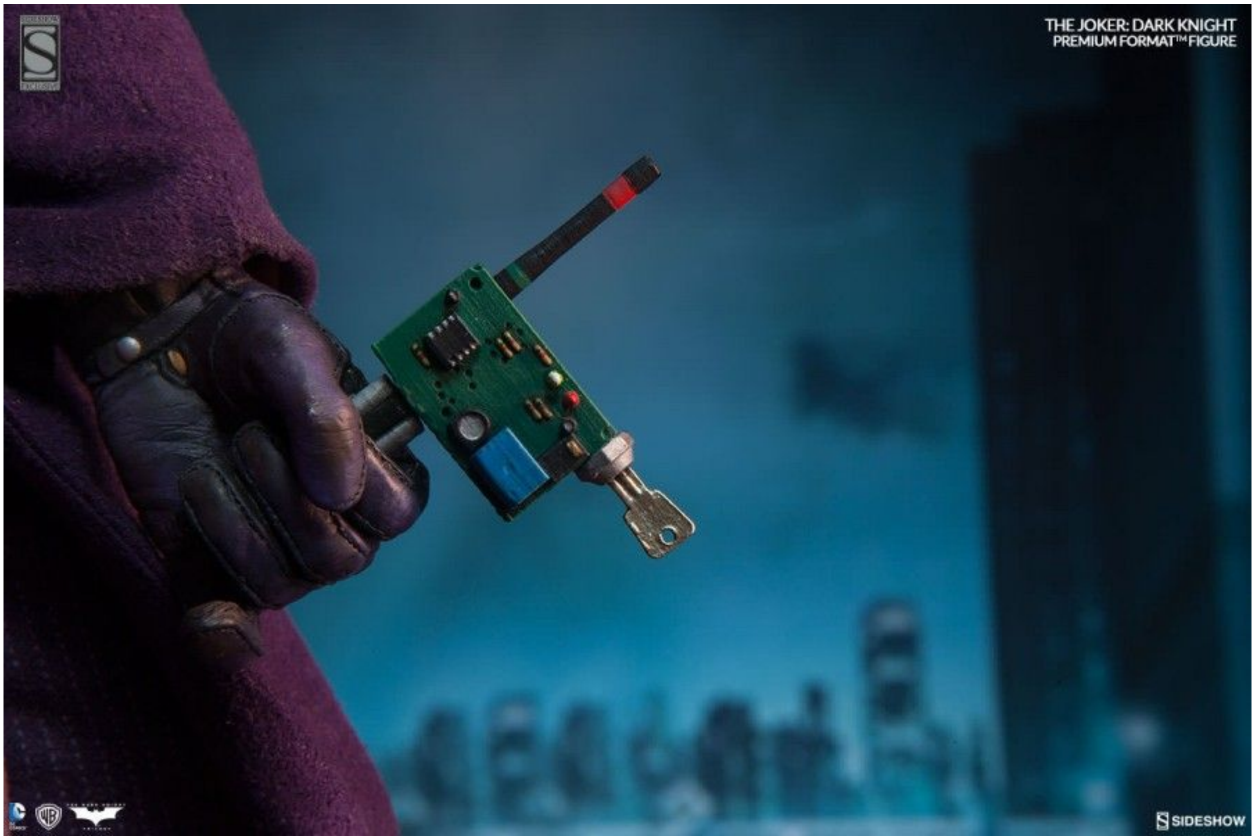
PRISONER'S DILEMMA

Modelling and Simulation

Group Number 26



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INTRODUCTION

Game Theory might be better described as Strategy Theory or Theory of Interactive Decision Making. A strategic situation involves two or more interacting players who make decisions while trying to anticipate the actions and reactions of others. Game theory studies the general principles that explain how people and organizations act in strategic situations.

The prisoner's dilemma is a standard example of a game analyzed in game theory that shows why two completely rational individuals might not cooperate, even if it appears that it is in their best interests to do so. The prisoner's dilemma is a paradox in decision analysis in which two individuals acting in their own self-interests do not produce the optimal outcome. The typical prisoner's dilemma is set up in such a way that both parties choose to protect themselves at the expense of the other participant. As a result, both participants find themselves in a worse state than if they had cooperated with each other in the decision-making process. The prisoner's dilemma is one of the most well-known concepts in modern game theory.

PROBLEM STATEMENT

In our project, we follow the iterated prisoner’s dilemma to showcase the simulation between various strategies such as Tit-for-Tat, co-operator, and defector, meanwhile, we also developed an interactive game where a user can play with the machine by choosing one of the aforementioned strategies. We also wrote a few functions where the average payoff a move can foster against all the other strategies and against itself is calculated.

Thus, the motive here is to compare different strategies with each other and itself. “Game Theory-Prisoner’s Dilemma” is interesting because individually, each player’s best strategy is determined by the strategy of the other player. On the other hand, a player’s strategy is independent of the choice made by the opponent, each player has a dominant strategy. Whereas dominant strategy represented as a player’s strategy is mixed or determined by the strategy of the other player.

DETAILS OF SCIENTIFIC RESEARCH PAPER

In 1996, Manuel Velasquez says, The research on prisoner’s dilemmas and social dilemmas shows that ethical behavior is more profitable and more rational than unethical behavior in terms of both the negative sanctions on unethical behavior when interactions with stakeholders are iterated[9], and the positive rewards of habitually ethical behavior when stakeholders can identify those who are predisposed to be ethical[8].

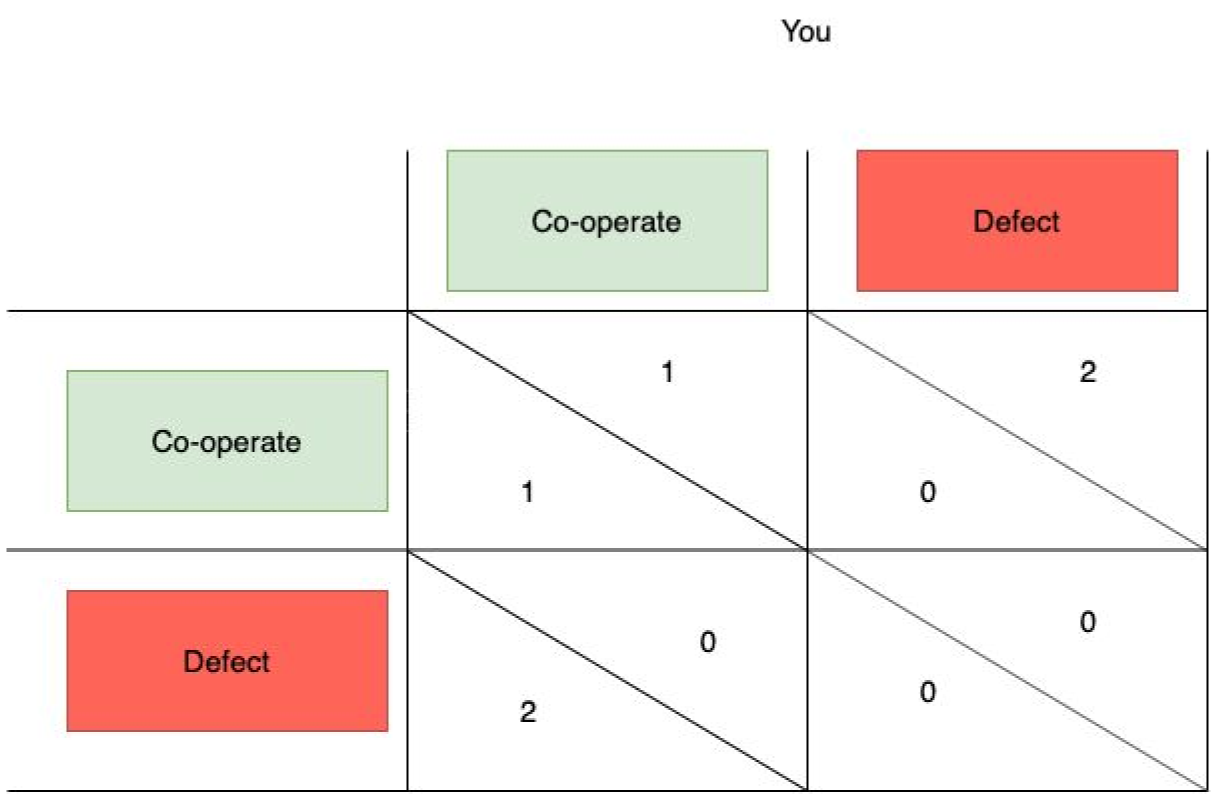
In 2003, Kevin Gibson, The research on Games Students Play: Incorporating the Prisoner’s Dilemma in Teaching Business Ethics deals with three important techniques which useful for pedagogically. First, raising awareness, with the assumption that when people realize the dynamics of the dilemma. Secondly, it puts the issue of whether there can be a prudential ethics front and center. Thirdly, the dilemma is descriptive since it demonstrates the sort of position in which people or businesses find themselves. These three rules to maximize their individual or mutual benefit[9].

In 2010, Janelle Reinelt & Gerald Hewitt, The research on The Prisoner’s Dilemma: Game Theory, Conflict Resolution, and the New Europe show the game emphasizes it as a sport or contest, with the premium on the skillful play, rather than a just outcome.

PAY-OFF MATRIX

The payoff matrix is shown in the image below. There are 4 cases we consider.

If both the players Co-operate, both get 1. If both players defect, no one wins, both get 0. If one defects and one co-operates, the one who defects wins, gets 2.



METHODS USED FOR SIMULATION

To simulate the Prisoner’s Dilemma we create an interactive game that helps to understand various strategies by comparing these strategies to one another and itself. We’ve used Python as a programming language to implement various strategies in the form of a game and compare these strategies to one another using the payoffs from the aforementioned payoff matrix.

IMPLEMENTATION

To implement the simulation we use Python as the programming language and follow the aforementioned payoff matrix. We have gone on to create an interactive game where the user can either play with the computer against a selected strategy for the computer or select one strategy for oneself and compare it with the other strategies. As we know the prisoner’s dilemma is an example of adaptive strategies, there can be many strategies one can develop. But, the main strategies we have considered for this project are “always co-operate”, “always defect”, “tit-for-tat”, “grudger” and “pavlov”.

DISCUSSION

Following we discuss the five strategies we have considered for the project.

1. **Always Defect**

   Strategy: Defect every move

   This strategy exemplifies lost faith in co-operation. If we follow the payoff matrix, this strategy will gain 2 if the opponent co-operates and lose 0 if the opponent defects. Thus, using this strategy you will always win or tie against any specific opponent because they never have an opening to grab points from you.

2. **Always Cooperate**

   Strategy: Cooperate every move

This is the strategy that exemplifies “why can’t we all just get along” [10]. It’s unconditional love where you always cooperate no matter how others treat you. Generally admitted to being an unsustainable strategy, if applied to all relationships. Always co-operate is the most altruistic strategy possible. If we follow the payoff matrix this strategy will effectively lose 1 if the opponent defects and effectively gain 0 if the opponent co-operates.

It’s a viable strategy in environments of extremely high trust. On the other hand co-operation without trust is an invitation for tons of abuse.

3. **Tit-For-Tat**

Strategy: Start by cooperating, then copy whatever the other player did the last move.

Tit-For-Tat is a strategy that can be implemented in games with repeated moves or in a series of games like a round-robin tournament.

Tit-For-Tat starts by cooperating and then copies the other player’s last move. It adapts with both strategies such as (it co-operates when interacting with co-operation) and defects when interacting with defect)[10]. On one hand, this behavior makes it retaliatory because a defection will be repaid by defection and on the other hand the behavior makes it forgiving because it will return to playing co-operate if the opponent returns to playing co-operate.

4. **Grudger**

Strategy: Start by co-operating, if ever cheated, play defect whatever *the opponent plays.*

Grudgers co-operate with the opponents who have previously co-operated with it. However, if any opponent cheats it, it will remember the incident and bear a grudge: they refuse to co-operate with that opponent in the future. It will behave altruistically if everybody does so, otherwise, it will start defecting. Grudgers are vulnerable as well in a way that they groom/co-operate with newborn cheaters (who defect after co-operation) without knowing who they are [5].

5. **Pavlov**

   Strategy: Co-operate only if both co-operated in the previous move, otherwise, play defect.

   If we look at the previous strategies, tit-for-tat seems to be a good one. But, there is a weakness it possesses, other than always playing for a tie. Tit-for-tat is prone to noise, it means that there is a small probability of a message (co-operate or defect) being misinterpreted. This was the two tit-for-tat players enter into a round of mutual retaliation.

   Pavlov takes both it's own and the opponent's last move into account to compute the next. Co-operates if and only if both players opted for the same choice in the previous move, otherwise it defects.

RESULTS

Taking the payoff matrix into consideration, for all the five strategies we ran the simulation (twenty rounds against each strategy) to compare each strategy against all the other strategies and against itself. The following are the results we found after running the simulation.

1. Always Co-operate
    a. Against other strategies

       Average score - 15.0

    b. Against itself

       Average score - 20.0

   Thus, the overall average score comes out to be 17.5

2. Always Defect
    a. Against other strategies

       Average score - 16.75

    b. Against itself

       Average score - 0.0

   Thus, the overall average score comes out to be 8.375

3. Tit-for-tat
    a. Against other strategies

       Average score - 15.0

    b. Against itself

       Average score - 20.0

   Thus, the overall average score comes out to be 17.5

4. Grudger
    a. Against other strategies

       Average score - 15.0

    b. Against itself

       Average score - 20.0

   Thus, the overall average score comes out to be 17.5

5. Pavlov
    a. Against other strategies

       Average score - 15.0

    b. Against itself

       Average score - 20.0

   Thus, the overall average score comes out to be 17.5

CONCLUSION

After reading about the prisoner's dilemma, we have come to the conclusion that the game is a multifaceted intellectual piece that should be studied even further because of its applicability to real-world scenarios. The game theory can be applied to real-life issues. Also, after analyzing various strategies we conclude that “always defect” gets the best output against other strategies, but fosters nothing when the opponent plays defect.

While running the simulations we observed that “always defect” could beat “tit-for-tat” and “grudger” just once. This is obviously because of the nature of such strategies.

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allwaysDefect beats titForTat 2 - 0
allwaysDefect beats titForTat 2 - 0


allwaysDefect beats grudger 2 - 0
allwaysDefect beats grudger 2 - 0
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This shows that “always defect” is not such a dominant strategy when we start looking at the mixed strategies and others such as “grudger” and “pavlov”.

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