Looking for stable pluralism

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Social phenomena

- how does a new fashion spread, e.g. wearing jeans?
- how does a new piece of music become popular?
- how can a new idea trump the old one?
- how can several different ideas coexist in the same society, e.g. political “left” and “right”?

Social phenomena

Relevance of understanding social processes:

- social and economic stability
- demographic trends
- etc.

Social phenomena are complicated and difficult to approach quantitatively

Present models offer only a very descriptive level of understanding – for example, unable to make any predictions

Need to model

We need an analytical framework for developing quantitative methods of studying social processes

This involves other fields such as:

- mathematics and computer science
- statistical physics

Various models developed over the past decade, with more or less success in capturing social phenomena

Network models

Typically, models are based on the framework of *complex networks*:

Society represented as a social network of individuals connected by relations such as friendship

Diffusion of idea/opinion modeled as a variable attached to the nodes.

Opinion dynamics

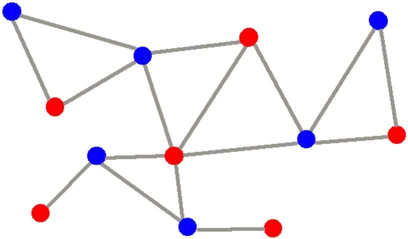
We start by choosing a network resembling real social networks

To each node attach an initial state (idea or opinion), say 0 or 1, which represent e.g. left or right political position

Establish a rule of evolution determining how do nodes' states change over time, i.e., how do opinions of your neighbors influence yours

Majority rule

A network with some initial states:



+ the dynamical model such as *majority rule*:

- if the majority of your neighbors are “1”/“0”, then you become “1”/“0”, regardless of what you were
- if the neighborhood is divided half-half between “1” and “0”, then you flip a coin

My model

A “common wisdom”:

Trusting only yourself is bad, but
trusting only others is even worse

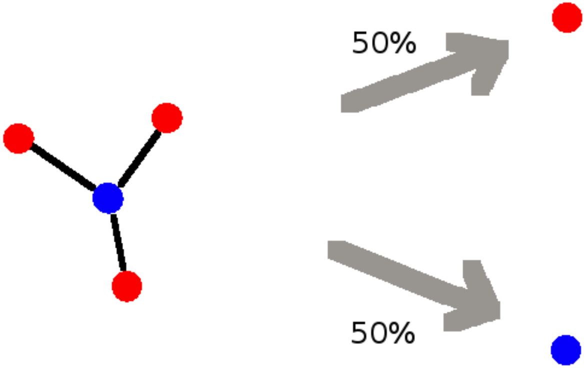
Model of opinion dynamics guided by trusting half yourself and half your neighbors:

If your state is “1”/“0”, then the chance you will stay “1”/“0” is

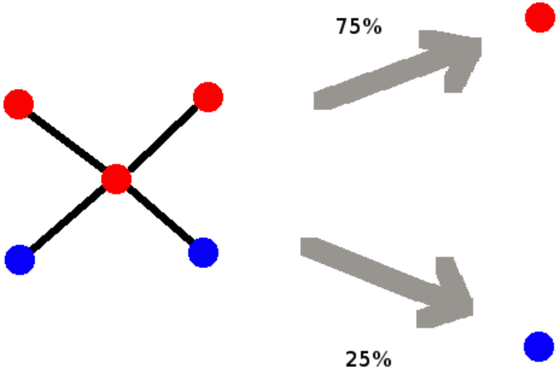
$$0.5 + \frac{1}{2}(\text{fraction of your neighbors with “1”/“0”})$$

and otherwise you change your state to “0”/“1”

Illustration



Illustration



General behavior

What happens when we run the dynamics of many iterations (time-steps)?

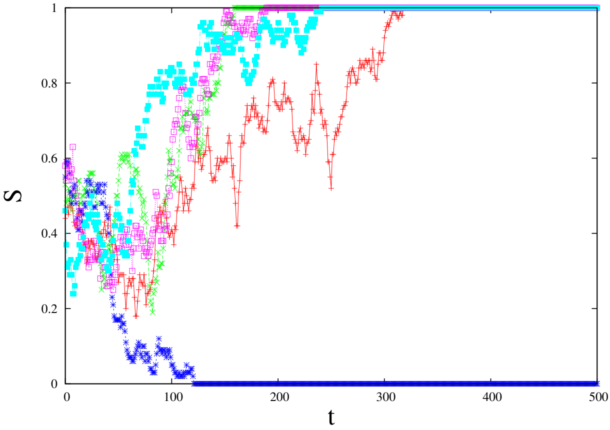
Regardless of the initial states, eventually all nodes end up having a single uniform state (either “1” or “0”)

Totalitarianism prevails, independently of where we start from...

General behavior

A way to measure this process

$$S(t) = \frac{1}{N} \sum_{i=1,N} s_i(t)$$



Problems

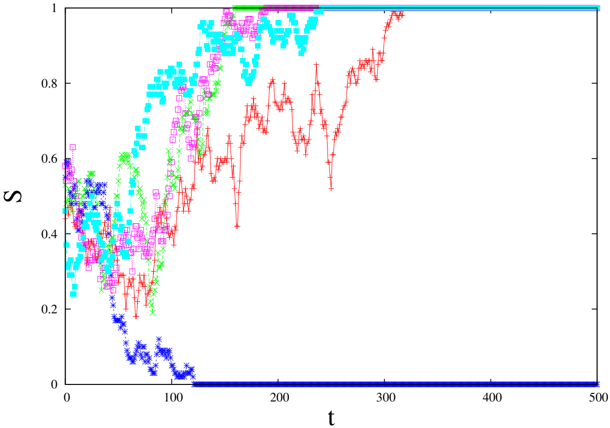
The same scenario occurs for any model of opinion dynamics, and in general, any similar binary-variable model of social processes

However, this is not accurate capturing of many processes, particularly those where there are always “two sides of the coin” (e.g. bi-partisan political systems in Western countries)

Can we look for alternative models which would support pluralism?

An observation

Looking again at the process of uniformization



Different transient times are needed for different networks to achieve the final uniform state – transient pluralism

Evolutionary algorithm

Can we look for those specific networks, for which the transient pluralist state will last the longest?

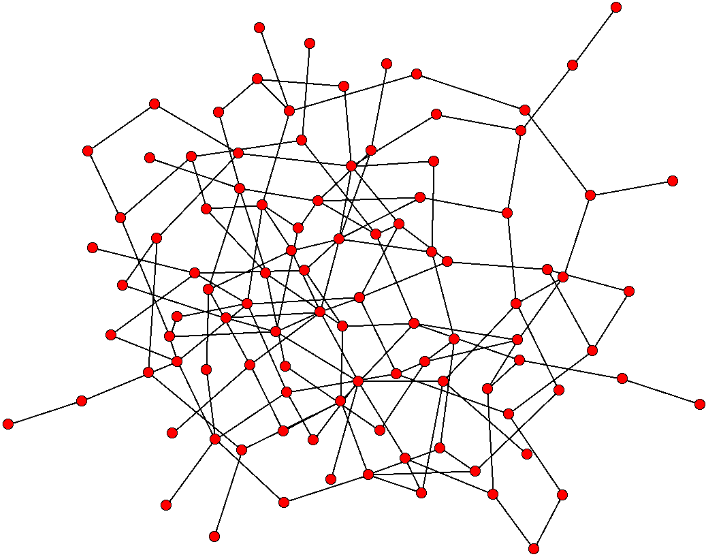
We implement a simple evolutionary algorithm, aimed at finding just such networks:

- start from some network, and measure the time T_0 it takes to reach the final uniform state (averaged over many realizations of the initial states)
- mutate the network, by e.g. randomly rewiring a link
- measure the same value T for this new network
- if $T > T_0$, accept the mutations, otherwise, when $T < T_0$, reject the mutation
- continue until the network with desired T is obtained

Evolutionary algorithm

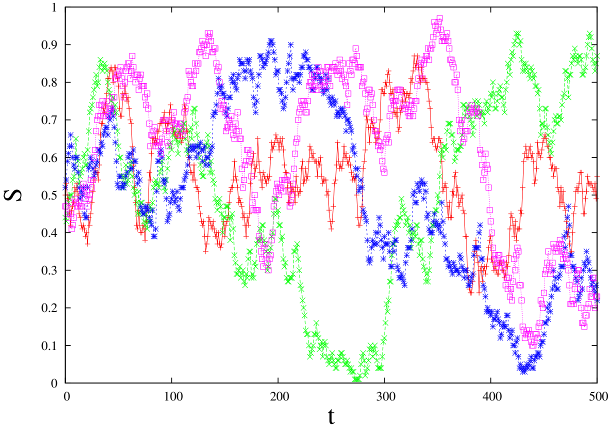
We run the algorithm starting with 10 realizations of random networks (ER graphs), with $N = 100$ nodes and $L = 150$ (non-directed) links. We run for 10^5 iterations (mutations), keeping track of the topology changes. For each mutation, time T is measured for the first 500 time-steps, and averaged over 20 random realizations of the initial states. To avoid local minima, mutations with $T < T_0$ were accepted with a probability exponentially small in $\frac{T_0 - T}{T_0}$.

Results - network example



Results - stable pluralism

$$S(t) = \frac{1}{N} \sum_{i=1,N} s_i(t)$$



Other results

For each realization of the initial network, the evolutionary algorithm eventually yielded a final network, able to support pluralist dynamics of much longer than other random networks.

These findings only preliminary – more detailed study of the network properties needed... which structural mechanism is behind this “non-equilibrium” behavior?

Conclusion

Evolutionary design of networks able to display certain emergent dynamics is a promising path towards new insights in modeling social processes

More detailed and systematic study is needed

My other work

- modeling biological networks
- network reconstruction
- modeling self-organization (e.g. synchronization) in complex networks
- etc.

Thanks!