



Introduction to Strategy & Game Theory

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Basic Concepts

► Definition of a "Game"

- Games, in the mathematical sense, are defined as strategic situations in which there are multiple participants.
- The outcome of the decision any individual makes is dependent on the decision *that* individual's decision **and** the decisions made by all of the other participants.

► Is Sudoku a "game?"

- No, not the way we defined "game." Sudoku is not a "game" because what you do when solving the game is independent of what anyone else does.

► Is Chess a "game?"

► Is the card game War a "game?"

► Are auctions "games"?

► What about selling products in a free market?



Basic Concepts

- ♦ What do you need to know about a game?
 - ♦ Players (*e.g., Teams, Companies, Negotiators etc*)
 - ♦ Rules (*e.g., simultaneously choose prices or take turns*)
 - ♦ Strategies (*e.g., a price between 10 and 30*)
 - ♦ Payoffs (*e.g., revenue minus production costs*)
- ♦ What can I do with it?
 - ♦ Determine how good each of my strategies is
 - ♦ Figure out what my rival is probably going to do

Blah

Blah

Blah

Basic Game – What number?

- ▶ I'm thinking of a number between 1-100
- ▶ You have 5 guesses.
- ▶ After each guess I'll tell you if you are too high or too low
- ▶ Payout –
 - ▶ 1st guess: \$20
 - ▶ 2nd guess: \$15
 - ▶ 3rd guess: \$10
 - ▶ 4th guess: \$5
 - ▶ 5th guess: \$1



Basic Game – What number?

**What does this
have to do with
robots?**

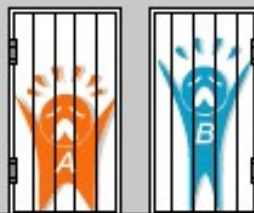
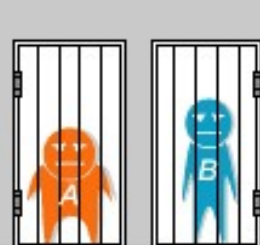
- ▶ Think from your opponent's perspective!

Prisoner's Dilemma, Introduction

- ▶ You and your accomplice get caught committing a crime. The police interrogate you separately. Before you're carted off, you promise not to snitch on each other.
- ▶ **Over the course of the "interrogations" by police the following things can happen:**
 - ▶ If you both remain silent then you **each get 1 years** in jail.
 - ▶ If you confess **you get 0 years in jail**, but **your friend gets 20**, and vice versa for you.
 - ▶ If you both confess you each get 5 years in jail
- ▶ Play how you want to, and see what happens:



Prisoner's Dilemma, Chart

Prisoners' dilemma		prisoner B			
		confess 		remain silent 	
prisoner A	confess 	 5 years 5 years	 0 year 20 years		
	remain silent 	 20 years 0 year	 1 year 1 year		

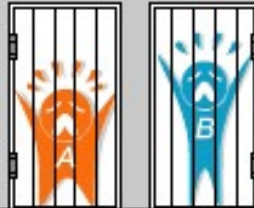
Prisoner's Dilemma, Answer



- ▶ Traditionally the Prisoner's Dilemma game has a dominant strategy of betrayal.
- ▶ Given that you have two choices, defect or cooperate, you're really choosing to:
 - ▶ Defect, and get the best or third best result (0 years, or 5 years of prison)
 - ▶ Cooperate, and get the second best or worst result (1 year in prison, or 20 years in prison)
- ▶ Since betrayal rewards far better than cooperation (and avoids a massively worse result) all purely self-interested people will betray each other.

Prisoner's Dilemma, Chart

Prisoners' dilemma

		prisoner B			
		confess		remain silent	
prisoner A	confess	 5 years 5 years	 0 year 20 years		
	remain silent	 20 years 0 year	 1 year 1 year		

Dominant and dominated strategies

- ♦ **Dominant strategy:** payoff is greater than any other strategy regardless of rival's choice.
 - ♦ Rule 1: if there is one, choose it and that's the end of it.
 - ♦ **Dominated strategy:** payoff is lower than some other strategy regardless of rival's choice.
 - ♦ Rule 2: do not choose dominated strategies.
- Check whether there are dominant and/or dominated strategies in the example above. What can we say based on this?

Prisoner's Dilemma

**What does this
have to do with
robots?**

- ▶ In any game, there can be better or worse strategies depending on other's decisions. Understand the rules and look for dominant strategies

Dominant Strategy now a bit more complicated....

		Player B		
		L	C	R
Player A	T	9 5	8 6	1 7
	M	1 3	2 5	0 6
	B	2 7	3 6	3 8

You are player B.

You want the highest number possible

What should you pick? L, C, R?

Dominant Strategy now a bit more complicated....

		Player B		
		L	C	R
Player A	T	9 5	8 6	1 7
	M	1 3	2 5	0 6
	B	2 7	3 6	3 8

R is the dominant strategy

Regardless of player A's choice, R is always best

What is player A's choice?

New Example: The power of money

- ▶ Auction a \$20 bill



- ▶ Rules:
- ▶ Min bid \$1 Bids increment by \$1
- ▶ Any number of players but
- ▶ **First and Second** highest bids pay! Third and below do not.
- ▶ Only highest bid wins - \$20 !



New Example: The power of money

Wait – What?

- ▶ What did we learn from that exercise?
- ▶ What is the dominant strategy?
- ▶ Could we have deduced that before the game started?

The Power of Money

What does this have to do with robots?

- ▶ You need to consider every game from all players perspectives and consider everyone's best action.
- ▶ And then plan for the consequences of those actions....

Game Analysis – Juicer

- ▶ Engineering challenge – The juice box challenge
- ▶ The Challenge: Build a machine to transfer the juice from a sealed box to a cup
- ▶ Technologies allowed:
 - ▶ Mechanical systems
 - ▶ Pneumatic systems
 - ▶ Electrical systems, servos
 - ▶ Lasers and microwaves
 - ▶ Other?



Game Analysis – Juicer

- ▶ The Rules:
- ▶ Max cost: for whole machine is \$400
- ▶ Size: must be within 3'x3'x3' cube
- ▶ Electricity and compressed air provided
- ▶ Max weight 300 kg
- ▶ Only human interaction is loading and activation of machine (one finger pressing)



Juicebox Game Analysis

- ▶ Scoring

▶ Points for	Points Calculated
▶ Cost:	\$400 – actual cost
▶ Time to transfer:	200 / time in seconds (max 200)
▶ Amount of fluid transferred:	% Fluid * 2
▶ Values for all averaged after 3 runs	
▶ Aesthetics / “Cool Factor”	0-50 points awarded by judges

Juicebox Game Analysis

- ▶ **Brainstorm**
- ▶ What is important about this game?
- ▶ What should be critical in the strategy to approach?
- ▶ What kinds of technologies should we consider?
- ▶ What is not a limitation according the rules?



Juicebox Game Analysis

- ▶ Brainstorm
- ▶ What is important about this game?
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Scoring	Points
Cost	\$400-Actual Cost
Time:	200/Time (sec) Max 200
Fluid Transferred:	% Fluid x2
	Values Averaged 3 runs
Cool Factor	0-50 points from Judges

Juicebox Game Analysis

Some ideas:

- ▶ Pneumatic pump out the fluid
- ▶ Motorized saw to cut the box
- ▶ Others?



Juicebox Game Analysis

► The Answer

- A Robot?
- A Shark?
- A Robot shark?
- No, a machine like this –The JuiceRat!



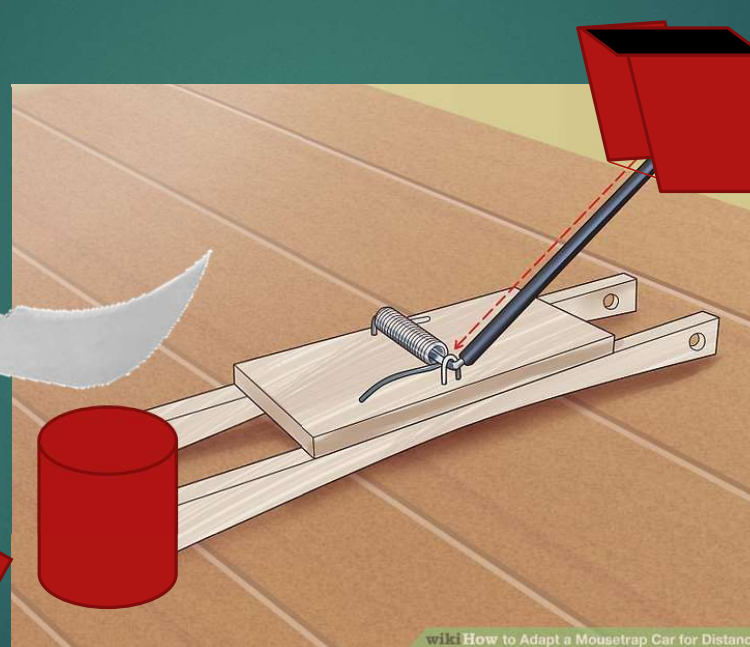
Juicebox Game Analysis

► Solution : **JuiceRat**

Nasty Blade

Cup
(with splashguard –not
shown)

Load Juicebox here



Did we consider the box can move?

Juicebox Game Analysis



Category	Points	JuiceRat	Pneumatic Delivery	Motorized Saw
Cost	\$400-cost	375	50	22
Time	200 / time sec	200	50	175
Juice Delivered	% of juice *2	196	194	89 (1 round didn't work)
Cool Factor	Judge award (0-50)	0	50	48
Total		771	344	334

Juicebox Game Analysis

- ▶ What's the dominant strategy?
- ▶ What's the prioritization?
- ▶ How would that change in a second season?



Game Analysis

**What does this
have to do with
robots?**

- ▶ A solution needs a strategy
- ▶ A strategy needs detailed analysis of the game to understand trade offs

Strategy vs Tactics



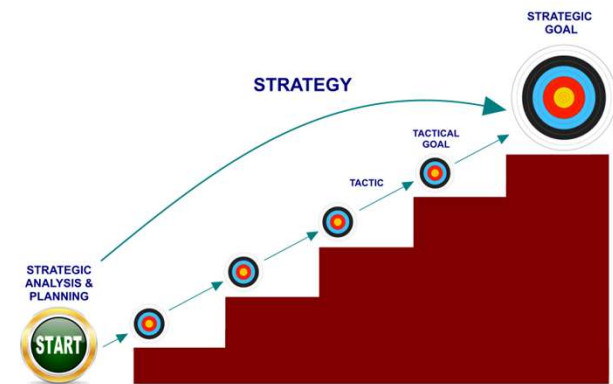
“Strategy without tactics is the slowest route to victory, tactics without strategy is the noise before defeat.”

—Sun Tsu

Strategy vs Tactics

- ▶ The **difference between strategy** and **tactics** is that **strategy** defines "what" is to be done but **tactics** defines the "how"
- ▶ **Example strategy:**
 - ▶ We're going to dominate cost & speed and not worry about Judges
- ▶ **Example tactics:**
 - ▶ We need to use springs and blades and not use electronics/ pneumatics

Simplified definitions of strategy and tactics



Definition of Strategy - An overall method for achieving a strategic goal.

Definition of Tactics - Sub-strategies, maneuvers and techniques used to achieve short-term, tactical goals.

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Strategy vs Tactics

- ▶ **Strategy is more concrete and long-term—but your tactics can change based on how successful your strategy is.**
 - ▶ Some tactics activate when certain circumstances occur
- ▶ **Strategy and tactics work together as means to an end.**
 - ▶ If your strategy is to climb a mountain, one key component of your strategy might be to decide which side of the mountain you should climb.
 - ▶ Your tactics would be the gear you'd buy, who you'd bring with you, your complete trip plan, how long it would take to get there, what season you'd go in, and so on.
- ▶ **Strategy and tactics always have to be in-line with one another.**

If you don't have a strategy, you are part of someone else's strategy."

— Alvin Toffler

Summary

- ▶ **Game Analysis:**

- ▶ Look for dominant strategies
- ▶ Optimize based what maximized benefits

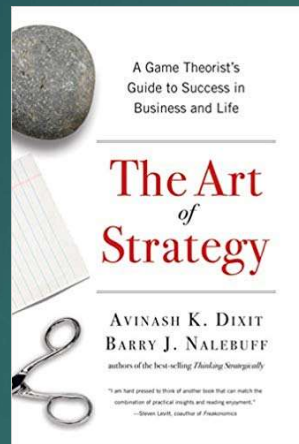
- ▶ **Play Analysis:**

- ▶ Consider your opponents actions before your own

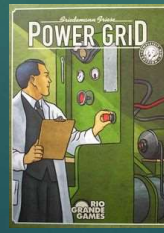
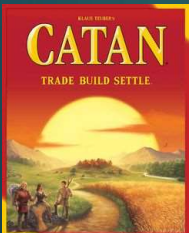
- ▶ **Strategy & Tactics:**

- ▶ Know your strategy and develop your tactics to support them

Further Reading



Further Practice: Play some games!





Thank you!

Questions?