ALGORITHMIC REDISTRICTING FOR THE STATE OF MICHIGAN

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I. Introduction

Redistricting is the process of analyzing census reports for population distribution changes and re-establishing congressional district boundaries to promote fair democratic processes. When this occurs, it gives states the opportunity to pursue reappointment for each of their districts to ensure equal representation and balance. Although the intended goal of redistricting aims to preserve the "one person, one vote" system put in place by the United States Constitution, the process is often subject to corruption, or gerrymandering, from politicians (Redistricting 101 2021). Gerrymandering results in the purposeful partitioning of new congressional districts that ensure majority votes for or against certain groups based on their political affiliation, age, race, gender, or socioeconomic status (Gerrymandering 2024).

This study focuses on redistricting efforts for the state of Michigan. The state was last redistricted in 2022 by the Michigan Independent Citizens Redistricting Committee (MICRC) and was partitioned into thirteen districts (Figure 1). The MICRC was formed in an effort to remove legislators from the process, subsequently decreasing bias and unfair identification of district boundaries. The committee operates under guidelines set forth in the Michigan Constitution and follows criteria dictating that districts must be of equal population size, be contiguous, reflect the state's diversity, not be biased toward any political party or incumbent, reflect county and township boundaries, and be compact (Redistricting 101 n.d.). Using linear programming methods, this study aims to optimize redistricting while adhering to the aforementioned guidelines.

II. Data Selection

Accurate and current data play an instrumental role in achieving successful redistricting. For this study, relevant data published in 2024 were sourced from the World Population Review

website. The associated excel file lists each of the 83 counties in the state of Michigan along with information regarding their respective population size, population growth since 2020, area, and geographic location. Additional geospatial data was gathered by accessing shapefiles available on the United States Census Bureau's website. Each of these sources are reputable organizations, so data reliability and accuracy were not a major concern in the preparation of this study.

III. Model Specification

The strategic approach employed in this study defined an objective function within an optimization problem. This function's purpose was to minimize the weighted sum of distances between counties in the same district. This helps to create compactness within the geographical ranges of the individual districts. Several constraints were also defined to ensure a balanced division of the population. The first being the requirement that each county be assigned to only one district and not partitioned amongst multiple. This promotes both simplicity and accountability in that all residents of a county know who their appointed representatives are and can address local issues and concerns as a united front. The population balance constraint ensures that each congressional district is of equal size, which in turn assigns equal weight to each voter within the state. Balance amongst political affiliations is a constraint that plays a large role in preventing gerrymandering. When the political parties are represented in equal proportions within a district, there is a decreased chance of any party dominating the vote. Finally, county contiguity is necessary to ensure that district constituents are concentrated to a single geographical area. It plays a vital role in promoting cohesion within the communities that make up a district.

IV. Linear Programming

Linear programming was employed to solve the problem of redistricting the state of Michigan. The full python code can be found in the GitHub repository. This was initiated by importing the necessary libraries and tools in Python including pulp, pandas, geopandas, matplotlib, and math. Several functions were used to accomplish pre-processing, geographic calculations, and downloading shapefiles. Converting degrees to radians, calculating distances between two points, converting the Universal Transverse Mercator (UTM) zone, and accessing shapefile data from a URL were vital to setting the foundation for the linear programming problem. The Michigan data frame was created by extracting data from an excel file containing demographic and geographic information about each of the counties. The data was then parsed so that each line could be iterated over and every county and its adjacent counties could be extracted to create a dictionary prior to distances between county pairs being calculated. The linear programming problem was set up using the pulp library, specifically LpProblem to define the problem, LpVariable to assign decision variables, and LpSum to define the objective function and each of the four constraints. The problem was solved and a list of districts and their corresponding counties were printed before mapping. A dictionary mapping counties was achieved by parsing the optimization results and extracting the district assignment for each county. The US Census counties shapefile was downloaded and filtered for the state of Michigan, then district assignments for each county were mapped by color to represent the optimal redistricting.

V. Solution

The optimal redistricting solution for the state of Michigan involves only ten distinct districts. The counties that would fall into each district using this study's optimization approach are listed in Figure 2. Counties were mapped in colors according to the district they were

assigned (Figure 3). There are concerns regarding the contiguity and compactness of the current solution, so refinement would be required prior to presenting these findings to the state's legislature. Making adjustments to the population constraint may alter the solution in a way that promotes district compactness and ensures the requirement that counties are not geographically separated.

VI. Discussion

In comparing the map from this study (Figure 3) to that developed by the Michigan Independent Citizens Redistricting Committee (Figure 1), clear differences can be observed. The most notable being the district assignments in the upper peninsula of the state. In the map created by the MICRC, one district covers the entirety of the upper peninsula and a significant portion of northern Michigan, whereas the algorithmic redistricting performed in this study resulted in five districts covering the same area. Central and eastern Michigan are also represented quite differently on the two maps, with the algorithmically created map displaying discontinuity within the districts. Considering the criteria, the state's current district designations better support the "one person, one vote" system that redistricting is meant to achieve in that it produces better contiguity and compactness.

References

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"Redistricting 101." Michigan Independent Citizens Redistricting Commission., n.d. Accessed May 4, 2024. https://www.michigan.gov/-/media/Project/Websites/MiCRC/MISC3/Redistricting_101.pdf?rev=6a8025af10ed436ab647dad865d51b71.

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Appendix

Figure 1: Map indicating the current Michigan congressional districts and their respective counties as of 2022 (United States Congressional Delegations from Michigan 2024).

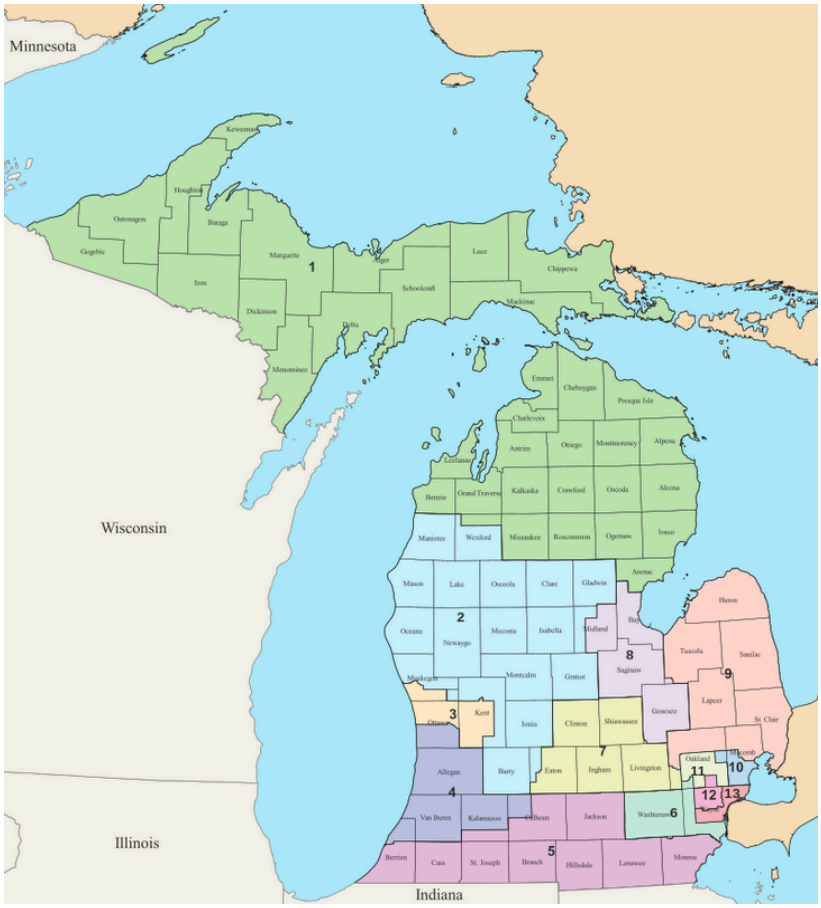

Figure 2: List of districts and the associated counties as a result of redistricting optimization.

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District 1: 'Antrim', 'Arenac', 'Baraga', 'Bay', 'Berrien', 'Branch', 'Calhoun', 'Cass', 'Charlevoix', 'Cheboygan', 'Chippewa', 'Crawford', 'Delta', 'Emmet', 'Genesee', 'Gladwin', 'Gogebic', 'Gratiot', 'Ionia',
'Iosco', 'Iron', 'Jackson', 'Kalkaska', 'Lake', 'Leelanau', 'Mackinac', 'Manistee', 'Marquette', 'Missaukee', 'Montmorency', 'Newaygo', 'Otsego', 'Presque Isle', 'Roscommon', 'Schoolcraft', 'Shiawassee', 'Van Bu
ren', 'Wexford'
District 2: 'Eaton', 'Ingham', 'Livingston'
District 3: 'Houghton', 'Ontonagon'
District 6: 'Alcona', 'Ogemaw'
District 8: 'Dickinson', 'Menominee', 'Oakland', 'Washtenaw'
District 9: 'Huron', 'Tuscola'
District 10: 'Alger', 'Allegan', 'Barry', 'Benzie', 'Clare', 'Clinton', 'Grand Traverse', 'Hillsdale', 'Kalamazoo', 'Keweenaw', 'Lenawee', 'Luce', 'Mason', 'Montcalm', 'Oceana', 'Osceola', 'Ottawa', 'Sanilac',
'St. Clair', 'St. Joseph'
District 11: 'Isabella', 'Kent', 'Lapeer', 'Macomb', 'Mecosta', 'Muskegon'
District 12: 'Alpena', 'Monroe', 'Oscoda', 'Wayne'
District 13: 'Midland', 'Saginaw'
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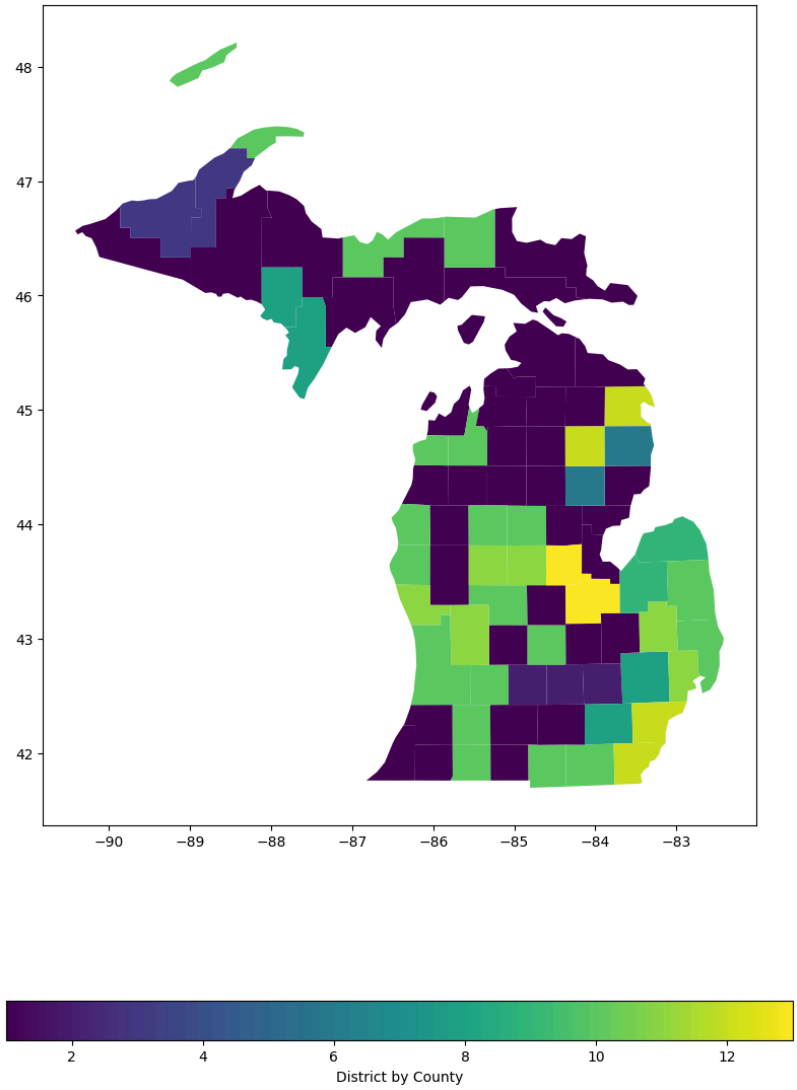
Figure 3: Map of the 10 congressional districts identified in this study through linear programming.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District by County