BL40A2010 Introduction to IoT-Based Systems

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Author: Kush Patel

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. It was originally framed by Merrill Flood and Melvin Dresher while working at RAND in 1950. Albert W. Tucker formalized the game with prison sentence rewards and named it "prisoner's dilemma", presenting it as follows:

"Two members of a criminal gang are arrested and imprisoned. Each prisoner is in solitary confinement with no means of communicating with the other. The prosecutors lack sufficient evidence to convict the pair on the principal charge, but they have enough to convict both on a lesser charge. Simultaneously, the prosecutors offer each prisoner a bargain. Each prisoner is given the opportunity either to betray the other by testifying that the other committed the crime, or to cooperate with the other by remaining silent. The possible outcomes are:

- If A and B each betray the other (not-cooperating to each other), each of them serves z years in prison (payoff of $-z$)
- If A betrays B (not-cooperating with B) but B remains silent (cooperating with A), A will serve y years in prison (payoff $-y$) and B will serve w years (payoff of $-w$).
- If B betrays A (not-cooperating with A) but A remains silent (cooperating with B), B will serve y years in prison (payoff $-y$) and A will serve w years (payoff of $-w$).
- If A and B both remain silent, both of them will serve x years in prison (payoff of $-x$)."

The payoff table is presented below.

	B cooperates	**B not-cooperating**
A cooperates	$A \rightarrow -x$	$A\rightarrow -w$
	$B\rightarrow -x$	$B\rightarrow -y$
A not-cooperating	$A\rightarrow -y$	$A\rightarrow -z$
	$B\rightarrow -w$	$B\rightarrow -z$

However, this is only a *Prisoner's Dilemma GAME* for A GIVEN RELATION between the years in prison (payoffs) as to be studied next.

ps. Text adapted from Wikipedia.

(1) Consider the Prisoner's dilemma description given above.

(a) What is the relation between the payoffs values $x\geq 0$, $y\geq 0$, $w\geq 0$ and $z \geq 0$ so that the game can be classified as Prisoner's Dilemma?

(b) Verify the results (i.e., the proposed inequality) with numerical examples using nashpy. Please provide one example when the inequality holds and one it does not (check my example for Dove and Hawyk game).

In [2]:
```
import matplotlib.pyplot as plt
import numpy as np
import nashpy as nash
```

In [3]:
```
A = [[0, 5], [1, 2]]
B = [[0, 1], [5, 2]]
hawk_dove = nash.Game(A, B)
hawk_dove
```

Out[3]:
```
Bi matrix game with payoff matrices:

Row player:
[[0 5]
 [1 2]]

Column player:
[[0 1]
 [5 2]]
```

In [7]:
```
eqs = hawk_dove.support_enumeration()
list(eqs)
```

Out[7]:
```
[(array([1., 0.]), array([0., 1.])),
 (array([0., 1.]), array([1., 0.])),
 (array([0.75, 0.25]), array([0.75, 0.25]))]
```

(2) Justify why the game from the previous exercise is or is not a good (reasonable) model when A and B are:

1. Two trained members from the army when they are in prison.

2. Competitive companies in the market discussing standardization.

3. Two different autonomous IoT-based home energy management algorithms that are focus on energy efficiency.

4. Two different autonomous IoT-based home energy management algorithms that are focus on profit maximization.

ps. You need to think about the assumption used in Game Theory and in the Prisoner's dilemma problem setting.

Answer:

1. i would say Yes. if country A has an crure external terms to create nuclear weapons. Country B may invade the country and cause a nuclear war (harmful to everyone), or being passive (timid) and let the other country make the weapon without cause war (A is in an advantageous situation and B cannot act without becoming worse off).

2. Probably yes if there is a competition between two standards. It may be a good model if we consider: both losing by having two standards. An aggressive company (A) can push its preferable standard and the other (B) being timid; this case has advantages of having only one standard.

3. No since they can work in cooperation and have the same shared goal. The energy efficiency of house A does not affect the payoff of house B.

4. Probably no. But it can also be yes if they are competing for the same resource and decisions of A and B may affect each other.