NME 2024

Network Modeling for Epidemics

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Separable Temporal ERGMs

STERGMs

More details

STERGMs

- The statistical theory in Krivitsky and Handcock 2014:
  - demonstrates a given combination of formation and dissolution model will converge to a stable equilibrium, i.e.:

Prevalence ≈ Incidence x Duration

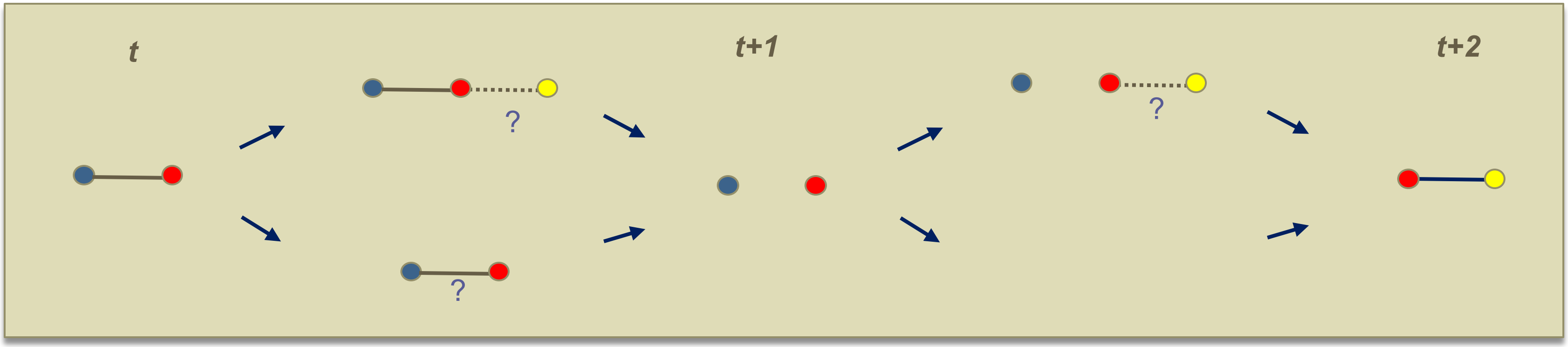
- This and other work in press provide the statistical theory for methods for estimating the two models, given certain kinds of data

STERGMs – dependence across time steps

- The “separable” part of STERGMS means that within a time step, formation and dissolution are independent
- But this does not mean that they must be independent across time steps
- Imagine this model:
  - formation = ~edges+degree(2:10)
  - dissolution = ~edges
  - with increasingly negative parameters on the degree terms.
  - i.e. there is some underlying tendency for relational formation to occur, which is considerably reduced with each pre-existing tie that the each actor involved is already in.
- In other words, there is a strong prohibition against being in multiple simultaneous romantic relationships.
- However, dissolution is fully independent---all existing relationships have the same underlying dissolution probability at every time step.

STERGMs – dependence across time steps

- Imagine that Chris and Pat are in a relationship at time *t*.
- During the step between *t* and *t+1*, whether they acquire a new partner does not depend on whether they break up and vice versa.
- Let us assume that they do break up during this time.
- Now, during the time period between t+1 and t+2:
  - whether or not they each form new partnership is dependent on whether they are still together are time t+1,
  - and that in turn depends on whether they broke up between t and t+1.



STERGMs – dependence across time steps

- The simple implication of this is that in this framework, formation and dissolution can be dependent, but that dependence occurs in subsequent time steps, not simultaneously.
- Note that a time step here is arbitrary, and left to the user to define. One reason to select a smaller time interval is that it makes this assumption more justifiable.
- I.e. with a time step of 1 month, then if I start a new relationship today, the earliest I can break up with my first partner as a direct result of that new partnership is in one month.
- If my time step is a day, then it is in 1 day
- The latter is likely much more reasonable.
- The tradeoff is that a shorter time interval means longer computation time for both model estimation and simulation
- At the limit, this can in practice approximate a continuous-time model---the only issue is computational limitations.`

Note on implementation

Dissolution is the inverse of persistence

$$logit\left(P\left(Y_{ij,t+1} = 1 \middle| Y_{ij,t} = 1, \text{rest of the graph}\right)\right) = \boldsymbol{\theta}^{-\prime}\boldsymbol{\partial}\left(\boldsymbol{g}^{-}(\boldsymbol{y})\right)$$

STERGMs can be operationalized in terms of relational persistence

- log odds that a tie = 1 now, given it = 1 at the last time step
- makes it consistent with formation model & math is convenient
- the coefficients should be interpreted as effects on relational persistence

To get dissolution effects, just flip the sign of the coefficient

- "dissolution" is the more common partner of "formation"
- and we will often use the language of dissolution