8_Speical+Networks

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Advanced Network Analysis
8. Special Networks

Weihua An

EMORY UNIVERSITY

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Outline

- Weighted Networks
- Two-Mode Networks
- Text Networks

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Weighted Networks

In a weighted (valued) network, each cell contains a weight that may indicate the frequency of interactions or strength of ties, etc.

$$A = \begin{bmatrix} 0 & 2 & 1 \\ 2 & 0 & 0.5 \\ 1 & 0.5 & 0 \end{bmatrix}$$

- Outdegree Centrality

$$\begin{bmatrix} 3 \\ 2.5 \\ 1.5 \end{bmatrix}$$

- Degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality are available in "statnet" or "tnet".

ERGMs on Weighted Networks

ERGM has been extended to model weighted networks (Krivitsky and Butts 2013). The weights are modeled as following a Poisson distribution (or a binomial distribution).

$$w_{ij} \sim \text{Poisson}\ (\mu_{ij}) \tag{1}$$

$$\Pr(w_{ij} = k) = \frac{\mu_{ij}^k e^{-\mu_{ij}}}{k!} \tag{2}$$

$$\log(\mu_{ij}|w_{ij}^c) = \beta_1 + \beta_2 \boldsymbol{X}_{i|j} + \beta_3 \boldsymbol{S}_{ij} \tag{3}$$

where w_{ij}^c represents the network except w_{ij}, $\boldsymbol{X}_{i|j}$ receiver and sender effects, and $\boldsymbol{S}_{ij}$ endogenous tie formation processes.

Table 4. ERGM Results for the Co-Advising Network

	Model 1			Model 2		
Variables	Est	SE	P	Est	SE	P
Main Effects						
Associate Professor	1.78	0.47	0.00	1.63	0.46	0.00
Full Professor	2.36	0.54	0.00	2.12	0.55	0.00
Tenure	-0.05	0.01	0.00	-0.04	0.01	0.00
Male	-0.15	0.18	0.40	-0.13	0.17	0.44
Quantitative Approach	0.25	0.25	0.33	0.18	0.22	0.41
Homophily						
Rank	0.32	0.32	0.31	0.40	0.35	0.25
Sex	0.16	0.24	0.52	0.20	0.26	0.44
Quantitative Approach	0.78	0.34	0.02	0.93	0.32	0.00
Area	0.28	0.27	0.29	0.38	0.29	0.20
Network Structure						
Transitivity				1.23	0.35	0.00
Constant	-4.52	1.01	0.00	-5.58	0.99	0.00
AIC	-324			-344		

- The dependent variable is the average connection.
- The average connection for members with a trait is expected to be e^{β} times the average connection for members without the trait.
- The average connection for a full prof. is $e^{2.12} = 8.33$ times the average connection for an assistant prof.
- The average connection between faculty using the same analytical approach is $e^{0.93} = 2.53$ times the average connection between faculty with different analytical approach.

Two-Mode Networks

A two-mode network (a bipartite network) is composed of relations between two types of nodes. For example, each student will select three to four faculty members to form a dissertation committee.

- A two-model network can be converted to a one mode network showing the ties between students.

$$A = BB^T$$

The diagonal shows the number of advisors each student has and the off-diagonal the number of advisors shared by any two students.

- A two-model network can also be converted to a one mode network showing the ties between faculty members.

$$F = B^T B$$

The the diagonal shows the number of students a faculty has and the off-diagonal the number of students co-advised by two faculty members.

Example: The Advising Network

Students in the rows; faculty in the columns.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23	X24	X25	X26
A	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0
D	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
F	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
H	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
I	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0
J	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
K	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
L	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0
M	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
O	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
P	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Q	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0

The Co-advising Network between Faculty Members

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23	X24	X25	X26
X1	5	0	1	0	0	0	1	0	0	0	0	1	2	2	0	2	1	2	0	0	1	0	0	1	0	0
X2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X3	1	0	2	1	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0	0	1	0	0	0	0	0
X4	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
X5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X6	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
X7	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
X8	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
X9	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0
X10	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	2	0	1	0	0	0	2	0	0	0	0
X11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
X12	1	0	0	0	0	0	0	1	0	0	0	2	1	0	1	1	0	1	0	0	0	0	0	0	0	0
X13	2	0	0	0	0	0	0	1	0	0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	0
X14	2	0	2	1	0	0	0	0	0	1	0	0	0	4	1	1	1	1	0	0	1	1	0	0	0	0
X15	0	0	1	1	0	0	0	1	0	0	0	1	0	1	3	0	0	2	0	0	1	0	0	0	0	0
X16	2	0	0	0	0	0	0	1	0	0	2	0	1	2	1	0	4	0	1	0	0	0	2	0	0	0
X17	1	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0	4	2	1	1	1	1	0	0	0	0
X18	2	0	0	0	0	0	0	0	1	0	1	1	0	1	2	1	2	7	1	0	1	2	0	1	0	0
X19	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	2	1	0	0	0	0	0	0
X20	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0
X21	1	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	1	0	0	3	0	0	1	0	0
X22	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	2	1	2	0	0	0	3	0	0	0	0
X23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X24	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	3	0	0
X25	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
X26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Text Networks

The goal is to study networks of words or concepts or to extract social networks from textual data (e.g., citations and biographies).

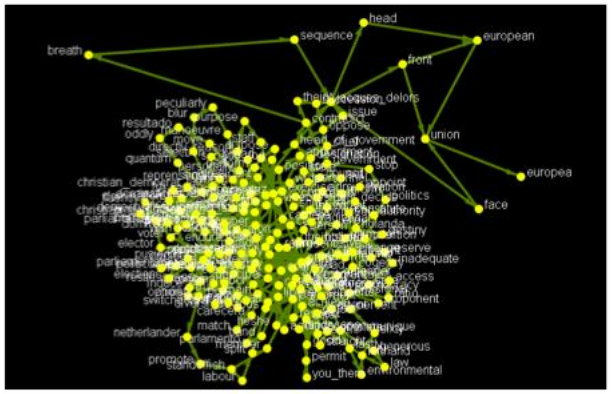
- Word networks
- Discourse network analysis
- Citation network analysis

Word Networks

Word network analysis examines the co-occurrence of words in texts (the building blocks of meanings and concepts) in order to study language patterns and writing features.

- If two words occur adjacently or within certain distance (e.g., in the same sentence), they are treated as co-occurring.
- "AutoMap" developed by Katherine Carley's lab at CMU is an useful tool for word network analysis.

Example



Source: Tanenbaum and Brand (2008)

Discourse Network Analysis

Discourse network analysis examines how actors utilizes different concepts to present and communicate ideas.

- Make a matrix with actors in the rows and the concepts in the columns. The cells could be coded according to whether the concepts are supported or opposed. 1 = support, 0 = not use, -1 = oppose.
- Convert the matrix to an actor network to study discourse coalition.
- Convert the matrix to a concept network to examine storyline.
- "DNA" in R is useful for this purpose.

Discourse Coalition Network (Leifeld and Haunss 2010)

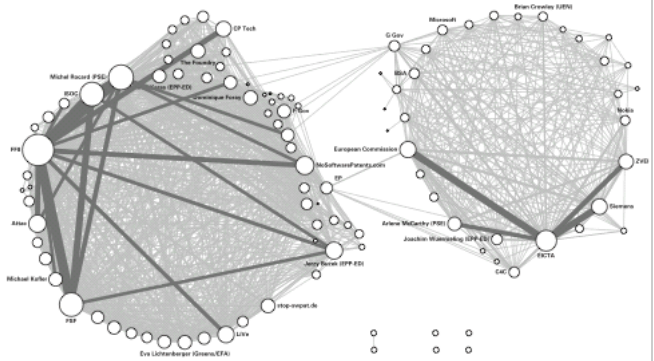
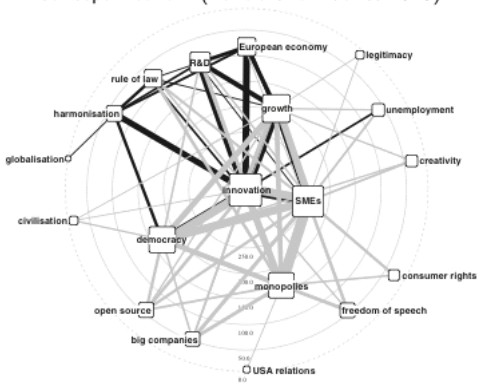
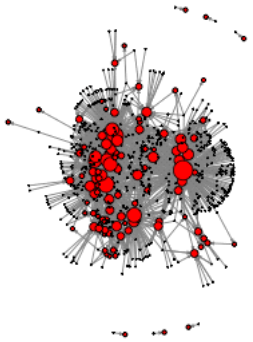


Figure 2. Actor congruence network, 1997-2005.
Note: Circles represent actors, size corresponds to degree centrality, line width reflects the number of concepts shared between two actors

Concept Network (Leifeld and Haunss 2010)



Citation Networks in Causal Inference



Papers

Top Authors

Table 7. ERGM Results for Predicting the Citation Networks

	Model 1 full network			Model 2 core network			Model 3 core network		
	Est	SE		Est	SE		Est	SE	
Edges	−13.82	0.15	***	−7.53	0.15	***	−6.82	0.32	***
Receiver effects									
Funding	1.25	0.05	***	1.20	0.05	***	0.63	0.12	***
U.S. Author	0.38	0.02	***	−0.02	0.02		−0.10	0.05	
Short Last Name	−0.54	0.04	***	−0.43	0.04	***	−0.23	0.08	**
More Authors	−1.25	0.04	***	−1.14	0.04	***	−0.91	0.08	***
Prestigious University	0.59	0.03	***	0.20	0.03	***	0.45	0.08	***
Article	−0.11	0.12		−0.52	0.12	***	−0.41	0.24	
Longer Publications	1.32	0.05	***	1.21	0.05	***	0.70	0.11	***
More Keywords	0.15	0.02	***	−0.01	0.02		−0.19	0.05	***
Recent Publications	−2.55	0.04	***	−3.03	0.04	***	−1.16	0.09	***
Method Journal	0.29	0.03	***	−0.93	0.03	***	−0.07	0.08	
Top Journal	1.14	0.02	***	0.25	0.02	***	−0.14	0.06	*
Sender effects									
Funding	0.36	0.03	***	0.16	0.03	***	0.09	0.06	
U.S. Author	0.50	0.02	***	0.20	0.02	***	0.27	0.05	***
Short Last Name	−0.07	0.03	*	−0.04	0.03		0.01	0.06	
More Authors	−0.34	0.03	***	−0.18	0.03	***	−0.38	0.06	***
Prestigious University	0.42	0.03	***	0.17	0.03	***	0.16	0.06	**
Article	−0.34	0.08	***	−0.37	0.08	***	−0.48	0.17	**
Longer Publications	0.13	0.03	***	0.04	0.03		0.27	0.07	***
More Keywords	0.17	0.02	***	0.13	0.02	***	0.33	0.05	***
Recent Publications	0.67	0.03	***	0.31	0.03	***	0.13	0.07	
Method Journal	1.60	0.02	***	0.52	0.02	***	1.01	0.06	***
Top Journal	0.66	0.02	***	0.09	0.02	***	0.04	0.05	
Homophily									
Same Field	0.83	0.02	***	0.82	0.02	***	0.94	0.06	***
Shared Authors	5.98	0.08	***	4.94	0.09	***	4.69	0.28	***
Network structures									
GWESP (Transitivity)							3.47	0.05	***
GWDSP (Two-Path)							−0.49	0.02	***
GWIDEGREE							−5.77	0.16	***
GWODEGREE							3.86	0.00	***
Forward Referencing							−5.E+15	4.E+04	***
Number of Nodes	33,306			4,769			4,769		
Number of Edges	8,367			8,367			8,367		