TJHSST Computer Systems Lab Senior Research Project
Prisoner's Dilemma with N participants and Optional Cooperation
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Abstract

This project is designed to simulate the classical Prisoner's Dilemma with options to cooperate mutually between other prisoners. The purpose of this project is to haver variable parameters so that a variety of situations and settings could be tested. The expected result is a variety of simulations that will show how a specific situation can turn out when prisoners are given the option to cooperate mutually with one another.

Keywords: Prisoner's Dilemma, Agent Based Modeling.

1 Introduction - Elaboration on the problem statement, purpose, and project scope

1.1 Purpose

The main purpose of my project is to see the effects of cooperation on Prisoner's Dilemma when multiple prisoners are implemented. Prisoner's Dilemma is normally played with two prisoners and the effects of cooperation and defection are easily noticeable. For my project, I would like to see what results would look like if multiple prisoners can participate in the Prisoner's Dilemma and how different strategies can affect their final payouts and choices.

1.2 Background

In Prisoner's Dilemma, two prisoners are given only two options, cooperate or defect. Each option gives prisoners an opportunity to gain a high payout, but it ultimately depends on what their opponent's decision is. If the prisoners make the same decision, then the payouts they receive will be the same, otherwise, one prisoner will receive the highest payout while the other will receive nothing at all. Statistically, the payouts in terms of decisions go as follows

T is greater than R
R is greater than P
P is greater than S

If the two prisoners have different decisions, then the one that defects gains the Temptation payout (T) while the prisoner that cooperated gains the Sucker payout (S). On the other hand, if both prisoners decide to cooperate, both receive the Reward payout (R), and if they defect, they both receive the Punishment payout (P). Statistically, it's best to have both prisoners cooperate for a chance at the Reward (R), but there is the Temptation (T) to gain the highest payout and leave the opponent with the Sucker's payout (S).

There have been many strategies available to gain the optimal output in this game, but the most robust strategy is tit-for-tat, a strategy that has the prisoner mimic his opponent after the first defection. Research has also been highly prevalent in this area, including the effects on genetics and future generations in-game and with various parameters including N-participants.

1.3 Type of research

This type of research falls under applied research, although it has some aspects of user inspired research.

2 Background and review of current literature and research

I have looked into Robert Axelrod's 'Evolution of Cooperation' to gain an understanding of how Prisoner's Dilemma operates and understanding the optimal strategy tit for tat. This has been my main source of research and literature review as of this time, and I plan to continue to refer to the text for aid and reference. Prisoner's Dilemma and the psychology of cooperation are explored very well here, therefore it is an excellent text to use as a reference and an aid.

Another recent research article that has caught my interest revolves around a variation of the Iterated Prionser's Dilemma called Turn Taking Dilemma. This new source is gaining interest from me and if possible, I would like to implement aspects of this project into my own. An interesting result that came through for this project was that the strategies that were optimal in the Iterated Prisoner's Dilemma, was not the case for the Turn Taking Prisoner's Dilemma. There was also another article that delved into this algorithm in comparison with the genetic algorithm, which had also determined that the top strategies of Iterated Prisoner's Dilemma were not optimal for the Turn-Taking Dilemma.

Yet another article that has caught my interest was an evolutionary study using Prisoner's Dilemma. This study was based around the use of preferential partner selection, which is very similar to my own project in that I allow two prisoners to always cooperate with each other, as if they were partners working together. The analysis that was done on this project are based on the results of allowing prisoners to cooperate and defect at their own will. A variety of parameters and their effects on the final results were also evaluated on this project, and it was found that most future ecologies had become mutually cooperative, but there were still some ecologies without this setting that had survived.

3 Development and Analysis

3.1 Progress

In the first quarter, the project started by allowing only two prisoners playable. An arrayList was constructed to keep future track of multiple prisoners and at the time, development into the tit-for-tat algorithm aws being done. Also, a random algorithm could be implemented by the prisoners.

In the second quarter, the option to allow N-prisoners playable was implemented into the program. Additional strategies could be implemented by the prisoners including tit-for-tat, and new methods were made into the program for more efficient runs. However, a problem had arose when I found that one tit-for-tat algorithm allowed a prisoner to, metaphorically speaking, 'foresee' his opponent's move.

In the third quarter, prisoners were now able to engage each in at least one round of the game and the problem from the previous quarter had been fixed. A graphical disaply was in development at this time.

Finally, in the fourth quarter, graphical display worked continued. Unfortunately, this was eventually dismantled due to time constraints. Algorithms have been fixed and fine tuned and a prototype of the ability to mutually cooperate with other prisoners had been established. Three strategies were available for use by prisoners and they were used in the analysis.

3.2 Procedure and Methodology

This program enables the user to set his or her own specific parameters before playing a game of Iterated Prisoner's Dilemma (IPD). The parameters that can be set are how many prisoners can be allowed to play, how many turns the IPD is to play through, which strategies each prisoner will implement, and finally, if the first two prisoners will always cooperate with each other.

Testing and analyzing will be done at this time by running the program multiple times. Error analyses will be done by reading printed lines to determine the program is running correctly. At the moment, since the graphics structure is still under construction, testing will also be done to ensure that the numbers and statistcs are being displayed properly.

I did this research project using three prisoners and four prisoners. Each game played through 10, 25, and 50 rounds separately, and each game had either prisoners with different strategies or some prisoners using the same strategies. Also, some games enabled mutual cooperation between either random players, tit-for-tat players, or a combination of both. After having set these parameters, I kept track of how many times each prisoner cooperated and defected, and their final payout at the end of the game.

3.3 Analysis

The results were fairly surprising to me. In nearly all the scenarios of three prisoners and four prisoners, both the suspicious tit-for-tat (STFT) player and the tit-for-tat (TFT) player had very high rates of defection. Mutual cooperation between the players only made the rates of defection for the TFT and STFT players slightly lower, but for the most part, defection rates remained quite high. Random, as expected, had almost a 1:1 ratio between cooperations and defections in all cases and number of rounds. As for payouts, all of them were nearly similar with very little variation. However, the more rounds played, the higher the final payout.

4 Results

TFT and STFT players always seem to have high rates of defection in comparison to the random players. By the number of turns played, it seems that cooperation raises the payouts of the specified prisoners only by a small margin. As for payouts, I can conclude that payouts differing between those that cooperated mutually did not differ significantly in comparison to those who didn't. However, I do believe that differences would be more significant if a larger number of rounds were played in the game.

References

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