Mathematics of Gerrymandering

WXML Spring 2018

What is Gerrymandering?

“Packing & Cracking “

North Carolina’s 12th Legislative district

Image Courtesy of WPSU

Motivation: North Carolina

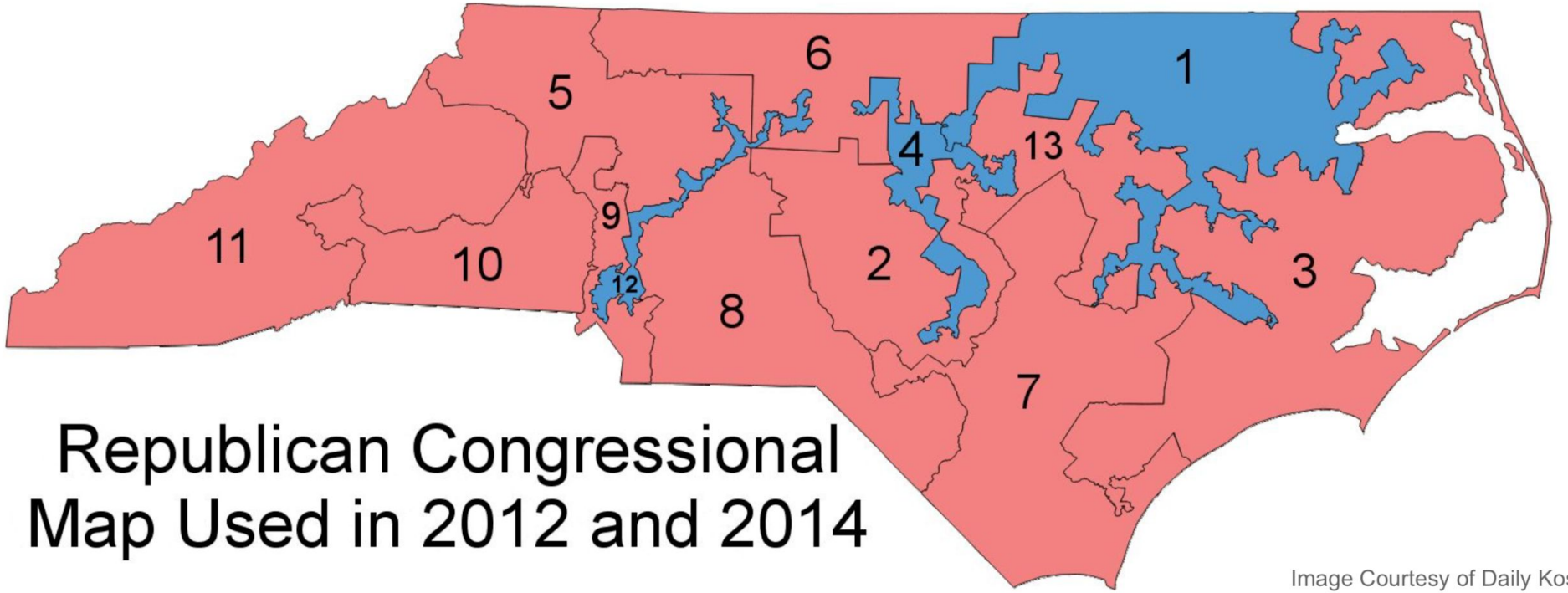


Image Courtesy of Daily Kos

Metropolis-Hastings Algorithm on Iowa

- Sampling from large space of possible Redistrictings of Iowa.
- Consider a graph which nodes are redistricting plans and edges connect redistricting only differ by 1 precinct.
- Starting with initial redistricting and random walk along graph. Determine if move on to candidate by evaluating candidate.

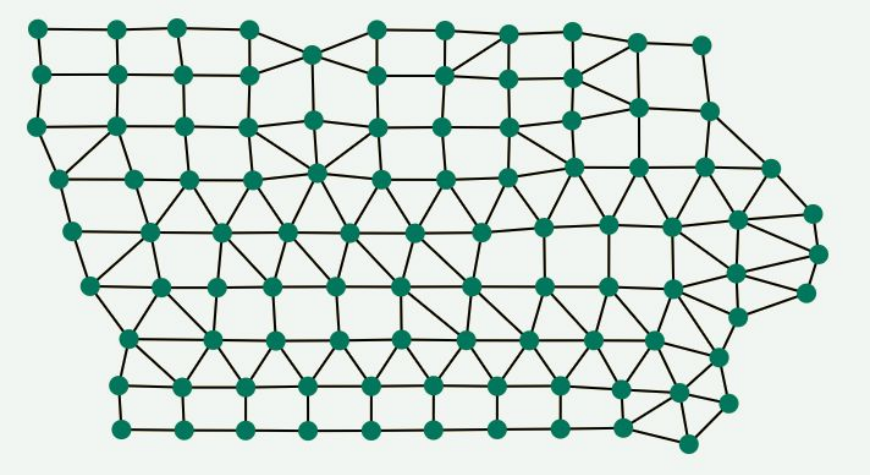


Image courtesy of Duke University.

Evaluate a candidate redistricting

States have varying types of requirements for redistricting plans. Common types include:

- **Contiguity & Compactness**
- **Even Population**
- **Minimize splits of cities and counties**
- **Voting Rights Act Compliance**

These requirements will be important for our model.

Evaluate performance of MH algorithm

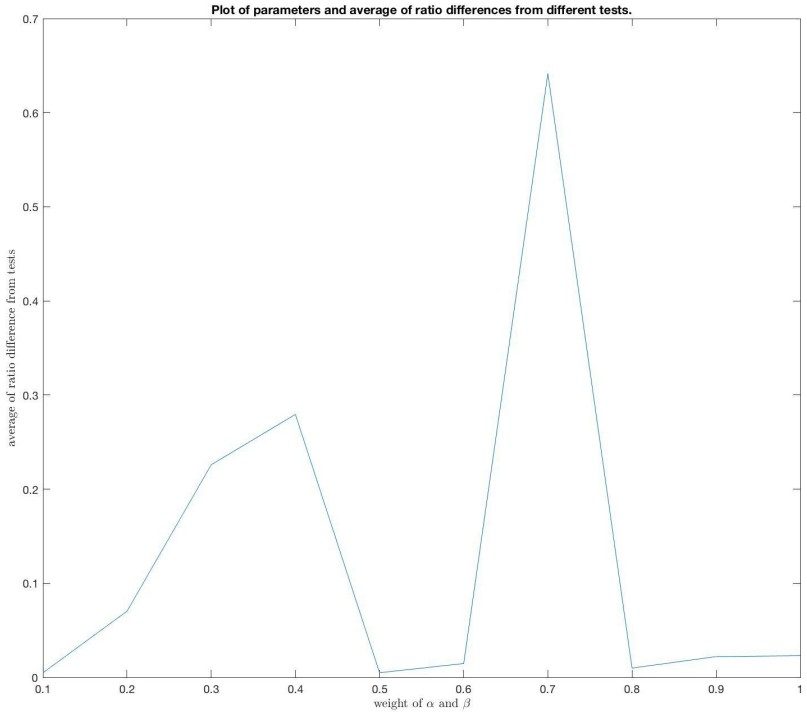
We want the samples to be independent: the final redistricting that results from the random walk should be independent of the initial map.

We are also testing different parameter values.

- Higher parameter values result in maps that more closely adhere to redistricting requirements but can drastically increase the number of iterations required for a random sample .
- Want lowest possible values that still give good samples.

We used an empirical test to determine independence.

Plot of $P(x_i=y|x_{i-1}=n)-P(x_i=y)$: Measure of correlation between initial sample and result



Simulated Annealing

We solved this issue by incorporating simulated annealing: the process of increasing parameter values over time.

- Starting with very low parameters allows us to reach an independently generated sample quickly.
- Raising the parameters over time gives us samples with better population distribution and compact shape.

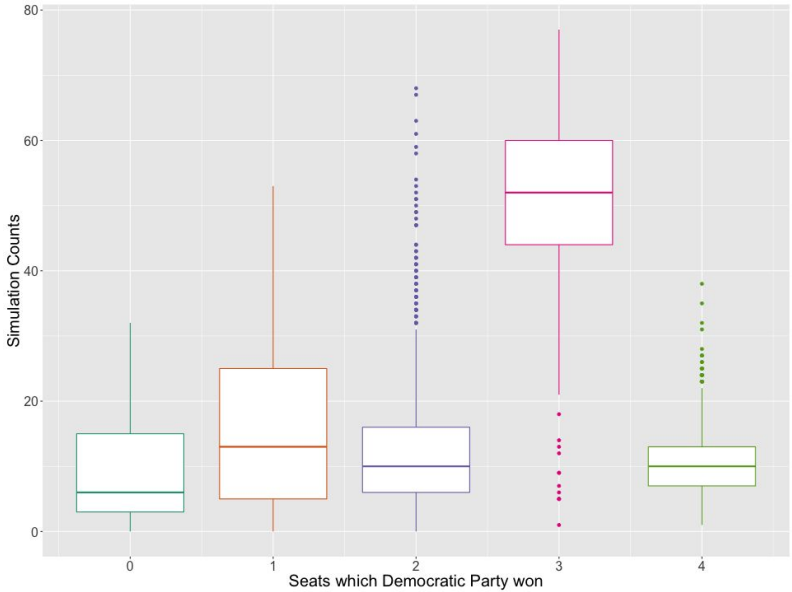
Result: the correlation between initial and final sample is within 0.1%, and the overall population difference from average district population is within 1% (per district)

Timelapse of algorithm

http://students.washington.edu/wfjiang/animation.mp4

Simulate election

- Use the data from past 3 presidential election to generate a distribution
- Simulate election for multiple times on each sample redistricting we generated with MH algorithm
- Simulate election on current Iowa redistricting map, to determine whether it is an outlier.
- PROBABLY NO GERRYMANDERING IN IOWA.



Future works

- Determine the most appropriate way for Washington’s adjacency graph
- Generate some redistricting samples for Washington state!

Thank you.

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