GAME THEORY – PART 2

1 Behavioural Game Theory

Traditional game theory is based on some theoretical models. Particularly, we assume that players are rational and they can predict moves and strategies of their opponents. However, in real life, we need to take into account some other aspects:

- **players' preferences** – traditionally, pay-off is equal to some utility; regarding some economic problems, we can assume that it is some amount of money and the main aim is to maximize our profits (so our players are kind of selfish),
- **strategic reasoning** – we can calculate the best strategies that each player can play but it is considered *ad infinitium.* However, real life problems are finite so the information about strategies is just partial,
- **learning** – how fast players learn each others' behaviour and how it can influence the game.

The important thing is to understand social preferences of human players. Different studies concerning cooperative games suggest that many players are not purely selfish. Yet, these games are rather blunt tools to measure social preferences because it is very difficult to explicitly measure, e.g., altruism, reciprocity, and selfishness.

Example (ultimatum game): Sam and Jack play the game. Sam receives 10$ and his task is to divide this amount of money between both of them. After his offer, Jack decides if he agrees on that or not. If not, none of them receives the money.

Standard game theory would say that Sam receives 9.99$ and Jack 0.01$ but the reality can be different. Güth et al. (1982) conducted an experiment which showed that:

- a fair offer (e.g., 5$:5$) is rejected around 30% times;
- unfair offers (even very close to equal split) are increasingly likely to be rejected.

This phenomenon is called **negative reciprocity**. It means that in some situation people are likely to lose some reward, just to make it impossible for their opponents to get any reward.

In contrast to the previous situation, we can also observe **positive reciprocity**. It means that some people want to behave in rather friendly way, even if they don't get any reward for their action.

Altruism is another behaviour that needs to be considered. Some people make anonymous donations to charities or spontaneously help other people who are in need. A person has altruistic preferences if his/her utility increases with the well-being of others. Consider the above example and assume that, this time, Jack cannot discard Sam's offer. In such a modified game, Jack can simply take 10$, leaving nothing to Sam. However, there are still people who would divide the money equally.

2 Multiplayer games

Tragedy of the commons: This example comes from *The Tragedy of the Commons*, Science, 1968, vol. 162, no. 3859, pp. 1243-1248.

Imagine a common pasture. Each herdsman wants to utilize it to feed his cattle. It is expected that a herdsmen will try to keep as many cattle as possible on the common pasture, so the pasture becomes full in quite a short time. However, adding more cattle would simply lead to overgrazing. Each herdsman tries to maximize his profit and asks himself: "What is the utility to me of adding one more animal to the herd"? The utility has one positive and one negative component:

1. **The positive component**: one additional cattle means better profits;

2. **The negative component**: In turn, more animals in the common pasture cause overgrazing. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is significantly smaller than the positive component.

Adding together all components, a rational herder concludes that the sensible decision is to add one cattle to the herd every time. This strategy, however, will completely destroy the pasture and, consequently, the cattle could not be feed.

What is the solution to this? According to the author, the rules of the game must be changed to avoid existence of such defective strategies. Garrett Hardin suggests few examples:

- commons can be sold off as private properties, or

- some restrictions may be imposed (one cow per person max, etc.).

Think about similar problems involving multiple players, where, from the point of view of a single player, positive component dominates the negative one. For instance:

- pollution caused by cars and other vehicles,

- air pollution caused by industry,
- water pollution,
- human population growth,
- deforestation,
- spam e-mail.

3 Programming assignment

The programming example which enables better understanding game theory in practice is iterative Prisoner's dilemma. Iterative version differs from the standard one in one aspect – there are more than one game in a row. This version enables decision making based on the previous situations and results.

Download the python file script. Your task is to write a function for your player (second prisoner) which enables winning with the opponent. Think about possible situations:

1. you know the total number of iterations (so you know when the game ends),
2. you have no idea about the total number of iterations (so you do not know when the game ends),
3. there is an"infinite" number of iterations (the game never ends).

Try to find out a solution for each scenario. Can you find out **one** solution which would be optimal, at the same time, for all these variants?

4 Homework

Your homework is based on the card game called *Cheater*. We play with one deck with cards from 9 to 14 (ace) – each with 4 color variants (24 cards). Cards are dealt randomly to two players – 8 cards for each player. Your task is to get rid of all your cards. Players take their turns in some order. A turn consists of placing one card on the common pile. Precisely, you may place one card face-down, claiming which card you placed (so you may lie). This card must have at least the same value as the card on the top of the common pile. Then, any remaining player may check if you lied. If (s)he catch you on the lie, you need to get 3 cards from the top of heap, if not – (s)he gets 3 cards.

Your main aim is to implement a strategy for a player. Your code should be written in Python and your player should be based on the example one which is in the script (especially regarding given input and output of the player). Firstly, your player will be tested in the game with our players, which are not available for you. Then, you will take part in the competition in your laboratory group:

- you will get 3 for a correct implementation,
- you will get 4 if your player beat our – simple – players,
- you will get 5 if your player will be among top 5 players in the group.

Deadline for the homework is “two weeks − 2 days”. Each day of delay means -0.5.