Complex System 530 Lab 2

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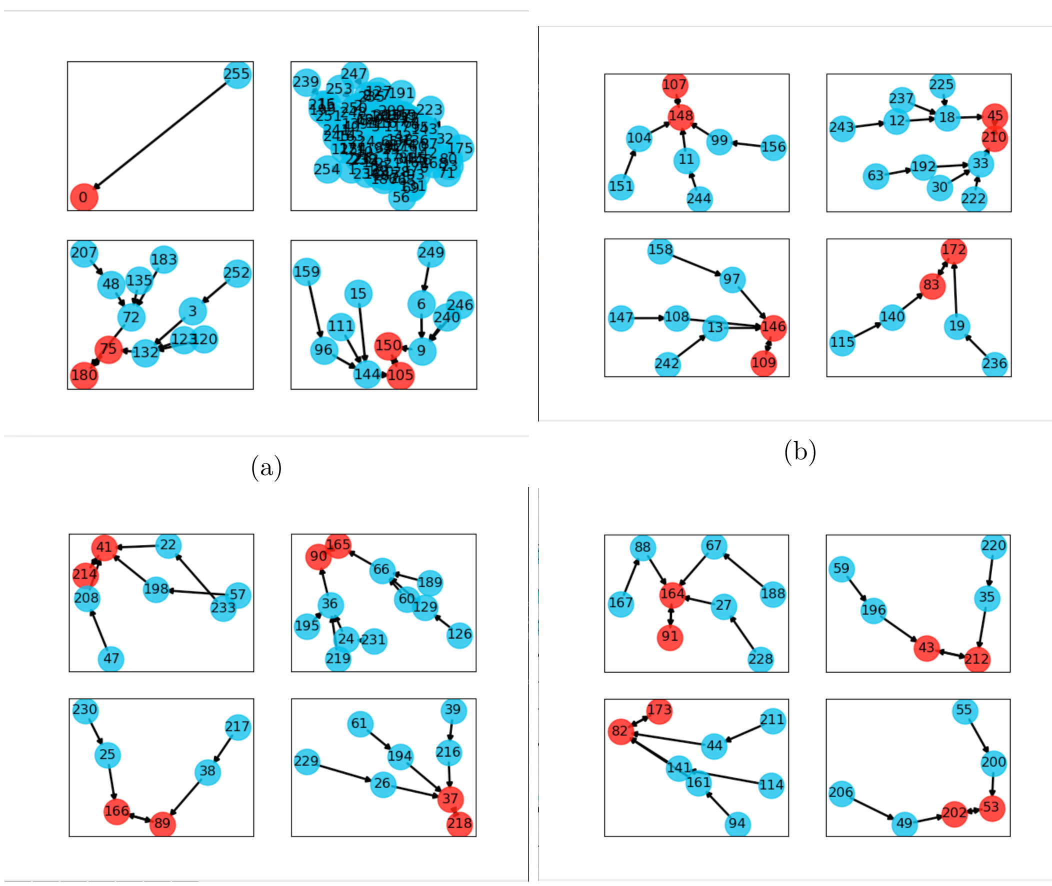
All codes and original figures are in Github:
`https://github.com/ShirlynWY/CMPLXSYS_LABS.git`

1 One dimensional cellular automata

(a) This is rule 122 because $2^6 + 2^5 + 2^4 + 2^3 + 2 = 122$.

(b) There are 24 basins of attraction. Only state 0 is a steady state, the other basins will approach an oscillation that has a period of 2. All basins of attraction are shown in figure 1.

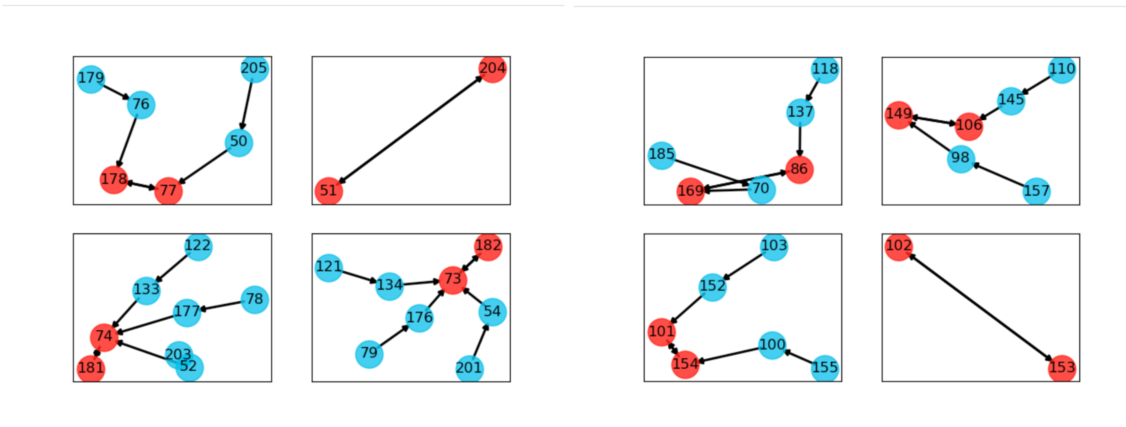


(a)

(b)

(c)

(d)



(e) (f)

Figure 1: Attraction basins of 1D cellular automata Rule 122

(c) Using initial configuration 11, the CA state is shown in figure 2.

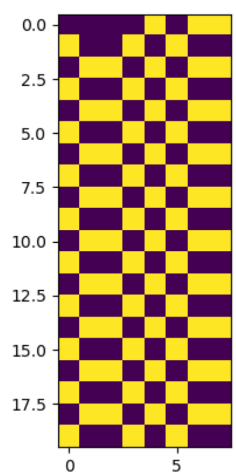
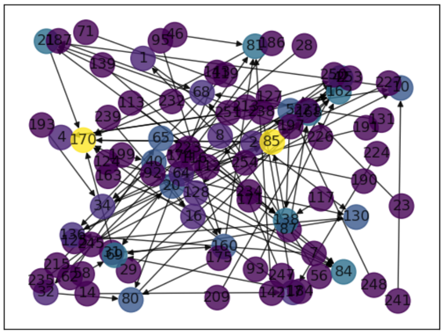
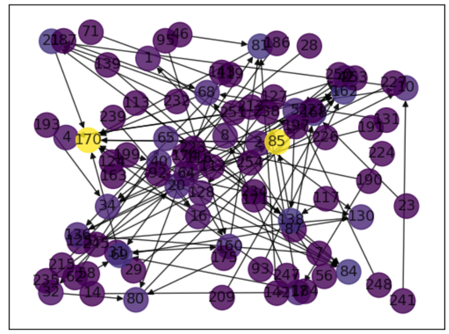


Figure 2: CA state after 20 steps

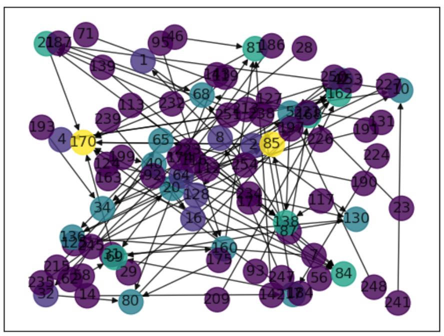
(d) For all 4 measures of centrality, the oscillatory steady state: 170 and 85 have the most centrality, shown in figure 3.



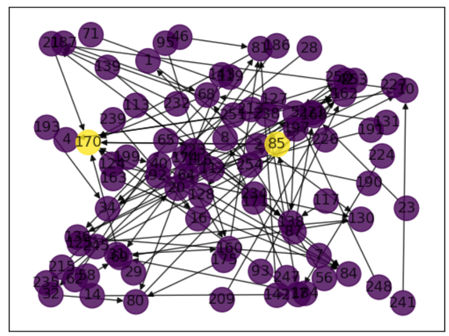
(a) Betweenness centrality



(b) Closeness centrality



(c) Degree centrality



(d) Eigenvector centrality

Figure 3: Centrality measures for the "hairy ball" basin

2 Two-dimensional cellular automata - Langton's Ant

There are $2^{11\times 11} \times 4$ possible initial states.

On the 101-by-101 grid, the pattern of the black tiles start being fairly regular and small. And then before around 10000th time step, the pattern is quite irregular. The ant appears to be wandering on the grid randomly. After some time, the "highway" emerges and the ant moves to the lower right corner of the grid in a straight line. Because we have wrap-around boundary conditions, the ant comes back from the top. The ant walks into the irregular patch of black tiles for a long time but eventually emerged from the mess and moves onto the "highway" again.

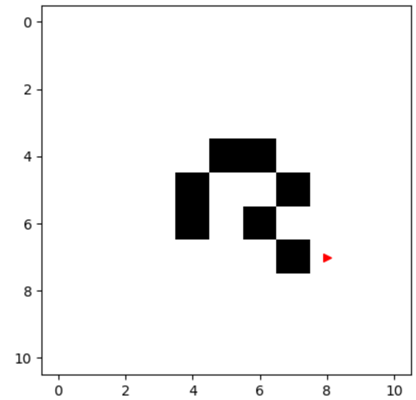
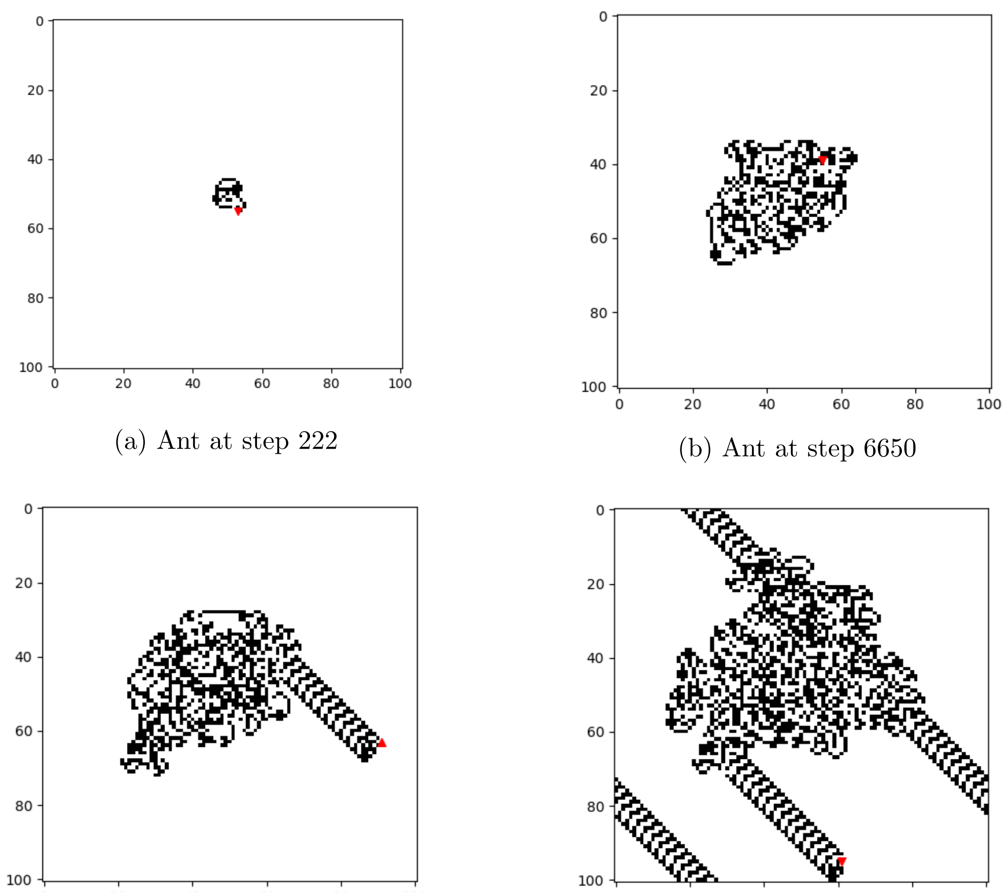


Figure 4: 11*11 grid, red arrow represents the ant



(a) Ant at step 222

(b) Ant at step 6650

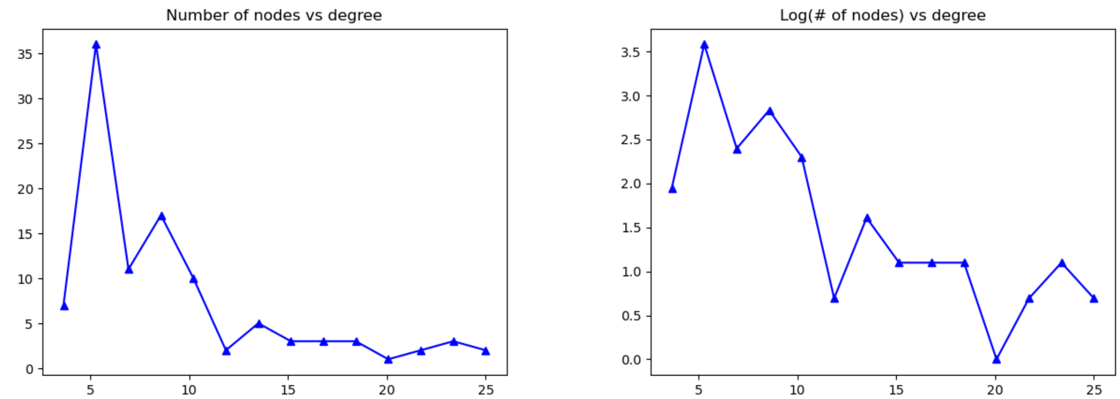
(c) Ant at step 11150

(d) Ant at step 26314

Figure 5: Langton's Ant: 101 * 101 grid

3 Exploring network data

(a) The distribution looks scale free to me. The log of the number of nodes vs degree is fairly linear. It makes sense to me because most people would buy similar small numbers of books and only very few would buy many books. People also don't need to buy book A in order to buy book B so there can be multiple paths from one node to another.

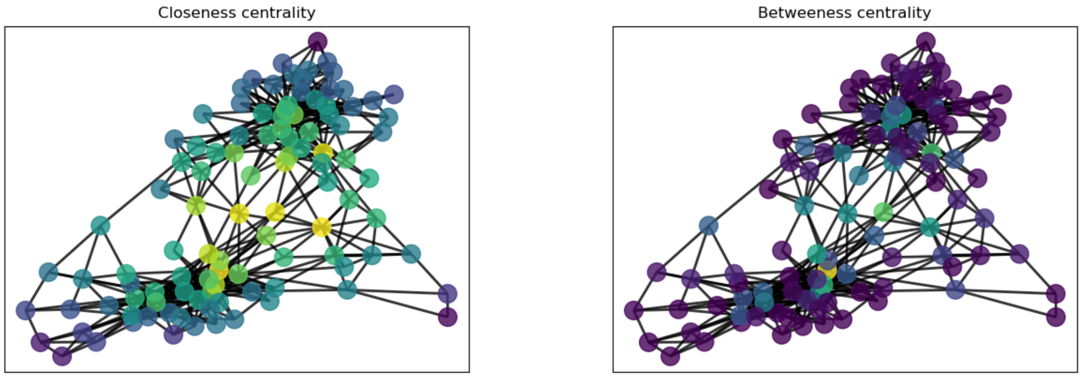


(a) Number of nodes vs degree

(b) Log(number of nodes) vs degree

Figure 6

(b) Closeness centrality measures the shortest paths from 1 node to other nodes. From figure 7(a), we can see that except for a few nodes at the boundary of the graph, many nodes are "central". Most nodes have similar number of shortest paths. People starting with more central books in this measure could easily end up buying other books with fewer number of buys in between.
Betweenness centrality measures how important a node is in terms of connecting other nodes. Compared to figure 7(a), we can see fewer brightly colored nodes, meaning that fewer nodes are central in this measure. The more central nodes are the more essential ones in introducing people to other types of books.



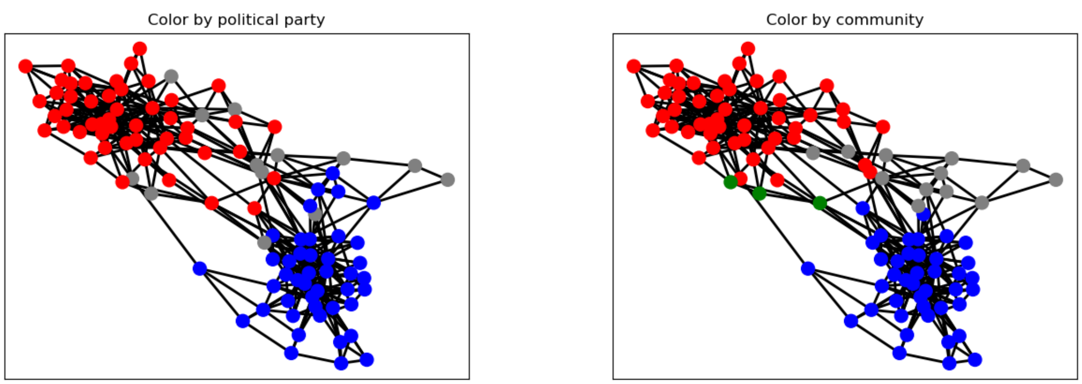
(a) Closeness centrality

(b) Betweenness centrality

Figure 7

(c) The assotativity of the network is 0.7233, meaning that the books in the network are quite assortative based on liberal, conservative or neutral labels. People who buy books with liberal labels are more likely to buy more liberal books than conservative books, vice versa.

(d) There are 4 communities in total. They align very well with the liberal/conservative/neutral labels on the nodes. The comparison between the color by political party and color by community are shown below.



(a) Color by community party

(b) Color by community

Figure 8

4 Final project ideas

(a) I plan to work with Jessie Conrad on a project modeling the spread and mitigation of livestock disease. Some common strategies include transmission control, culling and vaccination. We would like to know how effective the mitigation strategies are under different circumstances, e.g. different spread rate, livestock population density, delay between infectivity and observation and so on.

(b) Many ideas in part (a) comes from this paper: Mourant, Judith R., et al. "Decision Support for mitigation of livestock disease: Rinderpest as a case study." Frontiers in veterinary science 5 (2018): 182.
`https://www.frontiersin.org/articles/10.3389/fvets.2018.00182/full`

I also found another related paper: Bradhurst, Richard A., et al. "A hybrid modeling approach to simulating foot-and-mouth disease outbreaks in Australian livestock." Frontiers in Environmental Science 3 (2015): 17.
`https://www.frontiersin.org/articles/10.3389/fenvs.2015.00017/full` This paper used a hybrid approach where they used equation-based modeling for within-herd disease spread and Agent-Based Modeling for between-herd spread and control. It would be interesting if we can implement the hybrid approach to some extent.

(c) We can adapt the SIR model for our purpose. Each animal will be an agent with different states like: susceptible, infectious, ill, dead, immune and recovered. When one animal is infected, animals around it will have a probability of being infected as well. This doesn't have to only impact immediate neighbors, it may also impact more distance neighbors with a decreasing probability. The 3 strategies can change these animals from state to state. There can be a delay between the first infection and first strategy employed. The strategies can be used simultaneously too. In terms of the outcome, we will be most interested in whether the disease can be controlled and how long it takes to control the disease. We can also think about the social implications of these strategies, especially culling. Large scale culling might theoretically be effective in curbing the spread of the disease but in reality, it may have devastating social-economical impact.