NETWORK ANALYSIS - 90530

Third assignment: The SIR model (mandatory for the exam)

In this **3rd assignment** you will map the SIR model into a network. As usual, I recommend to start with a small graph and then, when your code works, to run it on your larger graph used in the other two assignments.

This assignment is a variation of the exercise on social contagion. Here we have 3 different states, S, I, and R, and several parameters (the disease transmission probability p, the minimum amount of time a node remains infected T_I, the recovery probability q). We assume discrete time, and use integer numbers to represent distinct, separate "points in time".

Steps:

1. Take a graph (first a small one and then your graph).
2. Label all nodes as S (e.g., Susceptible).
3. Color all S nodes in a color you like (you can take inspiration from https://ncase.me/covid-19/ which is a recommended lecture).
4. As in exercise num. 8 on social contagion, fix the position of the nodes. Remember that each time you draw a graph with Networkx you get a different layout since drawing algorithms start by placing nodes in random positions and then apply some computational steps to optimize the initial positioning. For more details you can see **Graph Layout.**
5. Define the model parameters:
   i. the **disease transmission probability p**
   ii. the **duration of the infection**. For simplicity, assume that **each node spends a minimum of T_I time steps in compartment I** and after that it can **move to compartment R with a given probability q**
   iii. the **number of individuals initially infected, i_0**
6. **Select i_0 nodes** to start the diffusion of the virus: **change the labels of these nodes into I** (Infected), **change their color, track the time step at which the infection starts for them.**
7. **Repeat** the recovery / contagion **until all nodes are in compartment R** (e.g., Recovered / Removed)
   i. **From I to R**: for each infected node, if a minimum of T_I time steps have elapsed, **move the node to the compartment R with probability q**, e.g., sample a random number and, if the result is less than q, move the node to the compartment R. Change node label and color, keep track of the time step at which the infection stops.
   ii. **From S to I**: for each infected node, look at their neighbors and **spread the contagion with probability p**, e.g., for each neighbor of an infected node, sample a random number and, if the result is less than p, a contagion occurs and the neighbor moves to the compartment I. Again, remember to change node label and color. Keep track of **the time step at which the infection starts.**
   iii. Draw the network and save an image to build an animation (see exercise num. 8).
8. Run your experiment for different values of the parameters and then write a short report describing your choices. Finding the "right" parameters is not easy, we are not domain experts. As a suggestion, since R = p*k, you might start from a known R value, compute the mean degree of your network, and then get p. But this is only a suggestion, any number is fine, the goal here is to see how things evolve, not to estimate the right parameters of the model.

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