CSCI 5350
Advanced Topics in Game Theory

Discussion Session 1

An Overview on Game Theory

Contact Information

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Assignment

- http://course.cse.cuhk.edu.hk/~csci5350
- Submit through CUHK backboard
- Due dates:

Assignment 1	12 October 2020
Assignment 2	16 November 2020
Assignment 3	21 December 2020

Content

- Definitions & applications of game theory
- Classical microeconomics theory VS game theory
- History of game theory
  - Non-cooperative VS Cooperative games

What is game theory?

- Maschler Solan, and Zamir:
  - “A methodology using mathematical tools to model and analyze situations involving several decision makers, called players.”
- Tijs:
  - “A mathematical theory dealing with models of conflict and cooperation.”

What is game theory?

- Oborne and Rubinstein:
  - “A bag of analytical tools designed to help us understand the phenomena that we observe when decision makers (which are rational and reason strategically) are interact.”
- John C. Harsanyi:
  - “Game theory is the theory of strategic interaction.”

What is game theory?

- Something in common:
  - Rationality
  - Strategic Behaviors
    - Each player makes decisions based on what he/she thinks the other players' counter-decisions are likely to be.

What is game theory?

- Connections of game theory with several other disciplines:

	1 payoff	n payoffs
1 player	Optimization	Multi-objective optimization
n players	Team theory	Game theory

Table 1: Connections of game theory with other disciplines [1].

Application Scenarios

- Military and civil defense

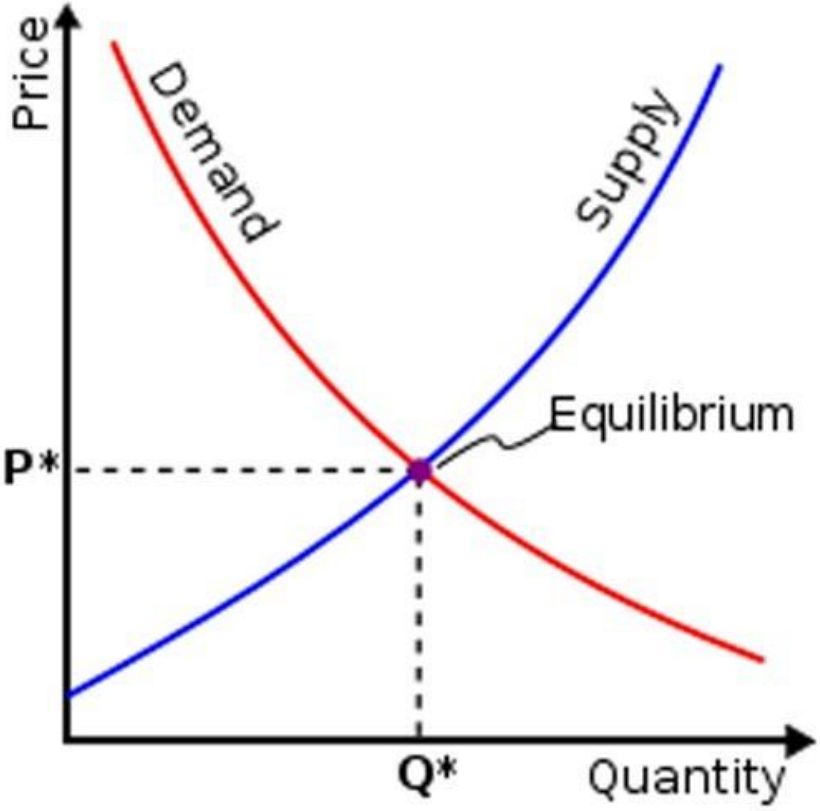
Application Scenarios

- Political science

Application Scenarios

- Engineering applications, robotics, multi-agent systems

Classical microeconomic theory VS game theory



Classical microeconomic theory VS game theory

- Perfect competition

Classical microeconomic theory VS game theory

- Oil market

History of Game Theory

John von Neumann

- Von Neumann laid the mathematical foundation of the theory of games in his paper “Zur Theorie der Gesellshaftsspiele” in 1928.

History of Game Theory

John von Neumann

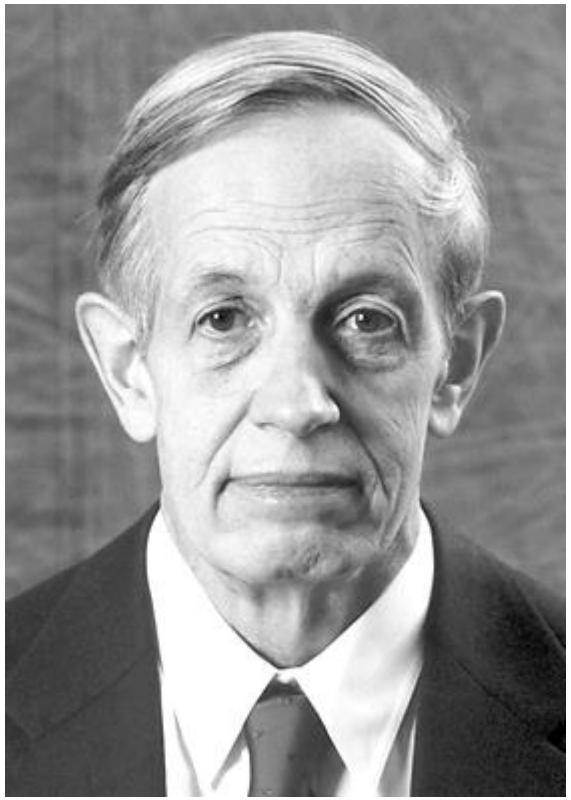
- In 1944, Von Neumann coauthored with Okcar Morgenstern (an economist) and published “Theory of Games and Economic Behaviour”, which is the foundation work of cooperative game theory.

History of Game Theory

Albert W. Tucker

- In 1950, Albert W. Tucker invented prisoner's dilemma game as an example of game theory for a seminar whose audience were mainly psychologist.

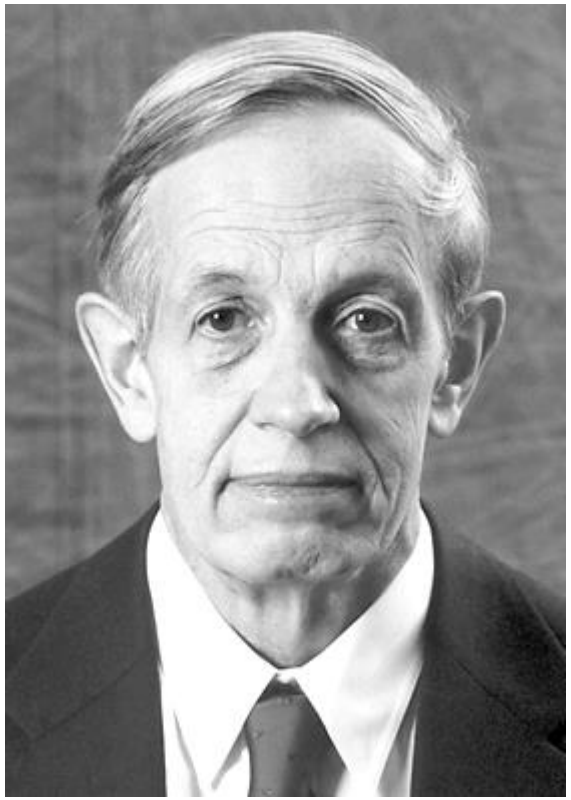
History of Game Theory



John F. Nash

- John Nash laid the groundwork for the general non-cooperative game theory and for cooperative bargaining theory.

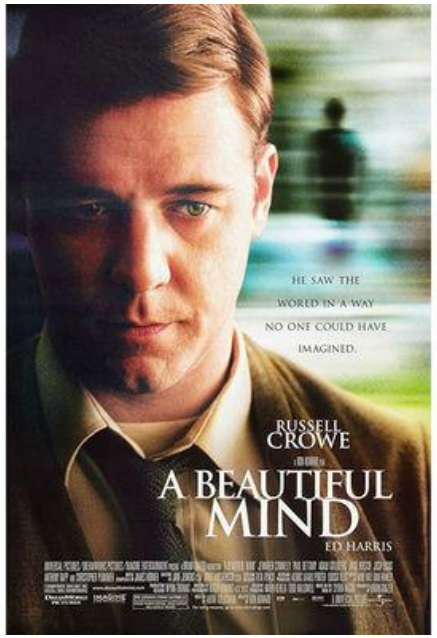
History of Game Theory



John F. Nash

- One sentence letter of recommendation:

  “This man is a genius.”



Non-cooperative VS Cooperative games

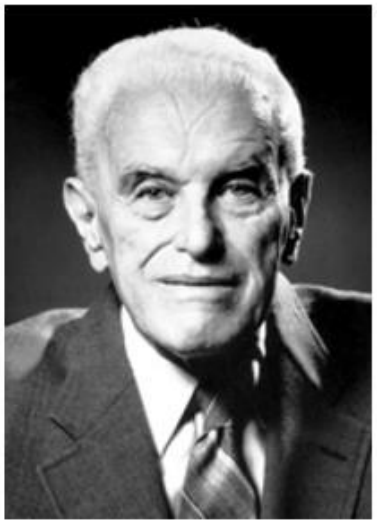
- Cooperative game theory:
  - Binding agreements can be made among players.

- Non-cooperative game theory:
  - Binding agreements are not feasible.

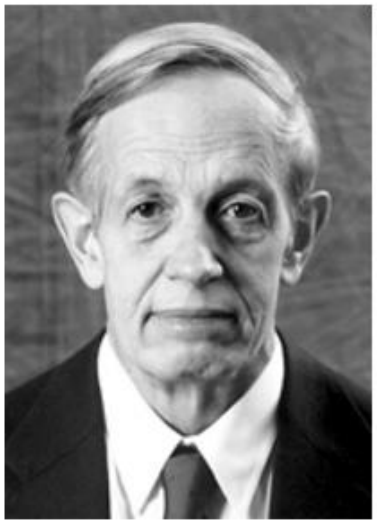
Non-cooperative VS Cooperative games

- Cooperative game theory:
  - Focuses on predicting which coalitions will form, the joint actions that groups take and the resulting collective payoffs.
- Non-cooperative game theory:
  - Focuses on predicting individual players' actions and payoffs and analyzing Nash equilibriums.

History of Game Theory



John C. Harsanyi
Prize share: 1/3

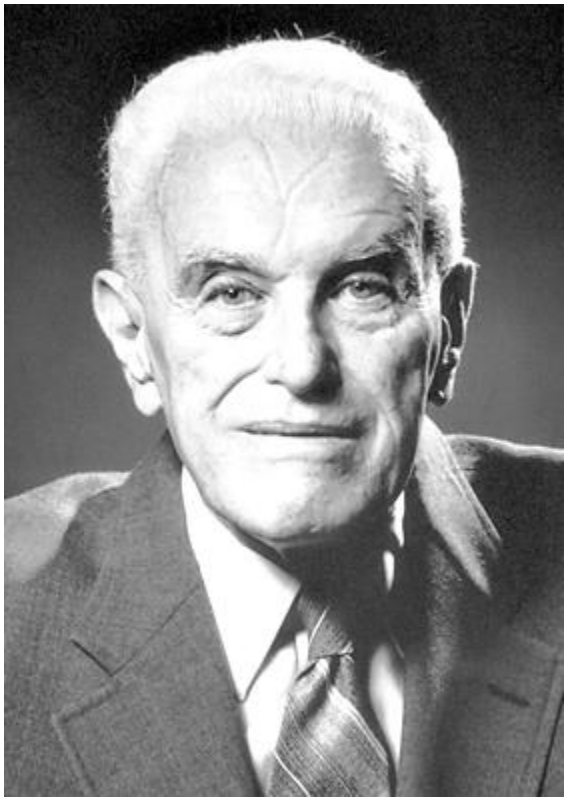


John F. Nash Jr.
Prize share: 1/3

Reinhard Selten
Prize share: 1/3

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1994 was awarded jointly to John C. Harsanyi, John F. Nash Jr. and Reinhard Selten *"for their pioneering analysis of equilibria in the theory of non-cooperative games"*.

History of Game Theory



John C. Harsanyi

- Showed how games of incomplete information can be analyzed, thereby providing a theoretical foundation for Bayesian games.

History of Game Theory

Reinhard Selten

- Refined the Nash equilibrium concept and proposed subgame perfect equilibrium for analyzing dynamic strategic interaction by getting rid of unlikely equilibria.

History of Game Theory

Lloyd S. Shapley

- Around the same time, Lloyd Shapley used cooperative game theory to study different matching methods. He defined the value of coalitional games and coinvented the notion of "core" with D.B. Gillies.

History of Game Theory

Photo: U. Montan
Alvin E. Roth
Prize share: 1/2

Photo: U. Montan
Lloyd S. Shapley
Prize share: 1/2

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2012 was awarded jointly to Alvin E. Roth and Lloyd S. Shapley *"for the theory of stable allocations and the practice of market design"*

Summary

- Game theory: rationality and strategic interactions
- Classical microeconomics theory VS game theory
- Cooperative game theory VS non-cooperative game theory

References

- [1] Bauso D. Game theory with engineering applications[M]. Society for Industrial and Applied Mathematics, 2016.
- [2] John C. Harsanyi – Nobel Prize Lecture: Games with Incomplete Information
- [3] Nobel Prize Seminar: The Work of John Nash in Game Theory.

First-Price Sealed-Bid Auctions

- b = (b_1, …, b_n)

$$p_i(b) := \begin{cases} v_i - b_i & \text{if } i = \operatorname{argsmax} b \\ 0 & \text{otherwise} \end{cases}$$

- Theorem
- b is a Nash equilibrium iff for $i = argmax_i b$ with
  - $b_i \leq v_i$
  - $max_{j \neq i} v_j \leq b_i$
  - $b_i = max_{j \neq i} b_j$

End