The Rise of the Hal-mander: Is Gerrymandering by Algorithm the Next Frontier of Partisan Gerrymandering?

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INTRODUCTION

We cannot automate partisan gerrymandering out of existence, but we might perpetuate it through automation. Every ten years, around the United States, state legislatures and independent commissions draw new districts for congressional and state legislative elections, and many of these mapmakers rely on complex software and computer algorithms.[1] A redistricting consultant can use an algorithm to generate thousands of gerrymandered maps that comply with state and federal redistricting requirements.[2] Reformers also craft redistricting proposals through algorithms.[3] Like the consultant who generates thousands of gerrymandered maps, a reformer can generate thousands of nongerrymandered[4] maps that comply with state and federal redistricting requirements.[5] Whether to gerrymander more efficiently under the cover of a facially neutral algorithm or to prevent gerrymandering by handing control to a facially neutral algorithm, states might consider an automated redistricting process.

One example can be found in North Carolina. North Carolina decided its state legislative districts in 2019 with a nearly automated redistricting process.[6] After a state court ruled that North Carolina's state senate and house districts were

1. Sam Levine, *'From Dark Art to Dark Science': The Evolution of Digital Gerrymandering*, GUARDIAN (Aug. 22, 2021, 4:00 AM), https://www.theguardian.com/us-news/2021/aug/22/gerrymandering-us-electoral-districts-congress [https://perma.cc/37FL-VDVN].

2. *Id.*

3. *See infra* Section I.C.2.

4. It is important to note that these maps are not necessarily objective because algorithms require choices, which have political consequences. *See infra* Section IV.A.1.

5. *See infra* Section I.C.2.

6. *See* Common Cause v. Lewis, No. 18 CVS 014001, 2019 WL 13198027, at *3 (N.C. Super. Ct. Oct. 28, 2019); Miles Parks, *A Surprise Vote, Thrown Phone and Partisan 'Mistrust' Roil N.C. as Maps*

unconstitutional because of partisan bias, the Republican majority had to redraw the districts.[7] The first step of the process was entirely automated. University of Michigan Professor Jowei Chen, who testified as an expert witness against the State in the litigation, produced a large set of redistricting plans for North Carolina's state senate and house.[8] The mapmakers ranked all of the computer-generated plans based on traditional redistricting criteria and selected the top five plans.[9] The legislators used a state lottery machine to randomly select one of the five redistricting plans to use as a base plan.[10] This new plan was enacted after a few minor modifications, such as unpairing incumbents who were placed in the same district.[11]

On its face, this process in North Carolina is what many reformers have called for. The legislature relied predominantly on a redistricting algorithm and facially neutral instructions to select its redistricting plans. However, the enacted state house districts had fewer Democratic-leaning seats than 95% of a sample of simulated plans.[12] In reviewing the new plan, the court admitted that mapmakers may not have selected the optimal plan, but it was reasonable to rely on an automated process despite evidence that the resulting districts were motivated by partisanship.[13] Thus, North Carolina's nearly automated redistricting process was affirmed by the court.

A second example can be found in Mexico. Mexico has relied on a nearly automated redistricting process for decades. Like the United States, Mexico's lower legislative body has single-member districts that are apportioned to its states.[14] The National Electoral Institute of Mexico, an independent administrative body, is responsible for drawing these districts.[15] Since 1996, the Institute has relied on a redistricting algorithm that weighs traditional redistricting criteria to generate

Are Redrawn, NPR (Sept. 16, 2019, 5:19 AM), https://www.npr.org/2019/09/16/760177030/a-surprise-vote-thrown-phone-and-partisan-mistrust-roil-n-c-as-maps-are-redrawn [https://perma.cc/7WW9-AZNG].

7. Parks, *supra* note 6; Common Cause v. Lewis, No. 18 CVS 014001, 2019 WL 4569584, at *135–37 (N.C. Super. Ct. Sept. 3, 2019).

8. Parks, *supra* note 6.

9. *Id.*; *Lewis*, 2019 WL 13198027, at *3.

10. Parks, *supra* note 6; Miles Parks (@MilesParks), TWITTER (Sept. 11, 2019, 8:28 PM), https://twitter.com/MilesParks/status/1171943607441530880 [https://perma.cc/8K82-NQJ5].

11. *Lewis*, 2019 WL 13198027, at *7.

12. Plaintiffs' Response to Legislative Defendants' Reply on Remedial Plans at 1–2, *Lewis*, No. 18 CVS 014001 (N.C. Super. Ct. Oct. 7, 2019). More specifically, Dr. Chen produced two sets for his analysis: Set 1, which followed traditional districting principles, and Set 2, which avoided pairing incumbents. *Lewis*, 2019 WL 4569584, at *18, *22. The remedial plans had fewer Democratic-leaning seats than 94.6% of Set 1 and 97.8% of Set 2. Plaintiffs' Response to Legislative Defendants' Reply on Remedial Plans, *supra*.

13. *See Lewis*, 2019 WL 13198027, at *3.

14. Alejandro Trelles, Micah Altman, Eric Magar & Michael P. McDonald, *Open Data, Transparency and Redistricting in Mexico*, 23 POLÍTICA Y GOBIERNO 331, 334–35 (2016).

15. Alejandro Trelles, Micah Altman, Eric Magar & Michael McDonald, No Accountability Without Transparency and Consistency: Redistricting-by-Formula in Mexico 2 & n.3 (Jan. 8, 2021) (unpublished manuscript) (available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3762805 [https://perma.cc/4WHG-FDVK]).

redistricting plans.[16] The result from the automated algorithm produces the "first scenario," to which political parties can submit counterproposals that attempt to score lower on the Institute's objective scoring function.[17] After evaluating the algorithm's result and the counterproposals, the Institute produces a "second scenario," to which the political parties may again submit counterproposals.[18] The Institute again evaluates the prior output with the counterproposals to select a "final scenario" that is recommended for adoption.[19] Theoretically, the Institute should only adopt counterproposals that score better on the objective function, but there is some question whether it actually does this.[20] Thus, like the process in North Carolina in 2019, the process in Mexico is nearly automated.

Many reformers have called for a fully automated redistricting process that relies entirely on an algorithm in an attempt to remove bias from redistricting.[21] Unlike the North Carolina and Mexico examples where politicians were able to submit minor modifications, under this approach, a redistricting algorithm would take an input, such as census data, and produce a single redistricting plan that would be automatically enacted. No human intervention is required. The reformers propose a variety of algorithms that could be used to produce legal redistricting plans.[22]

These examples show that "[redistricting] algorithms are here to stay. The only question is what role they will play."[23] This Note explores the legal limits of redistricting by algorithm and gerrymandering by algorithm, which this Note will call "hal-mandering," named after the computer villain, HAL 9000, in the film *2001: A Space Odyssey*.[24] Although academic literature has extensively debated the benefits and consequences of an automated redistricting process, it has not explored the legal limits of delegating authority to a computer, the limits of algorithms that gerrymander in states that prohibit partisan gerrymandering, or the risks that result from implementing a fully (or nearly) automated redistricting process. This Note aims to answer those questions and will proceed in four Parts.

Part I will review the background on redistricting, including the history of redistricting law, types of redistricting reform efforts, and the modern developments of redistricting technology. Part II will explore two potential motivations for redistricting by algorithm: reform by algorithm and hal-mandering. In the first scenario, algorithm designers have neutral intentions and could implement an

16. *See id.* at 2–5.
17. *Id.* at 5–6.
18. *Id.* at 6.
19. *Id.*
20. *See id.*
21. *See infra* Section I.A.
22. *See infra* Section I.C.2.
23. Emily Rong Zhang, *Bolstering Faith with Facts: Supporting Independent Redistricting Commissions with Redistricting Algorithms*, 109 CALIF. L. REV. 987, 989 (2021).
24. HAL 9000 is an omniscient computer villain in the film *2001: A Space Odyssey*. Gerry Flahive, *The Story of a Voice: HAL in '2001' Wasn't Always So Eerily Calm*, N.Y. TIMES (Mar. 30, 2018), https://www.nytimes.com/2018/03/30/movies/hal-2001-a-space-odyssey-voice-douglas-rain.html.

algorithm as an attempt to remove bias from the redistricting process. In the second scenario, algorithm designers have partisan interests and use a redistricting algorithm to implement partisan gerrymanders. Part III will evaluate whether redistricting by algorithm is legal under current state and federal law. In particular, the analysis will focus on whether states can delegate redistricting authority to a computer program and whether hal-manders are constitutional. Part IV raises risks that might emerge if states were to adopt redistricting by algorithm. These risks include fights over the redistricting criteria and their weights, loosening of the current redistricting requirements, and shifting gerrymandering to other arenas, such as the collection of census data.

I. BACKGROUND

In the United States, many federal and state elections follow an electoral district model where each representative is assigned to a geographical unit, which is called a *district*.[25] Most districts in the United States are required to be updated at a regular frequency; this is called *redistricting*.[26] The qualities of a "good" electoral district raise questions of political philosophy and are hotly debated.[27] This ambiguity has allowed mapmakers to engage in politically motivated redistricting, which is called *gerrymandering*.[28] There are many forms of gerrymandering, including racial gerrymandering, prison gerrymandering, partisan gerrymandering, bipartisan gerrymandering, and competitive gerrymandering.[29] This Note will focus primarily on partisan gerrymandering and proposes "hal-mandering" as a new category describing partisan gerrymandering by algorithm. This Part explores the historical background of redistricting and gerrymandering, modern redistricting requirements, and recent developments in redistricting technology.

A. BACKGROUND ON REDISTRICTING

History shows a push and pull between ambitious gerrymanders and efforts to prevent the practice. There is a long history of gerrymandering; historians have documented cases of partisan gerrymandering in the colony of Pennsylvania in

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25. *See What Is Redistricting?*, LOY. L. SCH.: ALL ABOUT REDISTRICTING, https://redistricting.lls.edu/redistricting-101/what-is-redistricting/ [https://perma.cc/6XTS-B3ZL] (last visited Feb. 10, 2023).

26. *Id.*

27. *See* Justin Levitt, *Essay: Weighing the Potential of Citizen Redistricting*, 44 LOY. L.A. L. REV. 513, 524 (2011).

28. Daniel D. Polsby & Robert D. Popper, *The Third Criterion: Compactness as a Procedural Safeguard Against Partisan Gerrymandering*, 9 YALE L. & POL'Y REV. 301, 301 (1991); *see* Vieth v. Jubelirer, 541 U.S. 267, 271 n.1 (2004) (plurality opinion) (citing *Gerrymandering*, BLACK'S LAW DICTIONARY (7th ed. 1999)).

29. *See* Shaw v. Reno, 509 U.S. 630, 641–42 (1993) (discussing racial gerrymandering); Justin Buchler, *The Inevitability of Gerrymandering: Winners and Losers Under Alternative Approaches to Redistricting*, 5 DUKE J. CONST. L. & PUB. POL'Y 17, 19–33 (2010) (discussing partisan, bipartisan, and competitive gerrymandering); Hansi Lo Wang & Kumari Devarajan, *'Your Body Being Used': Where Prisoners Who Can't Vote Fill Voting Districts*, NPR: CODE SW!TCH (Dec. 31, 2019, 5:00 AM), https://www.npr.org/sections/codeswitch/2019/12/31/761932806/your-body-being-used-where-prisoners-who-can-t-vote-fill-voting-districts [https://perma.cc/F363-QVXU] (discussing prison gerrymandering).

1701,[30] the colony of North Carolina in 1732,[31] the Commonwealth of Virginia in 1788,[32] and the Commonwealth of Massachusetts in 1812[33]—Governor Elbridge Gerry's infamous "Gerry-Mander."[34]

Throughout the mid-1800s, the push for reform came from Congress. From 1842 to 1901, Congress attempted to limit gerrymandering in House elections by requiring single-member districts,[35] population equality,[36] and compactness.[37]

The 1920s demonstrated a pullback to gerrymandering. The Republican majority in Congress was threatened by the demographic shifts toward urban areas, and in 1929, Congress removed the equal population and compactness requirements.[38] This change permitted "rural malapportionment," in which state legislatures would create small rural congressional districts and larger urban districts so that the state's congressional delegation had stronger rural representation.[39] For example, in the 1930s, New York's largest congressional district had 799,407 people and the smallest district had 90,671.[40] Many states did not change their election districts for decades, which allowed the disparity between urban and rural districts to grow further.[41]

The Supreme Court renewed the push for reform in 1962 in *Baker v. Carr*, in which it held that apportionment claims under the Fourteenth Amendment were justiciable.[42] A series of subsequent cases required that districts be equally sized for both congressional[43] and state legislative[44] districts under the "one person,

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30. ELMER CUMMINGS GRIFFITH, THE RISE AND DEVELOPMENT OF THE GERRYMANDER 26 (1907).

31. *Id.* at 28; *see Vieth*, 541 U.S. at 274 (quoting 3 COLONIAL RECORDS OF NORTH CAROLINA 380–81 (William L. Saunders ed., 1886)).

32. *See Vieth*, 541 U.S. at 274 (referring to alleged attempts "to gerrymander James Madison out of the First Congress"); GRIFFITH, *supra* note 30, at 31–32.

33. Jennifer Davis, *Elbridge Gerry and the Monstrous Gerrymander*, LIBR. CONG.: IN CUSTODIA LEGIS (Feb. 10, 2017), https://blogs.loc.gov/law/2017/02/elbridge-gerry-and-the-monstrous-gerrymander/ [https://perma.cc/XF3Y-G7N4].

34. *See, e.g.*, *The Gerry-Mander*, BOS. GAZETTE, Mar. 26, 1812, at 2, https://www.loc.gov/exhibits/treasures/tr22a.html#obj20 [https://perma.cc/5K7W-TJ6A]; *The Gerry-Mander*, SALEM GAZETTE, Apr. 2, 1813, https://americanhistory.si.edu/collections/search/object/nmah_509530 [https://perma.cc/FP27-SATG].

35. *Vieth*, 541 U.S. at 276 (citing GRIFFITH, *supra* note 30, at 12); *see* Apportionment Act of 1842, ch. 47, 5 Stat. 491. A single member district is an electoral geography that has a single representative. Anthony Bertelli & Lilliard E. Richardson, Jr., *Ideological Extremism and Electoral Design. Multimember Versus Single Member Districts*, 137 PUB. CHOICE 347, 347–48 (2008).

36. *Vieth*, 541 U.S. at 276 (quoting Apportionment Act of 1872, ch. 11, § 2, 17 Stat. 28, 28). Population equality requires districts to have roughly the same population. *See infra* Section I.B.1.

37. *Vieth*, 541 U.S. at 276 (citing Apportionment Act of 1901, ch. 93, 31 Stat. 733). Compactness measures whether a district shape is regular and whether district boundaries are close to the geographic center. *See infra* Section I.B.3.

38. Margo Anderson, Baker v. Carr*, the Census, and the Political and Statistical Geography of the United States: The Origin and Impact of Public Law 94-171*, 62 CASE W. RSRV. L. REV. 1153, 1161 (2012).

39. *See id.*

40. *Id.* at 1162.

41. *See id.* at 1162, 1166.

42. 369 U.S. 186, 187–88, 237 (1962).

43. Wesberry v. Sanders, 376 U.S. 1, 18 (1964).

44. Reynolds v. Sims, 377 U.S. 533, 568 (1964).

one vote" principle.[45] As a result of these decisions, states were forced to redraw their districts every ten years when the new census data was released.[46] Although these cases prevented malapportionment, decennial redistricting opened a new opportunity to gerrymander with increasingly precise census data.[47] The pull toward gerrymandering has become even more precise with advances in mapping technology and redistricting software.[48]

The modern push to reform has taken several forms, and most forms involve the use of redistricting algorithms.[49] First, the judiciary has pushed reform by striking down particular districts.[50] Today, most redistricting cases include evidence of alternative districts that were drawn by algorithm, which can be used to show intent to gerrymander and that certain technical requirements are achievable.[51] Second, accessibility and transparency initiatives allow voters to understand how the final districts were reached, evaluate proposals, and draw their own plans, often with redistricting algorithms.[52] Several free platforms allow voters to draw and evaluate redistricting plans with the aid of powerful algorithms.[53]

45. Gray v. Sanders, 372 U.S. 368, 381 (1963). *See generally Redistricting and the Supreme Court: The Most Significant Cases*, NAT'L CONF. ST. LEGISLATURES (Sept. 14, 2021), https://www.ncsl.org/research/redistricting/redistricting-and-the-supreme-court-the-most-significant-cases.aspx [https://perma.cc/7CV7-3G5J] (providing a comprehensive list of significant Supreme Court cases on redistricting).

46. *See* Anderson, *supra* note 38, at 1166–68.

47. *See* Adam B. Cox & Richard T. Holden, *Reconsidering Racial and Partisan Gerrymandering*, 78 U. CHI. L. REV. 553, 558 (2011); *see also* Anderson, *supra* note 38, at 1166–70 (discussing the data needs for decennial redistricting).

48. *See* Levine, *supra* note 1.

49. Zhang, *supra* note 23, at 987 ("[T]hese algorithms will play a prominent, if not starring, role in future redistricting reform."). Not all reform efforts require the use of technology. State legislatures have pushed for reform by restricting how the lines can be drawn, such as by requiring compactness, communities of interest, competitiveness, or proportionality, which makes it harder to gerrymander. *See* Kaila Preston, Note, *Overcoming Gerrymandering: Analyzing Past Approaches and Looking to Automation to Overcome Bias and Cognitive Limitations in Florida*, 50 STETSON L. REV. 659, 671–76 (2021).

50. *See* Zhang, *supra* note 23, at 995–97 (noting that "[g]ood government groups" have used state and federal courts as a mechanism for reform and that redistricting algorithms play a significant role in redistricting litigation).

51. *Id.* at 997–99; *see, e.g.*, Plaintiffs' Proposed Findings of Fact at 103, Whitford v. Nichol, No. 15-cv-421 (W.D. Wis. May 9, 2016), ECF No. 73 ("That the Current Plan falls so far outside the distribution of simulated plans in every respect both supports the inference that it was designed with partisan intent and indicates that its extreme partisan asymmetry was unjustified by legitimate factors."). The use of algorithms in redistricting litigation is a new approach that only started in 2015. *See* Zhang, *supra* note 23, at 997 n.33 (citing League of Women Voters of Fla. v. Detzner, 172 So. 3d 363, 407–08 (Fla. 2015)); *see also* Harry Stevens, *Can Computer Simulations Help Fix Democracy?*, WASH. POST (Aug. 22, 2022), https://www.washingtonpost.com/politics/interactive/2022/algorithmic-redistricting/ ("During this redistricting cycle, map ensembles have been used as evidence in litigation in 11 states.").

52. Rebecca Green, *Redistricting Transparency*, 59 WM. & MARY L. REV. 1787, 1831–33 (2018); *see Roadmap to Transparent Redistricting*, DRAW LINES PA (Aug. 3, 2021), https://drawthelinespa.org/blog/roadmap-to-transparent-redistricting [https://perma.cc/4X3U-58ZS] (proposing transparency reforms for Pennsylvania redistricting).

53. *See, e.g.*, *Welcome to Dave's Redistricting*, DRA 2020, https://davesredistricting.org [https://perma.cc/Z428-QJGY] (last visited Feb. 10, 2023); *redist: Simulation Methods for Legislative Redistricting*, COMPREHENSIVE R ARCHIVE NETWORK (June 16, 2022), https://cran.r-project.org/package=redist [https://perma.cc/G6Z2-XLBY] (offering an R software package that evaluates redistricting plans

Third, nine states have enacted independent redistricting commissions.[54] One proposal suggests supplementing the work of these commissions with redistricting algorithms to teach novice mapmakers about the possible maps available to them, enable the mapmakers to draw better maps, and illustrate the trade-offs of improving one criterion to the detriment of another.[55] Finally, some have proposed a fully automated redistricting process.[56] States could run a fixed algorithm that receives census data as its input and produces a redistricting plan that is automatically enacted.[57] In the push and pull between reform and aggressive gerrymandering, redistricting algorithms play a significant role in the push for reform. However, this Note will show that algorithms also might play an even stronger role in the pull back to aggressive gerrymandering.

B. REDISTRICTING REQUIREMENTS AND CRITERIA

Redistricting requirements create the basic specifications that any redistricting algorithm purporting to draw legal districts must follow. Redistricting requirements come from the U.S. Constitution, federal statutes, and state law. This Section discusses some common requirements, which are measured differently. Some states provide specific measures, but others do not. Some criteria, like population equality, are mandatory,[58] while others, like preserving political boundaries, tend to be more flexible, using language like "to the extent practicable."[59]

1. Population Equality

Under the U.S. Constitution, congressional and state legislative districts must be as equal in population as practicable.[60] The Court has required that congressional

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based on sampling, efficiency gap, and proportional representation); DISTRICTBUILDER, https://www.districtbuilder.org [https://perma.cc/G8TU-7R2R] (last visited Feb. 10, 2023).

54. *Who Draws the Lines?*, LOY. L. SCH.: ALL ABOUT REDISTRICTING, https://redistricting.lls.edu/redistricting-101/who-draws-the-lines/ [https://perma.cc/JSU9-M635] (last visited Feb. 10, 2023) (listing Alaska, Arizona, California, Colorado, Idaho, Michigan, Montana, New York, and Washington as states with independent redistricting commissions).

55. *See* Zhang, *supra* note 23, at 991.

56. *E.g.*, Preston, *supra* note 49, at 662 ("Florida should adopt the use of computer algorithms in its redistricting process."); Olivia Guest, Frank J. Kanayet & Bradley C. Love, *Gerrymandering and Computational Redistricting*, 2 J. COMPUTATIONAL SOC. SCI. 119, 121 (2019); Michelle H. Browdy, Note, *Computer Models and Post-*Bandemer *Redistricting*, 99 YALE L.J. 1379, 1385 (1990).

57. *See* Daniel B. Magleby & Daniel B. Mosesson, *A New Approach for Developing Neutral Redistricting Plans*, 26 POL. ANALYSIS 147, 147 (2018) ("Computers hold the potential to draw legislative districts in a neutral way."); Guest et al., *supra* note 56; *see also* Zhang, *supra* note 23, at 1007 ("With redistricting algorithms, the locus of commissions' legitimacy shifts from who the commissioners are to what they produce.").

58. *See What Is Redistricting?*, *supra* note 25.

59. *See Where Are the Lines Drawn?*, LOY. L. SCH.: ALL ABOUT REDISTRICTING, https://redistricting.lls.edu/redistricting-101/where-are-the-lines-drawn/ [https://perma.cc/D9T4-BS6H] (last visited Feb. 10, 2023) ("By state constitution or statute, 34 states require state legislative districts to show some accounting for political boundaries; 15 states impose similar constraints on congressional districts. Most often, state law concerning political boundaries leaves a fair amount of flexibility in the mandate — one common instruction is to keep to political boundaries 'to the extent practicable.'").

60. U.S. CONST. art. I, § 2, cl. 3; *id.* amend. XIV, § 2; *see* Wesberry v. Sanders, 376 U.S. 1, 7–8 (1964) ("[A]s nearly as is practicable one man's vote in a congressional election is to be worth as much as another's.").

districts have almost exactly equal-population districts unless the state can justify any population deviation as "necessary to achieve some legitimate state objective."[61] For example, the Court permitted West Virginia to have a total population deviation of 0.79% when the state had a legitimate interest to avoid contests between incumbents, preserve county boundaries, and minimize population shifts between districts.[62] Most congressional districts, however, have a population deviation of 0%.[63]

For state legislative districts, the U.S. Constitution still requires population equality,[64] but the Court has recognized the difficulty of reaching population equality for these smaller districts.[65] State legislative plans that have a total population deviation greater than or equal to 10% create a prima facie constitutional violation and must be justified by a legitimate state interest.[66] Plans with a population deviation of less than 10% are considered "minor deviations" and often held to comply with the constitutional requirement.[67]

2. Race-Based Redistricting

The U.S. Constitution and Voting Rights Act limit how race is used in drawing districts.[68] The Fourteenth Amendment prohibits laws that differentiate between people on the basis of race without a compelling state interest.[69] In redistricting, mapmakers cannot draw lines with the purpose of harming voters of a protected class.[70] The Supreme Court has found that race cannot be the predominant factor

61. Karcher v. Daggett, 462 U.S. 725, 730, 740–41 (1983).

62. Tennant v. Jefferson Cnty. Comm'n, 567 U.S. 758, 764–65 (2012) (per curiam).

63. In the 2010 redistricting cycle, thirty-eight states had a 0.0% population deviation. *2010 Redistricting Deviation Table*, NAT'L CONF. ST. LEGISLATURES (Jan. 15, 2020) [https://perma.cc/3YQH-R3FL]. Arkansas had 0.06% population deviation, Hawaii and Idaho had 0.1% population deviation, Mississippi had 0.2% population deviation, and West Virginia had 0.79% population deviation. *Id.* Thus, in practice, West Virginia is an outlier.

64. U.S. CONST. amend. XIV, § 1. *Reynolds v. Sims* applied the "one person, one vote" standard to state legislative districts. 377 U.S. 533, 558, 568 (1964) (quoting Gray v. Sanders, 372 U.S. 368, 381 (1963)).

65. *See Reynolds*, 377 U.S. at 577; Gaffney v. Cummings, 412 U.S. 735, 745–48 (1973).

66. Brown v. Thomson, 462 U.S. 835, 842–43 (1983) (citing Swann v. Adams, 385 U.S. 440, 444 (1967)); *see* Voinovich v. Quilter, 507 U.S. 146, 161–62 (1993) (concluding that a state legislative redistricting plan with a population deviation greater than 10% could be constitutional if justified by a legitimate state interest).

67. *Brown*, 462 U.S. at 842; *see, e.g.*, Connor v. Finch, 431 U.S. 407, 418 (1977); White v. Regester, 412 U.S. 755, 764 (1973). *But see* Larios v. Cox, 300 F. Supp. 2d 1320, 1332, 1338 (N.D. Ga. 2004) (holding that a redistricting plan with a population deviation under 10% violated the constitutional requirement when there was no legitimate state interest for the population deviation because the mapmakers in part aimed to protect incumbents).

68. *See generally* BENJAMIN HAYES, CONG. RSCH. SERV., LSB10273, RACIAL GERRYMANDERING: PAST CASES AND THE SUPREME COURT'S UPCOMING DECISION IN *BETHUNE-HILL II* (2019) (discussing racial gerrymandering precedents).

69. *See* U.S. CONST. amend. XIV; Shaw v. Reno, 509 U.S. 630, 643, 653 (1993).

70. Gomillion v. Lightfoot, 364 U.S. 339, 346 (1960) ("When a legislature thus singles out a readily isolated segment of a racial minority for special discriminatory treatment, it violates the Fifteenth Amendment."); Wright v. Rockefeller, 376 U.S. 52, 56 (1964) (applying the same logic to congressional districts); *Shaw*, 509 U.S. at 649 ("For these reasons, we conclude that a plaintiff challenging a reapportionment statute under the Equal Protection Clause may state a claim by alleging that the

for drawing lines, but if it is, its use must serve a compelling interest.[71] Complying with Section 2 of the Voting Rights Act is a compelling interest.[72]

Courts have required mapmakers to draw majority-minority districts in certain circumstances[73] to allow a minority community of interest to elect a candidate of its choice.[74] When a state does not have enough majority-minority districts, a court can invalidate its districts and require the mapmakers to redistrict with more minority representation in mind.[75]

The racial gerrymandering jurisprudence is outside the scope of this Note, but there are overlaps with partisan gerrymandering. Majority-minority districts impact partisan outcomes, so there may be a blurry line between racial and partisan gerrymandering.[76] Further, the manipulations described in this Note, such as using facially neutral algorithms to hide ulterior partisan motives, could also be used to hide race-based discrimination.

3. Compactness

Some state laws require compact districts.[77] Compactness is a complex concept that includes both whether a district shape is "regular" and whether the district boundaries are close to the geographic center, called *dispersion*.[78] Scholars have proposed nearly one hundred measures of compactness, and it is possible for a district to score well on one measure and poorly on another.[79] Although most states have compactness requirements, they do not provide specific measures.[80] A

legislation, though race neutral on its face, rationally cannot be understood as anything other than an effort to separate voters into different districts on the basis of race, and that the separation lacks sufficient justification."); *see Redistricting Criteria and Legal Requirements*, UCLA LATINO POL'Y & POL. INST., https://latino.ucla.edu/redistricting-criteria-and-legal-requirements/ [https://perma.cc/QY3G-NJ36] (last visited Feb. 13, 2023).

71. Cooper v. Harris, 581 U.S. 285, 291–92 (2017).

72. *Id.* at 292 ("This Court has long assumed that one compelling interest is complying with . . . the Voting Rights Act . . . .").

73. *See* League of United Latin Am. Citizens v. Perry, 548 U.S. 399, 425 (2006) (referring to the three requirements from *Thornburg v. Gingles*, 478 U.S. 30, 50–51 (1986)).

74. *See generally* HAYES, *supra* note 68 (discussing cases that required mapmakers to draw new districts).

75. *See id.*

76. Kristen Clarke & Jon Greenbaum, *Gerrymandering Symposium: The Racial Implications of Yesterday's Partisan Gerrymandering Decision*, SCOTUSBLOG (June 28, 2019, 2:01 PM), https://www.scotusblog.com/2019/06/gerrymandering-symposium-the-racial-implications-of-todays-partisan-gerrymandering-decision/ [https://perma.cc/Q7CH-JWRL] (discussing how mapmakers might have both racial and partisan motives).

77. Thirty-two states require state legislative districts to be compact, and seventeen require congressional districts to be compact. *Where Are the Lines Drawn?*, *supra* note 59.

78. Aaron R. Kaufman, Gary King & Mayya Komisarchik, *How to Measure Legislative District Compactness if You Only Know It When You See It*, 65 AM. J. POL. SCI. 533, 533, 535 (2021); *see What Are Measures of Compactness?*, CALIPER, https://www.caliper.com/glossary/what-are-measures-of-compactness.htm [https://perma.cc/5XXQ-GCY2] (last visited Feb. 13, 2023) (listing nine compactness measures that the Caliper software can evaluate).

79. *See* Kaufman et al., *supra* note 78, at 533–34, 536.

80. *See Where Are the Lines Drawn?*, *supra* note 59.

state might vaguely require mapmakers to avoid "oddly shaped" districts[81] or simply state "Legislative Districts shall be compact."[82] Thus, this redistricting requirement is difficult to enforce.

4. Preservation of Communities of Interest

Many states require mapmakers to consider communities of interest.[83] A community of interest is a group of people with a common interest, such as a group that holds common social, economic, cultural, or political interests.[84] Which communities to consider and how much weight to give each factor is debatable.[85] Preserving these communities tends to contradict other redistricting criteria, such as competitiveness,[86] and preserving one community may lead to the division of another community of interest.[87] Thus, this criterion is notoriously difficult to enforce because there is no agreed-upon measure for identifying which communities should be preserved.

5. Preservation of Political Boundaries

Many state laws require mapmakers to preserve political boundaries but allow flexibility to satisfy other redistricting requirements.[88] Political boundaries include county, town, city, or ward lines.[89] The most common measure is based on the number of splits, when a political boundary is split between two or more districts.[90] For example, North Carolina requires mapmakers to minimize the number of county splits.[91] Preserving political boundaries often involves a trade

81. IDAHO CODE § 72-1506(4) (2022) ("To the maximum extent possible, the plan should avoid drawing districts that are oddly shaped.").

82. ILL. CONST. art. IV, § 3(a) ("Legislative Districts shall be compact, contiguous and substantially equal in population. Representative Districts shall be compact, contiguous, and substantially equal in population."); *see* Kaufman et al., *supra* note 78, at 534.

83. BRENNAN CTR. FOR JUST., COMMUNITIES OF INTEREST (Nov. 2010), https://www.brennancenter.org/sites/default/files/analysis/6%20Communities%20of%20Interest.pdf [https://perma.cc/8WQH-V2W9] (listing twenty-four states with community-of-interest requirements).

84. *Where Are the Lines Drawn?*, *supra* note 59; *Redistricting Criteria*, NAT'L CONF. ST. LEGISLATURES (July 16, 2021), https://www.ncsl.org/redistricting-and-census/redistricting-criteria [https://perma.cc/F8YJ-RHRP].

85. *See* Karin Mac Donald & Bruce E. Cain, *Community of Interest Methodology and Public Testimony*, 3 U.C. IRVINE L. REV. 609, 635 (2013).

86. *See id.*

87. *See* United Jewish Orgs. of Williamsburgh, Inc. v. Carey, 430 U.S. 144, 152 (1977) (plurality opinion) (explaining that New York divided the Hasidic Jewish community into multiple districts to increase the representation of nonwhite voters).

88. *Where Are the Lines Drawn?*, *supra* note 59.

89. *Id.*

90. *See, e.g.*, OHIO CONST. art. XI, § 3(C)(3) ("Where feasible, no county shall be split more than once."); N.C. CONST. art. II, §§ 3, 5 ("No county shall be divided in the formation of a [senate or representative] district.").

91. N.C. CONST. art. II, §§ 3, 5; *see* JOINT SELECT COMM. ON CONG. REDISTRICTING, N.C. GEN. ASSEMBLY, 2016 CONTINGENT CONGRESSIONAL PLAN COMMITTEE ADOPTED CRITERIA (2016), https://www.ncleg.gov/Files/GIS/ReferenceDocs/2016/CCP16_Adopted_Criteria.pdf [https://perma.cc/9TVF-ENSN].

off with population equality,[92] but courts will permit higher population deviations to promote this traditional redistricting criterion.[93]

6. Competitiveness

In a competitive district, the representative's party affiliation is reasonably likely to change periodically.[94] The likelihood of change can be measured by past voting data or party registration data.[95] Competitiveness must be a subordinate goal to the Voting Rights Act, which might require less competitiveness in a majority-minority district so that the minority community of interest can elect a representative of its choice.[96]

7. Proportionality

A redistricting plan is proportional when the statewide proportion of votes for Democratic to Republican candidates is roughly equal to the proportion of Democratic to Republican representatives.[97] Only Missouri and Ohio require proportionality for state legislative districts.[98]

8. Measuring Redistricting Criteria

For most of the redistricting criteria described in this Section, there are several ways to measure whether the mapmakers have satisfied the criteria. This Note explains the common measures for population equality and proportionality as notable examples.[99]

Population equality can be measured by the total population deviation or the average population deviation.[100] Both measures require calculating the variance of each district population from the mean (the total population of the state divided

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92. For example, West Virginia has a historical practice of preserving county lines and produced a redistricting plan with a higher population deviation as a result. *See* Jefferson Cnty. Comm'n v. Tennant, 876 F. Supp. 2d 682, 685, 687 (S.D. W. Va. 2012).

93. *See supra* notes 62–63 and accompanying text.

94. *See* COLO. CONST. art. V, § 44.3(3)(d); *Redistricting Criteria*, *supra* note 84; *see also* ARIZ. CONST. art. IV, pt. 2, § 1(14)(F); WASH. REV. CODE § 44.05.090(5).

95. *See* COLO. CONST. art. V, § 44.3(3)(d) ("Competitiveness may be measured by factors such as a proposed district's past election results, a proposed district's political party registration data, and evidence-based analyses of proposed districts."); ERIC MCGHEE, PLANSCORE, MEASURING COMPETITIVENESS IN REDISTRICTING (2021), https://irc.az.gov/measuring-competitiveness-redistricting-presentation-72021 [https://perma.cc/2P84-2H6H]. *But see* Common Cause v. Lewis, No. 18 CVS 014001, 2019 WL 4569584, at *20 (N.C. Super. Ct. Sept. 3, 2019) ("[I]t is well-known in academic literature and in the redistricting community that party registration is not a reliable indicator of actual partisan voting behavior.").

96. *See supra* Section I.B.2.

97. *See Redistricting Criteria*, *supra* note 84.

98. *See id.*; MO. CONST. art. III, § 3(b)(5); OHIO CONST. art. XI, § 6(B).

99. Although this Note focuses on population equality and proportionality as notable examples, mapmakers can choose among several measures for compactness, communities of interest, political boundaries, and competitiveness. For a discussion of the many measures, see Kaufman et al., *supra* note 78, at 536 (compactness); Mac Donald & Cain, *supra* note 85 (communities of interest); *Where Are the Lines Drawn?*, *supra* note 59 (political boundaries, including counties, towns, cities, and ward lines); and COLO. CONST. art. V, § 44.3(3)(d) (competitiveness).

100. *See* L. PAIGE WHITAKER, CONG. RSCH. SERV., LSB10639, CONGRESSIONAL REDISTRICTING 2021: LEGAL FRAMEWORK 1 (2021), https://crsreports.congress.gov/product/pdf/LSB/LSB10639 [https://perma.cc/Q8TS-C7SM].

by the number of districts). Under the total population deviation, the variances of the districts with the largest and smallest populations are added together, hence the name *total* population deviation.[101] Under the average population deviation, the absolute values of the district variances are summed up and then divided by the number of districts, hence the name *average* population deviation.[102]

Proportionality can be measured by partisan symmetry or the efficiency gap.[103] The partisan symmetry approach measures the number of seats that a party would win based on different percentages of votes received in each district.[104] One variation measures the distance from a fifty-fifty seat-to-vote split—that is, a party should have roughly 50% of seats if it wins 50% of the vote.[105] The efficiency gap similarly measures wasted votes. For the winner of a district, every vote over 50% is a wasted vote, and for the loser, every vote over 0% is a wasted vote.[106] The efficiency gap takes the difference between the aggregate wasted votes for two parties and divides by the total number of votes.[107] A "fair" plan has an efficiency gap of zero.[108]

This Section shows that there are many, sometimes competing, redistricting requirements, and for many requirements, there are multiple options for measurements, which gives a programmer substantial discretion. Thus, automation is not routine but involves tradeoffs and choices.

C. REDISTRICTING TECHNOLOGY

Technology is used in a few different ways throughout redistricting. This Note defines three classifications of the technology: plan generators, plan evaluators, and map-drawing technology. Plan generators take inputs, such as census data and a set of precise instructions, and produce either a set of many redistricting plans[109] or a single redistricting plan.[110] Plan evaluators take a redistricting plan

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101. *See* Kirkpatrick v. Preisler, 394 U.S. 526, 528–30 (1969).

102. *See* IOWA CODE § 42.4(1)(a).

103. MOON DUCHIN, GERRYMANDERING METRICS: HOW TO MEASURE? WHAT'S THE BASELINE? 2–3 (Nov. 8, 2017), https://arxiv.org/pdf/1801.02064.pdf [https://perma.cc/SZ3Q-QSB9].

104. *Id.* at 2; Bernard Grofman & Gary King, *The Future of Partisan Symmetry as a Judicial Test for Partisan Gerrymandering After* LULAC v. Perry, 6 ELECTION L.J. 2, 6–7 (2007).

105. *See* Duchin, *supra* note 103. For example, in 2016, Republicans could have won 75% of the congressional seats in Ohio with just 50% of the vote, compared to 38% of the congressional seats in Minnesota with 50% of the vote. *Id*. Thus, Minnesota had greater proportionality in 2016 than Ohio.

106. *Id.*

107. *Id.*

108. *Id.*

109. Zhang, *supra* note 23, at 992 (defining *redistricting algorithm* as a set of instructions "that generate[s] large numbers of redistricting plans that satisfy a set of predetermined neutral criteria (e.g., population equality, compactness, or splitting no more than ten counties and twenty cities)").

110. *See, e.g.*, William Vickrey, *On the Prevention of Gerrymandering*, 76 POL. SCI. Q. 105, 106–08 (1961) (discussing what is widely believed to be the first redistricting algorithm); Jowei Chen & Jonathan Rodden, *Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures*, 8 Q.J. POL. SCI. 239, 248 (2013) (citing the work of Micah Altman; Nolan McCarty, Keith T. Poole & Howard Rosenthal; and Michael McDonald); Amariah Becker & Justin Solomon, *Redistricting Algorithms* (discussing various recent redistricting algorithms aimed at sampling or optimization), *in* POLITICAL GEOMETRY: RETHINKING REDISTRICTING IN THE US WITH MATH, LAW, AND

as an input, evaluate the plan based on a scoring formula, and output a score to show the strengths and weaknesses of a particular proposal.[111] Map-drawing technology offers an intuitive user interface that helps public officials or ordinary citizens draw maps, typically by dragging and dropping lines that are superimposed over a picture of a state's geography.[112] This Note only considers plan generators and evaluators and collectively refers to them as *redistricting algorithms*. This Section explores the theoretical limits of redistricting algorithms before diving into types of plan generators and evaluators.

1. Computational Limits of Redistricting Technology

Redistricting algorithms run up against theoretical limits in computer science, demonstrating some limits to their application. Because redistricting algorithms are theoretically limited, they are unlikely to consistently produce optimal results. As a result, scholarship has focused on heuristics that make educated "guesses" about the best redistricting plans.

A "brute force" algorithm would not work in the redistricting context. A brute force algorithm generates every possible combination of population units and evaluates each combination against an objective function to select the highest scoring plan. Yet, there are too many possible redistricting plans to generate them all in a reasonable amount of time.[113] For example, Micah Altman indicates that an algorithm that tried to evaluate every possible assignment of census block groups to districts in California would still be running today if it began evaluating possible plans at the start of the universe billions of years ago.[114] In North Carolina, Jonathan C. Mattingly estimated that there were more possible

EVERYTHING IN BETWEEN 303, 305 (Moon Duchin & Olivia Walch eds., 2022); Douglas Rudeen, *The Balk Stops Here: Standards for the Justiciability of Gerrymandering in the Coming Age of Artificial Intelligence*, 56 IDAHO L. REV. 261, 262 (2020) (proposing a redistricting algorithm as a reform measure); Bruce E. Cain, Wendy K. Tam Cho, Yan Y. Liu & Emily R. Zhang, *A Reasonable Bias Approach to Gerrymandering: Using Automated Plan Generation to Evaluate Redistricting Proposals*, 59 WM. & MARY L. REV. 1521, 1526 (2018) ("We provide an example of how [automated map generation technologies] could be used with the Parallel Evolutionary Algorithm for Redistricting (PEAR), the most advanced automated redistricting algorithm to date.").

111. *See* Duchin, *supra* note 103, at 2–5 (describing three kinds of evaluators based on partisan symmetry, efficiency gap, and sampling); *GerryChain*, GITHUB, https://github.com/mggg/GerryChain [https://perma.cc/RK4P-XVGV] (last visited Feb. 13, 2023) (offering code for a redistricting plan evaluator based on sampling); *redist: Simulation Methods for Legislative Redistricting*, *supra* note 53.

112. *See, e.g.*, Siobhan Roberts, *Mathematicians Are Deploying Algorithms to Stop Gerrymandering*, MIT TECH. REV. (Aug. 12, 2021), https://www.technologyreview.com/2021/08/12/1031567/mathematicians-algorithms-stop-gerrymandering/ [https://perma.cc/CHQ4-D9EA] (explaining that Caliper's Maptitude is the industry-standard mapping software); *About DRA*, DRA 2020, https://davesredistricting.org/maps#aboutus [https://perma.cc/87CX-CLAR] (last visited Feb. 13, 2023) ("DRA 2020 is a free web app to create, view, analyze and share redistricting maps for all 50 states, the District of Columbia and Puerto Rico."); DISTRICTBUILDER, *supra* note 53 ("DistrictBuilder puts the power of drawing electoral maps in the hands of the people.").

113. *See* Micah Altman, *The Computational Complexity of Automated Redistricting: Is Automation the Answer?*, 23 RUTGERS COMPUT. & TECH. L.J. 81, 91 & n.38 (1997).

114. *Id.* at 98 n.65.

combinations of census population units than atoms in the universe.[115] Thus, a brute force approach is impractical for solving redistricting.

Computer scientists can show that finding an optimal redistricting plan is theoretically difficult. They classify types of problems by their theoretical difficulty. A problem is computationally intractable "if the (provably) optimal algorithm for solving the problem cannot solve all instances in polynomial time."[116] Altman shows that most versions of the redistricting problem are likely computationally intractable.[117] In practice, this means that a redistricting algorithm is unlikely to consistently produce an optimal result in a reasonable amount of time.

Heuristic algorithms are the alternative. These algorithms can perform well, but there is no guarantee that the result will be the best result; "they are merely good guesses."[118] For example, if an algorithm aims to produce compact, equally sized districts, the programmer cannot guarantee that the result is the *best* compact, equally sized district because there might be a redistricting plan that the algorithm did not consider that is more compact and equally sized. Despite this theoretical limit, scholars have developed many redistricting algorithms with varying results.[119]

2. Types of Plan Generators

Plan generators come in many flavors, and a variety of algorithms can produce legal redistricting plans in every U.S. state.[120] The vast number of plan generators can be classified into three types of approaches: enumeration, optimization, and sampling.[121]

Enumeration is a brute force approach that attempts to "list every possible way to district a given piece of geography."[122] These algorithms are simply not practical for congressional or state legislative redistricting because there are too many possible combinations of population units.[123]

Optimization algorithms produce a single plan that attempts to maximize some criterion or score.[124] Common optimization algorithms include clustering,[125]

115. Exhibit 2 to Declaration of Jonathan Mattingly at 13, Common Cause v. Rucho, No. 16-CV-1026 (M.D.N.C. Mar. 6, 2017) (Report on Redistricting: Drawing the Line).

116. Altman, *supra* note 113, at 104–05.

117. *See id.* at 109 ("The most common redistricting sub-problems, such as finding the optimal set of compact districts, are NP-complete or NP-hard."); *see also* Clemens Puppe & Attila Tasnádi, *A Computational Approach to Unbiased Districting*, 48 MATHEMATICAL & COMPUT. MODELLING 1455, 1455 (2008) (demonstrating that, under geographical constraints, determining a proportional redistricting plan is an NP-complete problem); Richard Kueng, Dustin G. Mixon & Soledad Villar, *Fair Redistricting Is Hard*, 791 THEORETICAL COMPUT. SCI. 28, 29 (2019).

118. Altman, *supra* note 113, at 92.

119. *See infra* Section I.C.2.

120. *See* Zhang, *supra* note 23, at 992–93.

121. Becker & Solomon, *supra* note 110.

122. *Id.*

123. *See supra* Section I.C.1.

124. Becker & Solomon, *supra* note 110.

125. *Id.* at 26. The shortest splitline algorithm, which seeks to recursively divide a state in half by drawing the shortest possible line that equally divides the population in half, is a popular clustering

which groups population units based on proximity; random walks,[126] which starts with a plan and makes modifications to explore other possible plans; and integer programming,[127] which minimizes or maximizes a criterion subject to other constraints.

A sampling algorithm produces a large, but limited, set of possible plans.[128] Sampling algorithms are typically randomized so that different outcomes are produced with each execution of the program.[129] Sampling algorithms require an initial plan which is modified to produce alternative samples. An initial plan could be made from scratch using, for example, one of the optimization algorithms described above, or take an existing plan, such as the previous districting plan.[130] Samples could explore minimal changes to the initial plan by using flip algorithms that only change population units at the district boundaries.[131] Alternatively, samples could drastically differ from the initial plan by using recombination algorithms that combine adjacent districts and repartition them.[132]

This discussion just scratches the surface of research into potential plan generators. The algorithms vary in their approaches, the required inputs, and ultimately the quality of the outputs. Thus, a decision to use a redistricting algorithm must consider the political and practical implications of choosing an algorithm type, choosing an input, and choosing a potentially biased output.

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approach. Andrew Prokop, *This Is What America Would Look Like Without Gerrymandering*, VOX (June 29, 2015, 12:36 PM), https://www.vox.com/2014/5/8/5695350/this-is-what-america-would-look-like-without-gerrymandering [https://perma.cc/FB3U-MQJ3]. Voronoi diagrams are another popular approach—they start with district centers, called "hubs," and assign population units to the closest hub, subject to other constraints. Becker & Solomon, *supra* note 110, at 322–23; *see* Harry A. Levin & Sorelle A. Friedler, *Automated Congressional Redistricting*, ACM J. EXPERIMENTAL ALGORITHMICS, Mar. 2019, at 4; Lukas Svec, Sam Burden & Aaron Dilley, *Applying Voronoi Diagrams to the Redistricting Problem*, 28 UMAP J. 313, 317–18 (2007).

126. Hill climbing algorithms only permit changes to a plan that improve the score, such as swapping population units on the edge of the district to achieve a better population deviation. *See, e.g.*, Federica Ricca & Bruno Simeone, *Local Search Algorithms for Political Districting*, 189 EUR. J. OPERATIONAL RSCH. 1409, 1415 (2008) (analyzing the Descent algorithm); Levin & Friedler, *supra* note 125, at 5. Simulated annealing allows changes that score worse on an objective function to search a larger portion of the possible plans and avoid optimizing a suboptimal plan. *See* Michelle H. Browdy, S*imulated Annealing: An Improved Computer Model for Political Redistricting*, 8 YALE L. & POL'Y REV. 163, 172 (1990). Tabu search algorithms similarly search through a larger sample space by keeping track of recently generated plans to explore new kinds of plans. *See* Burcin Bozkaya, Erhan Erkut & Gilbert Laporte, *A Tabu Search Heuristic and Adaptive Memory Procedure for Political Districting*, 144 EUR. J. OPERATIONAL RSCH. 12, 16 (2003). Evolutionary algorithms explore a large sample space by mimicking the evolutionary process when it combines "parent" plans with different traits into a single plan. *See* Yan Y. Liu, Wendy K. Tam Cho & Shaowen Wang, *PEAR: A Massively Parallel Evolutionary Computation Approach for Political Redistricting Optimization and Analysis*, 30 SWARM & EVOLUTIONARY COMPUTATION 78, 83 (2016).

127. Becker & Solomon, *supra* note 110, at 329.

128. *Id.* at 3.

129. *Id.* at 18.

130. *Id.* at 19, 22.

131. *See id.* at 23–24.

132. *See id.* at 24; Daryl DeFord, Moon Duchin & Justin Solomon, *Recombination: A Family of Markov Chains for Redistricting*, HARV. DATA SCI. REV., Winter 2021, at 4.

3. Types of Plan Evaluators

Plan evaluators are similarly complex and diverse. Plan evaluators take a proposed redistricting plan as an input and produce a score measuring the quality of the plan. There are an infinite number of scoring formulas that could be used to evaluate redistricting plans. Most of the redistricting criteria described in Section I.B can be measured in several ways, and different scoring formulas could assign different weights to each criterion. For example, suppose States A and B only measured population equality and proportionality.[133] State A might measure population equality based on the total population deviation and measure proportionality based on the efficiency gap.[134] Further, State A might weigh population equality and proportionality equally, such that each measure is given a 50% weight. Now consider State B, which also measures population equality and proportionality. However, State B measures population equality by the average population deviation and proportionality by partisan symmetry.[135] Further, State B might care more about population equality and give the population deviation measure an 80% weight and proportionality a 20% weight. This example shows how evaluators can differ based on the criteria used, the measures used to assess the criteria, and the weights given to the measures.

Although most measures are based on simple arithmetic, newer scholarship has leveraged sampling to determine whether a proposed plan is an outlier among the possible redistricting plans.[136] A sampling algorithm is used to generate thousands of potential redistricting plans that can be compared to a proposed plan.[137] For example, Moon Duchin used a Markov chain Monte Carlo algorithm to generate 19,184 possible plans for Wisconsin's legislature and compared the possible plans to the enacted plan.[138] The comparison showed that the legislature's enacted plan, which produced sixty Republican seats, was more extreme than 99.5% of the proposed alternatives, in which fifty-five Republican seats was the most common outcome.[139] Plan evaluators are powerful redistricting tools that are likely to play a large role in future redistricting processes.

II. EXPECTATIONS

Given the variety of redistricting algorithms and their ostensible objectivity, self-interested actors could adopt a nearly automated or fully automated redistricting process.[140] On the one hand, reformers or a party that is currently harmed

133. This example may result in high scoring plans that are unconstitutional. *See supra* Section I.B. It serves only to demonstrate how plan evaluators can differ.

134. *See supra* Section I.B.8.

135. *See supra* Section I.B.8.

136. *See* DUCHIN, *supra* note 103, at 4.

137. *Id.*

138. *Id.* at 4–5

139. *Id.*

140. *Cf.* Jowei Chen & Nicholas O. Stephanopoulos, *Democracy's Denominator*, 109 CALIF. L. REV. 1019, 1020 (2021) (suggesting self-interested actors could adopt a different population count to produce better outcomes).

by gerrymandering might push an automated process that aims to create more competitive districts—reform by algorithm.[141] On the other hand, mapmakers who prefer gerrymanders may push an automated process that attempts to hide a partisan gerrymander under a seemingly objective formula of a redistricting algorithm—hal-mandering.[142]

This Note defines three levels of automation: a fully automated process, a nearly automated process, and a partially automated process. In a fully automated process, the legislature would have no discretion to change the output of a redistricting algorithm. Essentially, a public official would execute the program, and the output would be automatically enacted as the next district plan. In a nearly automated process, public officials can modify the algorithm's output but are constrained by an objective scoring function, as is the case in Mexico.[143] In a partially automated process, public officials may consider but are not bound by redistricting algorithms; this is the case in most states today.[144] This Note is only concerned with a nearly or fully automated process.

There is precedent for a nearly or fully automated process. Several geographies have already conducted redistricting with a nearly automated process, including Mexico[145] and North Carolina.[146] Although fully automated redistricting has no applied example, several researchers[147] have entertained a fully automated process, and several state bills have entertained various levels of automation in the redistricting process.[148] It is possible that if a certain redistricting algorithm were

141. *See, e.g.*, Rudeen, *supra* note 110, at 262 (proposing a redistricting algorithm as a reform measure).

142. *See* Jeanne C. Fromer, *An Exercise in Line-Drawing: Deriving and Measuring Fairness in Redistricting*, 93 GEO. L.J. 1547, 1571–72 (2005) (suggesting partisan actors could craft an algorithm to generate partisan results); Micah Altman & Michael McDonald, *The Promise and Perils of Computers in Redistricting*, 5 DUKE J. CONST. L. & PUB. POL'Y 69, 75–76 (2010) (same). A state legislature could attempt to justify a partisan redistricting plan by using an "objective" algorithm. *See* Common Cause v. Lewis, No. 18 CVS 014001, 2019 WL 13198027, at *3 (N.C. Super. Ct. Oct. 28, 2019) (finding that a random selection of an algorithmically generated county grouping was reasonable); *see also* Common Cause v. Lewis, BRENNAN CTR. FOR JUST. (Apr. 16, 2020), https://www.brennancenter.org/our-work/court-cases/common-cause-v-lewis [https://perma.cc/6STJ-JBQC].

143. *See supra* notes 14–15 and accompanying text.

144. *See* Levine, *supra* note 1.

145. *See supra* notes 14–15 and accompanying text.

146. *See supra* notes 6–13 and accompanying text.

147. *See supra* note 110; Reid J. Epstein & Nick Corasaniti, *The Gerrymander Battles Loom, as G.O.P. Looks to Press Its Advantage*, N.Y. TIMES (Nov. 17, 2021), https://www.nytimes.com/2021/01/31/us/politics/gerrymander-census-democrats-republicans.html ("Some good-government groups and political scientists have lobbied for more changes, such as the use of algorithms to determine district boundaries . . . ."); Daniel Oberhaus, *Algorithms Supercharged Gerrymandering. We Should Use Them to Fix It*, VICE (Oct. 3, 2017, 3:11 PM), https://www.vice.com/en/article/7xkmag/gerrymandering-algorithms [https://perma.cc/DG4D-PBQD] (citing Bdistricting and Auto-Redistrict as two open-source algorithms that could be used to enact a fully automated redistricting process). *But see* Buchler, *supra* note 29, at 18 (explaining that redistricting algorithms will always create winners and losers so no objective algorithm exists); Levitt, *supra* note 27, at 523–26 (explaining the limitations of automated redistricting).

148. *See* H.R. Res. 93, 2021 Gen. Assemb., Reg. Sess. (Pa. 2021) ("A transition to the use of computational redistricting would minimize human involvement in the redistricting process . . . ."); H.B. 603, 166th Gen. Ct., 1st Sess. (N.H. 2019) (requiring a plan created by computer algorithm to be

to gain popularity, a state legislature or ballot initiative could enact a fully automated process that promises to take biased human mapmakers out of the equation.[149] This Note considers the legal limits and risks of a fully or nearly automated approach in Parts III and IV.

III. LEGAL LIMITS OF REDISTRICTING BY ALGORITHM

This Part explores the legal limits of a nearly or fully automated redistricting process. There are surprisingly few limits. This Note makes a few assumptions about the algorithms and the procedures involved to simplify the legal analysis. Redistricting algorithms are rooted in different political and computational principles, so this Part cannot offer a definitive legal analysis of all possible applications; rather, it aims to offer some general conclusions based on core features of redistricting algorithms.[150]

First, this Note assumes the automated process selects a single plan.[151] In the nearly automated process, a plan evaluator that scores proposed plans would automatically enact the best scoring plan. In a fully automated process, a plan generator would produce a single result that would be automatically enacted as the state's next district plan. Without this assumption, mapmakers would have discretion to select among several plans, which is not nearly or fully automated redistricting but rather partially automated redistricting, where mapmakers are not bound by the algorithm.[152]

Second, this Note assumes there are no obvious challenges to the redistricting algorithm. The output must satisfy all federal and state laws.[153] For example, an algorithm that produces districts with extremely large population deviations would be easily found unconstitutional under the one-person-one-vote jurisprudence. The law itself must also satisfy all procedural requirements.[154] For example, if a constitutional amendment were required in order to enact an automated

introduced in both chambers without amendments); H.R.J. Res. 117, 2016 Sess. (Va. 2016) (requiring an independent redistricting commission to use the shortest splitline algorithm to create districts with changes permitted to account for political boundaries and geographic features); S.J. Res. 38, 91st Gen. Assemb. (Ill. 1999) (requiring a fully automated redistricting process in the event that a redistricting plan is not adopted by a certain deadline); H.B. 735, Gen. Assemb., 2017 Sess. (N.C. 2017) (requiring an independent redistricting commission to adopt a computer program to generate district plans).

149. *See* H.R.J. Res. 117, 2016 Sess. (Va. 2016) (requiring an independent redistricting commission to use the shortest splitline algorithm and allowing changes to the resulting maps in certain circumstances).

150. *Cf.* Cary Coglianese & David Lehr, *Regulating by Robot: Administrative Decision Making in the Machine-Learning Era*, 105 GEO. L.J. 1147, 1177 (2017) ("Machine learning is not a singular entity with one prescribed method of implementation, so we cannot pretend to offer a definitive legal analysis of all possible applications of artificial intelligence in the administrative process.").

151. *See* Browdy, *supra* note 56, at 1386 & n.44 (suggesting an "ideal" automated approach should produce a single plan, otherwise politicians would be able to pick the most favorable outcome among the options).

152. *See supra* notes 143–44 and accompanying text.

153. *See supra* Section I.B.

154. *Cf.* Brief in Support of Application for Summary Relief in the Form of a Declaratory Judgment at 19–23, McLinko v. Commonwealth, 270 A.3d 1243 (Pa. Commw. Ct. 2022) (No. 244 M.D. 2021), 2021 WL 6932986, at *19–23 (challenging a Pennsylvania mail-in ballot law under a procedural

process, this Note assumes the state followed this requirement and amended the state constitution with sufficient precision to permit the use of a specific redistricting algorithm.[155] Finally, this Note assumes that state and federal courts retain jurisdiction to hear challenges to the algorithm results, just as challenges to districts are heard today. This assumption rules out any kind of jurisdiction-stripping analysis.[156]

In this legal analysis, this Note considers whether delegating mapmaking authority to a computer is constitutional and whether partisan gerrymandering carried out by a computer is constitutional. The answer to both is likely yes.

A. REDISTRICTING BY ALGORITHM AND NONDELEGATION

State legislatures are likely permitted to delegate mapmaking authority to an algorithm. Two constitutional doctrines could potentially challenge an automated redistricting process: nondelegation, which limits how Congress can delegate legislative power to other institutions,[157] and the Elections Clause, which specifically delegates the power to draw districts to "the Legislature [of each state]."[158]

Is a state legislature permitted to "cyberdelegat[e]"[159] the authority to draw electoral districts to a redistricting algorithm? The answer is likely yes because it is not a delegation of legislative power. Cary Coglianese and David Lehr explore the use of artificial intelligence systems in the administrative state and discuss the risk that "decision-making authority could effectively become delegated still further—to computerized algorithms."[160] Coglianese and Lehr conclude, however, that if Congress were to "grant[] authority to an agency to deploy machine-learning algorithms," humans still maintain discretion.[161] "[U]ltimately algorithms are mere measurement tools, which the courts widely accept as legally permissible."[162] Just as the Food and Drug Administration (FDA) does not delegate rulemaking authority to thermometers to determine the best temperature at which to store fish, a government entity that relies on artificial intelligence does not delegate authority to, but rather leverages, technology to facilitate a complex process.[163]

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argument that the election law change should have been passed as a constitutional amendment instead of as an act of the legislature).

155. *See, e.g.*, Preston, *supra* note 49, at 682–83 (explaining how to constitutionally implement a redistricting algorithm in Florida).

156. *See* United States v. Klein, 80 U.S. 128, 146 (1871) ("It seems to us that this is not an exercise of the acknowledged power of Congress to make exceptions and prescribe regulations to the appellate power."). *See generally* KEVIN M. LEWIS, CONG. RSCH. SERV., R44967, CONGRESS'S POWER OVER COURTS: JURISDICTION STRIPPING AND THE RULE OF *KLEIN* (2018) (discussing key Supreme Court cases that examine congressional jurisdiction stripping).

157. *See* U.S. CONST. art. I, § 1; A. L. A. Schechter Poultry Corp. v. United States, 295 U.S. 495, 537 (1935).

158. U.S. CONST. art. I, § 4, cl. 1.

159. Coglianese & Lehr, *supra* note 150, at 1179.

160. *Id.* at 1178.

161. *Id.*; *see id.* at 1178–81.

162. *Id.* at 1181.

163. *Id.* at 1182.

The same principle applies to redistricting algorithms. With fully automated redistricting, the law that enacted this process "must still be so well specified that important discretion would remain with the human creators and overseers of the algorithms."[164] Humans would select the type of algorithm, the inputs, the redistricting criteria, and its measures.[165] Further, the legislature would retain the authority to "pull the plug" at any time if it did not support the machine-based redistricting plan.[166] Thus, a legislature that enacts an automated redistricting process does not delegate legislative power to a redistricting algorithm but rather uses the technology as a measurement tool.

Even if a court were to find a delegation, a redistricting algorithm would not be an improper delegation under the U.S. Constitution. Under federal administrative law, delegations must include an "intelligible principle."[167] Delegation of state legislative power follows a similar intelligible principle.[168] The bar for an intelligible principle is low.[169] For example, the Court has upheld an intelligible principle to make laws "in the public interest" as sufficient.[170] A redistricting algorithm, which requires an objective function with "precise, quantifiable, and measurable" goals, would satisfy the intelligible principle standard.[171] A law enacting an automated redistricting process would likely select the type of algorithm to be used, the inputs, and redistricting criteria to consider. Because this is more specific than "in the public interest," a court is unlikely to consider it an improper delegation.

Two factors might cause a court to reach a different outcome. First, Coglianese and Lehr caution that judges may have a "particular aversion" to algorithms and try to limit algorithm-based solutions with a stricter delegation standard.[172] The nondelegation doctrine and intelligible principle standard were not created with

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164. *Id.* at 1181.

165. *Cf. id.* ("[H]umans must specify the targets, commands, and consequences of potential rules from which an embedded machine-learning system might choose the best.").

166. *Id.*

167. J.W. Hampton, Jr., & Co. v. United States, 276 U.S. 394, 409 (1928).

168. *See* Randolph J. May, Opinion, *The Nondelegation Doctrine Is Alive and Well in the States*, REGUL. REV. (Oct. 15, 2020), https://www.theregreview.org/2020/10/15/may-nondelegation-doctrine-alive-well-states/ [https://perma.cc/Q53Q-3DD5] (explaining that the Supreme Court of Michigan follows state precedent that is similar to federal case law and asks whether a delegation of state legislative authority comes with an intelligible principle); *In re* Certified Questions from U.S. Dist. Ct. for the W. Dist. of Mich., 958 N.W.2d 1, 16–20 (Mich. 2020).

169. *See* Coglianese & Lehr, *supra* note 150, at 1179 ("As every lawyer today knows, the level of intelligibility demanded by the courts has hardly been substantial.").

170. *See* Nat'l Broad. Co. v. United States, 319 U.S. 190, 225–26 (1943).

171. *Cf.* Coglianese & Lehr, *supra* note 150, at 1179 ("It seems unlikely that any Congress that would expressly contemplate the use of artificial intelligence by agencies would not also include in legislation authorizing such use a sufficiently intelligible principle that would satisfy the demands of the nondelegation doctrine.").

172. *Id.* at 1183–84; *cf.* Andrea Nishi, Note, *Privatizing Sentencing: A Delegation Framework for Recidivism Risk Assessment*, 119 COLUM. L. REV. 1671, 1704–06 (2019) (suggesting that the use of algorithms in the risk-assessment context may result in "overly broad and undefined delegation[s] of power to private actors in sentencing").

algorithms in mind, so a new approach for algorithms is possible.[173] Second, the Supreme Court has signaled a willingness to reconsider the low bar for the intelligible principle, raising a risk that the nondelegation doctrine could change.[174] Changing law and new interpretations when applied to new facts are a risk for any question of law and do not pose any novel challenges here.

B. REDISTRICTING BY ALGORITHM AND THE ELECTIONS CLAUSE

Redistricting by algorithm for congressional districts might also be challenged under the Elections Clause, but Court precedent shows that such challenges would be meritless.[175] Under the Elections Clause, "[t]he Times, Places and Manner of holding Elections . . . shall be prescribed in each State by the Legislature thereof."[176] A narrow view of this clause might preclude algorithms from deciding the district boundaries because the Constitution says the legislature, not an algorithm, must decide the districts.[177] Yet, this narrow view does not stand up to Court precedent.

In *Arizona State Legislature v. Arizona Independent Redistricting Commission*, the Court adopted a broad interpretation of the Elections Clause. In an attempt to limit gerrymandering, Arizona adopted an independent redistricting commission through a citizen initiative.[178] The Arizona State Legislature argued that the Elections Clause precluded an independent redistricting commission from drawing district boundaries because only the legislature had the power to do so.[179] The Court disagreed, adopting a broad definition of the Elections Clause that permits independent redistricting commissions or the Governor, through a veto, to exercise power over the redistricting process.[180] In doing so, the Court echoed the views of certain congressmen involved in drafting a 1911 reapportionment act who thought that "Legislature" at the time of the Constitution's writing meant "constituted authorities, through whom [the State] choose[s] to speak."[181]

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173. *See* Coglianese & Lehr, *supra* note 150, at 1183–84.

174. *See* Paul v. United States, 140 S. Ct. 342, 342 (2019) (Kavanaugh, J., respecting denial of cert.) ("I write separately because Justice Gorsuch's scholarly analysis of the Constitution's nondelegation doctrine in his *Gundy* dissent may warrant further consideration in future cases.").

175. The Elections Clause does not apply to state legislative districts. *See* U.S. CONST. art. I, § 4, cl. 1; Ariz. State Legislature v. Ariz. Indep. Redistricting Comm'n, 576 U.S. 787, 847–48 (2015) (Roberts, C.J., dissenting).

176. U.S. CONST. art. I, § 4, cl. 1.

177. *Cf.* Nicholas O. Stephanopoulos, *The Anti-*Carolene *Court*, 2019 SUP. CT. REV. 111, 115 ("Taken to its logical endpoint, [the position that only the state legislature is permitted to regulate redistricting] would preclude not just independent commissions adopted through voter initiatives . . . but also state court suits and maybe even gubernatorial vetoes of gerrymandered maps.").

178. 576 U.S. at 796–97 (majority opinion).

179. *Id.* at 792.

180. *See id.* at 808, 813.

181. *See id.* at 810 (alterations in original) (citing COMM. OF ELECTIONS, CASES OF CONTESTED ELECTIONS IN CONGRESS, FROM 1834 TO 1865, INCLUSIVE., H.R. MISC. DOC. NO. 38–57, at 351–52 (2d Sess. 1865)).

A legislature can enable others to speak by establishing a citizen-initiative process or enabling the Governor to veto legislation.

Under the majority's view, the Elections Clause would not prohibit a redistricting algorithm. First, a legislature likely does not delegate authority to a redistricting algorithm.[182] If the redistricting algorithm is seen as a measurement tool, the legislature is still the entity that draws the districts. Second, even if the algorithm is not seen as a measurement tool, just as the Court held an independent redistricting commission was authorized to speak for the legislature, a redistricting algorithm could be authorized to speak for the legislature by defining instructions with sufficient precision. This Note assumes that a state follows all procedural requirements when enacting an automated process and that it would be possible for a legislature to satisfy any Elections Clause challenges if it designs the algorithm through legislation.

Going further, redistricting by algorithm would not be prohibited even by the dissent's narrower view of the Elections Clause.[183] The dissent would have limited "Legislature" to include only "the representative body which ma[kes] the laws of the people."[184] This interpretation would exclude independent redistricting commissions from having primary authority to draw congressional districts, but it would not preclude advisory commissions where the legislature "retains primary authority over congressional redistricting."[185] Just as advisory commissions satisfy this narrow view of the Elections Clause as long as the legislature retains primary authority, so does a redistricting algorithm enacted by the legislature as long as the legislature retains primary authority when it selects the type of redistricting algorithm, inputs, and redistricting criteria. Thus, a redistricting algorithm would not run afoul of either the broad or narrow view of the Elections Clause.

C. PARTISAN GERRYMANDERING BY ALGORITHM: HAL-MANDERING

Hal-mandering could circumvent limits on partisan gerrymandering. Federal courts are unlikely to address such a claim. Although partisan gerrymandering is unconstitutional in several states regardless of how the map is produced, an ostensibly objective algorithm might satisfy state-law standards. North Carolina's 2019 remedial map, which was produced primarily by an automated process,[186] offers a helpful case study to demonstrate how a hal-mander might avoid judicial scrutiny.

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182. *See supra* Section III.A.

183. It is crucial to evaluate the dissent's view because, at the time of this writing, the Supreme Court has an opportunity to reevaluate the scope of the Elections Clause. *See* Brief for Petitioners at 1, Moore v. Harper, No. 21-1271 (U.S. Aug. 29, 2022).

184. *Ariz. State Legislature*, 576 U.S. at 829 (Roberts, C.J., dissenting) (alteration in original) (quoting Hawke v. Smith, 253 U.S. 221, 227 (1920)).

185. *Id.* at 847–48.

186. *See supra* notes 6–13 and accompanying text.

1. Minimal Federal Limits to Hal-mandering

In *Rucho v. Common Cause*, the Supreme Court held that partisan gerrymandering claims are nonjusticiable under the U.S. Constitution.[187] Although the Court found that the congressional districts in Maryland and North Carolina were "highly partisan, by any measure,"[188] it still held that the Court lacked jurisdiction.[189] The Court reasoned that "reallocating power and influence between political parties" would be an "extraordinary step" without a "limited and precise standard."[190] Even a redistricting plan that allocated 100% of the seats to one political party despite that party only winning 57% of the vote would be permissible based on the Court's review of the Whigs' election defeat in Alabama in 1840.[191]

If a state were to enact a redistricting program guilty of hal-mandering, a claim of partisan gerrymandering would not be justiciable in federal court. Even if a hal-mander allocated every district to one political party—an egregious hal-mander—the Supreme Court explicitly affirmed this practice in *Rucho*. Thus, a federal court is unlikely to rule on any partisan gerrymandering claims and would rely instead on state court rulings on matters of state law.[192]

Hal-manders, however, could be adjudicated in federal court if a plaintiff alleged racial gerrymandering.[193] Although racial gerrymandering is outside the scope of this Note, racial gerrymandering and partisan gerrymandering are not mutually exclusive.[194] For this analysis, however, this Note assumes that the state satisfies all redistricting requirements, including the Voting Rights Act. Thus, this Note implicitly assumes that a redistricting algorithm does not violate racial gerrymandering law.

2. Some States Limit Partisan Gerrymandering but Not Hal-mandering

Although some states prohibit partisan gerrymandering, a hal-mander is less likely to be overturned. Prohibitions against partisan gerrymandering differ in each state, but most states rely on direct or circumstantial evidence of partisan intent to entrench the political party in power.[195] There are cases of direct partisan

187. *See* 139 S. Ct. 2484, 2508 (2019). This ruling does not mean that partisan gerrymanders are constitutional, only that a federal court cannot decide whether a partisan gerrymander violates the Constitution. Common Cause v. Lewis, No. 18 CVS 014001, slip op. at 320, 2019 WL 4569584, at *119 (N.C. Super. Ct. Sept. 3, 2019).

188. *Rucho*, 139 S. Ct. at 2491.

189. *Id.* at 2508.

190. *Id.* at 2502.

191. *See id.* at 2499 ("That meant that a party could garner nearly half of the vote statewide and wind up without any seats in the congressional delegation.").

192. *See id.* at 2507–08 (describing state laws that have prohibited partisan redistricting and explaining that partisan gerrymandering claims would be justiciable in state court in those states).

193. *See id.* at 2496–97.

194. *See* Clarke & Greenbaum, *supra* note 76 ("The reality is that in many areas of the country, partisanship and race are closely intertwined.").

195. *See, e.g.*, Harkenrider v. Hochul, 167 N.Y.S.3d 659, 664–65 (App. Div. 2022) (concluding gerrymander was partisan where one party dominated the process and statistical analysis demonstrated a partisan outcome); League of Women Voters of Ohio v. Ohio Redistricting Comm'n, 192 N.E.3d 379, 409, 413 (Ohio 2022) (concluding gerrymander was partisan based on statistical evidence of 5,000

intent where the legislature admits its partisan motives. For example, in North Carolina, legislators initially admitted their aim was to "preserve the supermajority."[196] In other cases where there is no explicit admission, statistical evidence is used as circumstantial evidence to demonstrate partisan intent. Expert witnesses generate thousands of proposed legal redistricting plans and demonstrate that the enacted plan was an outlier when traditional redistricting principles are considered.[197] The outlier status suggests that the legislature was unlikely to reach the enacted plan if it were only interested in traditional redistricting principles; therefore, the legislature must have subordinated traditional redistricting principles and been motivated by partisan intent.[198]

While direct and circumstantial evidence have become well-established for partisan gerrymandering claims at the state level, these arguments would face a tougher battle in a state with a hal-mander. Direct evidence might exist in a hal-mandering case. First, as in North Carolina, unashamed legislators might admit their partisan motives. Second, the algorithm instructions themselves might include explicit commands to make partisan choices. Third, as in North Carolina, where the court concluded that the files of a redistricting consultant demonstrated partisan intent,[199] it is possible that communications with a programmer or others involved in the algorithm's creation could reveal direct evidence of partisan intent.

However, it would not be hard to imagine that legislators would stop producing this direct evidence to strengthen their case against a legal challenge. In arguing for the remedial maps in North Carolina, the defendants denied any intent to create partisan gerrymanders, highlighted the formulaic approach that included random choice, and accused the *plaintiffs* of having partisan intent by attempting to undermine the formulaic process.[200] If a state defendant takes this approach, there will be no direct evidence of partisan intent.

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simulated maps); Szeliga v. Lamone, Nos. C-02-CV-21-001816 & C-02-CV-21-001773, slip op. at 60–68, 92–93 (Md. Cir. Ct. Mar. 25, 2022) (concluding gerrymander was partisan based on statistical evidence of hundreds of thousands of simulated maps); Common Cause v. Lewis, No. 18 CVS 014001, 2019 WL 4569584, at *3, *10, *29 (N.C. Super. Ct. Sept. 3, 2019) (concluding gerrymander was partisan based on an admission of partisan intent and statistical analysis of thousands of simulated maps); League of Women Voters of Pa. v. Commonwealth, 178 A.3d 737, 821 (Pa. 2018) (concluding gerrymander was partisan when statistical analysis of simulated maps showed traditional districting principles were subordinated); *see also* Gill v. Whitford, 138 S. Ct. 1916, 1928 (2018) (noting the difference between "gerrymandering for passing political advantage" and "gerrymandering leading to the 'unjustified entrenchment' of a political party" (quoting Vieth v. Jubelirer, 541 U.S. 267, 360–61 (2004) (Breyer, J., dissenting))).

196. *Lewis*, 2019 WL 4569584, at *10.

197. *E.g.*, *id.* at *19–22 ("The Court finds Dr. Chen's uniform swing analysis to be substantial evidence of the intent and effects of Legislative Defendants' partisan gerrymander.").

198. *See id.* at *115.

199. *Id.* at *10–11 (reviewing a redistricting consultant's files, which were used to advise the Republican majority and showed that maximizing the Republican advantage was a "[p]redominant [g]oal").

200. *See* Reply Brief in Response to Objections at 1–3, *Lewis*, No. 18 CVS 014001 (N.C. Super. Ct. Oct. 4, 2019) ("Plaintiffs' objections are a case of selective outrage that smacks of partisan manipulation.").

Courts would still consider circumstantial evidence, but several barriers make determining partisan intent less likely. First, algorithms are trusted more than people,[201] so judges (and voters) are less likely to ascribe malicious motives to districts drawn by an algorithm. When people know that a recommendation comes from an algorithm instead of a person, they show "algorithm appreciation" and rely on that advice even more than if it came from a person.[202] In the redistricting context, voters are influenced by a process that appears to be fair. When reviewing the work of independent redistricting commissions, voters are more likely to believe districts are fair if they are told that they are drawn by independent redistricting commissions, even though these commissions may not always be politically neutral.[203] Taken together, judges and voters are likely to trust districts drawn by an algorithm more than districts drawn by people, even when the districts are not neutral. In North Carolina, the remedial maps were far from politically neutral when the plan had more Republican-leaning seats than 94% of a sample of redistricting plans, yet the court accepted the plans, in part, because it was "reasonable" to rely on random choice and a facially neutral algorithm.[204] This justification suggests that the court may have been influenced, in part, by trust in an algorithm-based process.

Further, a programmer could game the statistical analysis. A programmer can easily generate thousands of redistricting plans that follow traditional criteria. In the North Carolina litigation, Dr. Chen provided 2,000 sample redistricting plans that followed traditional principles.[205] The North Carolina remedial map, which was derived from this sample, still favored Republicans by a significant margin, suggesting that mapmakers can use algorithms to satisfy traditional principles while still promoting partisan interests. The Pennsylvania Supreme Court has admitted this potential:

> We recognize, then, that there exists the possibility that advances in map drawing technology and analytical software can potentially allow mapmakers, in the future, to engineer congressional districting maps, which, although minimally comporting with these neutral "floor" criteria, nevertheless operate to unfairly dilute the power of a particular group's vote for a congressional representative.[206]

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201. *See* Jennifer M. Logg, Julia A. Minson & Don A. Moore, *Do People Trust Algorithms More than Companies Realize?*, HARV. BUS. REV. (Oct. 26, 2018), https://hbr.org/2018/10/do-people-trust-algorithms-more-than-companies-realize ("Our studies suggest that people are often comfortable accepting guidance from algorithms, and sometimes even trust them more than other people.").

202. *See id.*

203. *See* Eric Ruble, *Independent Redistricting Commissions Are Key to Increasing Trust in Elections*, USC PRICE (Sept. 15, 2021), https://priceschool.usc.edu/news/independent-redistricting-commissions-key-rebuilding-trust/ [https://perma.cc/6WJW-T929].

204. *See supra* notes 12–13 and accompanying text.

205. *Lewis*, 2019 WL 4569584, at *18.

206. League of Women Voters of Pa. v. Commonwealth, 178 A.3d 737, 817 (Pa. 2018).

The court recognized that even a mediocre programmer could simply add the court's neutral criteria—compactness, contiguity, and maintenance of political boundaries—to its partisan algorithm and continue to maximize partisan outcomes. Perhaps there is a higher "floor" when districts must have a minimal level of compactness and maintain political boundaries, but when algorithms can generate thousands, or hundreds of thousands,[207] of valid redistricting plans, it is hard to imagine that this floor is meaningful. Thus, the arguments that supported the findings of partisan gerrymanders in current litigation may be significantly weakened in a hal-mander scenario.

IV. TECHNOLOGY MAKES MORE MESS: RISKS OF AUTOMATION

While Part III shows why redistricting by algorithm and hal-mandering are likely legal, this Part explores the risks of automation. Some reformers imagine a utopia where redistricting technology removes all bias from redistricting and produces the best possible redistricting maps. Justin Levitt calls this imaginary redistricting algorithm the "Magical Redistricting Machine."[208] Unfortunately, this utopia will not be realized while there is both disagreement about how to automate redistricting and legal risks to automation.

A. NEGATIVE IMPACTS OF AUTOMATION

The redistricting literature describes three challenges to automation: (1) automation remains political while there is disagreement about what criteria to consider; (2) automation removes the democratic ideal of deliberation between informed citizens; and (3) computational limits prevent mapmakers from finding the optimal plan.[209]

1. Automation Is Still Political

Automation requires political choices when there is no widely agreed-upon method for creating districts. Reformers admit that an automated process would still be political but envision the argument shifting from a line-drawing fight to a "discussion of representational goals."[210] Citing Mexico's process, Kaila Preston imagines that "constant tinkering and revisions for partisan maximization" would disappear once all the parties agreed on an algorithm.[211] This imagined future assumes that agreement will be reached, and once reached, no one will want to make changes. It is unclear how officials could ever agree to a single set of precisely measured redistricting criteria.

First, there is no current consensus. Section I.B defined the common redistricting criteria, but there is no broad agreement about which criteria should be

207. Szeliga v. Lamone, Nos. C-02-CV-21-001816 & C-02-CV-21-001773, slip op. at 63 (Md. Cir. Ct. Mar. 25, 2022) (discussing the use of 250,000 simulated maps).

208. Levitt, *supra* note 27, at 523.

209. *See* Rudeen, *supra* note 110, at 277–78.

210. Preston, *supra* note 49, at 676 (quoting Browdy, *supra* note 56, at 1381).

211. *Id.* at 676–77.

considered. State laws show that states disagree about which criteria should be considered and how each criterion should be measured.[212]

Second, the principle of tradeoffs further complicates the problem because advancing one redistricting criterion often results in the subordination of another.[213] In the 1970s, New York aimed to increase the representation of non-white communities of interest but, in implementing this plan, divided the Hasidic Jewish community into multiple districts, suggesting that there might have been a tradeoff between selecting communities of interest.[214] There are also tradeoffs between redistricting criteria. For example, the goal of preserving a community of interest that votes as a bloc directly contradicts the goal of creating a competitive district.[215] There are no objective means of resolving these tradeoffs, and instead, these issues require political choices.

Third, algorithms must make the same tough choices that human mapmakers would face. Take the simple question of whether to divide or consolidate major metropolitan areas. Under the current political climate, cities divided into many districts likely favor Republicans while metropolitan areas that are consolidated into a few districts likely favor Democrats.[216] The precise instructions governing an algorithm must divide metropolitan areas in some way, and every algorithmic choice has political implications. It is hard to imagine how partisan actors could agree to a set of instructions that disfavored their self-interests.

Fourth, even if an agreement could be reached at some point in time, stakeholders are likely to want to tinker with any redistricting algorithm. Since the 1990s, the Mexican administrative state has tinkered with its automated process even when the underlying election law has not changed.[217] This should not be surprising given that redistricting, by definition, creates winners and losers.[218] Of course, the losers will want to tinker with the algorithm to try to gain an advantage, and the winners may want to tinker with the algorithm to maintain their advantage. Alternatively, politics change, and "groups would reasonably prefer to battle under the actual conditions of each redistricting occasion based on the

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212. *See Where Are the Lines Drawn?*, *supra* note 59; *Redistricting Criteria*, *supra* note 84.

213. *See* Zhang, *supra* note 23, at 991 ("[T]he algorithms can help unearth important and inevitable trade-offs in the redistricting process that are difficult for humans to identify given the many legal and prudential considerations involved.").

214. *See* United Jewish Orgs. of Williamsburgh, Inc. v. Carey, 430 U.S. 144, 152 (1977) (plurality opinion) (explaining that New York divided the Hasidic Jewish community into multiple districts to increase the representation of nonwhite voters).

215. *See* Mac Donald & Cain, *supra* note 85, at 617.

216. *See* Rudeen, *supra* note 110, at 279; Ally Mutnick, *Republicans Weigh 'Cracking' Cities to Doom Democrats*, POLITICO (July 6, 2021, 4:30 AM), https://www.politico.com/news/2021/07/06/republicans-redistricting-doom-democrats-498232 [https://perma.cc/6NRD-R6EM]. Douglas Rudeen suggests using randomness as a remedy. Rudeen, *supra* note 110, at 279. Yet, an algorithm that switches between favoring Democrats and Republicans has still made a political choice.

217. *See* Trelles et al., *supra* note 14, at 345.

218. *See* Buchler, *supra* note 29, at 18 (explaining that no objective algorithm exists because redistricting algorithms will always create winners and losers).

political goals most important to them at the time."[219] Thus, constant tinkering is likely.

A redistricting algorithm is no less political than a human-centered process.[220] A programmer is still faced with the question of what type of redistricting algorithm to use, what inputs to consider, what redistricting criteria to evaluate, how to measure those redistricting criteria, and how often to change the algorithm. Each choice has political implications.

2. Automation Removes the Democratic Ideal

Automation might be viewed as a less democratic process. Reformers suggest that redistricting by algorithm is more democratic because it removes the self-interested bias that corrodes trust in the electoral process.[221] Further, one study showed that citizens might prefer maps drawn by algorithms over maps drawn by a partisan legislature.[222] Yet, some critics argue that algorithms may lack transparency, hide biased motives, and dismiss the nuanced reality of debates about representational values.[223]

First, transparency is not an intrinsic quality of an automated process. Although a legislature *could* make every algorithmic choice available in a public record,[224] it is not a guarantee. For example, Mexico's redistricting algorithm is not public,[225] so its automated process might be less transparent than the biased process in the United States. Further, even if the information were public, the average citizen may not understand the "mathematical and computational technicalities."[226] And some algorithms do not lend themselves to transparent decisionmaking. For example, algorithms that rely on randomness and "black box" machine learning would not be able to disclose to the public how they arrived at a redistricting plan with any meaningful precision.[227]

Second, algorithms are not objective and raise a risk that citizens will assume objectivity where there is in fact bias.[228] The previous Section explained how redistricting algorithms require political choices. Partisan actors might consider hiding those choices behind facially neutral formulas. Most rules for drawing

219. Fromer, *supra* note 142, at 1572.

220. *See* Levitt, *supra* note 27, at 525 ("[T]here is no neutral way to program an automated machine to draw the district lines.").

221. *See* Preston, *supra* note 49, at 678 ("The biggest benefit to employing such a solution is the ability to minimize the involvement of political actors once the criteria for the algorithm have been determined.").

222. Guest et al., *supra* note 56, at 126–28.

223. *See* Preston, *supra* note 49, at 680; Fromer, *supra* note 142, at 1570–72.

224. *See* Fromer, *supra* note 142, at 1571 & n.137.

225. *See* Trelles et al., *supra* note 14, at 333.

226. Fromer, *supra* note 142, at 1572; *cf.* Nishi, *supra* note 172, at 1684 ("[O]pacity arising when judges with little to no technical knowledge apply incredibly complex software is equally troublesome.").

227. *Cf.* Nishi, *supra* note 172, at 1685 (noting that machine learning in the context of recidivism risk scores does not provide transparency).

228. *Cf. id.* at 1686–88 ("The guise of objectivity is an issue whenever data is used to supplement human decisionmaking . . . .").

district lines have "predictable political consequences."[229] But the public may not be aware of these connections. For example, imagine a state legislature decided to implement a redistricting algorithm that relied on equalizing the Citizen Voting Age Population (CVAP) instead of total population. The legislature might justify this choice on neutral grounds, suggesting that CVAP leads to better representation because it is not distorted by non-voting populations. On its face, this seems like a neutral choice, but a study conducted by Jowei Chen and Nicholas Stephanopoulos shows that this choice would likely lead to reduced minority representation.[230] Thus, a decision that appears to be politically neutral could hide ulterior motives.

Third, a rigid algorithm does not reflect a nuanced reality of debates about representational values.[231] For example, an algorithm that seeks to minimize county splits does not leave any room to debate whether districts that conform to county boundaries are, in fact, normatively correct.[232] Many redistricting criteria are debatable, which may explain why many states have not defined precise measures for most redistricting criteria.[233] Further, some district qualities are difficult to measure with precision. For example, compactness is notoriously difficult to measure.[234] Although most citizens want compact districts, some citizens may favor perimeter-based compactness measures, and others may favor area-based measures; an algorithm cannot consider these nuanced views within its precise instructions.[235] Thus, an algorithm is less democratic because it forecloses debate.

When an algorithm lacks transparency, hides ulterior motives, and dismisses the nuanced view of the people, it does not provide a democratic solution.

3. Automation Faces Computational Limits

Automation will not be perfect. As explained in Section I.C.1, redistricting algorithms cannot explore every possible redistricting plan, and the theoretical limits of modern computers prevent an algorithm from guaranteeing an optimal result. In practice, this means that the result of a redistricting algorithm may not be the best possible result. Thus, the Magical Redistricting Machine does not exist in practice.

This weakness may not be a significant concern because human mapmakers cannot guarantee an optimal plan either. A process without redistricting algorithms is likely to evaluate fewer plans, so it is even less likely to reach the optimal plan. Plus, the available algorithms produce strong results.[236] Thus, this weakness is a small one.

B. AUTOMATION LOOSENS OTHER REDISTRICTING LIMITS

Aside from technical or political issues, there are significant legal risks. A redistricting algorithm may permit a court to loosen the redistricting requirements

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229. Levitt, *supra* note 27, at 524.
230. Chen & Stephanopoulos, *supra* note 140, at 1020–22.
231. *See* Levitt, *supra* note 27, at 523–24.
232. *See id.*
233. *See id.* at 524–25.
234. *See supra* Section I.B.3.
235. *See* Levitt, *supra* note 27, at 525.
236. *See supra* Section I.C.2.

described in Section I.B.[237] Looser redistricting requirements open the door to more hal-mandering. When Congress wanted to fight gerrymandering in 1842, it sought to tighten redistricting requirements to limit how mapmakers could draw lines.[238] Scholarship has discussed tightening redistricting requirements as a way to prevent, or at least limit, gerrymandering.[239] If a state has no redistricting requirements, the number of possible districts is simply the number of permutations of every possible set of population units. If the state starts adding contiguity, compactness, and proportionality requirements, the number of valid sets will decline. With fewer possible legal redistricting plans, a mapmaker has fewer opportunities to gerrymander. Gerrymandering does not disappear, but it becomes harder. The inverse should also be true: if states loosen redistricting requirements, there is more opportunity to gerrymander because more legal gerrymandered maps are available to the mapmakers.

With a redistricting algorithm, several redistricting requirements might be loosened. First, this Note has already demonstrated the loosening of partisan gerrymandering limits when the districts were primarily created by an algorithm.[240] Second, a court may loosen the population deviation requirements for states that deploy a redistricting algorithm. Just as the Court concluded West Virginia's desire to maintain county boundaries was sufficient to permit a 0.79% population deviation when most states have a population deviation near 0%,[241] a court might be willing to find a facially neutral algorithm equally compelling. Third, a facially neutral algorithm might obscure illegal racial gerrymandering. A court may not see the discrimination at all when the algorithm does not explicitly use racial data but selects facially neutral data that correlate with race.[242] A court might find that race was not the "predominant" factor if a redistricting algorithm were to weigh other criteria more heavily than race, which may allow a redistricting algorithm to push racial gerrymandering to its limits.

Fourth, a clever redistricting algorithm could retroactively justify a hal-mander by selecting favorable measures *after* selecting a redistricting plan.[243] For example, suppose a state requires compact districts but does not require a specific measure to be used. Section I.B.3 explained that there are nearly one hundred measures for compactness. A clever redistricting algorithm might select a plan and then choose a favorable compactness measure that retroactively justifies the

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237. *Cf.* Coglianese & Lehr, *supra* note 150, at 1191–92 (finding that machine learning algorithms may have more leeway to use protected classifications than humans would in administrative decisionmaking).

238. *See supra* notes 35–37 and accompanying text.

239. *E.g.*, Levitt, *supra* note 27, at 526–27; Preston, *supra* note 49, at 671.

240. *See supra* Section III.C.

241. Tennant v. Jefferson Cnty. Comm'n, 567 U.S. 758, 764–65 (2012) (per curiam).

242. *Cf.* Nishi, *supra* note 172, at 1675 n.20 ("Rampant racial bias has nevertheless been documented in the results of risk assessment algorithms." (citing Julia Angwin, Jeff Larson, Surya Mattu & Lauren Kirchner, *Machine Bias*, PROPUBLICA (May 23, 2016), https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing [https://perma.cc/9Z6V-KPUT])).

243. Douglas Rudeen calls this "secondary distortion." *See* Rudeen, *supra* note 110, at 276–77.

redistricting plan as being compact. Thus, a redistricting algorithm can loosen ambiguous redistricting requirements with after-the-fact justifications.

Fifth, even if a state were to succeed in creating a neutral redistricting algorithm, partisan actors could try to manipulate the census data, which all redistricting algorithms are required to use as input. The United States has a long history of manipulating population counts for political gain dating back to the Three-Fifths Compromise.[244] Methods for counting Native Americans "led to inconsistencies in how the same person was enumerated over time,"[245] and, of course, recent attempts to undercount immigrants show that partisan actors still have an appetite for manipulating census data for partisan gain.[246] If the U.S. Census were the only partisan hack in the redistricting process, history suggests that partisan actors would exploit it.

These five risks show how a redistricting algorithm could lead to fewer redistricting requirements and further manipulation.

CONCLUSION

A Magical Redistricting Machine likely does not exist because of technology limits, historical political trends, and the risk of reduced gerrymandering limits. As a result, redistricting by algorithm may not be the best approach, but regardless, it is coming. Redistricting by algorithm is gaining steam partly because reformers have held it out as an anti-gerrymandering tool and partly because partisan actors can hide behind algorithms to obfuscate their motives. These forces raise a real risk that partisan gerrymandering carried out by a computer—hal-mandering—will be the next frontier of the gerrymandering fight. North Carolina shows the potential for hal-mandering and may have enacted the country's first hal-mander in 2019. Current redistricting law will not stand in the way of these hal-manders. This problem highlights a need for further discussion, which might involve legal reforms that seek to limit an automated redistricting process, public education initiatives that seek to inform the public about the potential for biased algorithms, and rigorous audits that seek to evaluate proposed algorithms. We can open the pod bay doors to a better redistricting process that fights the push for automation—or let the hal-mander take over.

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244. *See* Hansi Lo Wang, *Immigration Hard-Liner Files Reveal 40-Year Bid Behind Trump's Census Obsession*, NPR (Feb. 15, 2021, 5:01 AM), https://www.npr.org/2021/02/15/967783477/immigration-hard-liner-files-reveal-40-year-bid-behind-trumps-census-obsession [https://perma.cc/3UUS-KRTV].

245. Rose Buchanan, *Stand Up and Be Counted: Native Americans in the Federal Census*, NAT'L ARCHIVES NEWS (Apr. 21, 2022), https://www.archives.gov/news/articles/native-americans-census [https://perma.cc/5S7U-QAWS].

246. *See* Wang, *supra* note 244; *see also* Aloni Cohen, Moon Duchin, JN Matthews & Bhushan Suwal, Census TopDown: The Impacts of Differential Privacy on Redistricting (May 31, 2021) (available at https://drops.dagstuhl.de/opus/volltexte/2021/13873/pdf/LIPIcs-FORC-2021-5.pdf [https://perma.cc/Y7EH-MLQA]) (discussing TopDown, the Census Bureau's differential privacy initiative, which was developed to mitigate the threat of reconstruction and reidentification of census respondents' data).