Complex Networks

Project 4: Dynamical processes in networks

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1 – Failures and attacks

- Simulate failures in the following networks, obtaining the size of the largest component versus the fraction of removed nodes:
  a. Erdös-Rényi networks,
  b. Barabási-Albert scale-free networks,
  c. Small-world networks for p=0.001, p=0.01 and p=0.1.
  d. Which network is the most robust against failures? (Each point must be an average over at least 10 simulations).

- Perform the same analysis as before, but for the case of attacks.

- Compare the protein networks in terms of failures and attacks. Which species is the most robust? Consider the datasets:
  - Human protein network (http://konect.cc/networks/maayan-vidal)
  a. C. elegans protein network 2007 (http://interactome.dfci.harvard.edu/C_elegans/index.php?page=download)
  b. Mosquito interaction network (A. aegypti) (https://static-content.springer.com/esm/art%3A10.1186%2F1471-2164-11-380/MediaObjects/12864_2009_2974_MOESM1_ESM.XLS)

- Consider the networks with community structure you generated in the previous project. Verify how community organization influences the resilience of networks. That is, using the model by Santo Fortunato, generate networks with mu = 0.1, 0.3 and 0.5. For these networks construct the graph of the size of the largest component versus the fraction of removed nodes.

- Bonus: Implement the model of complex networks with assortativity by Xulvi-Brunet-Sokolov (https://en.wikipedia.org/wiki/Xulvi-Brunet–Sokolov_algorithm). Verify how the assortativity influences the network resilience against failures and attacks. That is, construct the plots of the size of the largest component in terms of the fraction of removed nodes for assortativity values: -0.2, 0 and 0.2.

2 – Epidemic spreading

- Compare the epidemic spreading in networks by simulating the reactive case in Erdös-Rényi networks, Barabási-Albert scale-free networks, and small-world networks for p=0.001, p=0.01 and p=0.1. N = 500 e <k>= 8. Construct the curves of the fraction of infected nodes (SIS model) versus lambda = beta/mu, where mu = 1.
- Consider the same analysis for the SIR epidemic model.

3 – Influential spreaders

- For the following networks:
    - Hamsterster friendships
    - (http://konect.uni-koblenz.de/networks/petster- friendships-hamster).
    - C. elegans neural network
    - (http://www-personal.umich.edu/~mejn/netdata/celegansneural.zip)
    - US airport network (http://toreopsahl.com/datasets/#usairports)
- Construct the plot of the fraction of removed nodes (in the SIR dynamics) versus a centrality measure (degree, betweenness centrality, closeness centrality, eigenvector centrality, accessibility, k-core and communicability centrality). Verify which of these measures most influence the fraction of removed nodes.

- Bonus: Implement the model of complex networks with assortativity by Xulvi-Brunet-Sokolov (https://en.wikipedia.org/wiki/Xulvi-Brunet–Sokolov_algorithm). Verify how the assortativity influences the epidemic spreading in complex networks for the SIR model.