Research Project Proposal:

Learning correlated equilibria in constrained normal form games

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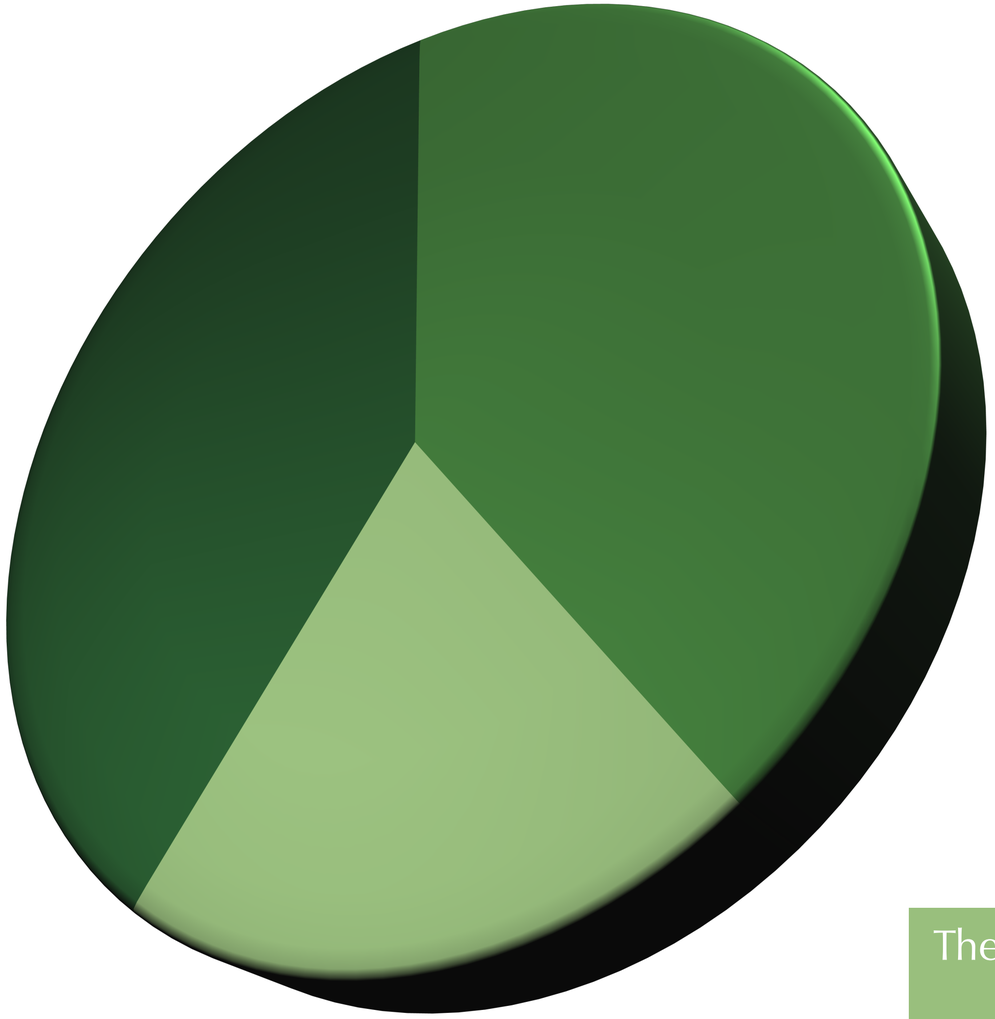
Main research areas

Machine Learning

Game Theory

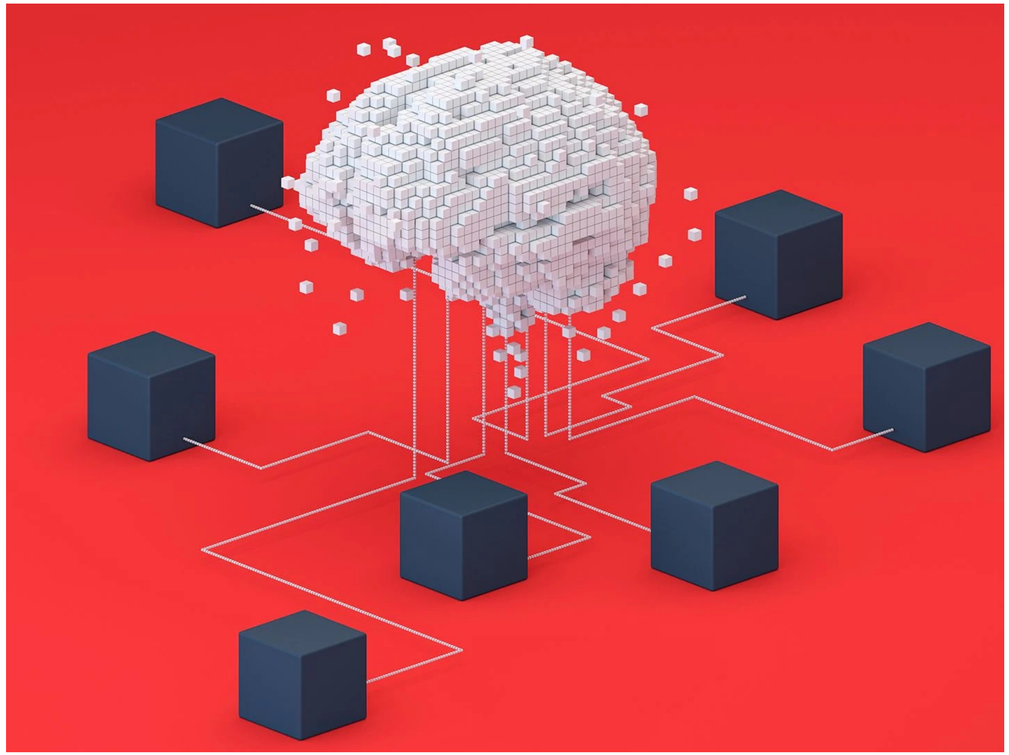


Theoretical Computer Science

Game Theory

- Main research area of the topic
- Problems representation in game form

Machine Learning



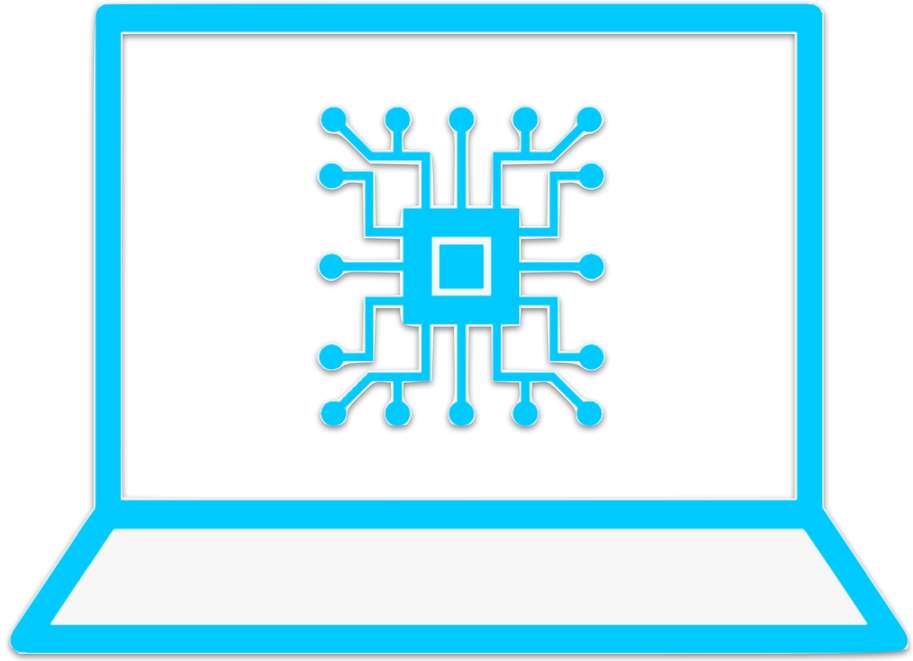
- Application of Machine Learning algorithms in Game Theory contexts

Theoretical Computer Science

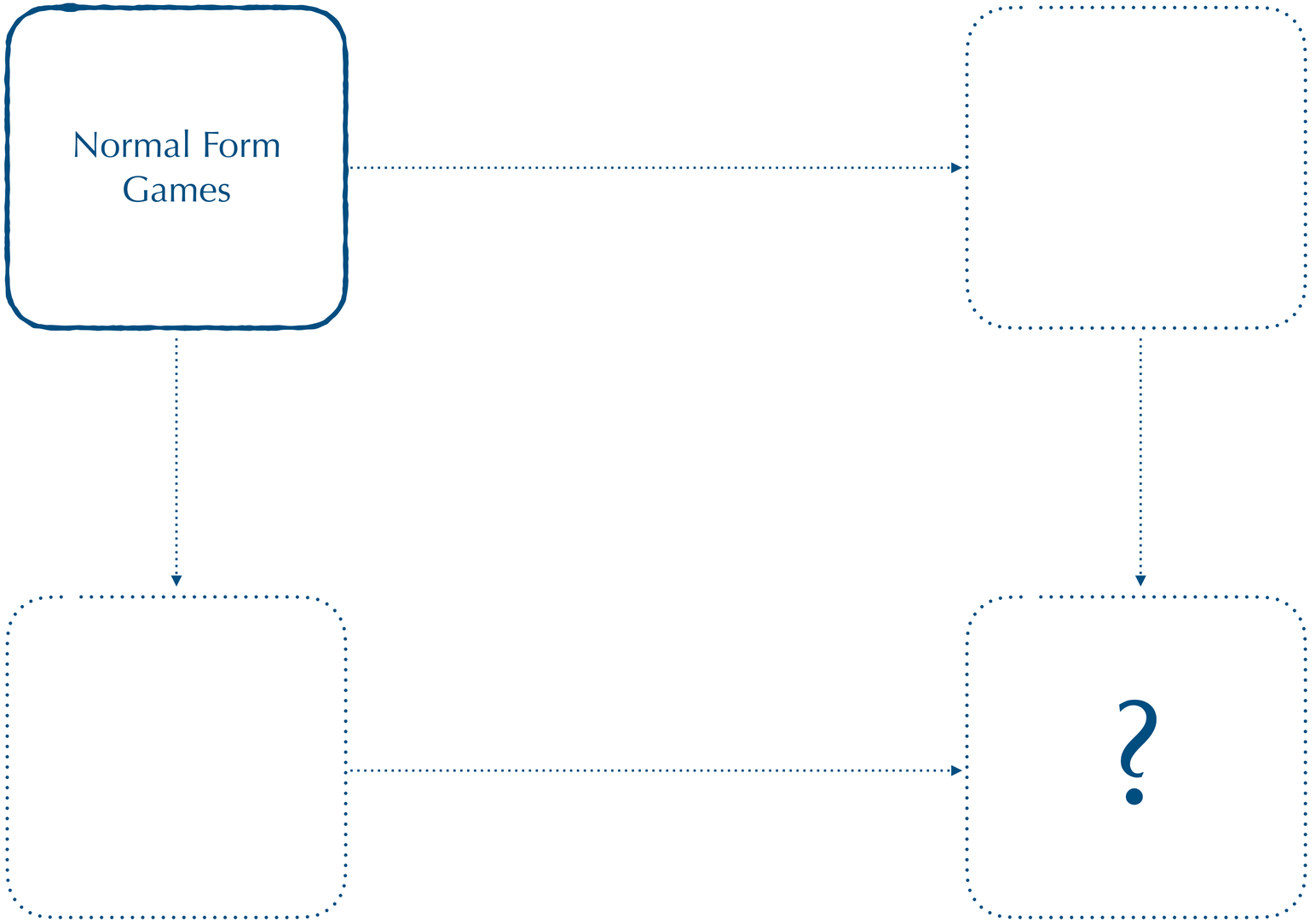
- Understand the difficulty of the problems

  in terms of:

  - Temporal complexity
  - Spatial complexity



The research topic



What is a game?

- N players
- Each player has a set A of actions
- For each possible combination of actions each agent receives a utility

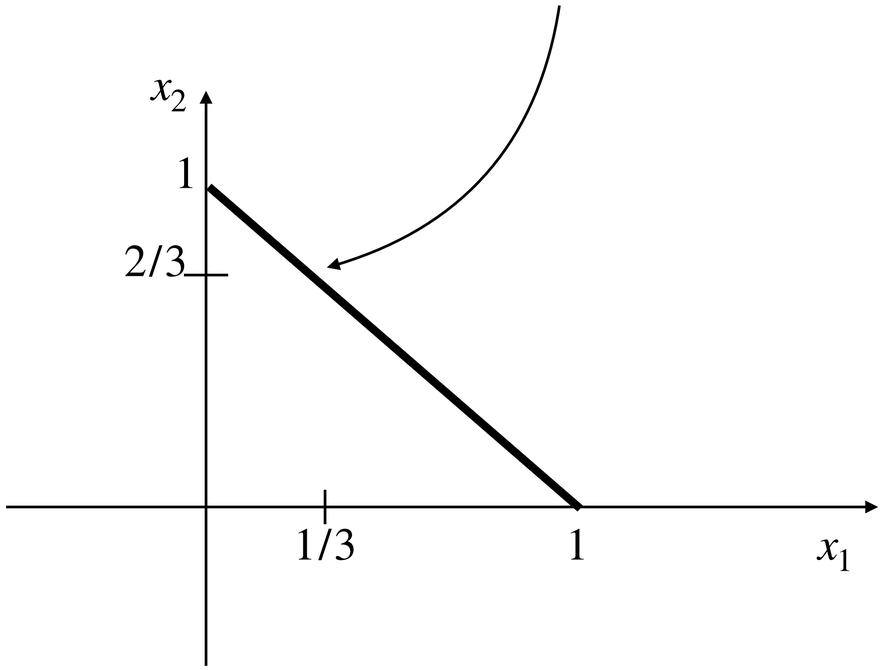
- In this context the most important concepts are:
  - Strategies
  - Equilibria, in particular Nash equilibria

	Rock	Paper	Scissors
Rock	0, 0	-1, 1	1, -1
Paper	1, -1	0, 0	-1, 1
Scissors	-1, 1	1, -1	0, 0

Example of two players zero-sum game

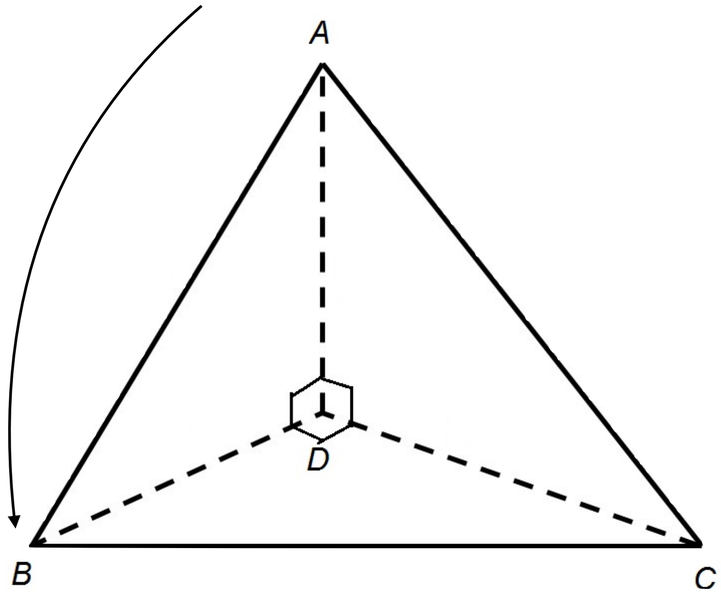
Strategy visualization

	A	B
P1	1/3	2/3



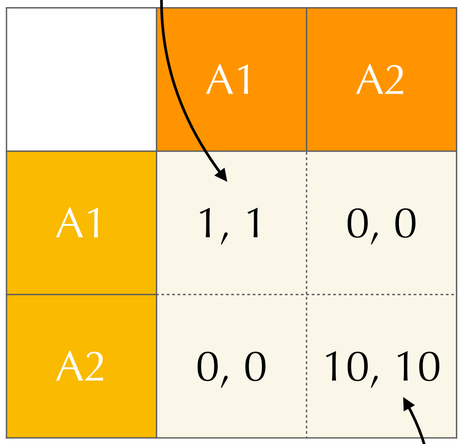
The strategy space in 2D

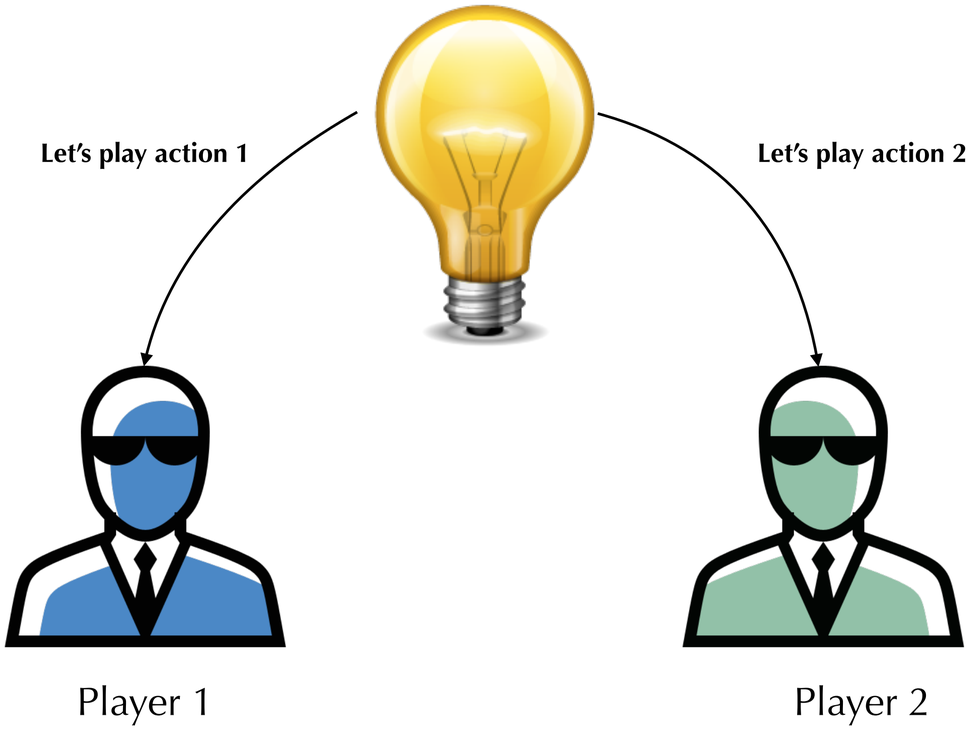
	A	B	C
P1	0	1	0



The strategy space in 3D

Correlated equilibria





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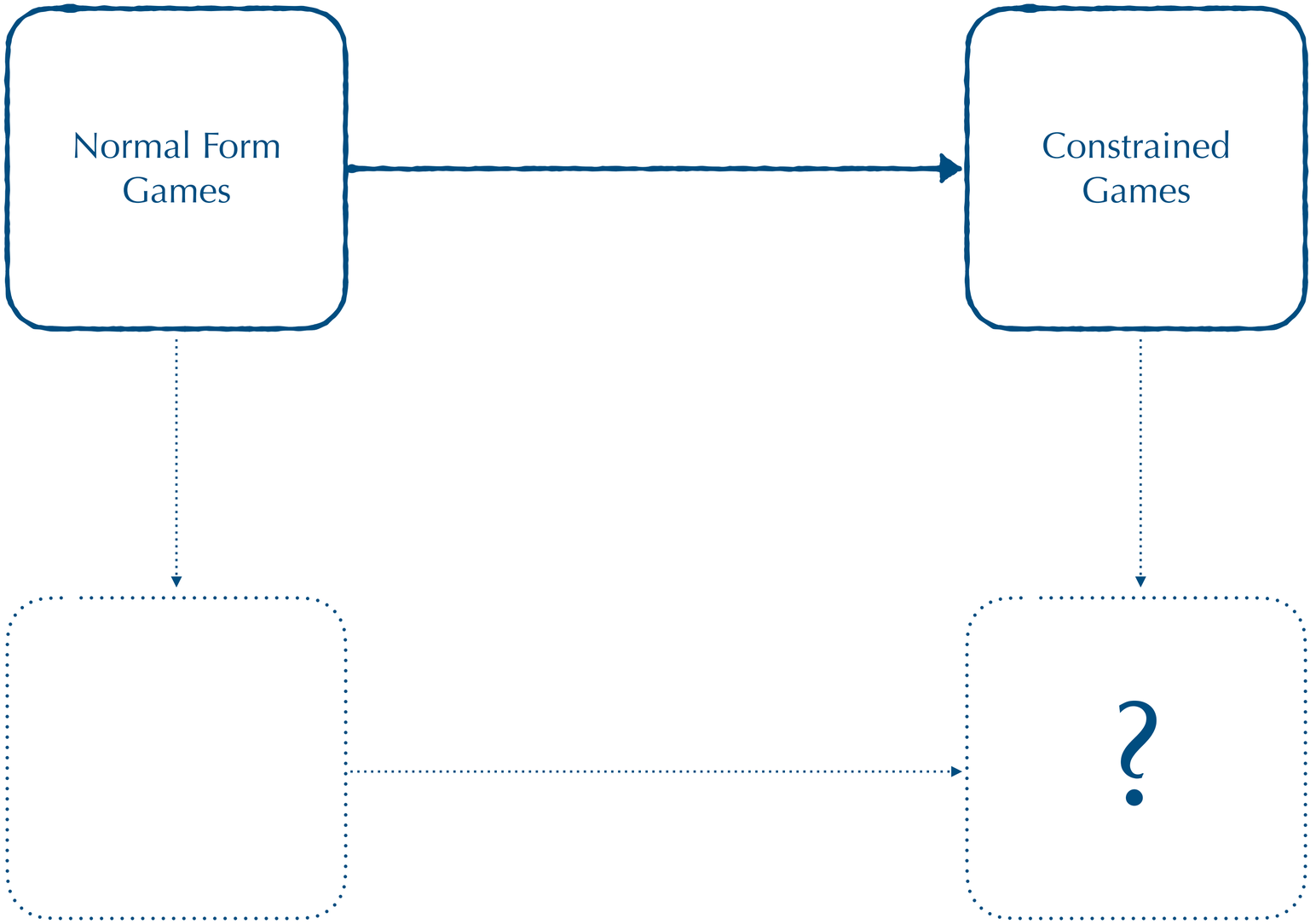
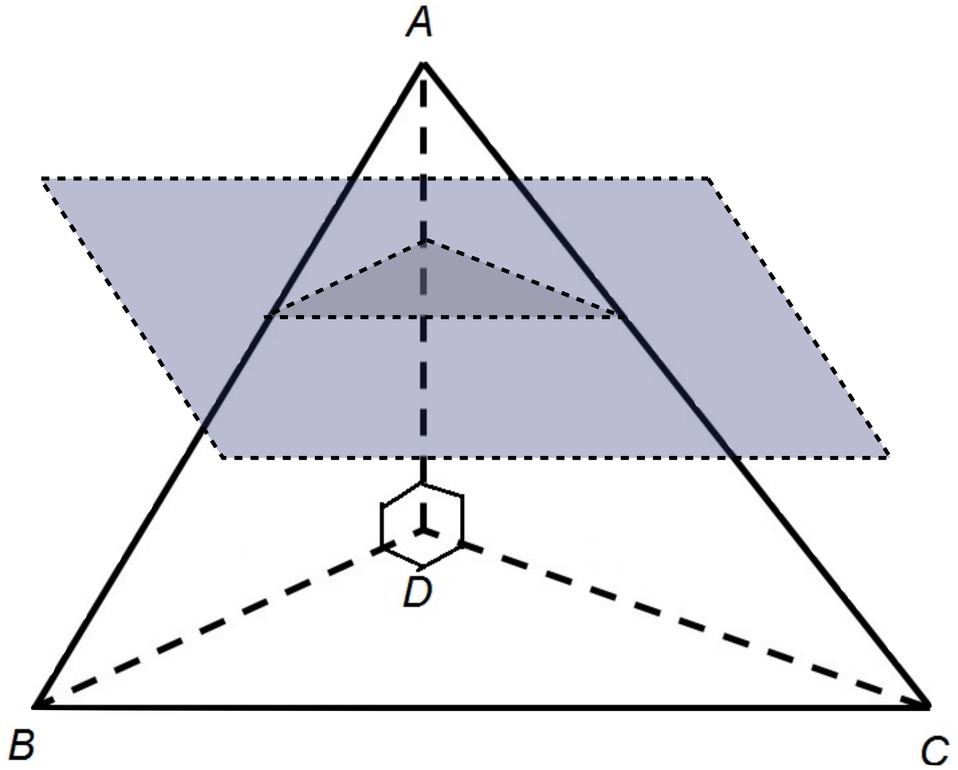


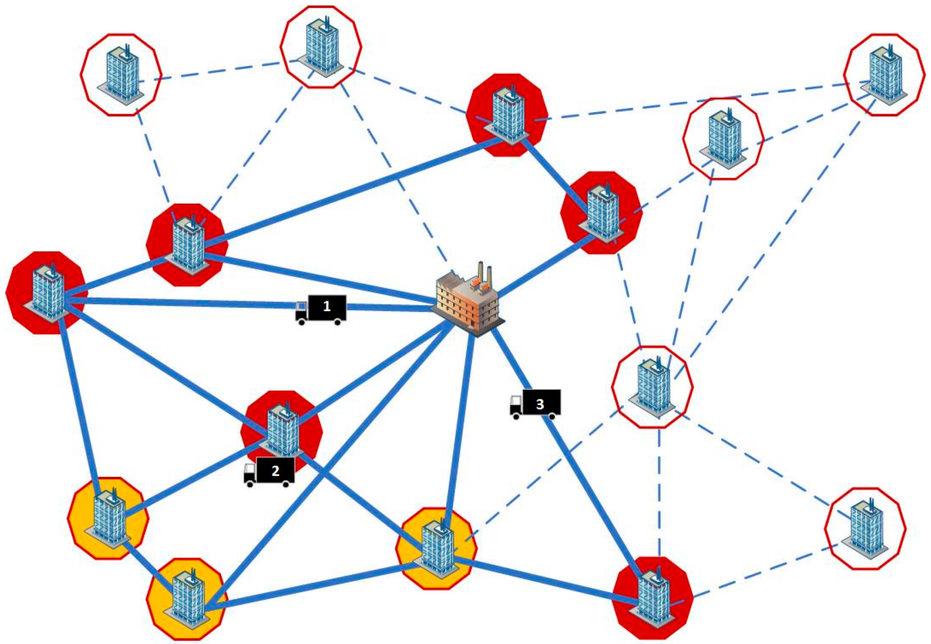
Add constraints to a game



- A game can have constraints of heterogeneous nature
- They are significant in many real life situations
- We need to add a budget vector B, with one element for each constraint

Google Maps example

- Routing problems, both for:
  - Packets in networks
  - Cars or people in streets

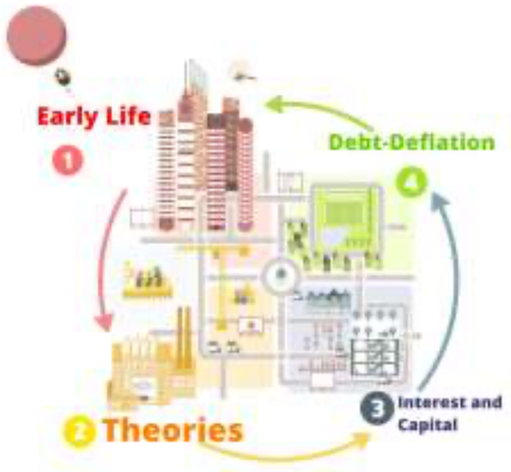


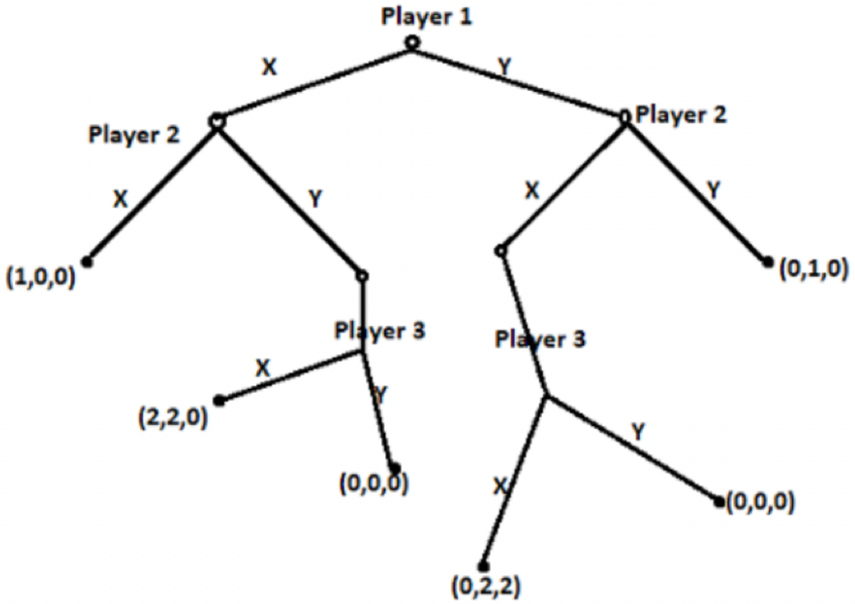
Problem Formalization

1. Players → Cars
2. Actions → Right, Left, Forward, Back
3. Utilities → Time spent
4. Costs → Fuel, smaller number of curves, tolls

State of the art for constrained games

- Algorithms for computing Fisher's Market clearing prices (Orlin, J. B.) [2010]
- Learning in constrained tree-form sequential games (Bernasconi et al.) [2022]





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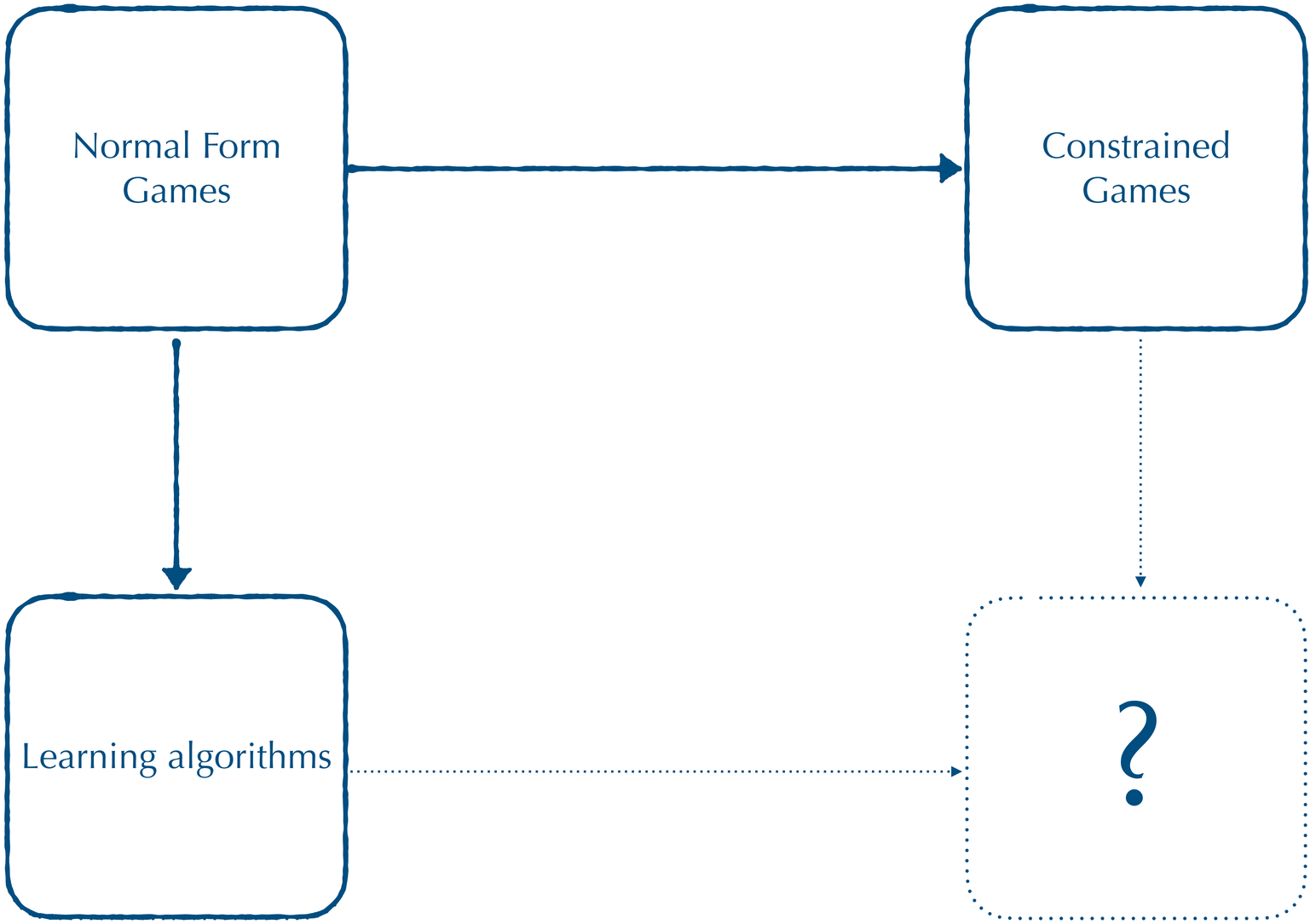
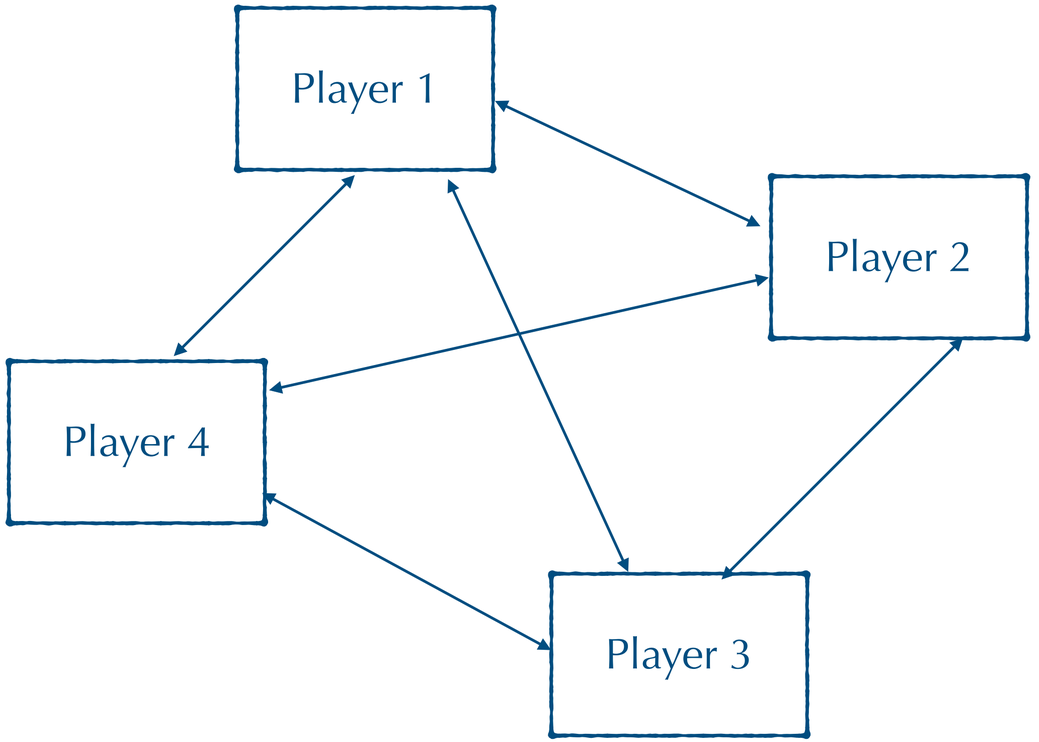


Algorithm evolution in Game Theory

- Traditional approach before the introduction of Machine Learning

- Decentralized approach with Machine Learning algorithms



Algorithm evolution in Game Theory

Machine Learning Algorithms

- Faster in finding approximate equilibria:

  Regret minimization strategy

- Decentralized and, then, more scalable
- Guarantee privacy for each user

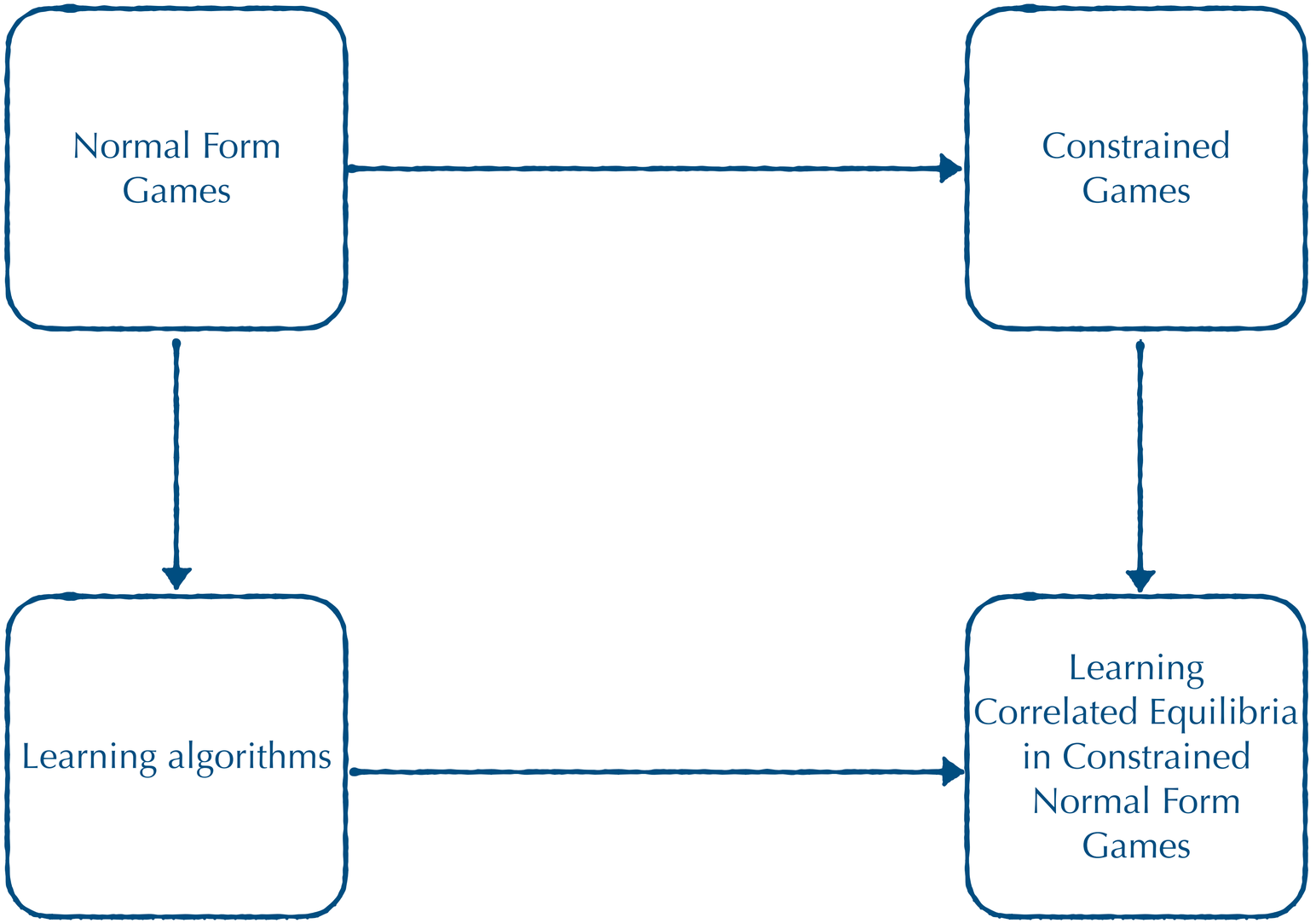
State of the art

- The main inspiration has been the concept of

  No-Φ-Regret algorithms introduced by

  Greenwald, A., Jafari, A., and Marks, C. [2011]

The research topic



Preliminary results

The work until this moment has produced some preliminary results related to the situation in

which each player has only one constraint

Result: In the constrained subspace it is possible to bound the number of vertices to analyze to 2*n

where n is the number of actions

Solutions

Centralized version:

Linear Programming

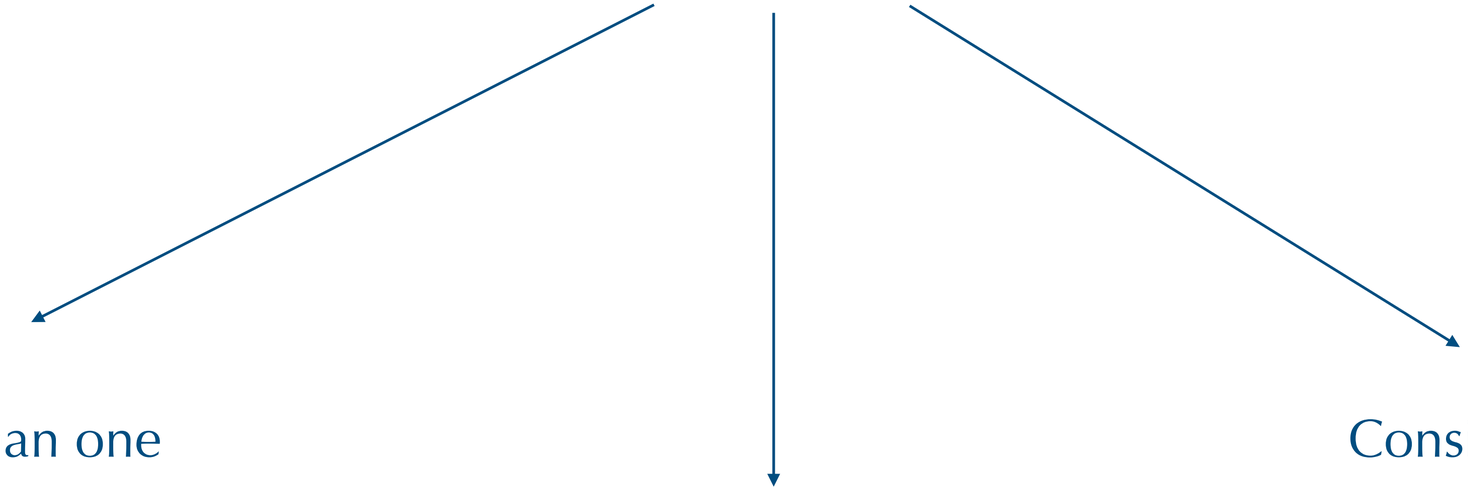
Decentralized version:

Online mirror descent

Next works

The main objective is to find a good algorithm in the described context

Then, some possible future works can include:



Consider more than one constraint for player

Analyze the problem in tree-form

Consider the costs when they depend on the joint strategy

Thanks for the attention!

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