Complexity in social dynamics : from the micro to the macro
Laboratory 3

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Social Dynamics

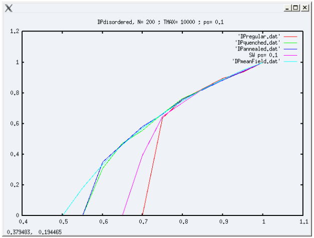
1. Network structure and directed percolation.
2. Antoconformistic model.
3. Ising model.
4. Deffuant model.
5. Axelrod model.

Topology, disorder and mean field

- The topology of the network plays a fundamental role.
- In general, we can distinguish among regular and disordered networks.
- The *mean field* analysis, that hold in the absence of correlations, is in general a good approximation to the dynamics on random networks.
- With the program `DPdisordered.f90` we can explore what happens to the directed percolation problem using regular, random (annealed and quenched) networks, small worlds and the mean field approximation.

Disordered directed percolation

- One can see that away from the critical value of the probability, the mean field is a quite good approximation.
- The dirdered lattices are very similar to mean field. The annealed version more than the quenced one.
- Random rewiring (small world) is intermediate. By increasing N and $TMAX$, it approaches more the mean field.

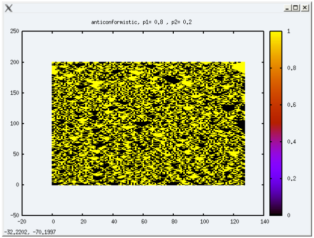


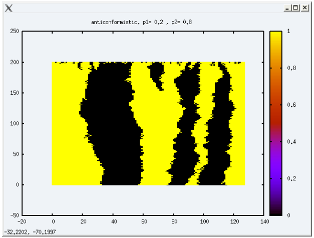
Antoconformistic model

- The anticonformistic model is a simple extension of the DK model, with two absorbing states.
- The basic idea is that one may take decision in opposition to a marginal majority, but cannot violate strong "social norms".
- It is modeled using a one-dimensional cellular automata whose transition probabilities $\tau(1|s)$ depends on the sum s of neighbors $(0 \leq s \leq 3)$.
- The absorbing states (social norms) all-zero and all-ones are given by $tau(1|0) = 0$ and $tau(1|3) = 1$.
- The fcontrol parameters are $tau(1|1) = p_1$ and $tau(1|2) = p_2$

Simulations

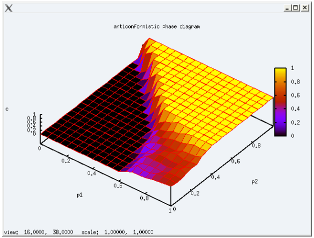
- When you run `anti.f90`, and experiment with parameters, you find all-zero and all-ones regions, and also an "active state" with a lor of triangles.
- The absorbing states are reached after a transient phase in which the system is divided into homogeneos regions, whose dividing walls perform a sort of random motion.





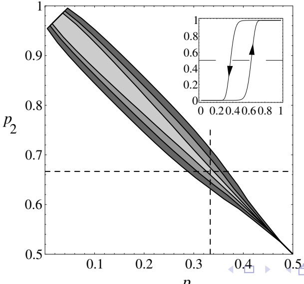
Simulations

- In order to have an idea of the phase diagram, let run `antiPhase`. The order parameter is the density c of ones in the asymptotic configuration.
- You can see that there is a region in which the transition between all-zeros to all-ones is sharp (a "first-order" phase transition), and a phase (active) whene the transition is smooth ("second-order").



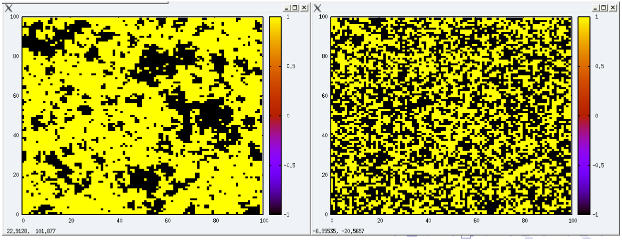
Extensions

- The first-order phase transitions are characterized by histeresys (moe than one stable state at the same time). If you change the parameters during the run, you may see that the all-zero phase does not looses stability when entering the all-one phase. If you want to see the transition, you have to add a small perturbation: $tau(1|0) = \varepsilon$ and $tau(1|3) = 1 - \varepsilon$.
- You may also experiment with different topologies. What about developing a 2d version?



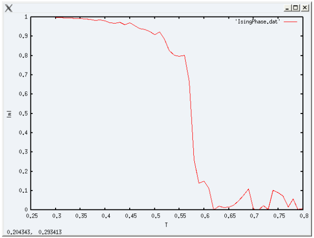
Ising model

- The ising model is a prototype of phase transitions without absorbing states (in at least 2D: `Ising.f90`).
- It is also the base of many models (impact factor, Hopfield, etc.)
- At high temperature, the typical configuration is disordered, with small clusters and small correlation lenght.
- At low temperature, there is a majority of spin in an orientation. Clusters are large, but the correlation length is small.
- At the critical temperature, the correlation length diverges.



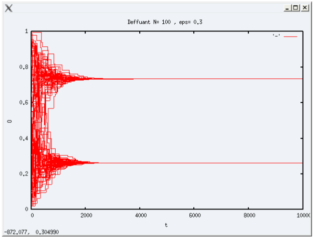
Ising model

- In order to put into evidence the phase transition, try `IsingPhase.f90`.
- In the y axes, there is the absolute value of the magnetization m, since starting from $m = 0.5$ in the magnetized phase one can obtain either $m > 0$ or $m < 0$.
- Try to add a magnetic field, and measure the size of a cluster that forms around a spin forced to stay in the opposite direction.



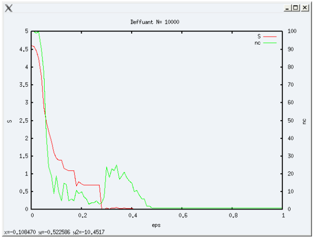
Deffuant model

- The deffuant model `deffuant.f90` uses continuous opinions from 0 to one.
- when two individuals meet, if the distance between their opinion is smaller than a certain threshold ε, their opinion converges.
- The final state is given by one or more clusters.
- It is an example of an irreversible process to a fixed point. In this case the phase transition corresponds to a change in stability of different attractors.



Deffuant model 1

- If one want to have an idea of the phase transition, as usual one has to "scan" for different values of ε (`deffuantScam.f90`).
- Two possible order parameters are the number of clusters n_c or the entropy S of the final distribution. As can be noticed on the graph, the entropy is a much more robust quantity, since it "weights" the clusters with their size. There can be situations with a lot of tiny clusters and a big one: the entropy almost neglects the small ones.



Axelrod model

- The Axelrod model (`axelrod.f90`) is a sort of "microscopic" version of the Deffuant one.
- In this case individuals are represented as vectors of discrete variables (Boolean in the example). We visualize the sum O of Boolean variables.
- Since the phase space is high dimensional, more configurations may correspond to the same value.
- It may happen that two individuals with similar values of the "macroscopic" variable O are actually quite distant and do not merge