

# Day 14: Game Theory

<https://s3-us-west-2.amazonaws.com/secure.notion-static.com/fbe01edf-09cd-426c-bdec-8c3c74208dc1/15-canonical.pdf>

## Game Playing ProTips

- Complete Unrolling
  - Some games can be turned into a complete truth table, which makes playing just a lookup
- Caching: memoization makes things faster
  - If you can store representations as integers, comparison becomes much faster
    - Ex (tic tac toe): treat the board as a base 3 number, where each number is one position of the board. (ie. If 0 = empty, 1 = other player, 2 = us,  $B$  = board,  $R$  = representation:  $R_B = \sum (3^i) B_i$ )
- Canonicalizing: If you can canonicalize a board (ex. rotate, mirror, etc.) you can store/explore way fewer states.
  - One way: generate all permutations/representations of the state, convert to integer representation, pick the lowest one

## Game Theory

- Not often used in AI, more in econ
  - Why? Story about an old guy who didn't like it
- Why is it valuable? Mathematical model of decision making
- What is a two player game, in normal form?
  - Each player has a choice to make, and makes it simultaneously

- They each get some reward (or punishment) based on the combination of their choices
- In a zero-sum game, the sum of payoffs of all players is zero for all possible outcomes (if I win you lose)
  - Implies that collaboration is infeasible
- Pure Strategy: player always chooses the same option
  - Deterministic
- Mixed Strategy: player has a probability distribution
  - Weighted distribution of pure strategies, with one chosen randomly each time
- Expected value: sum of probability ( $p$ ) \* reward ( $r$ ) for each possible outcome:  

$$E = \sum p_i r_i$$
- Nash Equilibrium: for all zero-sum games of  $n$  players, there exists an equilibrium of mixed strategies that is a local maximum of payoff for each player.
  - Doesn't mean that the equilibrium is an absolute maximum.
  - Very famous, he won the Nobel Prize for this
- Lots of game theory literature, out of scope for this course
- Very famous game: The Prisoner's Dilemma

Prisoner's Dilemma	Cooperate	Defect
Cooperate	3, 3	0, 5
Defect	5, 0	1, 1

- Robert Axelrod popularized it for AI by running a tournament with lots of possible algorithms
  - See Axelrod reading