Vivekanand Education Society's
Institute of Technology
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Artificial Intelligence and Data Science Department

Game Theory/Odd Sem 2023-23/Experiment 2

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Title of Experiment : Program for creation of Pure Strategy Nash Equilibrium.

Objective of Experiment : To Develop a comprehensive understanding of Nash Equilibrium as a fundamental concept in game theory, exploring its implications for decision-making and strategic interactions. Implement a program to calculate Pure Strategy Nash Equilibrium, using the Prisoner's Dilemma as an illustrative example, and demonstrate the practical application of Nash Equilibrium in real-world scenarios.

Outcome of Experiment: The experiment identifies Pure Strategy Nash Equilibrium points in the Prisoner's Dilemma, revealing stable strategies where both players' choices lead to the best possible outcomes given their opponent's choice.

It demonstrates the counterintuitive result that mutual cooperation is not the equilibrium, highlighting the tension between individual and collective rationality.

The experiment's outcomes exemplify the practical relevance of Nash Equilibrium in understanding strategic interactions, decision-making, and the challenges of achieving cooperation in various real-world scenarios.

Problem Statement: To write a python code for creation of Pure Strategy Nash Equilibrium.

Description / Theory :

The concept of Nash Equilibrium, pioneered by mathematician John Nash, is a foundational principle within game theory. It characterizes a situation in which each participant's strategy is optimal given the choices of all other participants. This implies that no player has an incentive to unilaterally deviate from their chosen strategy, assuming that the strategies of others remain unchanged.

To illustrate this concept, consider the classic example of the Prisoner's Dilemma, a fundamental scenario in game theory. Two players face the choice of cooperation or defection, with potential outcomes influenced by mutual cooperation. However, individual self-interest often leads to less favorable results.

<u>The Nash Equilibrium can be exemplified in this context:</u>

1. If both players cooperate, they both receive moderate payoffs.
2. If both players defect, they both receive lower payoffs due to the penalties associated with both confessing.
3. If one player defects while the other cooperates, the defector obtains the highest payoff by exploiting the cooperator's choice.

Although mutual cooperation is the socially preferable outcome, the Nash Equilibrium frequently entails both players defecting. This is because neither player has an incentive to alter their strategy when assuming the other player's strategy remains fixed.

<u>The Nash Equilibrium is characterized by three crucial properties:</u>

1. No player can enhance their payoff individually by altering their strategy while others keep their strategies constant.
2. Each player's chosen strategy is the best response to the strategies chosen by other players.
3. The players' strategies align harmoniously; no player is motivated to adjust their strategy given the choices of others.

This concept finds diverse applications in fields such as economics, political science, and biology. It offers valuable insights into decision-making, competitive behavior, and interactions among rational agents. While Nash Equilibrium identifies stable points in strategic interactions, it may not always yield the most desirable outcomes from a societal standpoint. This underscores the challenges posed by conflicts between individual and collective rationality.

Possible outcomes of prisoner's dilemma:

	cooperate	defect

cooperate	(5, 5)	(0, 10)
defect	(10, 0)	(0.5, 0.5)

The dominant strategy here is for each player to defect (i.e., confess) since confessing would minimize the average length of time spent in prison. Here are the possible outcomes:

- If A and B cooperate and stay mum, both get one year in prison—as shown in the cell (a).
- If A confesses but B does not, A goes free and B gets three years—represented in the cell (b).
- If A does not confess but B confesses, A gets three years and B goes free—see cell (c).
- If A and B both confess, both get two years in prison—as the cell (d) shows.

Algorithm/ Pseudo Code / Flowchart (whichever is applicable):

- Define the payoff matrices for Player 1 and Player 2.
- Initialize an empty list to store Pure Strategy Nash Equilibrium points.
- Iterate through all possible strategy combinations:
  - For each combination, calculate the utility/payoff for both players.
  - Check if changing the strategy for either player would result in a lower payoff.
  - If neither player can improve their payoff by changing their strategy, add the combination to the Nash Equilibrium list.
- Display the Nash Equilibrium points found

Program :

1. **Code:**

```
[1] import numpy as np
    import nashpy as nash
```

```
[2] A = np.array([[3,0],[5,1]]) #A = row
    B = np.array([[3,5],[0,1]]) #B = column
```

```
game1= nash.Game(A,B)
game1
```

```
Bi matrix game with payoff matrices:

Row player:
[[3 0]
 [5 1]]

Column player:
[[3 5]
 [0 1]]
```

```
equilibria = game1.support_enumeration() #find nash equilibrium
for eq in equilibria:
  print(eq)
```

```
(array([0., 1.]), array([0., 1.]))
```

Output Screenshots :

```
Bi matrix game with payoff matrices:

Row player:
[[3 0]
 [5 1]]

Column player:
[[3 5]
 [0 1]]
```

```
equilibria = game1.support_enumeration() #find nash equilibrium
for eq in equilibria:
  print(eq)
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(array([0., 1.]), array([0., 1.]))
```

Results and Discussions :

- Recognized instances of Pure Strategy Nash Equilibrium within the Prisoner's Dilemma.
- Examination of equilibrium reveals that mutual defection stands as the enduring result.
- Illustrated the dominance of rational self-interest over shared gain.
- Emphasized the complexities of societal predicaments and collaborative actions.
- Relevance to practical situations underscored, accentuating the role of strategic judgment.