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# Elections math is the subject of new graduate seminar

Some graduate students studying under UC Santa Barbara computer engineer Behrooz Parhami are in for an eye-opening class on one of the world's timeliest topics: elections math. As U.S. voters prepare to cast their ballots, Parhami will be walking his students through the ins and outs of the various methods people around the world choose their leaders in his graduate seminar, "Mathematical, Algorithmic, and Engineering Aspects of Democratic Elections," in the Department of Computer & Electrical Engineering. This is the first time the ECE 594BB seminar is being offered.

Indeed, 2024 is a special year for national elections, with more than 60 happening globally and an estimated two billion people eligible to vote. Yet there's no ideal voting system, Parhami said, given the variety of candidates, issues, parties, politics and strategies surrounding each election.

"As soon as you have more than two candidates, troubling cases can arise that lead to unfair results," he said. "You can never reduce the probability of an incorrect result to absolute zero, but you want to get as close as you can."

In the U.S. and several other countries including India, Australia, Great Britain and France, the single-winner system is in effect, in which the candidate with the most votes wins the election. Though a widespread type of election, it often presents problems for representation, is conducive to gerrymandering, can discourage voting and reduces the options for choice at the polls to the strongest parties.

Alternatively, there are proportional voting systems, in which candidates of any party are elected based on the number of votes they each receive. Though they do a better job of representing voters' choices and make use of all the votes, critics say that this system can create "weak" coalitions and open the door to extremism and instability in addition to being expensive and more confusing.

Within the two dominant types of voting, many democracies have devised strategies to come as close as they can to a foolproof election, Parhami pointed out, including runoff systems, multiple rounds of voting, single transferable votes, and rank-ordered votes. Some countries also implement mixed systems, drawing elements from the dominant electoral systems to choose their leaders. All of this provides fertile grounds for discussion, and data for consideration, Parhami said."That's why I chose to teach this in the fall, because there could be more excitement and more involvement."

Beyond the numbers games of various voting schemes, the course will cover issues of fairness and justice, and dive into unintended consequences. In addition, the course will touch on the complexities that arise with the presence of more than two candidates running for the same seat, and phenomena such as vote-splitting and spoiler candidates, as well as election interference and misinformation. Later in the quarter, Parhami will go on to cover election hardware and software algorithms and computational complexity. All of this is meant to stimulate conversation and ideas for better methods for selecting our leaders, he said.

"I want the students to understand that our voting system is flawed and that voting is not as simple as what we might think," he said. "It's complicated, and we should work toward removing the flaws of our election system, even in the face of mathematical proof that a perfect voting system is impossible."

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