Opinion and spreading information models in complex networks

Lidia Braunstein
Lazaros Gallos
Maksim Kitsak
Qian Li
Fredrik Liljeros
Hernan Makse
Lev Muchnik
Diego Rybski
Jia Shao
H. E. Stanley

Shlomo Havlin
Bar-Ilan University

Human Relationships-Social Network
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>How social networks are created?</td>
<td>Gallos et al PRX (2012)</td>
</tr>
<tr>
<td>How opinions are formed?</td>
<td>Shao et al, PRL (2009)</td>
</tr>
</tbody>
</table>
How People Interact in Online Networks?

Following dynamics

P. R. Monge and N. S. Contractor, Theories of Communication Networks (Oxford University Press, New York, 2003).

How People Interact in Online Networks?

How People Interact in Online Networks?

Identification of influential spreaders in complex networks

METHOD: k-shell decomposition analysis

SIR on inpatient network
Test: SIR on real networks: email ($\beta=0.08$) and inpatient networks ($\beta=0.04$)

Consensus Opinion Models

• Voter Model (Holley and Ligget 1975, Redner 2005): The agents imitate their neighbors
• Majority Rule Model (S. Galam et. al, 2002, P. L. Krapivsky et. Al 2003): Agents follow the majority opinion of their friends

How opinions are formed?
How opinions are formed?

Consensus Opinion Models

- Voter Model (Holley and Liggett 1975, Redner 2005): The agents imitate their neighbors

Non-Consensus Opinion (NCO) Models (J. Shao et.al, 2009):

- Agent’s opinion is influenced by both its own current opinion and the opinions of his friends
- Agent follows the majority opinion of his local community, which include agent’s friends and itself

Considering the agent’s own opinion leads to **non-consensus** state
NCO Model on Single Networks

\[ f : \text{Initial fraction of one of the opinions} \]

(a) ER networks with average degree=4

(b) SF networks with \( \lambda = 2.5 \)
When the average degree of the networks increases, the importance of one’s own opinion decreases and the NCO model converges to the Majority Rule model.
NCO Model on Coupled Networks

Second Order Transition (NCO on Single Network)

Hybrid Transition
(Abrupt Transition Dominate)

Similar to percolation in interdependent networks
Buldyrev et al., Nature (2010)

FOUR QUESTION ON SOCIAL NETWORKS---PARTIAL ANSWERS

MAIN MESSAGES:

How social networks are created? Gallos et al PRX (2012)

Motifs occur significantly in social interactions


In many cases K-shell better than degree or betweenness

How opinions are formed? Shao et al, PRL (2009)

Agent’s own opinion should be considered


Agents surrounding by less extreme people are more stubborn