Diffusion of Opinions and Innovations among Limitedly Forward-looking Individuals

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Who matters in coordination problems on networks?

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Objectives

- We analyze a coordination game
- Agents are connected on a fixed undirected network
- We focus on the role of heterogeneity of players: extreme/ moderate and myopic/ farsighted
- We study the coordination outcome

Questions:

- How do these outcomes form?
- What happens when a larger proportion of people in the society becomes farsighted?

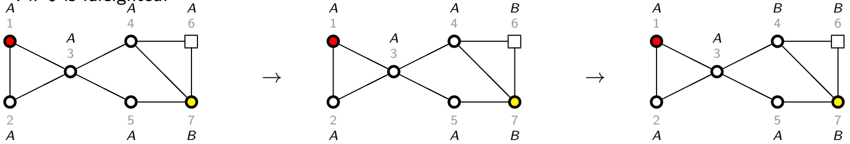
Improving path

Definition:

A myopic-farsighted improving path of length L from a strategy profile $p \in \mathcal{P}$ to a strategy profile $p' \in \mathcal{P}$ is a finite sequence of strategy profiles $p^0, \dots, p^L \in \mathcal{P}$ with $p^0 = p$, $p^L = p'$ and $p^j \neq p^k$ for all $j, k \in \{1, \dots, L-1\}$ such that for every $\ell \in \{0, \dots, L-1\}$ there is a unique player i such that $p_i^{\ell+1} \neq p_i^\ell$ and

$$\begin{cases} u_i(p^{\ell+1}) > u_i(p^\ell), & \text{if } i \in M \\ u_i(p^L) > u_i(p^\ell), & \text{if } i \in F \end{cases}.$$

Pl. 6 is farsighted.



Impact of farsightedness

Proposition:

1. If all players are myopic then the set of stable profiles is the set of Nash equilibria.
2. Turning a myopic player farsighted makes the set (weakly) smaller.
3. If all players are farsighted there exists at least one stable profile.

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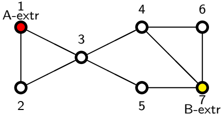


All players myopic. Stable profiles:

1 $\{A, A, A, A, A, A, B\}$

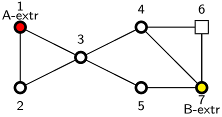
2 $\{A, A, A, A, B, A, B\}$

3 $\{A, A, A, B, A, B, B\}$

4 $\{A, A, A, B, B, B, B\}$

5 $\{A, A, B, B, B, B, B\}$

6 $\{A, B, B, B, B, B, B\}$



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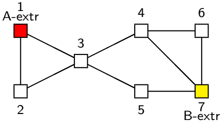

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Results

- We define a new stability concept for farsighted and myopic players and analyse it for coordination games on networks, where players can choose between different projects.

- We proof that the set of stable strategy profiles is always a subset of the set of Nash equilibria and never empty.

- We show how the set of stable strategy profiles depends on the four main components of our model:
    * Farsightedness,
    * Extremism,
    * Thresholds,
    * Network.

Social learning with Bayesian and non-Bayesian agents

Updating beliefs

* DeGroot(1974)

$$y_{i,t+1} = \sum_{k=1}^{n} w_{ik} y_{k,t}$$

* Jadbabaie et al.(2012)

$$y_{i,t+1} = w_{ii} BU(y_{i,t}; s_{i,t+1}) + \sum_{k \neq i}^{n} w_{ik} y_{k,t}$$

* Fernandes(2018)

$$\alpha_{i,t+1} = w_{ii}[\alpha_{i,t} + s^1_{i,t+1}] + \sum_{k \neq i}^{n} w_{ik} \alpha_{k,t}$$

$$\beta_{i,t+1} = w_{ii}[\beta_{i,t} + s^0_{i,t+1}] + \sum_{k \neq i}^{n} w_{ik} \beta_{k,t}$$

$$y_{i,t+1} = \frac{\alpha_{i,t+1}}{\alpha_{i,t+1} + \beta_{i,t+1}}$$

Decision problem

Stages of the game:

* $t = 0 : y_{i,0}$
* $t > 0 : s_{i,t} \rightarrow y_{i,t} \rightarrow x_{i,t}$

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Reference group:

* $\boldsymbol{R}$ - $\{0, 1\}$ reference group matrix
* r_i - number of agents in reference group of agent i, $r_i \leq d_i$

$$\mathbb{E}[u_{i,t}] = \underbrace{\gamma_i x_{i,t} - \frac{1}{2}(x_{i,t})^2}_{\text{indiv. incentives}} - \underbrace{\frac{1}{2}(x_{i,t} - \mathbb{E}[y_{i,t}])^2}_{\text{close to his beliefs}} - \underbrace{\frac{1}{2}\mu_i(x_{i,t} - \sum_j \hat{r}_{ij} x_{j,t})^2}_{\text{coordination with reference group}}$$

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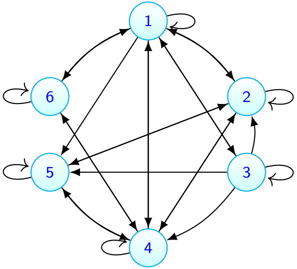
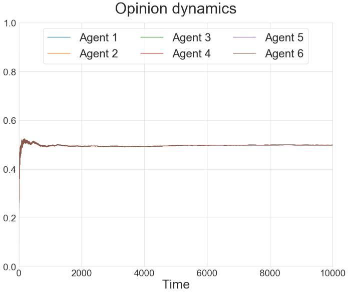
$$\mathbb{E}[x^*_{i,t}] = \frac{1}{2+\mu_i}\gamma_i + \frac{1}{2+\mu_i}\mathbb{E}[y_{i,t}] + \frac{\mu_i}{2+\mu_i}\sum_j \hat{r}_{ij}\mathbb{E}[x^*_{j,t}]$$

Homogeneous society

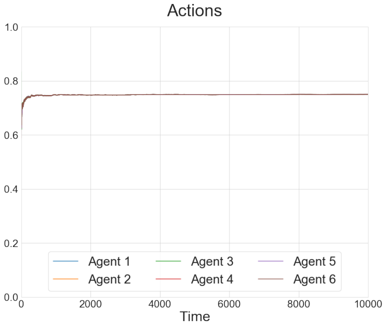


$$\mathbf{W} = \begin{bmatrix} 0.133 & 0.25 & 0.292 & 0.083 & 0.075 & 0.167 \\ 0.3 & 0.15 & 0 & 0.3 & 0.25 & 0 \\ 0.1 & 0.03 & 0.38 & 0.26 & 0.23 & 0 \\ 0.12 & 0.35 & 0 & 0.1 & 0.22 & 0.21 \\ 0 & 0.54 & 0 & 0.18 & 0.28 & 0 \\ 0.34 & 0 & 0 & 0.27 & 0 & 0.39 \end{bmatrix}$$

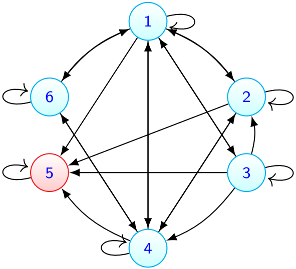
Interaction matrix



Opinion convergence with $\theta = 0.5$



Stubborn player



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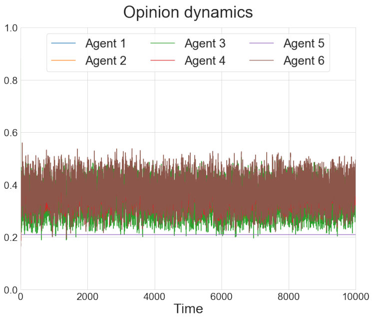
Interaction matrix

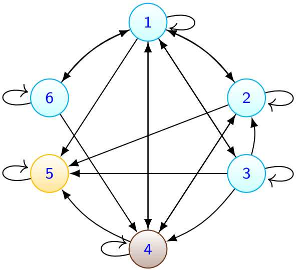
i	1	2	3	4	5	6
$\alpha_{i,0}$	0.6	0.3	1.5	0.4	0.31	0.2
$\beta_{i,0}$	0.4	0.8	0.2	3	1.17	10
$y_{i,0}$	0.6	0.27	0.88	0.12	0.2	0.02

Initial opinions of players



Opinion fluctuations with $\theta = 0.5$

Polarization



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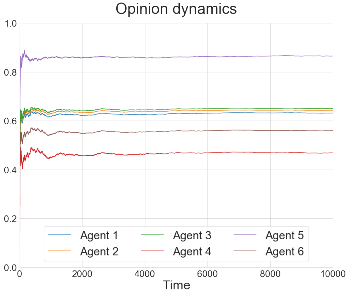

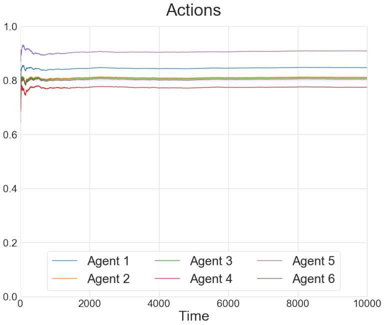

Convergence in the society, $\theta = 0.67$.

Conclusion

Social learning:

* Persistent opinion fluctuations with Stubborn agent
* Polarization shifts aggregate opinion according to the level of polarization and influence of Optimist-Pessimist agents

Decision problem:

* Coordination with Stubborn and Optimist-Pessimist agents significantly decreases the total welfare of the society

Further research:

* Introduction of (limited) farsighted agents
* Policies for social welfare maximization

Thank you for your attention!