Elections with Many Candidates: From Politics to Artificial Intelligence (and back)

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Talk Outline

- *Elections:* from Politics to Technological Applications
- The Problem of *Voting in Combinatorial Domains*
- The Bigger Picture: *Computational Social Choice*

Elections

Many different scenarios, common structure:

- Big Politics: electing the president of a country
- Small Politics: electing the treasurer of your local bowling club
- Technology: agents often need to aggregate information
  - robot teams agreeing on a joint plan
  - recommender systems combining ratings of past users
  - search engines aggregating their results

Voting Theory

Abstractly speaking, an election has the following components:

- a (finite) set of *voters* $\mathcal{N}$
- a (finite) set of *candidates* $\mathcal{X}$
- a *ballot* for each voter, usually a strict ranking of the candidates, i.e., a linear order on $\mathcal{X}$ (*might* be identical to her true *preferences*)
- a *voting procedure* F mapping ballot profiles to (sets of) winners

$$F : \mathcal{L}(\mathcal{X})^{\mathcal{N}} \to 2^{\mathcal{X}} \setminus \{\emptyset\}$$

Well-known voting procedures include *Plurality*, *Borda*, *Copeland*, ...

This simple model has been studied extensively in *social choice theory*, a highly successful branch of *economic theory* (witness Nobel Prizes to Kenneth Arrow and Amartya Sen).

Voting in Combinatorial Domains

Many social choice problems have a *combinatorial structure:*

- Elect a *committee* of k members from amongst n candidates.
- During a *referendum* (in Switzerland, California, places like that), voters may be asked to vote on n different propositions.

Seemingly small problems generate *huge numbers of alternatives:*

- Number of 3-member committees from 10 candidates: $\binom{10}{3} = 120$ (i.e. $120! \approx 6.7 \times 10^{198}$ possible rankings)
- Number of distinct ways of voting in a referendum with 20 yes/no questions: $2^{20} = 1048576$

The Challenge

The challenge is to balance *choice-theoretic* and *computational* concerns.

- **Example 1** (paradox): we have money for *at most two projects*

	fund museum?	*fund school?*	*fund metro?*
Voter 1:	Yes	Yes	No
Voter 2:	Yes	No	Yes
Voter 3:	No	Yes	Yes
		?	

- **Example 2** (combinatorial explosion): For a referendum with n propositions we get 2^n *meta-candidates*. What do you do?
  - Use Plurality? Chances are no option gets more than 1 vote.
  - Use Borda? Very expensive to rank so many meta-candidates.

We need: *good languages* to model the problem + *good algorithms!*

Computational Social Choice

Research can be broadly classified along two dimensions —

The kind of *social choice problem* studied, e.g.:

- electing a winner given individual preferences over candidates
- aggregating individual judgements into a collective verdict
- fairly dividing a cake given individual tastes

The kind of *computational technique* employed, e.g.:

- algorithm design to implement complex mechanisms
- complexity theory to understand limitations
- logical modelling to fully formalise intuitions
- knowledge representation techniques to compactly model problems
- deployment in a multiagent system

The COMSOC Research Community

History of the field:

- a couple of (by now) seminal papers around 1990
- increased research activity since early 2000s
- name "COMSOC" + recognised community since 2006

Activities:

- Biannual workshop since 2006 (∼100 participants in 2010)
- Dagstuhl Seminars in 2007, 2010, 2012 (planned)
- Spring School 2010 with ∼50 participants (COST Action IC0602)

Visibility:

- highly represented at top AI conferences (IJCAI, AAAI, AAMAS)
- very successful young researchers (dissertation awards, etc.)
- expository articles in AI Magazine, Communications of the ACM
- (some) well-funded research groups (national funding)

Last Slide

From politics to technology, and back again:

- Voting isn't just about politics: many technological applications
- Techniques from AI can help, with both technology and politics

An exciting new research area:

- *Computational social choice* = study of social choice problems with the tools of computer science + integration of social choice concepts into computing

  `http://www.illc.uva.nl/COMSOC/`

- Example for work in COMSOC: *voting in combinatorial domains* (internal structure of the domain gives rise to *many* candidates)

Y. Chevaleyre, U. Endriss, J. Lang, and N. Maudet. Preference Handling in Combinatorial Domains: From AI to Social Choice. *AI Magazine*, 29(4):37–46, 2008.