

# Vote Prediction Models for Signed Social Networks

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# Overview

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# Voting and Signed Networks

# Voting in Communities

- Communities need to take collective action
- Voting is a popular method
- Members of the community vote on the agenda
- E.g.
  - Politicians voting for bills in the parliament
  - Wikipedia users voting for promoting administrators
- Understanding voting behaviour is beneficial
- Can propose agendas items which will be be successful
- Identify ideological fault lines amongst members

# Votes as Signed Graphs

- Votes are usually for or against an agenda
- Intuitively maps to positive and negative edges in signed graphs
- More tools to analyse voting patterns, e.g.,
  - Correlation clustering [Brito et al., 2020, Arinik et al., 2017]
  - Balance and Status [Levorato and Frota, 2016, Derr and Tang, 2018]
- Two main prediction tasks exist with regard to voting
  - 1 Predicting the Result
  - 2 Predicting an individual vote
- We focus on predicting votes

# Predicting Votes

Predicting a vote can be split into two phases

① **Who** will vote next

- Same as link prediction task
- Is trivial when voting order is known, e.g., parliament roll calls
- Combinatorial if no known underlying process

② **How** they will vote

- Same as sign prediction task
- Triad features encode balance and status theory
- Train a supervised ML model using network and triad features  
[Leskovec et al., 2010a, Leskovec et al., 2010b]

We propose an *unsupervised iterative model* to predict the sign of a vote using balance and status theory.

# Local Signed Network

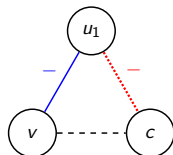
- Current voting sessions is a signed graph  $S = (V_S, E_S, w_S)$
- It contains current voter  $v$ , candidate  $c$  and prior voters  $U$
- We also have a *Relationship Graph*  $R = (V_R, E_R, w_R)$
- It is created from the history of voting sessions  $H$
- The *Local Signed Network* is the intersection of these two graphs  
 $LSN = S \cap R$
- Essentially the subgraph of the voter's neighbours in  $R$  who have already voted in  $S$
- Can use balance and status theory in the LSN to predict votes



# Balance Theory

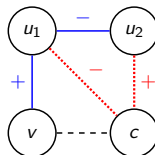
# Agreement Graph

# Iterative Balance Model



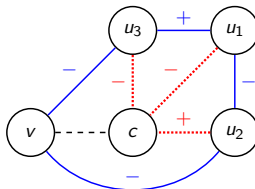
$$\lambda_1^+ = 0, \lambda_1^- = 1$$

(a)  $i = 1$



$$\lambda_1^+ = 0.58, \lambda_1^- = 0$$

(b)  $i = 2$



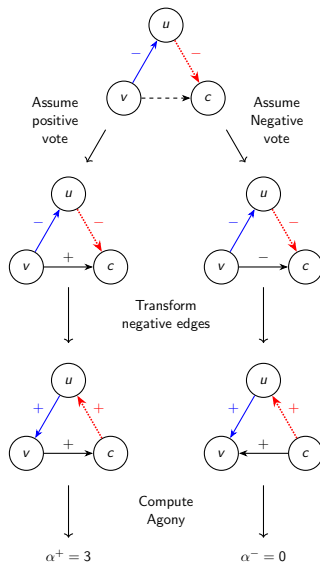
$$\lambda_1^+ = 0.55, \lambda_1^- = 0.55$$

(c)  $i = 3$

# Status Theory

# Follows Graph

# Iterative Status Model



# Iterative Prediction

# Algorithm

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**Input:** Candidate  $c$ , Relationship graph  $R = (V_R, E_R, w_R)$ , Order of voters in current session  $O$  and true votes  $w^*$

**Result:** Predictions for current session

```
1  $k \leftarrow |O|$ 
2  $u \leftarrow O[1]$  // First voter
3  $V_S \leftarrow \{c, u\}$  // candidate and first voter
4  $E_S \leftarrow \{(u, c)\}$  // first vote
5  $w_S((u, c)) \leftarrow w^*((u, c))$  // Assign true vote
6 Initialize session graph  $S = \{V_S, E_S, w_S\}$ 
7  $predictions \leftarrow \emptyset$ 
8 for  $i \leftarrow 2$  to  $k$  do
9    $v \leftarrow O[i]$ 
10   $V_S \leftarrow V_S \cup \{v\}$ 
11   $LSN \leftarrow S \cap R$ 
12   $p \leftarrow \text{Predict}(v, c, LSN)$ 
13   $predictions \leftarrow predictions \cup p$ 
14   $E_S \leftarrow E_S \cup \{(v, c)\}$ 
15   $w_S((v, c)) \leftarrow w^*((v, c))$  // Assign true vote
16 end
17  $\text{Update}(R, S)$  // Update Relationship graph
18 return  $predictions$ 
```

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# Results



Arinik, N., Figueiredo, R., and Labatut, V. (2017).

Signed graph analysis for the interpretation of voting behavior.



Brito, A. C. M., Silva, F. N., and Amancio, D. R. (2020).

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