Election Manipulation

Summary

What do we know?

- How to mine a social network

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- How to mine a social network
- Main features of social and information network
  - Which are the factors leading to these features
    - We used tools from both Graph and Game Theory
  - How to replicate these features
- How the information spread over these networks

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  - Mechanism Design tools serve to this aim
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  - Viral Marketing
  - Electoral Campaign on Social Media
    - The role of fake news

Viral Marketing

Description of the problem

- Spend your **budget** to choose a set of **influencers**
- that are able to influence as many nodes as possible

Viral Marketing

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- Spend your **budget** to choose a set of **influencers**
- that are able to influence as many nodes as possible
  - Not only direct influence
  - but also influence by
    - people influenced by influencers
    - people influenced by people influenced by influencers
    - and so on...

Viral Marketing

Some results

Hardness

It is provably **hard** to design an **efficient** algorithm that computes the **best** set of influencers

Viral Marketing

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- The greedy algorithm
  - returns a set of influencers whose influence is **provably**
  - a **constant** approximation of the optimal influence

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Monotone and Submodular Diffusion Processes

- The greedy algorithm
  - returns a set of influencers whose influence is **provably**
  - a **constant** approximation of the optimal influence
- Heuristics based on centrality measures
  - They have been experimentally showed to work in practice
  - No guarantee on approximation
  - Usually faster than greedy algorithm

Viral Marketing

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Majority Dynamics and manipulation of the order of updates

Viral Marketing

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Majority Dynamics and manipulation of the order of updates

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- It is possible to efficiently compute a sequence of updates leading a **minority to become a majority**
- It is possible to efficiently compute a sequence of updates leading a **bare majority to become consensus**
  - For essentially any network topology
- When the new product enters in a network on which there are already **two (or more) competing products**, above results do not hold

Election Manipulation

Examples

- 2016 US presidential election
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  - 23% of them remembered the pro-Clinton fake news

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  - automated accounts on Twitter spread considerable amount of political news
- 2018 Italian political election
  - fake news are linked with the content of populist parties that won

Modeling Voting

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- Alternatives $X, Y, \ldots$
- Preference $X \succ_i Y$

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- Ranked List $X \succ_i Y \succ_i Z \succ_i W \succ_i \cdots$
  - Ranked list exists iff preferences are complete and transitive

Voting systems

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A function that takes the individual rankings of voters and produces a single group ranking

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Example: Majority Rule

- For two alternatives: the winner is the alternative that is ranked first by the majority of voters
- For more than two alternatives:
  - for any pair of alternative X and Y...
  - the majority rule ranks X before Y...
  - if X is preferred to Y by the majority of voters

Majority Rule and Condorcet Paradox

Example

- $X \succ_1 Y \succ_1 Z$
- $Y \succ_2 Z \succ_2 X$
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Condorcet Paradox

Non transitive group preferences can arise from transitive individual preferences

Majority rule in tournaments

Tournaments

- Arrange alternatives in some elimination tournament
- Compare pairs accordingly until one alternative is left

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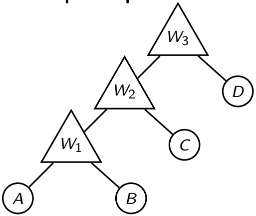

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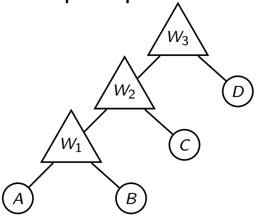

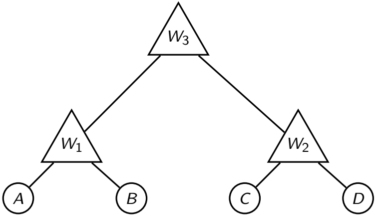

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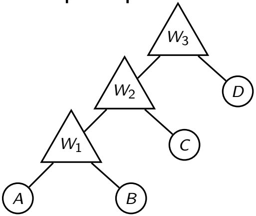

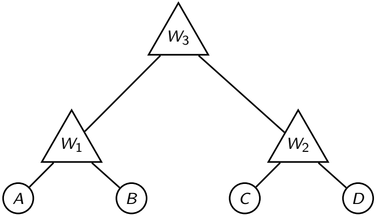

Strategic Agenda-Setting

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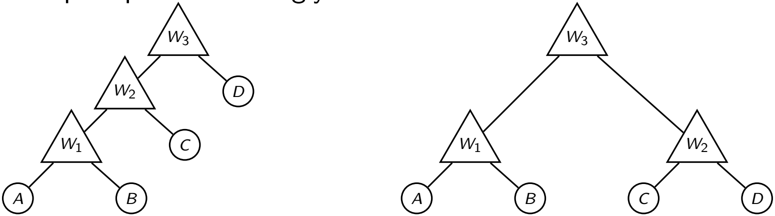

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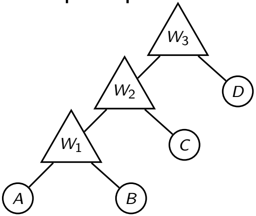

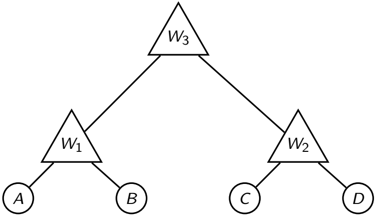

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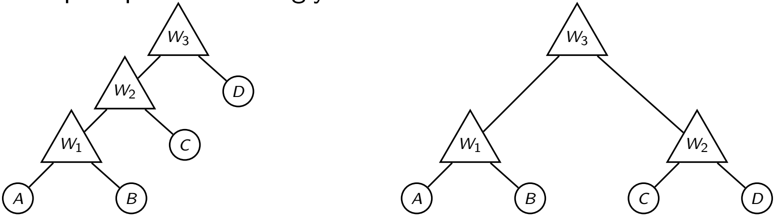

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- Strategic misreporting of preferences

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Description

- Assigns a weight to each position in voters' ranked list
- Ranks alternatives according to the sum of weights

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Arrow's Impossibility Theorem

Desiderata

Unanimity: if $X \succ_i Y$ for any i, then $X \succ Y$

Independence of Irrelevant Alternatives (IIA): Preference between X and Y do not depend on Z

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If there are at least three alternatives, then there is no voting system that satisfies Unanimity, IIA and No-Dictatorship

Escaping from the Arrow's Theorem

Single-Peaked Preferences

- Alternative are ordered $X_1, X_2, \ldots, X_k$
- No voter has an alternative X_s such that...
- both X_{s-1} and X_{s+1} are ranked above X_s

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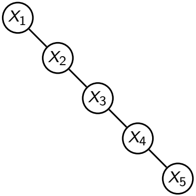

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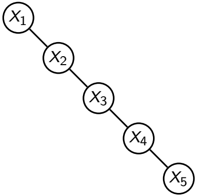

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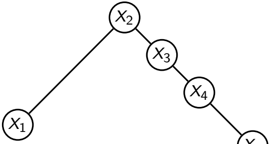

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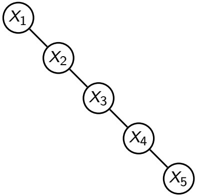

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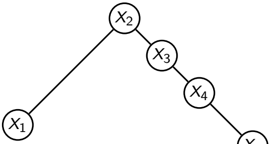

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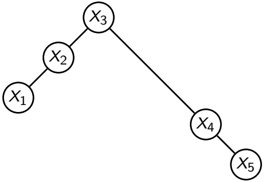

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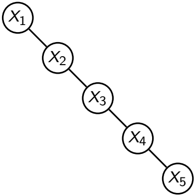

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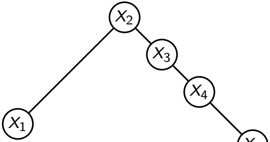

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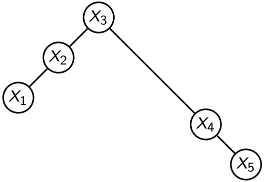

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Theorem

With single-peaked preferences, the majority rule always produces a group ranking that is complete and transitive

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Description of the problem

- There are m candidates
- Social Network nodes are voters

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Election Manipulation vs. Viral Marketing

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Election Manipulation vs. Viral Marketing

- Being influenced is not sufficient
  - need to alter rankings
- Promote candidate c may be insufficient
  - need to reduce votes of strong candidates

Election Manipulation

A first setting

The setting

- Plurality Voting Rule
- Independent Cascade Model Diffusion Process
- Ranking update: each message increases the rank by one

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The result

The problem is monotone and submodular

Election Manipulation

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The result

The problem is monotone and submodular

- Greedy algorithm returns a constant approximation
- Heuristics based on centrality measures work in practice

Election Manipulation

A second setting

The setting

- Any scoring Based Voting Rule
- Linear Threshold Model Diffusion Process
- Ranking update: improves of more than one position if influence is much larger than the threshold

Election Manipulation

A second setting

The setting

- Any scoring Based Voting Rule
- Linear Threshold Model Diffusion Process
- Ranking update: improves of more than one position if influence is much larger than the threshold

The result

The problem is monotone and submodular

- Greedy algorithm returns a constant approximation
- Heuristics based on centrality measures work in practice

Election Manipulation

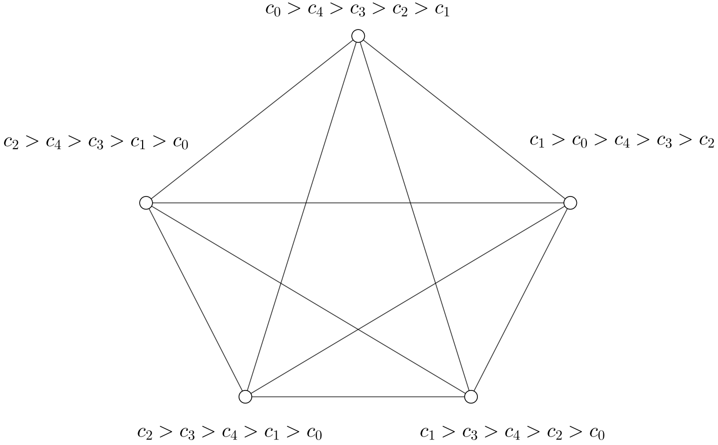
A limitation in previous results

Only one message may be spread over the network

Election Manipulation

A limitation in previous results

Only one message may be spread over the network



Election Manipulation

A third setting

The setting

- Plurality Voting Rule
- Independent Cascade Model Diffusion Process

Election Manipulation

A third setting

The setting

- Plurality Voting Rule
- Independent Cascade Model Diffusion Process
- Different messages may be sent over the networks
  - Number of sent messages limited by budget
- Ranking update: ranking may improve of more positions

Election Manipulation

A third setting

The setting

- Plurality Voting Rule
- Independent Cascade Model Diffusion Process
- Different messages may be sent over the networks
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The result

Computing efficiently the optimal choice of messages is hard

Election Manipulation

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- Plurality Voting Rule
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Computing efficiently the optimal choice of messages is hard

- Even efficiently computing a good approximation is hard
  - Unless budget is very high

Election Manipulation

A third setting

The setting

- Plurality Voting Rule
- Independent Cascade Model Diffusion Process
- Different messages may be sent over the networks
  - Number of sent messages limited by budget
- Ranking update: ranking may improve of more positions

The result

Computing efficiently the optimal choice of messages is hard

- Even efficiently computing a good approximation is hard
  - Unless budget is very high
- Greedy algorithms and Centrality based heuristics may fail
  - even in simple networks

Future directions

- Understanding when manipulation is feasible
  - How it depends on network topology
  - How it depends on assumption on rankings
  - How it depends on assumption of network diffusion

Future directions

- Understanding when manipulation is feasible
  - How it depends on network topology
  - How it depends on assumption on rankings
  - How it depends on assumption of network diffusion
- Understanding how to limit manipulation
  - Budget limitations
  - Forcing a network topology
  - Blocking fake news diffusion