Game Theory and the Web

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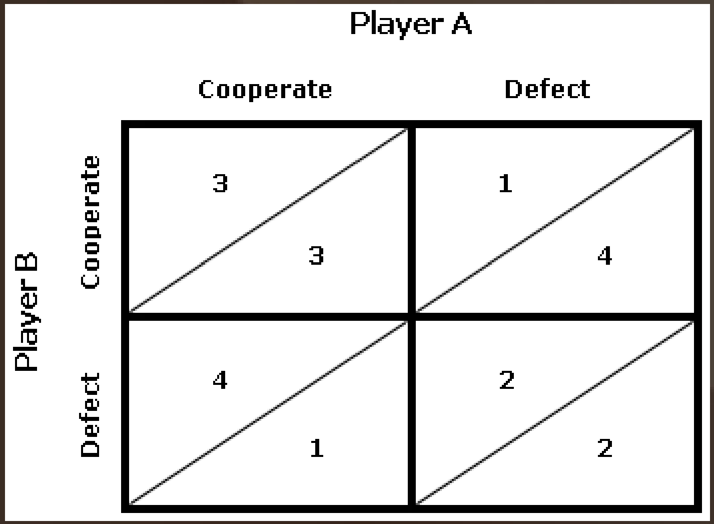
What is game theory?

- Area of applied mathematics that uses models to study interactions and help in decision making
- Commonly used to find balance and best strategies in games
- For example, what's the best strategy here?

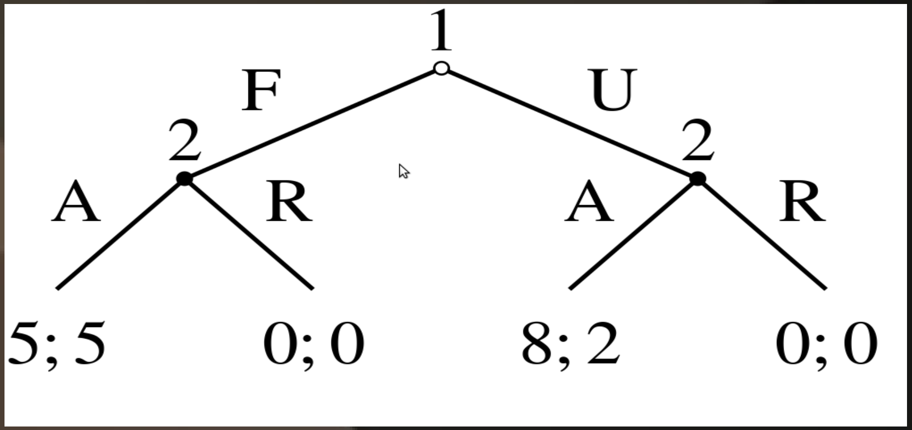


History of game theory

- First known discussion about game theory applied to a game in letter by Waldegrave (1713)
- Game theory started existing as its own field after Von Neumann published a paper (1928)
- In the 1950s many new key ideas and concepts were developed
- In the 1970s extensively applied to biology

Representation of games

- Extensive form
- Normal form
- Characteristic function form
- Partition function form



	Player 2 chooses *Left*	Player 2 chooses *Right*
Player 1 chooses *Up*	**4, 3**	**–1, –1**
Player 1 chooses *Down*	**0, 0**	**3, 4**

Uses

- Economics and business
- Political science
- Biology
- Computer science and logic
- Philosophy

Nash equilibrium

- Published in 1950 by John Forbes Nash
- A group of players in a game are in Nash equilibrium if they are all making the best decision they can make taking into account the decisions of the other players
- What's the Nash equilibrium here?

	Player B plays H	Player B plays T
Player A plays H	-1, +1	+1, -1
Player A plays T	+1, -1	-1, +1

Properties of games

- **Number of players:** each person in the game that either makes decisions or receives a payoff from the result of the decisions
- **Strategies per player**: a player can carry out different actions. In some games some players might have a different number of strategies than others.
- **Number of pure Nash equilibria**: in games where players play a pure strategy, a game can have any number of Nash equilibria

Properties of games

- **Sequential game**: a game is sequential if players perform their actions after the other players. If it's at the same time, it's a simultaneous move game.
- **Perfect information**: it has perfect information if it's sequential and players know the actions of players preceding them
- **Constant sum**: In this type of games a player gains if and only if another player loses

Game theory and the web

- Millions of people interact on the web
- They cooperate and compete
- Businesses thrive in this environment
- Game theory can help analyze and understand this system

Prisoner's dilemma

- “Two members of a criminal gang are arrested and imprisoned. Each prisoner is in solitary confinement with no means of speaking to or exchanging messages with the other. The police admit they don't have enough evidence to convict the pair on the principal charge. They plan to sentence both to a year in prison on a lesser charge. Simultaneously, the police offer each prisoner a Faustian bargain. If he testifies against his partner, he will go free while the partner will get three years in prison on the main charge. Oh, yes, there is a catch ... If both prisoners testify against each other, both will be sentenced to two years in jail.”
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	Prisoner B silent	Prisoner B betrays
Prisoner A silent	1 year each	A: 3 years B: none
Prisoner A betrays	A: none B: 3 years	2 years each

Prisoner's dilemma

- Players: 2
- Strategies per player: 2
- Number of pure strategy Nash equilibria: 1
- Sequential: No
- Perfect information: No
- Zero sum: No
- Applied to the web: Trusting each other on the internet

Chicken game

- “The game of chicken models two drivers, both headed for a single lane bridge from opposite directions. The first to swerve away yields the bridge to the other. If neither player swerves, the result is a costly deadlock in the middle of the bridge, or a potentially fatal head-on collision. It is presumed that the best thing for each driver is to stay straight while the other swerves (since the other is the "chicken" while a crash is avoided). Additionally, a crash is presumed to be the worst outcome for both players. This yields a situation where each player, in attempting to secure his best outcome, risks the worst.”
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	Swerve	**Straight**
Swerve	0, 0	-1, +1
Straight	+1, -1	-10, -10

Chicken game

- Players: 2
- Strategies per player: 2
- Number of pure strategy Nash equilibria: 2
- Sequential: No
- Perfect information: No
- Zero sum: No
- Applied to the web: two competing bloggers writing about the most recent news

	Blogger B writes about it	Blogger B doesn't
Blogger A writes about it	50%, 50%	100%, 75%
Blogger A doesn't	75%, 100%	87.5%, 87.5%

Centipede game

- “Consider two players: Alice and Bob. Alice moves first. At the start of the game, Alice has two piles of coins in front of her: one pile contains 4 coins and the other pile contains 1 coin. Each player has two moves available: either "take" the larger pile of coins and give the smaller pile to the other player or "push" both piles across the table to the other player. Each time the piles of coins pass across the table, the quantity of coins in each pile doubles. For example, assume that Alice chooses to "push" the piles on her first move, handing the piles of 1 and 4 coins over to Bob, doubling them to 2 and 8. Bob could now use his first move to either "take" the pile of 8 coins and give 2 coins to Alice, or he can "push" the two piles back across the table again to Alice, again increasing the size of the piles to 4 and 16 coins. The game continues for a fixed number of rounds or until a player decides to end the game by pocketing a pile of coins.”

Centipede game

- Players: 2
- Strategies per player: variable
- Number of pure strategy Nash equilibria: 1
- Sequential: Yes
- Perfect information: Yes
- Zero sum: No
- Applied to the web: same bloggers cooperating on an article about the same topic

Dollar auction

- "A dollar is auctioned. All bidders must pay the maximum amount they bid. The game begins with one of the players bidding 5 cents (the minimum), hoping to make a 95 cent profit. He can be outbid by another player bidding 10 cents, as a 90 cent profit is still desirable. Similarly, another bidder may bid 15 cents, making an 85 cent profit. Meanwhile, the first bidder may attempt to convert his loss of 5 cents into a gain of 80 cents by bidding 20 cents, and so on. Every player has a choice of either paying for nothing or bidding five cents more on the dollar. Any bid beyond the value of a dollar, is a loss for all bidders alike. Only the auctioneer gets to profit in the end."

Dollar auction

- Players: 2
- Strategies per player: 2
- Number of pure strategy Nash equilibria: 0
- Sequential: Yes
- Perfect information: Yes
- Zero sum: No
- Applied to the web: flame wars

Virality

- Ideas that spread quickly are viral
- May not entirely depend on exposure
- Tested in a scenario with people connected in a network, some nodes were not completely aware of everything going on with their neighbors
- Nodes with local connections spread innovations more quickly
- May not apply as much to individual pieces of content

Conclusions

- Game theory is a relatively new field of mathematics
- Extremely useful to study interactions between humans
- Can be applied to the web
- Further research is necessary to uncover more models that can be applied to the web

References

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