

Lab exploration 6: Evolutionary algorithms

Math 309 Fall 2023

Deadline: 6 November

- Conduct experiments as indicated.
- **Journal entry.** Respond to each of the “journal queries.” Using *concise and clear sentences*, incorporate data, symbols, and illustrations into your text. Have an audience in mind. Focus on *developing* an explanation or argument that stems from your simulations.
Submit 300-400 words 2-3 pages double-spaced to the class dropbox.
- **Recommended.** Work in groups of 2 or 3. Submit one journal entry for the group.
- **Suggestion.** Before running the simulations, read the “What is it?” and “How it works” sections under the [Info](#) tab.

Model: Simple Genetic Algorithm. (Location: [Models Library/Computer Science](#).) The basic task here is to find a string of all 1s among a population of strings of 1s and 0s (represented as vertical segments that are white and black). A string is considered more fit than another if it contains more 1s. The model evolves strings by means of cloning a single string (selected for its fitness) or mating two strings (selected for their fitness). Mutations can occur at a specified rate as can crossover (how much of a given parent string is included in the offspring string). The number of time-steps required to produce the all-1 string measures the speed of evolution.

6.1 Journal query.

With [mutation-rate](#) set at 0, look for settings for [population-size](#) and [crossover-rate](#) for which the algorithm finishes (that is, obtains all-1).

6.2 Journal query.

Set [population-size](#)=200 and [crossover-rate](#)=50. Estimate a value of [mutation-rate](#) that minimizes the number of time-steps to completion. Does the value that you found make evolutionary sense?

Model: Robby the Robot. (Location: [Sample Models/Computer Science](#)) As discussed in class, this is the can-collecting robot whose protocol-directed actions evolve by application of a genetic (evolutionary) algorithm (GA). Notice the parameters that you can set:

[number-of-generations](#): how many times the population will be reconstituted by mating and mutation when the [go-n-generations](#) button is pressed

[population-size](#): how many protocols (called strategies in the *NetLogo* model) there are in each generation

[mutation-rate](#): probability that a random change is introduced into a new protocol.

6.3 Journal query.

Set

[number-of-generations](#) = 100 [population-size](#) = 100.

With [mutation-rate](#) = 0, run the GA for 100 generations and note the best fitness score (BFS) achieved. Do the same with [mutation-rate](#) = 1. How do the two BFSs compare? Is the outcome reasonable?

For values of [mutation-rate](#) from .1 to .9 incrementing by .1, run the GA and record the BFS for each. (The data will be more robust if you run the GA several times for a given mutation-rate and then take the average.) On the interval $[0, 1]$, plot the BFS as a function of mutation-rate. In which interval $[.k, .(k + 1)]$ does the BFS achieve its maximum value?

6.4 Journal query.

On the interval $[.k, .(k + 1)]$, find a BFS for the mutation-rates

$$.k + .01, .k + .02, \dots, .k + .08, .k + .09.$$

Plot the BFS as a function of mutation-rate on $[.k, .(k + 1)]$ and estimate a rate that maximizes the BFS.

6.5 Journal query.

How sensitive is the BFS to the rate of mutation? That is, can relatively small changes in mutation-rate lead to a large change in BFS?

6.6 Journal query.

What does the [Best Fitness](#) plot reveal about the relationship between BFS and number of generations? How do the plots change with mutation-rate?

6.7 Journal query.

Note that you can test the best protocol (BP) by pressing

[set up environment](#) and then [step through best strategy](#).

How much variability is there in the scores achieved by the BP over five runs where a run executes the strategy until a steady state appears or all cans are gone? Is there a “simple” description of how some BPs behave?

6.8 Journal query.

Does the BP ever *not* pick up a can when it could do so? How could such an action be better than always picking up a can when available?

6.9 Journal query.

(Bonus) Can a protocol benefit from having the robot revisit a site? Can site re-visitation be excluded by a protocol? That is, can a protocol “remember” which sites it visits?