

# Illinois Redistricting - Integer Programming

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## Methods

This project is an attempt to write an integer programming problem to create 17 fair congressional districts for the State of Illinois.

Our group defined fair as the following:

- Population balance within a certain range ( $\pm 10\%$  of the total population/)
- Grouping communities with similar concerns that they want their representation to address
- Does not block minority groups from electing candidates of choice

The criteria in which Illinois's congressional districts follow, according to Loyola Law School, are:

- equal population requirement where the US constitution requires each district have the same population or about the same population
- “abide by the Voting Rights Act and constitutional rules on race”
- “state law further directs the redistricting body to create, where legally and pragmatically possible, districts that allow racial or language minority communities to elect — or influence the election of — the candidates of their choice, even if no comparable district would be required by the federal Voting Rights Act.”
- be “contiguous and reasonably compact”

Our solution aims to follow the more concrete rules of equal population requirement and is contiguity and compact through our adjacency constraint to address the one person one vote goal. The first two criteria are required for all states, the third and four criteria described are state law. The concerns that come up are how to create constraints that promote the second and third criteria. How do you ensure the rights of all voters especially when it comes to creating

districts that allow racial/language minorities to elect candidates of their choice? This requirement was implemented recently (2020) and hasn't been interpreted by courts yet.

## Data Sources

Overall, there were no concerns with most of our data sources. The voting data and county adjacency data came directly from a government source, so there seem to be no concerns with the sources themselves. With that said, there is room for error in all of the data collected, and in some cases it is impossible to have perfect data collection. For example, population data came from the world population review, which included data for 2024 and 2020. While this is helpful, districts that are created last at least 10 years. Data changes and impactful events like a global pandemic can greatly change the distribution of a population in a country, state, and county. This same logic applies to the proportion of democrat and republican voters across Illinois. References for our data sources in the references section of this write up.

## Problem Specifications

The objective function decided upon was minimizing the difference between the district population and the total population of Illinois divided by the number of districts, 17. When creating the model, three major constraints were considered. The first was balancing the population across the districts. The next is that each county must be in exactly one district. The third is that all counties in a district must be adjacent to one another. The third constraint is how we addressed geographically compact districts. Minimizing the maximum pairwise distance between two counties in each district was considered but not implemented. In order to implement the principle of one person one vote, the paramount objective was to balance the population across the districts, which is why the current objective function was chosen. Minimizing the maximum distance between counties in the district was also considered as an

objective function. However, we decided it did not fulfill the idea of one person, one vote as well as population balance.

## Programming and Solution

The programming used to solve this problem is in the github repo in the folder titled Code. The file with the code for the set partition problem is titled `MSDS460Assignment3.py` and the data preprocessing steps are in `preprocessing_data.ipynb`. The output is in a file titled `redistricting_output.txt`. We ran into challenges setting up this problem. While the set up for the set partition started fairly simple, actually ensuring the constraints resulted in a feasible problem was a challenge. We tweaked constraints along the way, but still struggled with the contiguity constraint.

The optimal solution we found is under `redistricting_output.txt` in our github. As discussed above, the integer programming problem set up is not sophisticated enough to prepare a solution to present for implementation because it does not meet the requirement of contiguity. Recommended next steps include ensuring the districts are continuous, checking the proportion of democratic and republican voters is equal to that of the entire state of Illinois. It is also recommended that trends from 2020 through 2024 and beyond are studied to ensure that the map represents the current trend instead of a past one in political belief. In addition, checking the demographics of each district is essential in ensuring that the redistricting does not prevent a minority group from fairly electing representation. Additionally, another measure to add compactness would be to add a constraint that minimizes the pairwise distance between counties in a district and set that up as the objective function.

## Maps and Discussion

The current map for Illinois has odd shapes and unfairly groups all democrats and republicans into certain regions. It is currently in the github repository with the map from our code output. I would use the Districtr map that we could create for our selected state. Because Districtr allows us to see the breakdown by demographic and population, it's easy to make small tweaks. I think our map would be a great starting point, but using Districtr would allow a more specific map where humans can manually check for demographic parity, economic parity, and more. Additionally, the map generated by our code does not meet the contiguity requirement, and does not balance the population as well as we were hoping. While it is difficult and takes a long time to use Districtr, it is not like we must do this problem every day. It happens every ten years, which makes this a feasible problem to do by hand. It is difficult to define fair and equitable and what tangible aspects of a map that translates to. While no plan is perfect, this is more fair and more equitable than the previous redistricting plan. These plans are consistent with one person, one vote, because by making the population evenly distributed and evenly distributing the proportion of republicans and democrats, everyone's vote matters the same.

## References

All About Redistricting-Loyola Law School. *Illinois*. Accessed November 3, 2024.  
<https://redistricting.lls.edu/state/illinois/?cycle=2020&level=Congress&startdate=2021-11-23>

COIN-OR Foundation. *A Set Partitioning Problem*. Accessed November 3, 2024.  
[https://coin-or.github.io/pulp/CaseStudies/a\\_set\\_partitioning\\_problem.html](https://coin-or.github.io/pulp/CaseStudies/a_set_partitioning_problem.html).

IECAM. *Geographic Region: Congressional Districts*. Accessed November 3, 2024.  
<https://iecam.illinois.edu/data-descriptions/geographic-region-congressional-districts>

Data sources:

**County adjacency data:**

U.S. Census Bureau. *County Adjacency File*. Washington, D.C.: U.S. Census Bureau, accessed November 3, 2024. [https://www2.census.gov/geo/docs/reference/county\\_adjacency.txt](https://www2.census.gov/geo/docs/reference/county_adjacency.txt).

**Population and demographic data:**

World Population Review. *U.S. County Population and Demographics*. Accessed November 3, 2024. <https://worldpopulationreview.com/us-counties>.

**Proportion of democrats and republicans in each county:**

Illinois State Board of Elections. *Vote Totals Search*. Accessed November 3, 2024.  
<https://www.elections.il.gov/electionoperations/votetotalsearch.aspx>.

**Current Congressional Districts Maps:**

The Map Shop. *Illinois 2024 Congressional Districts Wall Map* by MapShop. Accessed November 3, 2024.  
<https://www.mapshop.com/illinois-congressional-districts-wall-map/>

**Current Congressional Map**

[https://www.google.com/maps/d/viewer?mid=1qfnRiuOZ3yok6WGVvBHZ9P6u3EMy\\_LwRv&ll=41.50442556057701%2C-87.9031195&z=10](https://www.google.com/maps/d/viewer?mid=1qfnRiuOZ3yok6WGVvBHZ9P6u3EMy_LwRv&ll=41.50442556057701%2C-87.9031195&z=10)