Computational Complexity of Fundamental Problems in Social Choice Theory

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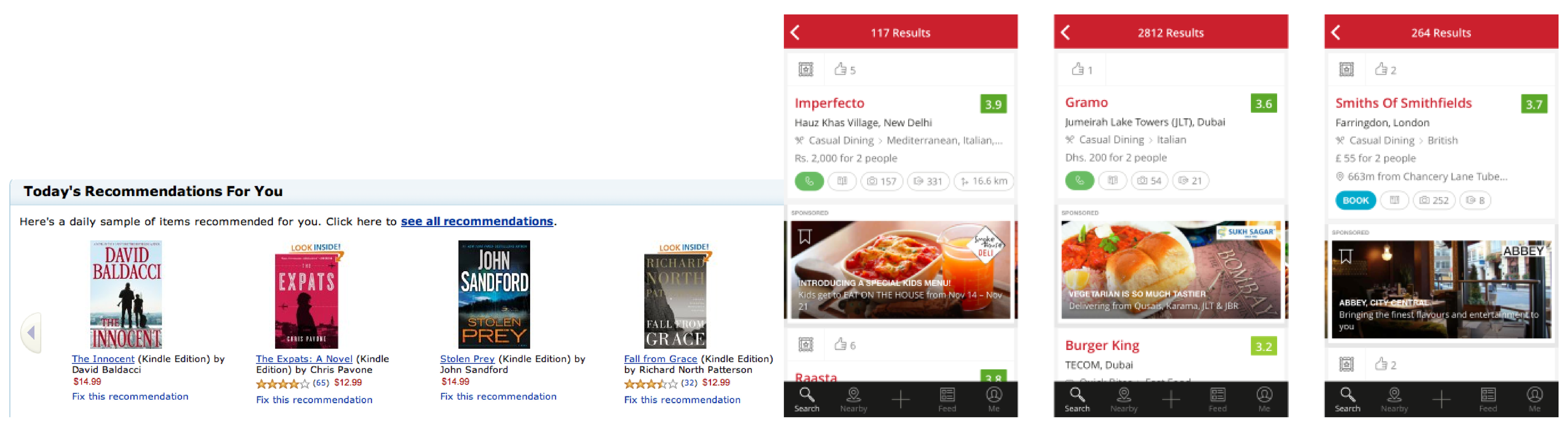
Applications of Voting in AI



Basic Framework

§ There is a set of agents V and a set of alternatives C

§ Each agent in V has a preference ordering over C

§ There is a voting rule which selects a winner from a set of preference ordering. Examples of commonly used voting rules are as follows.

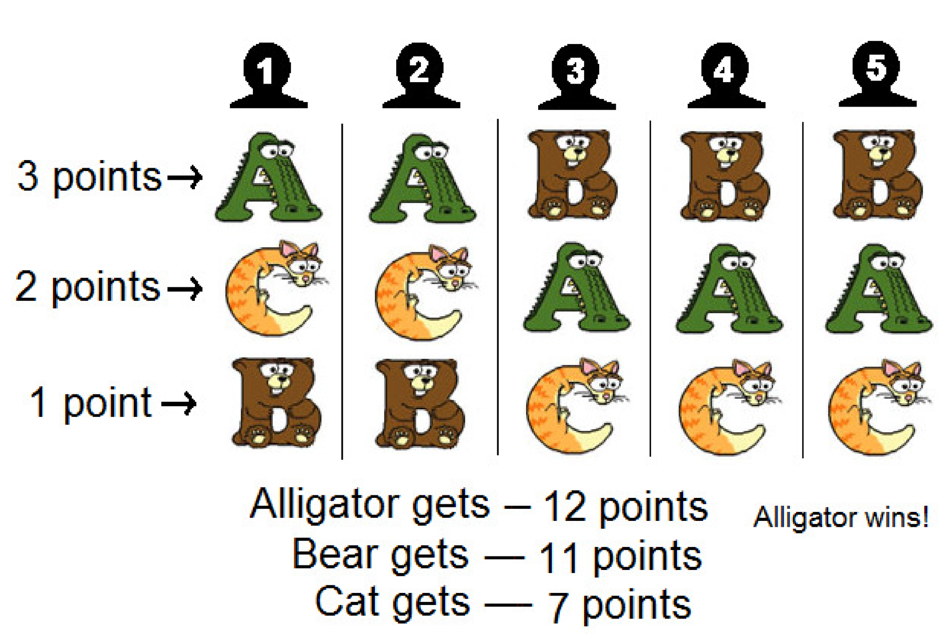
✓ **Scoring rule** : Defined by $\bar{\alpha} = (\alpha_1, \cdots, \alpha_m) \in \mathbb{R}^m$. Candidate ranked at i^{th} position gets score α_i. Winner is the candidate with highest score.

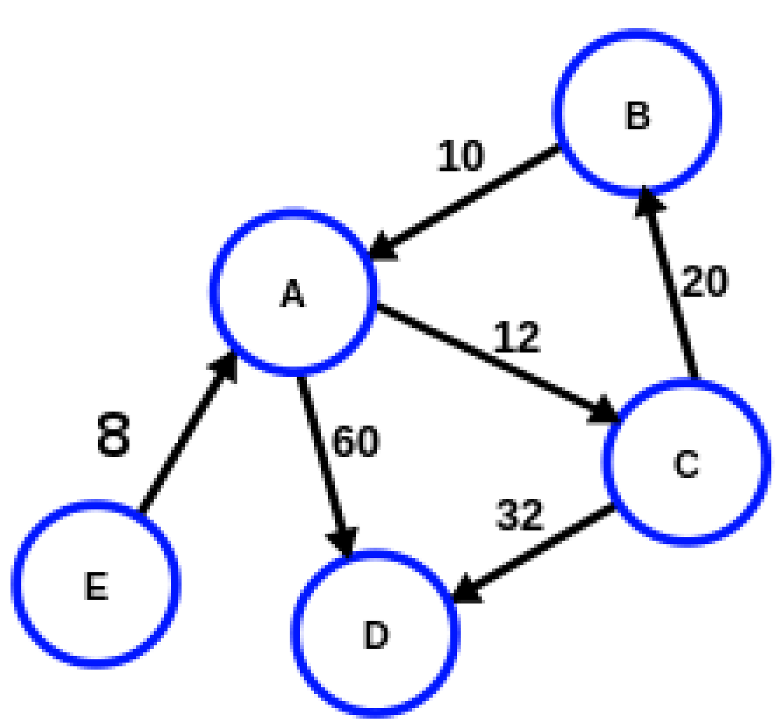
✓ **Borda rule** : Scoring rule with $\bar{\alpha} = (m-1, m-2, \cdots, 1, 0)$.

✓ **Maximin rule** : Winner is the candidate with minimum margin of victory in its worst pairwise election.

✓ **Copeland rule** : Winner is the candidate with maximum pairwise wins.

✓ **Bucklin rule** : Winner is the candidate getting majority within minimum number of top positions.





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Winner Determination

Winner Prediction [AAMAS 2015]

In many applications e.g. pre-election polls, surveys etc., one would like to predict the winner of an election by sampling as few votes as possible. In this work, we prove tight bounds on the number of votes one has to sample to predict correctly with 99% probability for many common voting rules.

Margin of Victory Estimation [IJCAI 2015]

The margin of victory captures how far the winner is from the runner up candidate in an election. Estimating margin of victory is crucial for polling, post-election audits and so on. In this work, we provide efficient algorithm for estimating the margin of victory of an election by sampling a few votes for many common voting rules.

Winner Determination in Streaming [PODS 2016]

With rapid increase in the volume of data, it has become extremely important to design algorithms for solving problems (either exactly of approximately) which make only one pass over the data and use little space. Such algorithms are called streaming algorithms. In this work, we design optimal streaming algorithms for winner determination for many common voting rules.

Committee Selection with Outliers

In many applications e.g. voting in social networks, restaurant ratings and so on, it is impertinent to consider the noise and outliers in data to find interesting patterns. In this work, we show that outliers consideration often makes the problem of Committee Selection intractable. However, a study under the lens of parameterized complexity reveals that considering outliers may often be easy in practice.

Preference Elicitation for Single Peaked Preferences on Trees [IJCAI 2016]

It is often a tedious job for agents to rank all the candidates, whereas they can easily compare two candidates. Hence, eliciting preferences of agents using only comparison queries become an important problem. In this work, we show that we can find the preferences of agents with much small number of queries when the preferences are single peaked in a tree.

Preference Elicitation for Single Crossing Profiles [IJCAI 2016]

We show that the preferences of agents can be elicited by making a small number of comparison queries when the preference profile is single crossing.

Manipulation

Manipulation Detection [AAMAS 2015]

Manipulating an election has survived several decades of research effort. In this work, we initiate research for detecting instances of manipulation. We show that often it can be the case that detecting manipulation is easy whereas manipulation itself is intractable.

Kernelization of Possible Winner and Coalitional Manipulation [AAMAS 2015, TCS 2016]

Designing fixed parameter tractable algorithms for various important problems in social choice theory has been an active area of research for the last decade. Surprisingly there are very few results on kernelization and showing kernel bounds for problems in social choice theory has recently been posed as an important open problem in a Dagstuhl workshop on computational social choice theory in 2014. We in this work show kernel bounds for two important problems in social choice theory, namely, possible winner and coalitional manipulation.

Frugal Bribery [AAAI 2016]

The computational problem of bribery or campaigning is a well studied problem in computational social choice theory. In this work, we propose an important model of bribery where the briber is frugal in nature and wants to bribe only "vulnerable" voters. We show that the bribery problem remains intractable even for this restricted type of briber.

Manipulation under Partial Information [IJCAI 2016]

Determining the computational complexity of manipulating an election is a classical and well-studied problem in computational social choice theory. However, almost the entire body of research focuses on the complete information setting where the manipulators know the other votes. In this work, we extend the notion of manipulation in the more practical incomplete information setting and show that manipulation becomes a significantly harder problem.

Acknowledgements

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