Lab G6 - Basic natural selection

Shaoyong Guo
Politecnico di Torino
s296966
s296966@studenti.polito.it

I. Introduction

This experiment simulates an interesting natural selection based on a number of conditions, average reproduction rates, improvement factors, improvement probabilities and different population sizes. The final results will show the effect of different factors on the final population size. Theoretically, the process of natural selection is more like a Galton-Watson process, where the extinction of species mainly depends on the average reproduction rate.

II. The simulation model

A. Stochastic Elements

Initial Populations of Species. I provide a random number of ancestors in the initial species. It represents the number of ancestors of the species in the first generation. Each ancestor will produce a different number of offspring in the generation, which follows the Possion distribution.

The Max Generation. "Maximum generation" assists the system in modelling how long a species will continue. In my simulations, if the average reproduction rate is less than or equal to 1, then the species will almost go extinct over time. If the average reproduction rate is greater than 1, the species will also become extinct over time, but will generally produce more descendants, so I set the "Maximum Generation" to improve the efficiency of the system.

B. Input Parameters

The intial populaton of species. In general, the larger the population of a species, the better the chances of survival of its offspring. I provide a list of population sizes of ancestors [10,20,50,100,500] to model the extinction trends and rates for different initial ancestor numbers.

Average Reproduction Rate.
The average parent mean of each pair of parents remains bounded throughout all generations and does not exceed 1 if the population size is large enough, then the probability of eventual extinction is always 1. I set a list of average reproduction rate of ancestors [0.5,0.7,1,1.5,1.7] to model the extinction trends and rates for different initial ancestor numbers.

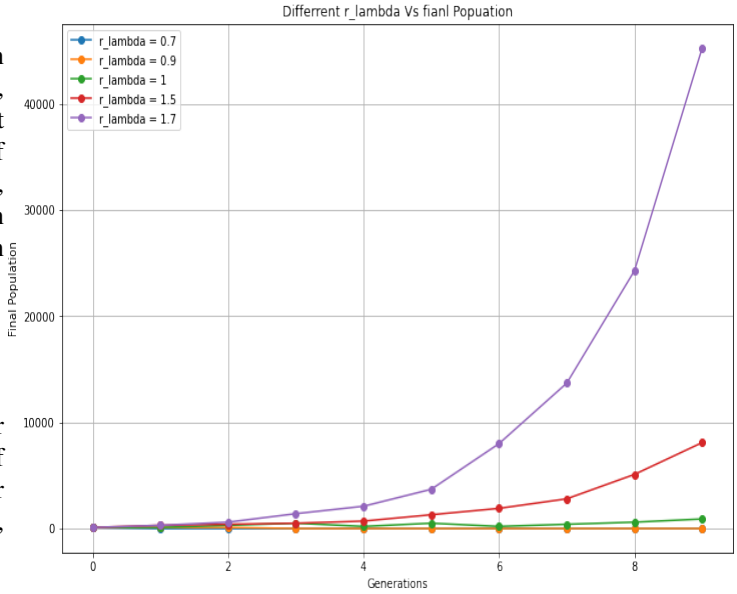

Fig. 1. All Courses Grades distribution

The Improve Factor and The Improve Probability
The improvement factor and the improvement probability determine the lifespan of the offspring. In each generation, the improvement probability is a threshold for whether the next generation will live longer than the previous one, while the improvement factor determines how long the next generation can improve its lifespan.

C. Algorithm and Data Structure

The Tree Model. In my simulation, a tree structure would be the appropriate data structure to store all the descendants, because the tree simulation is a typical incremental model. The nodes of the tree represent the parents and the branches represent the children. In the first generation, each ancestor has a number of descendants, and their descendants will have a number of descendants in the next generation. I use a dictionary to record all offspring events and a dok-matrix to record the population size for each generation.

How to generate offspring. In the simulation, I provide 3 functions to construct the natural selection process.

Born-child. For each parent, they will have a number of children (Children class), which include all of information (born time, life time, etc,.)

gen-child-atmostgeneration. For each ancestodant, they will have different quantity of offspring at the end of simulation.

all-generation-population. This method will process all the specific parents in the initial species and return a dictionary to record all the offspring events, and a matrix to record the number of offspring in each generation.

D. Output Metrics

Average Extinction Time. The time to extinction of a species may vary under different conditions. The mean time to extinction indicates the average survival time under a given set of conditions.

The Population Size Over Time. The population size over time represents the number of offspring in each generation. I show the population size under different conditions in the results.

III. Results

Different Lambda vs final population As shown in Figure 1, the effect of different lambda on the final population size of a species is predictable. If lambda is less than 1, the population will remain stable and eventually become extinct. If lambda is greater than 1, the population will remain stable and eventually become extinct, while if lambda is greater than 1, the population will continue to grow significantly.

Different improve factor vs final population As shown in Figure 2, the improvement factor does not affect the population size per generation when the population size and the average reproduction rate are fixed. However, it affects the average lifespan of each generation.

Different improve population vs final population As shown in Fig. 3, when the population size and average reproduction rate are fixed, the probability of improvement also does not affect the population size per generation. However, it affects the average lifespan of each generation.

Different population size vs final population In summary, the more population of species, the more offspring, as shown in figure 4.

IV. Conclusion

My simulations show that average reproductive rate is the main determinant of whether a species goes extinct or not. Improvement factor and improvement probability affect the average survival life span of a species. In the same generations and environments, species with better improvement factors always outnumber species with less good improvement factors.

However, the simulations do not take into account variations in species evolution and environmental selection over time. It is necessary to investigate these factors in the next experiments.

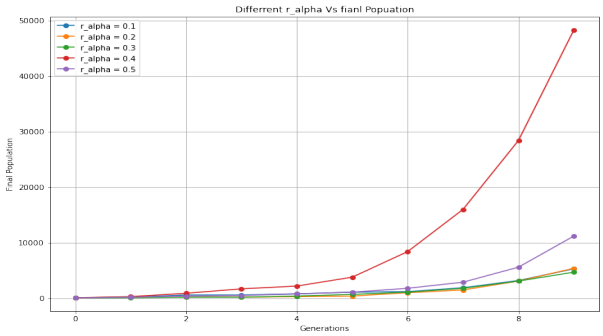

Fig. 2. Attended exams distribution

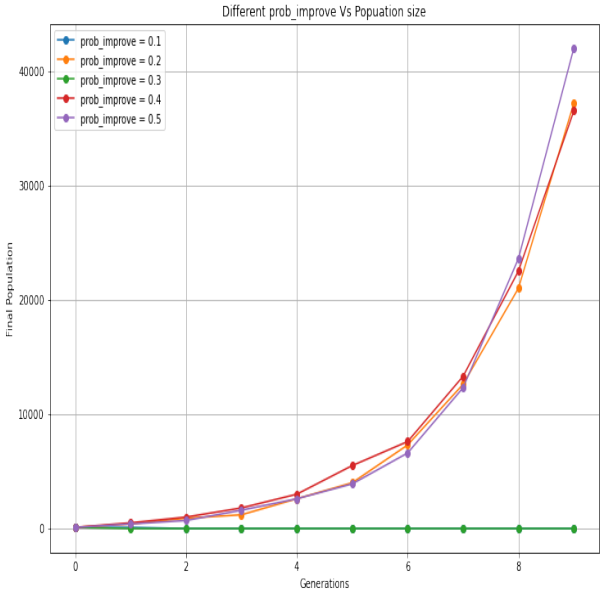

Fig. 3. Graduation grades and year

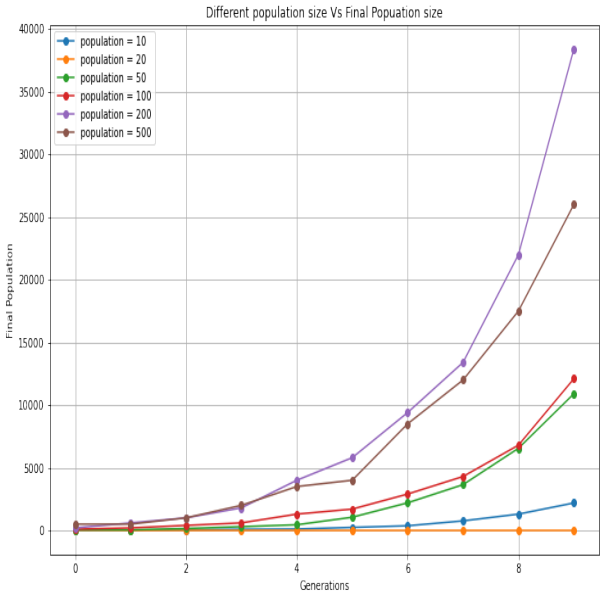

Fig. 4. Graduation grades and year