POLICY FORUM

Human-centered redistricting automation in the age of AI

Human-machine collaboration and transparency are key

By **Wendy K. Tam Cho**[1,2,3,4,5] *and* **Bruce E. Cain**[6,7]

Redistricting—the constitutionally mandated, decennial redrawing of electoral district boundaries—can distort representative democracy. An adept map drawer can elicit a wide range of election outcomes just by regrouping voters (see the figure). When there are thousands of precincts, the number of possible partitions is astronomical, giving rise to enormous potential manipulation. Recent technological advances have enabled new computational redistricting algorithms, deployable on supercomputers, that can explore trillions of possible electoral maps without human intervention. This leaves us to wonder if Supreme Court Justice Elena Kagan was prescient when she lamented, "(t)he 2010 redistricting cycle produced some of the worst partisan gerrymanders on record. The technology will only get better, so the 2020 cycle will only get worse" (*Gill* v. *Whitford*). Given the irresistible urge of biased politicians to use computers to draw gerrymanders and the capability of computers to autonomously produce maps, perhaps we should just let the machines take over. The North Carolina Senate recently moved in this direction when it used a state lottery machine to choose from among 1000 computer-drawn maps. However, improving the process and, more importantly, the outcomes results not from developing technology but from our ability to understand its potential and to manage its (mis)use.

It has taken many years to develop the computing hardware, derive the theoretical basis, and implement the algorithms that automate map creation (both generating enormous numbers of maps and uniformly sampling them) (*1–4*). Yet these innovations have been "easy" compared with the very difficult problem of ensuring fair political representation for a richly diverse society. Redistricting is a complex sociopolitical issue for which the role of science and the advances in computing are nonobvious. Accordingly, we must not allow a fascination with technological methods to obscure a fundamental truth: The most important decisions in devising an electoral map are grounded in philosophical or political judgments about which the technology is irrelevant. It is nonsensical to completely transform a debate over philosophical values into a mathematical exercise.

As technology advances, computers are able to digest progressively larger quantities of data per time unit. Yet more computation is not equivalent to more fairness. More computation fuels an increased capacity for identifying patterns within data. But more computation has no relationship with the moral and ethical standards of an evolving and developing society. Neither computation nor even an equitable process guarantees a fair outcome.

The way forward is for people to work collaboratively with machines to produce results not otherwise possible. To do this, we must capitalize on the strengths and minimize the weaknesses of both artificial intelligence (AI) and human intelligence. Ensuring representational fairness requires metacognition that integrates creative and benevolent compromises. Humans have the advantage over machines in metacognition. Machines have the advantage in producing large numbers of rote computations. Although machines produce information, humans must infuse values to make judgments about how this information should be used (*5*).

Accordingly, machines can be tasked with the menial aspects of cognition—the meticulous exploration of the astronomical number of ways in which a state can be partitioned. This helps us classify and understand the range of possibilities and the interplay of competing interests. Machines enhance and inform intelligent decision-making by helping us navigate the unfathomably large and complex informational landscape. Left to their own devices, humans have shown themselves to be unable to resist the temptation to chart biased paths through that terrain.

HOW MIGHT COLLABORATION HAPPEN?

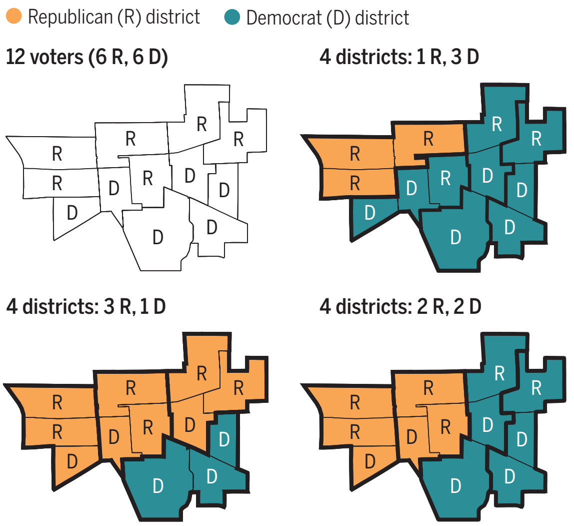
The ideal redistricting process begins with humans articulating the initial criteria for the construction of a fair electoral map (e.g., population equality, compactness measures, constraints on breaking political subdivisions, and representation thresholds). Here, the concerns of many different communities of interest should be solicited and considered. Note that this starting point already requires critical human interaction and considerable deliberation. Determining what data to use, and how, is not automatable (e.g., citizen voting age versus voting age population, relevant past elections, and how to forecast future vote choices). Partisan measures (e.g., mean-median difference, competitiveness, likely seat outcome, and efficiency gap) as well as vote prediction models, which are often contentious in court, should be transparently specified.

Once we have settled on the inputs to the algorithm, the computational analysis produces a large sample of redistricting plans that satisfy these principles. Trade-offs usually arise (e.g., adhering to compactness rules might require splitting jagged cities). Humans must make value-laden judgments about these trade-offs, often through contentious debate.

The process would then iterate. After some contemplation, we may decide, perhaps, on two, not three, majority-minority districts so that a particular town is kept together. These refined goals could then be specified for another computational analysis round with further deliberation to follow. Sometimes a Pareto improvement principle applies, with

Time to regroup

Markedly different outcomes can emerge when six Republicans and six Democrats in these 12 geographic units are grouped into four districts. A 50-50 party split can be turned into a 3:1 advantage for either party. When redistricting a state with thousands of precincts, the potential for political manipulation is enormous.



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the algorithm assigned to ascertain whether, for example, city splits or minority representation can be maintained or improved even as one raises the overall level of compliance with other factors such as compactness. In such a process, computers assist by clarifying the feasibility of various trade-offs, but they do not supplant the human value judgments that are necessary for adjusting these plans to make them "humanly rational." Neglecting the essential human role is to substitute machine irrationality for human bias.

Automation in redistricting is not a substitute for human intelligence and effort; its role is to augment human capabilities by regulating nefarious intent with increased transparency, and by bolstering productivity by efficiently parsing and synthesizing data to improve the informational basis for human decision-making. Redistricting automation does not replace human labor; it improves it. The critical goal for AI in governance is to design successful processes for human-machine collaboration. This process must inhibit the ill effects from sole reliance on humans as well as overreliance on machines. Human-machine collaboration is key, and transparency is essential.

IRCS AND TRANSPARENCY

The most promising institutional route in the near term for adopting this human-machine line-drawing process is through independent redistricting commissions (IRCs) that replace politicians with a balanced set of partisan citizen commissioners. IRCs are a relatively new concept and exist in only some states. They have varied designs. In eight states, a commission has primary responsibility for drawing the congressional plan. In six, they are only advisory to the legislature. In two states, they have no role unless the legislature fails to enact a plan. IRCs also vary in the number of commissioners, partisan affiliation, how the pool of applicants is created, and who selects the final members.

The lack of a blueprint for an IRC allows each to set its own rules, paving the way for new approaches. Although no best practices have yet emerged for these new institutions, we can glean some lessons from past efforts about how to integrate technology into a partisan balanced deliberation process. For example, Mexico's process integrated algorithms but struggled with transparency, and the North Carolina Senate relied heavily on a randomness component. Both offer lessons and help us refine our understanding of how to keep bias from creeping into the process.

Once these structural decisions are made, we must still contend with the fact that devising electoral maps is an intricate process, and IRCs generally lack the expertise that politicians and their staffs have cultivated from decades of experience. In addition, as the bitter partisanship of the 2011 Arizona citizen commission demonstrated, without a method to assess the fairness of proposals, IRCs can easily deadlock or devolve into lengthy litigation battles (*6*). New technological tools can aid IRCs in fulfilling their mandate by compensating for this experience deficiency as well as providing a way to benchmark fairness conceptualizations.

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To maintain public confidence in their processes, IRCs would need to specify the criteria that guide the computational algorithm and implement the iterative process in a transparent manner. Open deliberation is crucial. For instance, once the range of maps is known to produce, say, a seven-to-eight likely split in Democrat-to-Republican seats 35% of the time, an eight-to-seven likely Democrat-to-Republican split 40% of the time, and something outside these two choices 25% of the time, how does an IRC choose between these partisan splits? Do they favor a split that produces more compact districts? How do they weigh the interests of racial minorities versus partisan considerations?

LEVELING THE PLAYING FIELD

Regardless of what technology may be developed, in many states, the majority party of the state legislature assumes the primary role in creating a redistricting plan—and with rare exceptions, enjoys wide latitude in constructing district lines. There is neither a requirement nor an incentive for these self-interested actors to consent to a new process or to relinquish any of their constitutionally granted control over redistricting.

All the same, technological innovation can still have benefits by ameliorating informational imbalance. Consider redistricting Ohio's 16 congressional seats. A computational analysis might reveal that, given some set of prearranged criteria (e.g., equal population across districts, compact shapes, a minority district, and keeping particular communities of interest together), the number of Republican congressional seats usually ends up being 9 out of 16, and almost never more than 11. Although the politicians could still then introduce a map with 12 Republican seats, they would now have to weigh the potential public backlash from presenting electoral districts that are believed, a priori, to be overtly and excessively partisan. In this way, the information that is made more broadly known through technological innovation induces a new pressure point on the system whereby reform might occur.

Although politicians might not welcome the changes that technology brings, they cannot prevent the ushering in of a new informational era. States are constitutionally granted the right to enact maps as they wish, but their processes in the emerging digital age are more easily monitored and assessed. Whereas before, politicians exploited an information advantage, scientific advances can decrease this disparity and subject the process to increased scrutiny.

PERVERSION VERSUS PROMISE OF SCIENCE

Although science has the potential to loosen the grip that partisanship has held over the redistricting process, we must ensure that the science behind redistricting does not, itself, become partisanship's latest victim. Scientific research is never easy, but it is especially vulnerable in redistricting where the technical details are intricate and the outcomes are overtly political.

We must be wary of consecrating research aimed at promoting a particular outcome or believing that a scientist's credentials absolve partisan tendencies. In redistricting, it may seem obvious to some that the majority party has abused its power, but validating research that supports that conclusion because of a bias toward such a preconceived outcome would not improve societal governance. Instead, use of faulty scientific tests as a basis for invalidating electoral maps allows bad actors to later overturn good maps with the same faulty tests, ultimately destroying our ability to legally distinguish good from bad. Validating maps using partisan preferences under the guise of science is more dangerous than partisanship itself.

The courts must also contend with the inconvenient fact that although their judgments may rely on scientific research, scientific progress is necessarily and excruciatingly slow. This highlights a fundamental incompatibility between the precedential nature of the law and the unrelenting

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need for high-quality science to take time to ponder, digest, and deliberate. Because of the precedential nature of legal decision-making, enshrining underdeveloped ideas has harmful path-dependent effects. Hence, peer review by the relevant scientific community, although far from perfect, is clearly necessary. For redistricting, technical scientific communities as well as the social scientific and legal communities are all relevant and central, with none taking over the role of another.

The relationship of technology with the goals of democracy must not be underappreciated—or overappreciated. Technological progress can never be stopped, but we must carefully manage its impact so that it leads to improved societal outcomes. The indispensable ingredient for success will be how humans design and oversee the processes we use for managing technological innovation. ■

REFERENCES AND NOTES

1. W. K. T. Cho, Y. Y. Liu, arXiv:2007.11461 (22 July 2020).
2. W. K. T. Cho, Y. Y. Liu, "A massively parallel evolutionary Markov chain Monte Carlo algorithm for sampling complicated multimodal state spaces," paper presented at SC18: The International Conference for High Performance Computing, Networking, Storage and Analysis, Dallas, TX, 11 to 16 November 2018.
3. Y. Y. Liu, W. K. T. Cho, S. Wang, *Swarm Evol. Comput.* **30**, 78 (2016).
4. Y. Y. Liu, W. K. T. Cho, *Appl. Soft Comput.* **90**, 106129 (2020).
5. Conceptualizing "fairness" for a diverse society with overlapping and incongruous interests is complex (*7*). Although we primarily discuss algorithmic advances that enable automated drawing and uniform sampling of maps, other measurement issues remain. Stephanopoulos and McGhee (*8*) suggest that the efficiency gap, their measure of "wasted votes," should be the same across parties. Chikina *et al.* (*9*) submit that a map should not be "carefully crafted" (i.e., producing different outcomes than geographically similar maps). Fifield *et al.* (*10*) and Herschlag *et al.* (*11*) present local ensemble sampling approaches to identify gerrymanders. Each of these is but one point in a massive evolving discussion. Along these lines, Warrington (*12*) explores various partisan gerrymandering measures. Saxon (*13*) examines the impact of various compactness measures; Cho and Rubinstein-Salzedo (*14*) discuss the concept of "carefully crafted" maps; and Cho and Liu (*15*) highlight difficulties involved in uniformly sampling maps.
6. B. E. Cain, *Yale Law J.* **121**, 1808 (2012).
7. B. J. Gaines, in *Rethinking Redistricting: A Discussion About the Future of Legislative Mapping in Illinois* (Institute of Government and Public Affairs, University of Illinois, Urbana-Champaign, Chicago, and Springfield, 2011), pp. 6–10.
8. N. O. Stephanopoulos, E. M. McGhee, *Univ. Chic. Law Rev.* **82**, 831 (2015).
9. M. Chikina, A. Frieze, W. Pegden, *Proc. Natl. Acad. Sci. U.S.A.* **114**, 2860 (2017).
10. B. Fifield, M. Higgins, K. Imai, A. Tarr, *J. Comput. Graph. Stat.* 10.1080/10618600.2020.1739532 (2020).
11. G. Herschlag *et al.*, *Stat. Public Policy* 10.1080/2330443X.2020.1796400 (2020).
12. G. S. Warrington, *Elect. Law J.* **18**, 262 (2019).
13. J. Saxon, *Elect. Law J.* **28**, 372 (2020).
14. W. K. T. Cho, S. Rubinstein-Salzedo, *Stat. Public Policy* **6**, 44 (2019).
15. W. K. T. Cho, Y. Y. Liu, *Physica A* **506**, 170 (2018).

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PERSPECTIVE

Campaigns influence election outcomes less than you think

Campaigns have small effects but are built to win close races

By **David W. Nickerson**[1] *and* **Todd Rogers**[2]

U.S. presidential campaigns spend hundreds of millions of dollars each election cycle to maximize their chance of electoral victory. Media coverage analyzes individual campaign advertisements, activities, and decisions as if they are hugely influential. Yet, whether an election is close or not is due to factors that are outside the control of electoral campaigns, such as wars and pandemics or even candidate characteristics. In fact, roughly two-thirds of the variance in U.S. presidential election outcomes—where both sides always run substantial campaigns and frame these fundamentals for voters—can be explained by simple models using just economic performance and whether the incumbent is running (*1*). Several strands of academic literature may support a perception that some small campaign decisions can make big differences in voter attitudes and behaviors [e.g., how arguments are framed (*2*) or where field offices are placed in battleground states (*3*)]. This work likely overstates the effect of campaigns in the field, though, because it isolates specific elements from the chaotic din of real-world politics and therefore either cannot control for the endogenous strategic decisions campaigns make or does not occur in environments when voters' partisan identities are fully activated. By pulling together disparate strands of research and situating presidential campaigns in their broader electoral, social, and media contexts, we argue that sizable persuasive effects from campaign activities seem very unlikely to be observed in real-world elections (*4*).

Partisanship is the most important determinant of vote choice and is an extremely stable trait. Strong partisans (roughly 40% of the population) are deeply committed to their political beliefs and preferences, which makes them extraordinarily nonresponsive to electoral persuasion from the other side but excellent candidates for mobilization. But even when targeting people with weaker partisan attachments (~50%), campaign communications have difficulty overcoming the psychology of partisanship. First, people prefer to consume messages consistent with their partisan identities, which makes contact difficult, even through paid advertising (*5*), a finding that holds true even in online outlets (*6*).

Second, even when campaigns reach their intended persuasion targets, partisan-motivated reasoning counteracts acceptance of the appeals. Affective polarization (i.e., the difference in how warmly people feel toward their own party and the opposing party) and negative partisanship (i.e., the extent to which people dislike the opposition) lead partisans to automatically dislike, distrust, and resist communications from members of the opposing party (*7*), to the point of dehumanizing the opposition (*8*). This leads partisans to reject counter-partisan messages, even when these messages align with their political values (*9*).

Finally, the roughly 10% of the population that lack attachment to a party—and the polarizing cognitive processes that come with such attachment—should make nonpartisans ideal targets for persuasion. However, these "true independents" are relatively less interested in politics and actively avoid political content in daily life. Thus, they are rarely exposed to campaign messages and often respond negatively to partisan outreach, not because of ideological reasons but because they tend to find politics generally objectionable (*10*). Whether these individuals are nonpartisan because they dislike politics or vice versa is an open question that can be addressed as long-term political panel surveys get more numerous and run longer.

Campaigns segment the electorate into groups to target for different purposes: convincing strong supporters to volunteer and donate; mobilizing less engaged supporters to vote; persuading nonsupporters. But the crowded communication environment moderates the effects of these efforts. Countermessaging by opponents can eliminate initial persuasive effects of political messaging and reduces a message's persuasive effects by casting doubt on the veracity of basic facts (*11*). Over the course of an election cycle, affective partisan polarization increases by 50 to 150% (*12*); this

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