CS 7642: Reinforcement Learning and Decision Making **Homework #6**

Rock, Paper, Scissors

1 Problem

1.1 Description

Rock, Paper, Scissors is a popular game among kids. It is also a good game to study Game Theory, Nash Equilibriums, Mixed Strategies, and Linear Programming.

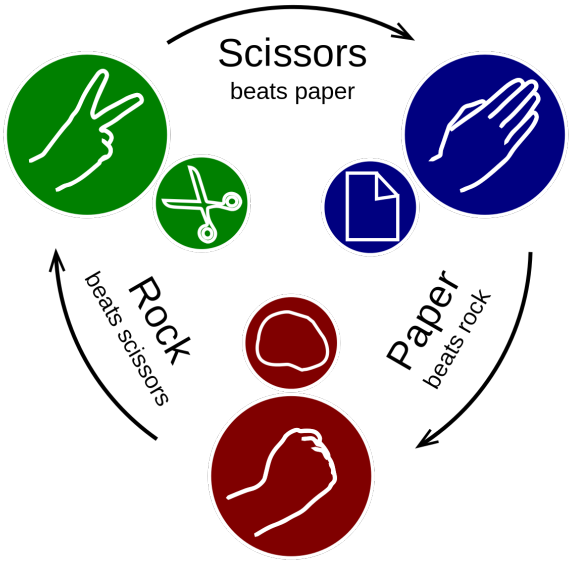

Figure 1: The rules of Roshambo

1.2 Procedure

For this assignment, you are asked to compute the Nash equilibrium for the given zero sum games. You will be given the reward matrix `R` for Player A. Since this is a zero-sum game, Player B's reward matrix will be the opposite of Player A's matrix. The first column of the matrix specifies player A's reward for playing rock against player B's rock (row 1), paper (row 2) and scissors (row 3). The second column specifies player A's reward for playing paper, and the third column player A's reward for playing scissors.

- You need to find the ideal mixed strategy for the game. While there are different ways to calculate this, we will use Linear Programming in the hopes of preparing you for your final project. Use a Linear Programming solver—such as CVXOPT—to create a program that can solve Rock, Paper, Scissors games with arbitrary reward matrices. For an example of how to create a linear program to solve Rock, Paper, Scissors, see Littman 1994.
- You will submit the **sum of the squares** of the Nash equilibrium probabilities for player A found by your Linear Program (i.e., you will be submitting only **ONE** numerical value, $\pi^2_{\text{rock}} + \pi^2_{\text{paper}} + \pi^2_{\text{scissors}}$, derived from the three probabilities that are output by your linear program).

  Provide answers for the specific problems you are given on Canvas. Your answer must be correct to 3 decimal places, truncated (e.g., 3.14159265 becomes 3.141).

2 Examples

The following examples can be used to verify that your agent is implemented correctly.

- Input : `R` $= [[0, 1, -1], [-1, 0, 1], [1, -1, 0]]$, Output : 0.333
- Input : `R` $= [[0, 2, -1], [-2, 0, 1], [1, -1, 0]]$, Output : 0.375

3 Resources

The concepts explored in this homework are covered by:

3.1 Lectures

- Lesson 11A: Game Theory
- Lesson 11B: Game Theory Reloaded

3.2 Readings

- Littman-1994.pdf Littman 1994
- Littman-Stone-2003.pdf Littman and Stone 2005

3.3 Software

- CVXOPT

4 Submission Details

The due date is indicated on the Canvas page for this assignment.
Make sure you have set your timezone in Canvas to ensure the deadline is accurate.
Submit your answers on Canvas, as outlined in section 1.2. You will have a total of 10 submission attempts—only the highest score is kept.

References

[Lit94] Michael L Littman. "Markov games as a framework for multi-agent reinforcement learning". In: *Machine learning proceedings 1994*. Elsevier, 1994, pp. 157–163.

[LS05] Michael L Littman and Peter Stone. "A polynomial-time Nash equilibrium algorithm for repeated games". In: *Decision Support Systems* 39.1 (2005), pp. 55–66.