**University of Central Florida**

Department of Computer Science

**CAP6675**

**Complex Adaptive Systems**

Homework 3

**Iterated Prisoner’s Dilemma**

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1. EXPERIMENT

**Bryan’s Strategy:**

This strategy is dependent on the opponent’s previous move to change its cooperation probability. This strategy will cooperate depending on its cooperation probability which is dependent on the number of defects the opponent makes over the game. This cooperation probability changes as a function of the number of defects and a variable ‘alpha’ which can be thought of as a learning factor.

The player’s next move will be determined by the following statement: If the opponent’s previous move was defect, then the player’s cooperation probability will decrease by a factor of alpha \* (cooperation probability / number of defects). If the opponent’s move was cooperate, then the player’s cooperation probability will increase by a factor of alpha \* (cooperation probability / number of defects). This approach was influenced by the idea of the reinforcement model in the division of labor of ants where the probability of cooperation increases by a certain factor every time the opponent cooperates and same for its counterpart so there is more willingness to cooperate if the opponent continuous to cooperate or less willingness if the opponent continues to defect. The learning factor, alpha, can be thought about as a memory mechanism where a higher value means the opponent's move history is more impactful .

**Joseph’s Strategy:**

This strategy looks at the move taken by the opponent three games ago and plays whatever would either beat or tie with that move. The idea was to both counter any moves that have a pattern to them as well as minimize the loss incurred by being over aggressive.If the opponent’s move three games ago was to defect, then in this game the player will also defect. If the opponent’s move three games ago was to cooperate, then in this game the player has a 50% chance to cooperate or defect.

The strategy was developed as an attempt to dynamically learn pattern based strategies. Three was chosen because it's the lowest number in which a pattern can start to be seen. 50% chance was chosen so that the strategy the chance of taking the suckers payoff with the chance of cooperating so as to not set off retaliatory strategies.

**Samantha’s Strategy:**

This strategy consists of analyzing the opponent's previous moves and including a random factor with a 50% chance. This strategy will keep a counter to the number of defects. It is assumed that it starts with the opponent choosing to cooperate. The player's next moves will be determined by the following statement: If the opponent chooses to defect, the player's next move will be random unless the opponent has defected three times in a row. If the user has defected more than three times in a row, then the player will also defect. If the opponent chooses to cooperate, the player will defect and the defect counter will be set to zero.

To develop this strategy, all 5 strategies were analyzed. Tit for Tat and Tit for Two Tats are the two best strategies in the tournament. Therefore, making a choice to defect or cooperate based on the opponent's last moves is an effective technique that was implemented into the strategy. Another factor was randomness. In this type of game, having a random choice might be more effective than having set choices. As seen in the tournament, Random usually ranks higher than Always defect and Always cooperate. The way that the random probability was implemented was by having a 50% chance of defecting/cooperating when the opponent had defected in the last move but has not defected more than 3 times in a row. The reason why there is a condition regarding the consecutive times that the opponent has defected is because when playing against Always Defect, the strategy will be more effective than Random.

1. RESULTS

**Always Cooperate**

* Always Cooperate vs Bryan:

In this game, the player and opponent will end up with the same score of 250 points. This is due to the strategy’s predisposition to cooperate as long as its opponent cooperates. The strategy will increase its probability of cooperation every move so it will most likely cooperate at all turns.

* Always Cooperate vs Joseph:

In this game, since the opponent always cooperates, the player will always randomly pick between cooperating and defecting, taking the temptation to defect about 50% of the rounds, having an average score of 298 against Always Cooperate’s average score of 147

* Always Cooperate vs Samantha:

In this game, the player will take the most advantage of the opponent because the player will defect every single time, while the opponent continues cooperating. Summing up to 350 points for the player, when setting up the max steps to 50. This game will get the player the most points out of all the strategies in the tournament.

**Always Defect**

* Always Defect vs Bryan:

In this game, player 2 (StrategyCamacho1) scores 148 vs player 1 (Always Defect) scores 154. This is because the strategy changes the probability of cooperation at lower rates as the number of defects increases causing the chances of cooperating to be higher when the opponent is defecting in later runs.

* Always Defect vs Joseph:

In this game, the player starts the first three rounds assuming the last three moves were cooperation and so its first three moves will be random. Because of this, there is a chance that it will get sucker’s payoff at the start, but after the initial three rounds the player will always defect. Because of this in the best case scenario the player always defects and in the worst case the player will get the suckers payoff for the first three rounds. Average score was 145 against Always Defect average score of 156

* Always Defect vs Samantha:

In this game, the player will start by defecting, since we had set the first move of the opponent to cooperate. After the first move, the defect counter will start to increase. The opponent will continue to defect and the player will start making random choices for the next 3 steps. Once the defect counter reaches 3, This game will get the player the least points out of all the strategies in the tournament.

**Random**

* Random vs Bryan:

This certain strategy works well with random due to its adaptive nature. If the Random strategy has a history or certain tendency to favor defecting, then the strategy will adjust its probability accordingly. This can be seen in the average scores where the strategy scored 218 vs the Random strategy scoring 128.

* Random vs Joseph:

Against a random opponent, this strategy offers no real advantage and in turn just reacts to the randomness, effectively making random vs random, therefore the results will vary drastically each round. Average score was 203 vs Random’s 148.

* Random vs Samantha:

Playing against random is unpredictable and challenging to strategize. Although it is not possible to know how the gameplay develops, there is an extremely low possibility for the Random strategy to always choose defect or always choose cooperate. With this in mind, we can assume that our counter for the number of defects will restart multiple times. Every time that the counter restarts, the player will make random choices. Therefore, we can say that this game has a lot of chances of being Random vs Random.

**Tit for Tat**

* Tit for Tat vs Bryan:

In this game, being faced against a TitForTat strategy will cause the game outcome to be similar to the game against the AlwaysCooperate strategy. This is due to the nature of both strategies being of reciprocal nature where TitForTat will cooperate as long as the opponent does and similar for the tested strategy. Both scores averaged to 250

* Tit for Tat vs Joseph:

The start of this game will be set randomly by player A’s first three moves. Since Tit for Tat copies its opponent and this strategy will either copy or beat a previous move, a pattern occurs, they become the same but offset for a few rounds until this strategy’s randomness factor kicks in. Because of that this strategy is more likely to get the temptation to defect and will pull out ahead, even if not by much. Average score was 162 vs Tit for Tat’s 156.

* Tit for Tat vs Samantha:

Since the opponent's first move will be to cooperate, the player will take advantage and defect to get more points. However, in Tit for Tat, this will play out to a disadvantage because the opponent will then choose to defect. Once this happens, the game will have the same outcome as Always defect.

**Tit for Two Tat**

* Tit for Two Tats vs Bryan:

Similar to the previous outcomes of the TitforTat and Always Cooperate games, all strategies seem to favor cooperation and are reciprocal so both players will end up with the same score most of the time because a ‘Sucker’ outcome is never reached. Both scores averaged to 250.

* Tit for Two Tats vs Joseph:

This game plays the same as Tit for Two, the player will start the first three rounds randomly and that will set the pattern until this strategy breaks the pattern, likely getting the temptation to defect. The difference is that now the pattern is offset by two, allowing the player to take the temptation twice per pattern and win by more compared to Tit for Tat. Average score was 213 vs Tit for Two Tat’s 156

* Tit for Two Tats vs Samantha:

Similar to Tit for Tat, the player will start by defecting. Tit for Two Tats will give the player a chance to cooperate. The player will continue to defect and after two chances, the opponent will start defecting. Once the opponent defects the player will make random choices until the opponent has defected three times. At that point, the player will defect and the opponent will defect until the game is over.