Algorithmic Governance[1]

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[1] A nontechnical overview

Initial Problem

- When making decisions, we want to consider the desires of all the people involved.
- Various cultures have created participatory democracies in order to solve this problem.
- One of the most notable examples of this is Athenian democracy[1]. [Man97]
- Given a set of n agents with ordinal, complete, transitive preferences over a set of m choices/alternatives, we want to aggregate decisions to compute a collective ranking/or select a selective alternative. [Arr51]
  - Ideally we would like for certain properties ("axioms") to be fulfilled:
    - Independence of irrelevant alternatives
    - Non-dictatorship
    - Pareto-Efficiency
    - Anonymity
    - Onto-ness/Neutrality
  - We want for the election not to be manipulable

[1] because it's always greek people in EC

Governance is interesting in that it starts off with a series of bad results.

- We say a winner is *Condorcet* if they beat every other alternative in pairwise majority comparisons [Con85]
  - But we can easily construct examples where A beats B by pairwise comparison, then B beats C, then C beats A
  - A cycle! So who wins?

Borda, what do you think?

- Rank alternatives, assign each position a score (for example $m - 1, \ldots, 0$), add those scores across voters, and choose the highest total. [Bra+16]
- "Spoilers" cause big problems; Borda doesn't fulfill independence of irrelevant of alternatives
  - When comparing two choices (alternatives), other candidates should not affect the vote [Arr51]
- Even an alternative ranked first by a majority of voters need not win.

Arrow, can we fix this?

- Arrow's impossibility states that with at least three alternatives, no social-welfare function on unrestricted preference profiles can produce a complete and transitive social ranking while satisfying Pareto efficiency, independence of irrelevant alternatives, and non-dictatorship. [Arr51]

Gibbard & Satterthwaite, surely it can't be worse??

- With at least three alternatives, every deterministic, onto, strategyproof social-choice function is dictatorial; equivalently, every non-dictatorial such rule is manipulable. [Gib73, Sat75]

A light at the end of the tunnel

- [ITT89] establish that there are ranked-choice voting rules for which computing a manipulation is NP-hard.
- [IO91] establish that in STV, computing a manipulation is NP-complete.
- This is the precursor to a new age. The age of **computational social choice**. [Bra+16]

Computer Scientists began to ask:

- How can we represent preferences and aggregate choices when the alternative space is exponentially large? [Lan04]
- What if we want to vote multiple representatives? [Azi+17, Elk+17]
- How do we aggregate judgements/beliefs?
  - Voting on beliefs and what is correct? Problems like Condorcet cycles apply here as well [EGP12, LP02]
- How computationally difficult is it to find a successful bribery strategy? [FHH09]
- How do we elicit preferences efficiently/design ballots (how much information do we need from voters) [CS02]

New Directions[1]

- Once the 2016 Handbook is published, COMSOC has matured enough to form distinct subfields. [Bra+16]
- The field broadens away from purely computational results about voting related to voting to other kinds of decision making [Bri21]

Multiwinner Voting

- Choose a committee $W \subseteq \mathcal{M}$ with $|W| = k$. [LS23]
- We want proportional representation of groups of voters by diversity. [Azi+17, Elk+17]
  - Strategyproofness
  - Proportionality/Distortion

Sortition

- Theoretical and Empirical nature
- Random selection of panels was used in Athenian democracy[1]. [Man97]
- It “smooths things out” mathematically
- The panel is selected by lottery rather than by aggregating preferences over candidates. Mathematically both select a committee, but multiwinner voting represents preference groups whereas sortition aims at fair/statistical representation of people. [Azi+17, Fla+21, Fla+20]

[1] (because it’s always the greek people)

Fairness vs Representation in Sortition

- Randomly selecting may mean that people in minority groups are unrepresented
- But you may also want the panel to approximately satisfy chosen demographic representation targets. [Eba+22, Fla+20]

Some Ideas

- We can't force people to participate; self-selection itself biases the volunteer pool. What can we do? [Fla+20]
  - Setting a quota lower and upper bound for every group, adjust probability of sampling each person based on the subgroups they are part of so that the quota is met [Fla+21]
    - Minimax/Leximin/Nash-style objectives give different notions of fairness over volunteers' marginal selection probabilities. [Fla+21, FKP21, Fla+24]
    - Leximin is highly fair but can be highly manipulable; Minimax is highly manipulation-robust but can be arbitrarily unfair. [Fla+24]
    - Goldilocks objective balances fairness and manipulation robustness [BF24]
    - You also need things to be transparent externally [BF24, FKP21]
- Alternates, Constraints, Adversarial Dropouts [Ass+25, GFR26]

Deliberation?

- In practice, a citizens' assembly can also form opinions after being assembled. Deliberative-democracy work explicitly studies learning and preference formation rather than treating preferences as immutable inputs. [Fis91, Lan20]
- Using LLMs to generate representative statements from citizens' assemblies. [Fis+24]

Budgeting[1]

- The canonical modern participatory-budgeting experiment began in Porto Alegre, Brazil, in 1989. [WMT21]
- Participatory budgeting asks citizens to help allocate a fixed public budget among projects. [AS20, RSM23]
  - With indivisible projects, the selection problem is knapsack-like: choose a subset of projects whose total cost is at most the budget. [RSM23]
- Empirically, what are good designs for ballots? [Ben+17, Goe+19]
- What is the distortion (optimal social welfare/social welfare with the format) of any format?
- How do different satisfaction functions (for example, nonlinear utility from multiple approved projects) affect achieved social welfare? [RSM23]

Blockchain

- Starts with bitcoin, and expands rapidly in the early 2010s. [Nak08]
- Unifies several areas:
  - Cryptography
  - Distributed Systems
  - Mechanism Design [ES14, Rou21]
  - Economics

DAO

- Blockchain gives the ability to make decentralized autonomous organizations (DAO) from the ground up [HLL25]
- Natural questions arise like:
  - Who can vote?
  - What should their power be relative to their stake?

DAO Attacks in voting

- A wallet isn't enough
  - Sybil attacks [HLL25]
- With linear one-token-one-vote, splitting a fixed token holding across many wallets does not increase total voting weight. [Ben+26, HLL25]
  - But power becomes concentrated to those with large wallets [FMW24]
- Concave voting gives diminishing marginal voting weight, e.g. $w(x) = \sqrt{x}$ or $\log(1 + x)$. But if identities/wallets are cheap, splitting holdings can defeat wallet-balance-only concavity. [Ben+26, LW18]
- How do you deal with bribery? [Aus+23]

Proportional/Weighted votes in DAO

- Dealing with whales [FMW24, HLL25]
- Quadratic (payment)/concave voting reduces the marginal voting power of additional stake [Ben+26, LW18]

Liquid Democracy

- Voters are lazy, they don't want to do the work of making decision over and over again
  - What if they can delegate their decision to someone else? [KMP21]
- Does it make better decisions? [KMP21]
- Does it produce too much concentration of power? [Göl+18]

DAO Constitution

- DAOs are complex, and need more than voting [HLL25, Tan+24]
- A DAO constitution can propose a new constitution define: [Tan+24]
  - Who can vote
  - How agents can propose changes
  - How can rules be amended
  - etc
- Smart contracts can enforce specific procedures (such as proposals, quorums, treasury, etc.) [HLL25, Tan+24]
- Vetoes / emergency powers / security councils / timelocks countering malicious proposals. [HLL25, Tan+24]

That’s All Folks!

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