Course: CS30A1570 Complex Systems

Assignment 8: Models of Cooperation in Social Systems

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**Title:**

**Introduction:**

**Research Question:** The key research question of this investigation is “What are the most effective strategies in iterated Prisoner’s Dilemma games under different conditions and payoff matrices, and how can a new strategy be developed to perform well in these games?” The tasks undertaken to complete this investigation are as follows:

* Task 1.1.1: The objective is to analyze the performance of different strategies in a two-person iterated Prisoner’s Dilemma game.
* Task 1.1.2: The aim is to modify the payoff matrix and observe its impact on the game’s outcomes.
* Task 1.1.3: The goal is to run a multi-agent iterated Prisoner’s Dilemma game and identify the strategy that yields the highest payoff.
* Task 1.1.4: The objective is to conduct a tournament among specific strategies and observe the winning strategy under different ratios of cooperators to defectors.
* Task 2.2.1: The aim is to implement a custom strategy in a two-person iterated Prisoner’s Dilemma game and evaluate its performance.
* Task 2.2.2: The goal is to implement a custom strategy in a multi-agent iterated Prisoner’s Dilemma game and assess its performance.
* Task 3: The objective is to develop and describe a unique strategy for a Prisoner’s Dilemma tournament among students.

**Results:**

The following results were obtained by analyzing Prisoner's Dilemma Strategies in NetLogo.

Task 1.1.1: In the Human vs. Computer with random strategy setup of the experiment, ‘Defect’ showed to have the best average score for the human. The human score (920) is the highest here, and the computer score (145) is the lowest. This is because humans are always defecting, therefore benefiting from the computer's cooperation. It also ensures rewarding for the human when the computer also defects. However, this strategy isn't generally considered ideal as it creates distrust and might not be the best long-term approach. The results from the experiment are presented in Table 1.

Table 1: Human (varying strategy) vs Computer (random strategy)

|  |  |  |
| --- | --- | --- |
| **Entity** | **Strategy** | **Average Score** |
| Computer | Random | 680 |
| Human | Random | 670 |
| Computer | Random | 1168 |
| Human | Cooperate | 498 |
| Computer | Random | 145 |
| Human | Defect | 920 |
| Computer | Random | 670 |
| Human | Tit-for-tat | 665 |
| Computer | Random | 952 |
| Human | Tit-for-two-tats | 577 |
| Computer | Random | 162 |
| Human | Unforgiving | 867 |

Task 1.1.2: In the modified version of the payoff function to represent a new payoff matrix. And repeat task 1.1.1 with the new payoff matrix, the outcome shows that the best strategy for the human changes depends on the modified payoffs. Rewarding mutual defection in the payoff matrix resulted in defect having best average score.

**3. N-Person Prisoner's Dilemma Dynamics**

* Download PD-N-Person-Iterated-New.nlogo.
* Set the number of agents with each strategy to 20 (except n-unknown to 0).
* Run the model for 100,000 time steps (fastest speed).
* Repeat this process four more times.

**Expected Results:**

* The strategy with the highest average payoff might vary across runs.
* This is because strategies like tit-for-tat benefit from a predictable environment. With many agents, the interaction might not be consistent, leading to fluctuations.

**4. Tournament: Cooperators, Defectors, and Tit-for-Tat**

* Set n-random to 0, n-cooperate to 20, n-defect to 20, n-tit-for-tat to 20, and n-unforgiving and n-unknown to 0.
* Run the simulation and observe which strategy has the highest average payoff.

**Expected Results:**

* Tit-for-tat might not always win.
* In a balanced environment with equal cooperators and defectors, tit-for-tat performs well. However, if there are more defectors, tit-for-tat might be exploited, leading to lower payoffs.

**Experimenting with Cooperator vs. Defector Ratios:**

* Gradually increase n-cooperate while keeping n-defect constant.
* Observe the point where tit-for-tat becomes the dominant strategy.

**Explanation:**

* Tit-for-tat thrives in a mostly cooperative environment. As the number of cooperators increases, tit-for-tat benefits from their cooperation and flourishes.

These analyses showcase how strategies perform differently based on the opponent's strategy and the overall population makeup in the Prisoner's Dilemma.

**Discussion:**

**Conclusion:**