Bacterial Game Dynamics

CS 523: Complex Adaptive Systems

Assignment 3

Due: Oct. 26, 2015, 12:30 pm

1 Introduction

The idea of this assignment is to design a cellular automaton (CA) to play a simple two-player game known as Rock-Paper-Scissors (RPS) and use it to simulate the dynamics of three interacting populations of bacteria. We begin with RPS, where each player has a choice of three alternatives: Rock, Paper, and Scissors. After each player has made her choice, the winner is determined as follows: Rock beats Scissors (by smashing the scissors); Paper beats Rock (by wrapping the Rock); Scissors beats Paper (by cutting the paper). Your assignment is to implement RSM in a two-dimensional wrap-around CA and study the patterns that emerge over time.

2 Assignment

Each cell in the CA represents a single agent, and the state of the cell represents what strategy the cell is playing (rock, paper, or scissors). It will be convenient to represent each different state using a different color. After one round of RPS, each losing cell adopts the state of the winning cell in its neighborhood. Each winning cell remains in the same state. Because RPS is a two-player game, and each cell has more than one neighbor, we need to decide which neighbors it will play with on any given move. Here are two reasonable possibilities:

- Random: Each cell chooses one of its neighbors randomly and plays RPS with the neighbor. This technically violates the formal definition of CA as having deterministic rules, but it is a common extension.
- All: Each cell plays against all cells in its neighborhood and adopts the state of any cell that beats it. For any given state, there is only one state that can beat it, so this rule is deterministic.

Implement both of these rules and compare their behavior, for both Moore and von Neumann neighborhoods of radius 1 and radius 2. Note, the radius 2 von Neumann neighborhood includes all squares that are Manhattan distance 2 or less from the cell. For initial conditions, you can try two different variations (or others that you think might be interesting):

- Random: Each cell is set randomly to one of the three possible states.
- Segregated: Assign one sector of the grid to R, a second sector to S, and the third sector to P, so that there are three solid blocks, corresponding to the three states.

Next, read the Kerr et al. paper, available on the course web site, and consider Box 1 that describes their simulation of the C-S-R game. First, discuss how your implementation differs from theirs, then modify your implementation to mimic Box 1, and attempt to replicate their results.

3 What to hand in

Hand in a short report (not more than 3 – 4 pages) that describes your project. Think carefully about which runs to report and select those that best illustrate the phenomena you want to show. Document the programming language, any external or built-in libraries that you used, major design decisions, etc.

For each assigned experiment, include a short discussion of your results and what you think they mean. Think carefully about how to present your results in a convincing but succinct manner. Organize your paper into the following sections:

- Introduction: Summarize briefly the problem you are trying to solve and how you went about it.
- The Cellular Automata implementation and any extensions that you used for replicating the Kerr et al. results. Describe basic details about your algorithm, your default parameter settings, and report the experiments you did to convince yourself that the CA is working correctly.
- Results for different neighborhoods and update rules.
- Replicating the Kerr et al. results. Report how your results capture or do not capture the dynamics reported in the paper, and if you find differences, speculate about what causes them. How easy was it for you to replicate their results based on the published description of their simulation?
- Discussion and conclusion

Remember to cite all of your sources using a consistent citation style and include a proper bibliography.

Please include a listing of your code and instructions for how to run it as an appendix to your report.

4 Late Policy

You are allowed three free "late days" to be used at your discretion throughout the semester. After you have used up your late days, I will deduct 10% per day from the grade you would have received on any late work.