Simulation of SIS model over networks

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Version 0.0
Complex and Social Networks (2014-2015)
Master in Innovation and Research in Informatics (MIRI)

1   Simulating an SIS infection

In this session you will have to simulate the spreading of a disease in the SIS model and check that the epidemic threshold for arbitrary networks is indeed $\frac{1}{\lambda_1}$ as forecast by [Chakrabarti et al., 2008].

In particular, we consider the spreading of the disease following these rules at each time step:

- An infected node recovers with probability γ

- An infected node attemps to infect each neighbor with probability β

You should be careful when implementing you simulation; please make sure that the updates of the nodes' statuses are done in parallel, that is, to update the status for time t only statuses of time $t-1$ of the other nodes are considered.

Initially, only a random fraction p_0 of nodes are infected.

2   Network models

You will run simulations on different types of networks, to see what their differences are in the spreading of the disease under the same initial conditions and with the same model parameters β, γ. We will consider networks of size $n = 1000$.

In particular, you should consider at least three of the following network kinds:

- Fully connected network (complete graph)

- Scale-free network of Barábasi-Albert

- Small-world network of Watts-Strogatz

- Trees

- Star network

- Regular lattices

- Erdös-Rényi random graphs

3   Tasks

3.1   Task 1

For a fixed set of β, γ and p_0 values, simulate what happens with the spread of the disease and plot the proportion of infected nodes over time (for each of the networks). Do you have among the networks you chose one that is more prone to epidemic? Check the leading eigenvalue of each network and see whether your result makes sense.

3.2   Task 2

For each of the network types you chose, check what its threshold is. Then, pick two sets of parameter values for γ, β, one slightly above and one slightly below the threshold and simulate the spread of the disease. Are your simulation results consistent with the theory?

4   Deliverables

You have to prepare a report detailing the results you obtain and any additional design decisions you may have taken while solving this lab session.

Important rule: The lab session, and especially the report you have to hand in, are strictly individual work. Plagiarism will be prosecuted. Nevertheless, you are encouraged to ask the teacher as soon as possible if you think you do not understand what you are supposed to do, and also if you feel you are spending much more time than the rest of the group – sometimes a tiny error can be tricky to find and does not add much to your knowledge. Questions can be asked either in person or by email, and you will never be penalized by asking questions, no matter how stupid they look in retrospect.

To deliver: You must deliver the report (explained above) and the source code in `R` (or other languages) that you have used (including some minimal comments that can help the reader).

Procedure: Submit your work through the raco platform as a single zipped file.

Deadline: Work must be delivered within **3 weeks** from the lab session you attend. Late deliveries risk being penalized or not accepted at all. If you anticipate problems with the deadline, please tell us as soon as possible. Notice that due to the holiday break we are giving you an extra week.

References

[Chakrabarti et al., 2008] Chakrabarti, D., Wang, Y., Wang, C., Leskovec, J., and Faloutsos, C. (2008). Epidemic thresholds in real networks. *ACM Transactions on Information and System Security (TISSEC)*, 10(4):1.