Final Report

Introduction to Computer Programming

Karen Ghazal & Aren Melkonian,

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**Prisoner’s Dilemma**

For our project, we wanted to discuss and evaluate the challenge of the prisoner’s dilemma in real-life. Outside the context of the riddle, the issue of the prisoner’s dilemma can be portrayed in different scenarios. For this project, we wish to bring this matter to another level, incorporating certain changes and advancements to be able to relate it in a realistic standpoint. Therefore, the question we want answered is **what would be the best strategy to get the best possible outcome in prisoner’s dilemma (game theory) and how we relate that to real life?**

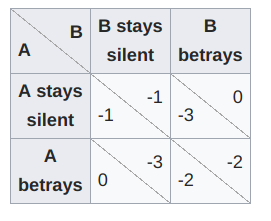
First, we need to know what prisoner’s dilemma is. This simple idea consists of two criminals caught for their actions and interrogated by the police. They are given two options:

Betray your partner and tell on the other or choose to stay silent. Depending on the decision each prisoner takes, there are four possible outcomes:

1) If you confess and agree to testify against the other suspect, who does not confess, the charges against you will be dropped and you will go free.

2) If you do not confess but the other suspect does, you will be convicted and the prosecution will seek the maximum sentence of three years.

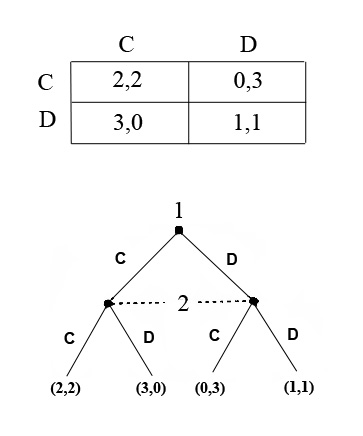
3) If both of you confess, you will both be sentenced to two years in prison.

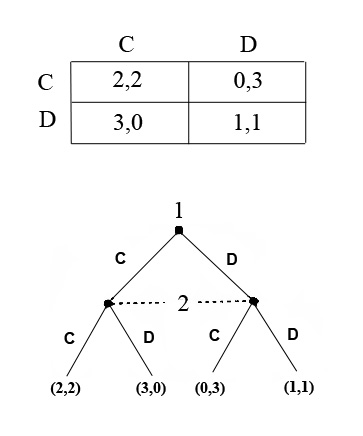
4) If neither of you confess, you will both be charged with misdemeanors and will be sentenced to one year in prison. (1)

These scenarios may be represented by the following matrix:

The best choice for you to make in this context would always be to talk because no matter what person B chooses to do, the outcome would always be better for you if you were to stay silent (0 / -2 compared to -1 / -3). Although, this is not a realistic case study for us because we’re not criminals. In our lives, we take actions with intention to gain the most awards. Then the point system must be altered to consider the benefits we can achieve rather than compare the worst consequences. This challenge is called game theory and is a much more strategic game than prisoner’s dilemma.

**Description of Model - Game Theory**

To win the game, you’re required to understand the way your opponent thinks and take decisions with respect to his or her playing style. The only difference in the points or actions is that you have the option to cooperate (stay silent) or defect (betray), and the points accumulate the more **rounds** you play. At the end, all the points are added once all the competitors faced each other. This point system below is the one we followed:



Each person’s strategy is determined by their behaviour, which is why we chose 5 common and distinct characters present in our community to see how the results vary. The first individual is the Cheater: he always defects no matter the situation. Second comes the Copycat: after playing a random move the first round, he copies the previous move done by his opponent. Thirdly, the grudger: he plays nice until the adversary defects. If so, he will hold a grudge against you for the rest of the game and will continuously play defect. Then comes the Cooperator: he always cooperates no matter what. He likes to hold good relationships with others. Finally, there’s the Random player: this individual constantly generates random moves and uses no strategy.

**Mathematical Model and Numerical Techniques:**

First off, we need to set our characters, and define the behaviour of each:

1. Copycat: repeats the last move as their opponent
2. Cheater: always cheats
3. Grudger: will always cooperate until its opponent cheats, then he will always cheat
4. Cooperator: newest value added after the presentation, character which cooperates no matter what the opponent places
5. Random: Outputs random values for cheating/cooperating

In the code, each character was programmed and dependent on the opponent whom it played against. There was a random class created for all the players which needed a random value and a seed was added in order to create the same generated random value.

In our mathematical model, we evaluated each character and analyzde them depending on the span of time in which the game is taking place (i.e. on the long run and on the short run). Trust and behaviour were evaluated depending on the different arrangements and how the length of time will influenced the outcome.

**Results**

|  |  |  |
| --- | --- | --- |
| Series 1: | Cheater | Opponents |
| Series 2: | Copycat |
| Series 3: | Grudger |
| Series 4: | Cooperator |
| Series 5: | Random |

When comparing the results, we were mostly interested in the best strategy we can use depending on the length of each series. For example, for a game with 2 rounds, cheater comes on top always with the most amount of points. This was obvious because, as explained earlier, defect will always promise the best outcome no matter what the other person decides to do. But how will the results change if we incorporate more rounds?

The first graph for each series shows the amount of points accumulated against each competitor and the one underneath is the sum of the points earned at the end of the match by each player.Our interpretations showed that the Copycat and the Grudger were very close and scored more than the others for their points. Therefore, we concluded that Copycat and the Grudger are the best out of all the players on the long run.

**Discussion**

We believe these two characters came on top because they are the only ones who’s moves depend on the previous move of their opponents and act accordingly. All the other characters repeat the same move no matter what their opponent did, meaning that they don’t adapt their strategy to try and outsmart their rival. Although Grudger and Copycat came on top, the Copycat had a better overall score but not by much compared to the Grudger, unlike what we had hypothesised. We had believed that on the long run, Copycat was going to be the best outcome by far when compared to the others. However, Grudger came very close to Copycat unexpectedly. Looking back, we think this is because we have a major flaw in our program that doesn’t allow us to obtain the expected results. In theory, Copycat always wins in the long run. The issue with our program is the basic and fixed tactics assigned to each player, there’s a lack of diversity which makes the Grudger and the Copycat almost the same character. The Cheater and the Cooperator keep consistent actions throughout every match, and so does the Grudger at a certain extent. Then the Copycat and the Grudger will simply become the character they play against if you compare how each of them behave against the others. The only time there’s a noticeable difference is against the Random player, but the score is always inconsistent against him and the obvious winner is always the opponent facing him.

In our code, we decided to fix the way our random character was generating numbers by introducing a seed in our code (see line 392 in TermProject.java). This way the seed would ensure that every time we call the random class, the same value we set (in our case the value was 1).

**Relation to the Economy**

We can relate this topic with the issue of the U.S. dept problem between Democrats and Republicans, and how these two parties approach the situation (through cooperation or self-interest). When we compare the number of votes depending on the choices brought up by the two sides, the matrix, once again, is identical to the first two demonstrated. But how can we apply such a topic in our lives. The example given on Investopedia refers to car shopping. Imagine you’re searching for a new car at a car dealership and wish to dispute the prices of a vehicle with the salesman. How should you act? Cooperation for this case means not to debate the amount and to buy the automobile with the given price on the tag while defecting will mean to bargain. In the table below, the numbers assigned in each cell represents the level of happiness for the buyer and the salesman:

|  |  |  |
| --- | --- | --- |
|  | Cooperate | Defect |
| Cooperate | 7 / 7 | 0 / 10 |
| Defect | 10 / 0 | 3 / 3 |

**Relation to Business**

|  |  |  |
| --- | --- | --- |
|  | Cooperate | Defect  (The numbers represent the profit made in hundreds of millions)  of millions) |
| Cooperate | 500 / 500 | 0 / 750 |
| Defect | 750 / 0 | 250 / 250 |

In business, every company and corporation has a rival with whom they compete for the most successful enterprise. Take Walmart and Target for example. Both associations have big names and are very successful in the United States, but they’re interdependent. Each party’s financial position changes in accordance with the other party. Let’s say Walmart wishes to drop its prices, Target would have no choice but to do the same to preserve their clients and gain profit. Or else, they will face an economical crisis. But if they both cooperate and increase their prices, they will make more profit.

This example may also be represented in a similar matrix as the first:This matrix shows that benefits are similar to the original question of the prisoner’s dilemma: defect will always favour your own success. But this is if we take into account the short term. Businesses last much longer than a few months or one year, that’s why we need to compare these statistics to the long run. A perfect example would be McDonald’s against Tim Hortons. They have been big competitors in Canada since there foundation and they’re in a constant battle to overcome the other. A few years ago, McDonald’s released the concept of stickers that you can collect from buying coffee and get the eight one free. A few months ago, it was Tim Horton’s time to strike and they decided to play the role of the Copycat; they introduced their own version of this idea with a membership card, but with more accessibility. Now, they’re attracting more people to consume they’re product. This back-and-forth behaviour has been going on for years and explains why these two companies are booming compared to other fast-food restaurants. This is another proof that Copycat is the best way to go.

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