Exploring Effect of Different Network Topologies on Fixation Time in Evolutionary Graph Theory
07-300

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https://violachenyt.github.io/07300.html

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1 Major changes

In general, I would say there is no major changes in the overall plan of the project. However, inevitably there are minor changes that come along the way.

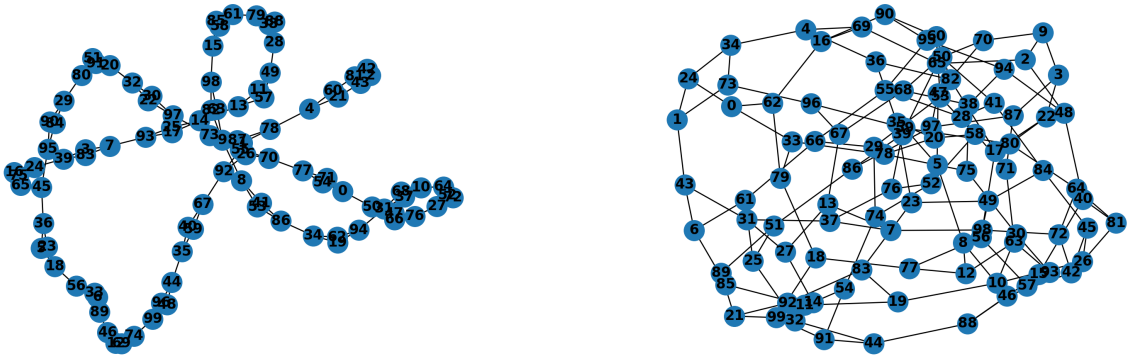
- I think I would switch gear first to study the evolutionary performance on regular graphs which are more deterministic, since I might have been too ambitious regarding experimenting with different network topologies.
- I would like to do more theoretical work besides simulations, as it seems that simulations alone is not convincing due to its random nature, and it is difficult to draw conclusion directly from simulation result.

2 Meeting your milestone

Overall, I think I am meeting my milestone for this semester. I am attaching some of the preliminary results below.

2.1 Generating graphs

I have constructed 3 different types of graphs, a low degree graph with a few triangles, a 3-regular graph, and complete graph.
Note: a k-regular graph is a graph where all vertices have degree k. In a complete graph, there is an edge between every pair of vertices. (Therefore it is not visualized here).

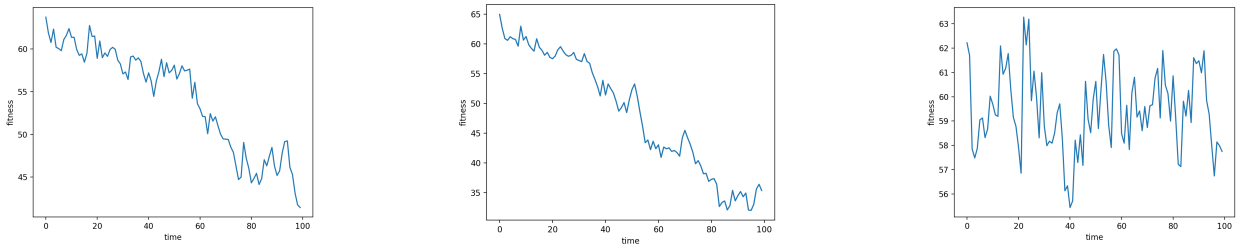


(a) low degree graph (b) 3-regular graph

Figure 1: 2 graphs of 100 vertices with different network topologies

2.2 Simulation evolution with simple fitness function

I have also simulated the evolutionary process on the 3 types of graphs mentioned above, and examined the mean population fitness in each of the three cases. However, since these are single simulation runs, the results are not conclusive enough and therefore I have not interpreted the results.



(a) low degree graph (b) 3-regular graph (c) complete graph

Figure 2: Mean population fitness over time for 3 different network topologies

Based on these preliminary figures, it to some extent confirms the idea that simpler graphs may have better evolutionary performance over more complex and dense graphs. However, since these results may be affected by the random seeding, more work needs to be done to quantify the effect of network topologies on evolutionary performance.

3 Surprises

Overall, there are not many surprises along the way. However, some tasks appear to be more challenging than initially thought of.

- Generating network topologies is more tricky than what I initially perceived. Existing methods in current library `networkx` all have their own limitations, and there is not a single method that allow me to generate exactly the kind of network topologies I would like to

experiment on. Currently I am going with simpler network topologies to get started, and plan to either modify some existing methods or potentially manually construct graphs in the future.

- Simulation results appear to be a lot more unpredictable than what I imagined. I guess I should either research on the methods to aggregate turbulent simulation results, or come up with more theoretical work to support the simulations.

4 Revisions to your 07-400 milestones

I do not plan to make any major revision to my 07-400 milestones.

I plan to read up more on evolutionary graph theory during the winter break, and aim to come up with ways to generate random graphs with specified arbitrary topologies if possible. It seems that in the work so far, the network used is pre-defined and is not generated randomly, [1] therefore I think I would try to spend some time on generating arbitrary graph, potentially consulting more resources on graph theory.

5 Resources needed

I think I have all the resources needed to complete my 07-400 project. Most if not all of the resources I need are open-source libraries that are freely available online. As for the computation, the project does not seem to demand very high performance computing and therefore my own personal computer should be more than sufficient.

References

[1] Carja, O., and Kuo, Y. Evolutionary graph theory beyond pairwise interactions: higher-order network motifs shape times to fixation in structured populations.