Opinion formation under global steering with application to social network data analysis*

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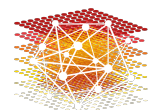


Motivation

Our goal is to integrate **information aggregation** and **participation** into an opinion dynamics model. Motivating examples:

- Stockpiling, bank runs
- Media coverage of protests
- Voting and polls

Stockpiling during Covid-19 crisis (Source: BBC)

The model

N agents are located on a **weighted digraph**. At each period t, they are characterized by:

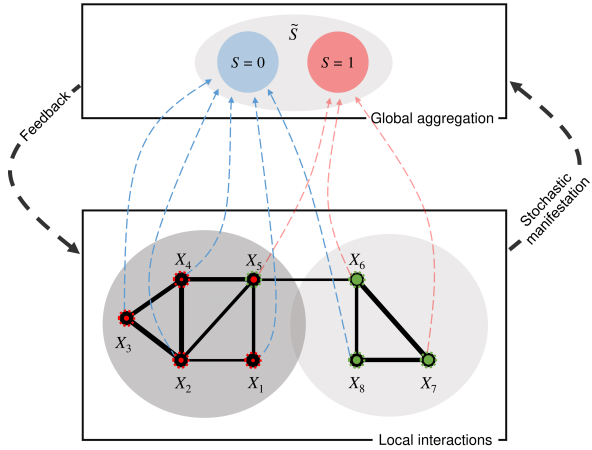
- An **opinion** $X_{i,t} \in \mathbb{R}$.
- A **state** $S_{i,t} \in \{0, 1\}$ modeling whether the agent takes some action (e.g. running to the bank, protesting...)

They evolve according to:

$$\textbf{State update:} \quad \underbrace{S_{i,t} \sim \text{Bernoulli}}_{\text{event generation}}\left(\frac{1}{1+\exp(-\lambda X_{i,t})}\right) \tag{1}$$

$$\textbf{Opinion update:} \; X_{i,t+1} = \underbrace{\beta_i}_{\substack{\text{agent's} \\ \text{reaction}}} \underbrace{g(S_t)}_{\substack{\text{global} \\ \text{steering}}} + \underbrace{\sum_{j=1}^{N} w_{ji} X_{j,t}}_{\substack{\text{local opinion} \\ \text{propagation}}} \tag{2}$$

Illustration



Properties of the mechanisms

Opinion propagation mechanism

The OPM acts like a converging force

Proposition

If $\gamma = 0$, under aperiodicity of the weigthed digraph, $\lim_{+\infty} X_{i,t} = C$, for all i. (DeGroot 1974)

Global Steering Mechanism

The GSM acts like a diverging force:

Proposition

For a strictly increasing $g(S_t)$ function, we have:

$$\min_{i,j\in} \left(\lim_{+\infty} \left(X_{i,t} - X_{j,t} \right) \right) \geq \lim_{+\infty} \mathbb{E}\left[g(S_t) \right]. \tag{3}$$

Corollary: **no consensus can be reached in the limit**.

Fitting to Twitter data

Fitting method

- Frequency of **selected terms** in different languages treated as a **state**.
- **Synthetic SBM network** used to run the model.
- Dynamics fitted to the Twitter data.

Results

- r: probability to connect nodes of **different clusters**. Small r correspond to **highly clustered networks**.
- One r is obtained per language using simulated annealing.
- Outcomes are compared based on the linguistic area.

Results: Map for Ukrainian flag emoji