(Work Group) Assignment 3: Integer Programming Example---Algorithmic Redistricting

**Group objectives:**

* Pick a state
* How shall we define "fairness" in the assignment of counties to congressional districts?

**Assignment Tasks:**

* **Obtain a complete list of counties** for the selected state.
* **Obtain demographic data** relating to the total population and the percentage of the population that is white only in each county. These data should come from the US Census of Population from 2020 or later. A summary list is provided at <https://worldpopulationreview.com/us-counties>. If possible, gather data relating to past statewide elections, so you can see proportions of votes for Democratic versus Republican candidates.
* **Note counties** that are geographically adjacent to one another: <https://www2.census.gov/geo/docs/reference/county_adjacency.txt>
* **Set partitioning.** Use integer programming (set partitioning) to obtain an algorithmic/optimal redistricting. After simplifying the problem by assigning high-population areas to their own districts, use integer programming to assign every county in your selected state to exactly one congressional district while striving to meet a one-person/one-vote objective through maximization or minimization.
* **Population balance.** Try to achieve population balance (one-person-one-vote). That is, congressional districts should have approximately the same population. Consider strategies for assigning more than one representative to counties with high-population centers as long as elections are county-wide. Do not divide counties geographically.
* **Compact districts.** Try to ensure that congressional districts are geographically compact (are composed of counties that are adjacent to one another). Describe constraints or objectives employed to accomplish this goal. Note any difficulties encountered in setting up constraints or objectives.
* **Solve the integer programming problem** using Python PuLP or AMPL. Note any difficulties encountered, given the size of the integer programming problem.
* **Consider secondary goals of redistricting**, such as encouraging equal representation across races. For example, you may try to achieve as much racial balance (percentage white alone versus other races) as possible across all congressional districts. Another secondary goal may be to ensure that the proportions of Democratic versus Republican representatives are approximately equal to the proportions of Democratic and Republican voters in recent statewide elections.
* **Prepare a written report of your work.** One paper per work group. **Members of the work group will share a common grade on this assignment with the understanding that all work group members contribute to the work.**

**Rubric (paper and deliverables should address the following questions):**

1. **Data sources (30 points).** What did you use for data sources? Do you have any concerns about these sources?
2. **Specification (Objective function and Constraints) (30 points).** How did you define the objective function? To what extent were you able to accommodate set covering, as well as the idea of defining geographically compact districts? Did you use county adjacency information, district compactness measures, or distance metrics. How did you implement the principle of one-person-one-vote?
3. **Programming (30 points).** Implement the linear programming problem using Python PuLP, AMPL/amplpy, or Pyomo. Provide the program code and output/listing as plain text files, posting within a GitHub repository dedicated to this assignment.
4. **Solution (30 points).** What is the optimal redistricting solution for your state? Are you prepared to submit your redistricting plan to the state's legislature, the governor, or the courts? Or does the plan need more work? Do you have any concerns about your solution?
5. **Maps and discussion (30 points).** Draw color-coded maps for your algorithmic/optimal redistricting and for the actual redistricting that was implemented by your selected state. How does your plan compare with other possible plans, such as a plan developed using the [Districtr](https://districtr.org/#how) utility? Which map would you recommend for your selected state? Can either of these plans be described as "fair and equitable"? To what extent are these plans consistent with the principle that citizens should have equal representation in voting (one person, one vote)? See Evenwel v. Abbott *(*2016). You may want to consult background information under **References**, as well as [gerrymandering on Wikipedia](https://en.wikipedia.org/wiki/Gerrymandering)

Specifics on paper:

**Paper (pdf file).** The paper/write-up should be submitted as a pdf file **(double-spaced, 4 pages max)**. Think of the paper as comprising the *methods and results* sections of a written research report. Provide a paragraph or two on methods and a paragraph or two about results for each part of this assignment. Include the redistricting maps within the paper. Submit the paper as a single pdf file with your work group number at the beginning of the file name such as **workgroup-X-assignment-3.pdf**