Project 2 - Evolutionary Dynamics of Social Learning

INFO-F409

Julien Baudru - ULB - 000460130

November 26, 2021

Contents

1 Introduction

This second project of the Learning Dynamics course focuses mainly on the dynamic evolution of several populations. In the different parts of this project, populations are composed of members with unique strategies, these strategies are : *copycats*, *grudgers*, *always cheats*, *always cooperates* and *detectives*. The game that populations face is the Itarated Prisoner's Dilemma (IPD), the payoff matrix for this game is shown below.

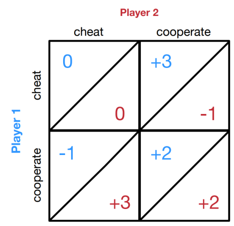


Figure 1: IPD payoff matrix

2 Requirements

The code of this project was written in Python 3.8.8, to run this project smoothly you will need to install the following libraries if they are not already present on your machine :

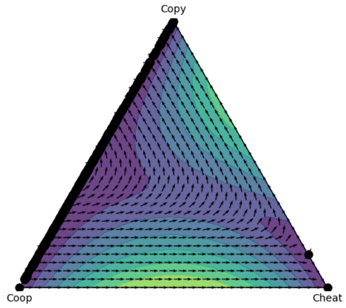
```
pip install -r requierments.txt
```

To execute the third part of this project, you just need to enter the following command in your terminal:

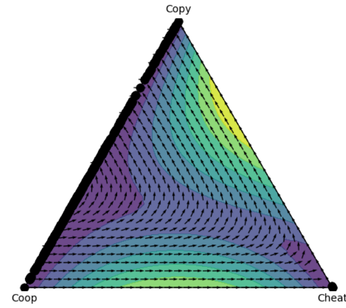
```
python moran_process.py
```

3 Part 1

For this part, the three strategies present in the population are *always cheats*, *always cooperates* and *copycats*. Below you will find graphs of the replicator dynamics for a number of rounds equal to 5 and 100.



(a) R=5



(b) R=100

Figure 2: Replicator dynamics

3.1 Question A

In both cases there are unstable equilibrium points along the side of the triangle going from the *Copycat* strategy to the *Cooperator* strategy as well as an unstable equilibrium point at each vertex of the triangle. However, we notice that when the number of rounds (R) is fixed at 5, an unstable equilibrium point appears along the side of the triangle linking the *Cheater* strategy to the *Copycat* strategy, this one is located closer to the *Cheater* strategy.

3.2 Question B

In both cases we notice that the *Copycat* strategy dominates the *Cheater* strategy and that the *Cheater* strategy dominates the *Cooperator* strategy. Moreover, these dominances are all the more marked as the number of rounds (R) is high.

4 Part 2

In this second part of this project, we study the evolutionary dynamics in finite populations of the iterated prisoner's dilemma, assuming that mutations are rare. The parameters that can vary in this part are β and Z. β being the intensity of the selection and Z the size of the population.

4.1 Question A

(a) $\beta = 0.1$ and $Z = 100$

(b) $\beta = 10$ and $Z = 100$

Figure 3: Invasion diagram

We notice that the higher the beta value, the higher the values of the transitions from one strategy to the others. Moreover, with $\beta = 10$, we notice that the *Detective* strategy disappears totally from the population. Moreover, when the value of β is 100, the remaining transitions are those going from : the *Cooperator* strategy to the *Cheater* strategy, the *Cheater* strategy to the *Grudger* strategy and the *Cheater* strategy to the *Copycat* strategy. In both cases, for $\beta = 0.1$ and $\beta = 10$, the strategies chosen by most of the population seem to be those of the *Copycat* and the *Grudger*.

4.2 Question B

(a) $\beta = 1$ and $Z = 30$

(b) $\beta = 1$ and $Z = 100$

Figure 4: Invasion diagram

Here the β value is set to 1 for both cases. We notice that the transitions from one strategy to another remain unchanged when this parameter varies, however the larger the population, the higher the values of these transitions will be and the higher the percentage of the population having chosen one of the dominant strategies. Indeed, for $Z = 30$, 44% of the population will play the *Copycat* strategy against 47% when $Z = 100$, the same for the *Grudger* strategy.

4.3 Question C

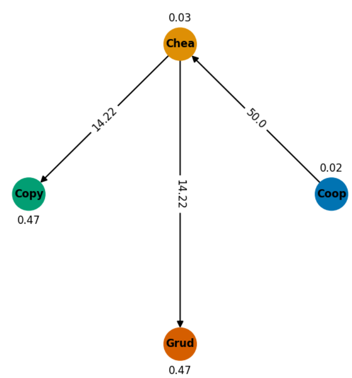


Figure 5: Invasion diagram

For $\beta = 10$ and $Z = 50$, we notice that the detective strategy disappears from the population. Moreover, we notice the elimination of multiple transitions between strategies compared to the cases encountered earlier in this report. The only strategy that is not invaded by any other strategy is the *Cooperator* strategy, so it would seem that this is the dominant strategy.

5 Part 3

5.1 Stationary distribution

In the last part of this project, we were asked to set up a Monte-Carlo simulation with the final goal of displaying the graph of the stationary distribution for each possible number of *Copycats* in the population. The graph resulting from this simulation is shown below.

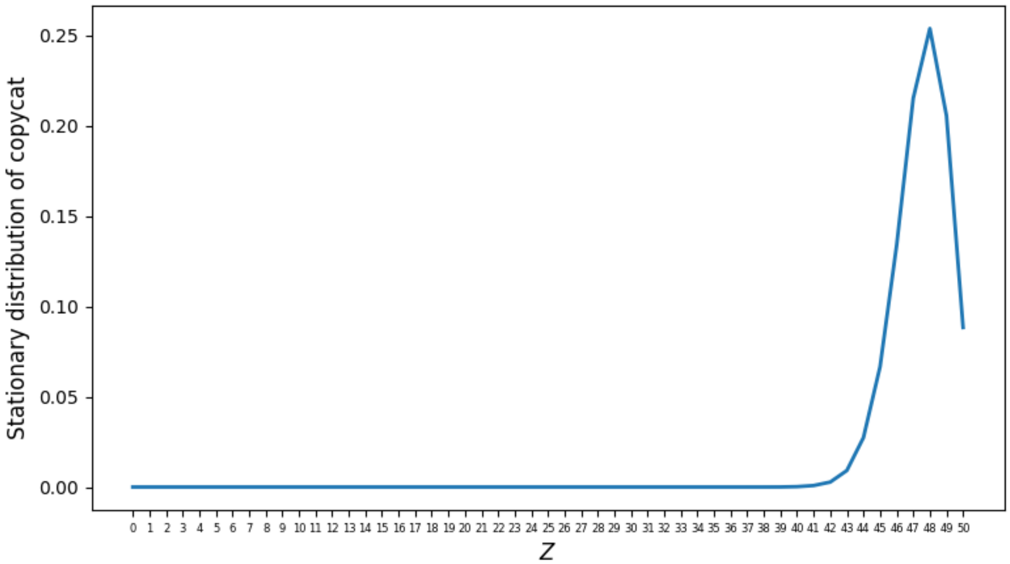


Figure 6: Stationary distribution of Copycat