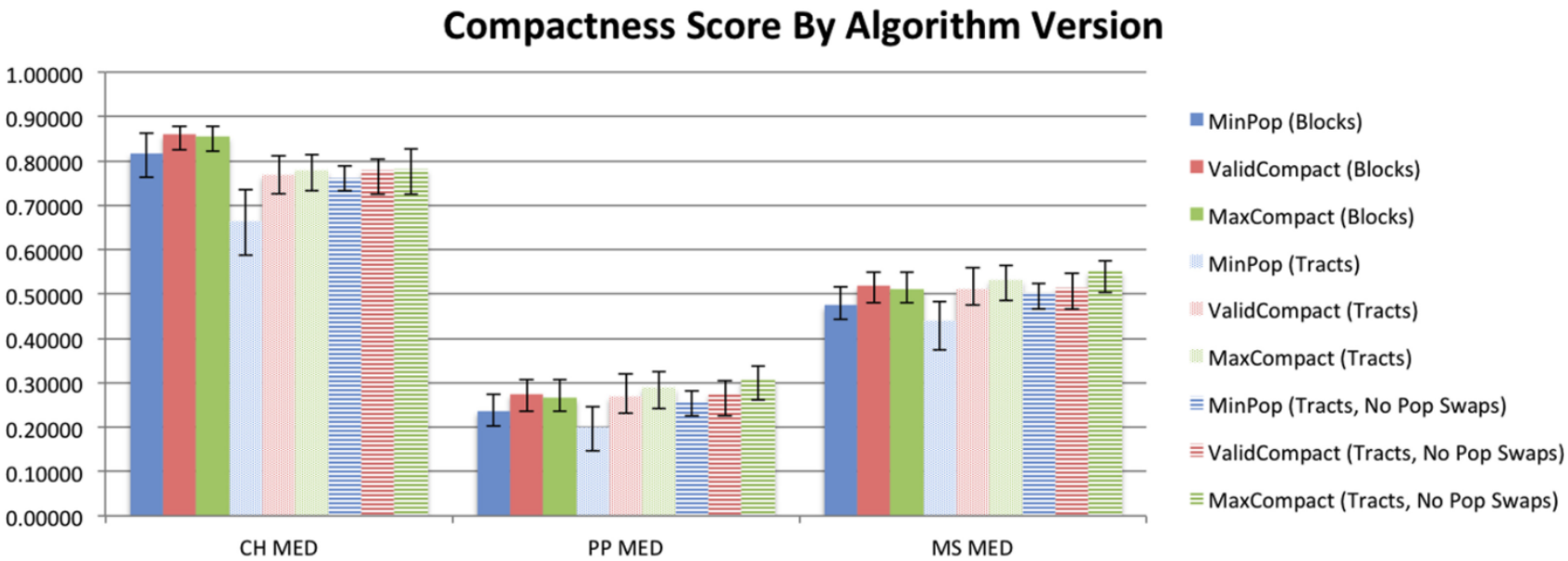
Population Deviation Results



Population Deviation scores on every version of the algorithm [4]

- Scores reflect median values with 25th and 75th percentile error bars
- Scores get worse when using tracts
- Scores also get worse when population swapping is removed

Compactness Results



Compactness scores on every version of the algorithm [4]

- Scores reflect median values with 25th and 75th percentile error bars
- Scores mostly improve when using tracts
- Scores also slightly improve when population swapping is removed

Outline

Closing Remarks

- Source code is available online!
- Not every state will want the same thing
- Human input is still needed for communities of interest
- Majority-minority merge trick can be done by combining population units

Thank you!

Questions?

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https://github.com/newspapercentral/automated-congressional-redistricting


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