COSC 420/427/527 — Biologically Inspired Computation
Extra Credit Project 6

Due May 4, 2020

Note: This optional project is for *extra credit*; it will count *one-half* as much as the other projects. Any points that you earn will be added to your project score.

In this project you will investigate how different IPD (Iterated Prisoner's Dilemma) strategies fare against each other under different conditions in a spatial simulation.[*] You will be using the `SIPD-async.nlogo` simulator, which you can run as a web applet or download and run under your own NetLogo installation (see course website).[1]

General Instructions on Simulator Use

The simulator controls are as follows:

- Setup is used to initialize a new simulation, which can run for a specified number of generations (go for) or by clicking/unclicking the go button. The slider rounds determines the number of rounds of interaction (or game play) per generation.
- The second group of sliders controls the payoff matrix (CC-R, CD-S, DC-T, DD-P). You will not need to change them for this project unless you want to investigate effects of the payoff matrix.
- The next group of sliders controls the initial populations of the five strategies (N-All-C, N-All-D, N-TFT, N-Pav, N-RAN). Only the relative values of these quantities matter, and they are used to probabilistically initialize the starting population.
- RANCoop controls the Rand strategy's probability of cooperating; you do not need to use it. The noise slider controls the probability that in a given interaction a cell will act randomly rather than in accord with its strategy. The mutation slider sets the probability that an agent will adopt a random strategy, rather than the best of its neighbors.
- The final two controls allow inoculation of the population by a chosen strategy (see Part II below). The insert-strategy chooser allows you to select the strategy to be inserted. Clicking toggle insert allows you to use the mouse to paint the chosen strategy anywhere in the space. Click to paint.
- The current generation number and the populations of the different strategies are shown by the six monitors. Note that the total population (number of cells) is 2500. The metric chooser controls the plot, but you will want to leave it set at population.

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* For background information, read ch. 17 of Flake.

1 The web applet runs under Firefox, Chrome, and perhaps other browsers, but it is slow. You might prefer to download the netlogo source code from the website and run it on your own netlogo installation. Controls that ask for input, such as go for cannot be used in the web app.

Part I: Well-mixed Populations

In the first part of the project you will explore the relative competitiveness of pairs of strategies, their ability to "invade" and take over a region, and the effect of noise and the number of interactions (rounds) on these results. The pair of strategies will be "well mixed," that is, distributed randomly through the spatial region, but notice the formation of clusters. In each case, try to predict what will happen before you run the experiments and record your predictions.

For each pair of strategies (20 pairs), do the following: Initialize the population to the two strategies in various proportions (50:50, 9:1, 1:9, 99:1, 1:99, etc.). For each of these, try several levels of noise (e.g., 0%, 1%, 5%, 10%) and, if TFT or Pav are involved, several numbers of rounds (e.g., 1, 10, 20, 40). If you find different qualitative behaviors at two different parameter settings (e.g., converging to strategy 1 at one setting and to strategy 2 at the other), then explore the intermediate values to see where the transition occurs. If large values of a parameter seem to be leading to interesting behaviors, then try some even larger values. I have provided a spreadsheet (in .xls and Open Office .ods format), which you are welcome to use to record your results. There is also an example partially-filled spreadsheet.

Here is the general protocol for running an experiment:

1. Set the parameters required for the experiment (relative populations, noise, rounds).
2. Click setup.
3. Record the initial populations.
4. Enter go for the required number of generations (e.g., 50).
5. Observe the qualitative behavior as the simulation runs.
6. Record the final populations.

You are not required to produce any plots as part of this project (although, of course, you are welcome to do so). Rather, what I would like you to look for are qualitative effects of pairs of interacting strategies. Further, you should be looking at some general statements that you can make about the effects of the parameters (relative initial populations, noise, rounds). Try to explain the results that you have observed.

Part II: Localized Inoculation of Base Population

In these experiments you will inoculate a base population of one strategy with a small, localized population of another strategy.

Here is the general protocol for running an inoculation experiment:

1. Set all the initial populations to 0 except for the base strategy, which you can set to 100 (or any other nonzero number).
2. Click setup.
3. Use the insert-strategy chooser to select the inoculating strategy.
4. Click toggle-insert and you can paint the inoculating strategy into the base population. Try inoculating a circular region of 15–25 cells, but you are welcome to try other inoculations.
5. Click toggle-insert again and note the initial populations.
6. Enter go for the required number of generations (e.g., 50).
7. Observe the qualitative behavior as the simulation runs.
8. Record the final populations.

As in Part I, I am looking for qualitative predictions, descriptions, and explanations of behavior and major effects of the parameters.

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This project does not ask you to investigate the mutation rate, but you are certainly welcome to do so. In particular, you may want to look at initially homogeneous populations with a non-zero mutation rate. As usual, you are welcome to implement your own simulator or to propose alternative projects.