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Simulation of Stance Perturbation

Background

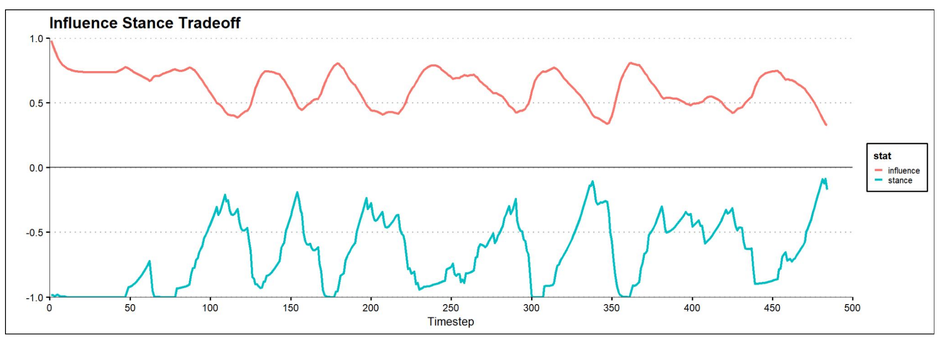
- Use of Agent Based Modeling (ABM) to determine when & why intentional social influence operations are likely to succeed
- Simulation studies can be categorized into endogenously, exogeneously, co-evolutionary emerging networks.
- Endogenous: how agent network changes over time, keeping individual agent states constant
- Exogenous: keep network structure constant and model state changes
- Co-evolutionary approach: hybrid of both (used here)
- Agreement that stance 'tipping points' exist, but various estimates for % of confederates needed (ranging from 2% - 25%)

Contributions

- Definition of evaluation criterion for intentional stance perturbations
- Development of co-evolutionary Social Influence model to capture both endogenous (new nodes are introduced with strategic links/stances) & exogenous (stances of existing nodes are targeted) perturbations
- Modelling of stance perturbation strategies
  - exploration of influence - effect tradeoff

Model

- **Stance update:** $y(t) = AWy(t-1) + (I - A)y(1)$
- **Influence update:** $w_{ij,t+1} = \lambda y_{jt} y_{it} + (1 - \lambda) w_{ijt}$



References

Centola, D., J. Becker, D. Brackbill, and A. Baronchelli. 2018, June. "Experimental evidence for tipping points in social convention". Science 360(6393):1116–1119.

Friedkin, N. E., and E. C. Johnsen. 1990. "Social influence and opinions". Journal of Mathematical Sociology 15(3-4):193–206. Publisher: Taylor & Francis.

Macy, M. W., J. A. Kitts, A. Flache, and S. Benard. 2003. "Polarization in dynamic networks: A Hopfield model of emergent structure". Dynamic Social Network Modeling and Analysis:162–173. Washington DC: National Academies Press.

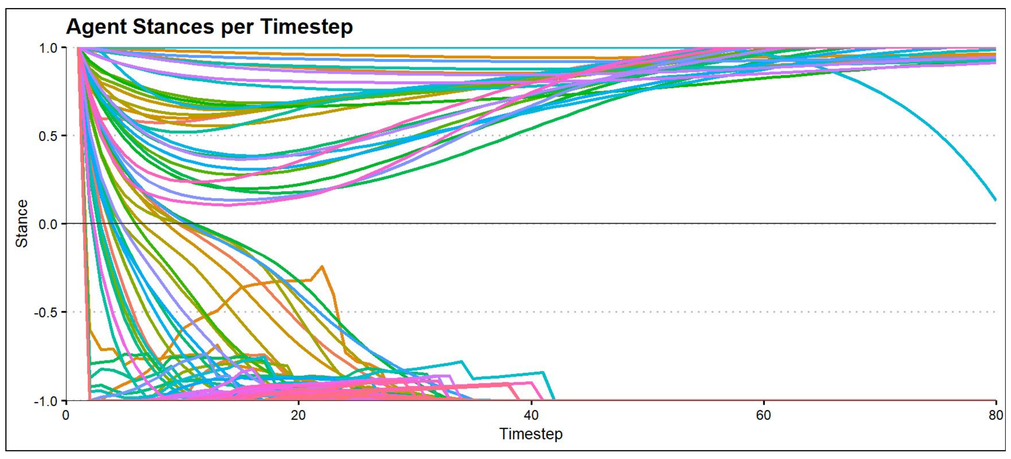
Ng, L. H. X., and K. M. Carley. 2022. "Pro or Anti? a Social Influence Model of Online Stance Flipping". IEEE Transactions on Network Science and Engineering:1–18.

Ross, B., L. Pilz, B. Cabrera, F. Brachten, G. Neubaum, and S. Stieglitz. 2019, July. "Are social bots a real threat? An agent-based model of the spiral of silence to analyse the impact of manipulative actors in social networks". European Journal of Information Systems 28(4):394–412.

Will, M., J. Groeneveld, K. Frank, and B. M¨uller. 2020, Feb.. "Combining social network analysis and agent-based modelling to explore dynamics of human interaction: A review". Socio-Environmental Systems Modelling 2:16325.

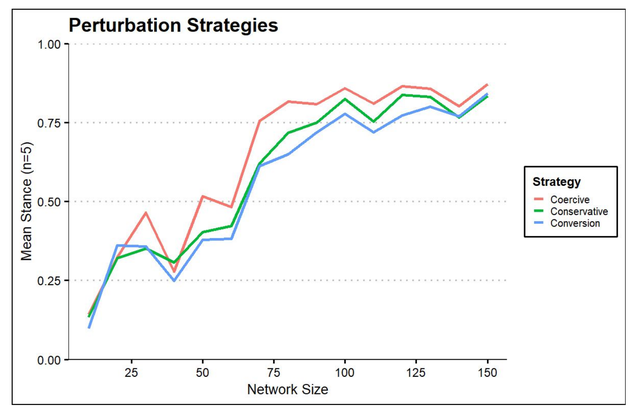
Methodology

- Construct series of generalized scale-free networks (5 replicates per size)
- Choose Confederates according to an Agent Selection Strategy
- Apply a Perturbation Strategy
- Run the simulation until the stances in the network converge
  - average change in stance < 0.05

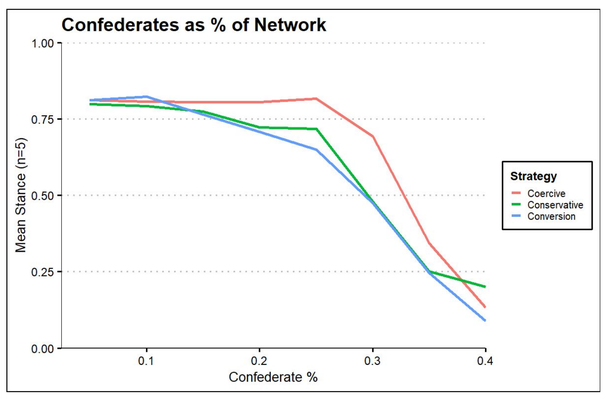


Optimal confederates 'coerce' local ego-networks

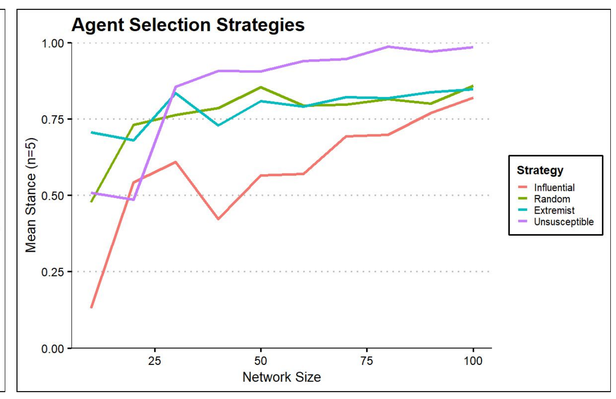
- Conservative:
$$y(i,t) = \begin{cases} \mu_y & \Sigma_j^N w(j,i) \leq \theta \\ -1 & \Sigma_j^N w(j,i) > \theta \end{cases}$$
- Coercion:
$$y(i,t) = \mu_y^g + w_i^g * (-1 - \mu_y^g)$$
- Conversion:
$$y(i,t) = \mu_y^l + w_i^l * (-1 - \mu_y^l)$$



Minority stance 'tipping points' exist



Influential agents are better confederates



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