Decision Under Uncertainty

An introduction

Guillaume Lozenguez

@imt-lille-douai.fr

IMT Nord Europe
École Mines-Télécom
IMT-Université de Lille

Last improvement in Artificial Intelligence

- *Nov. 2007*, Carnegie-Mellon win the Darpa Urban Challenge ($2M\$$)

- *Oct. 2015*, Victory of d'**AlphaGo** over professional player

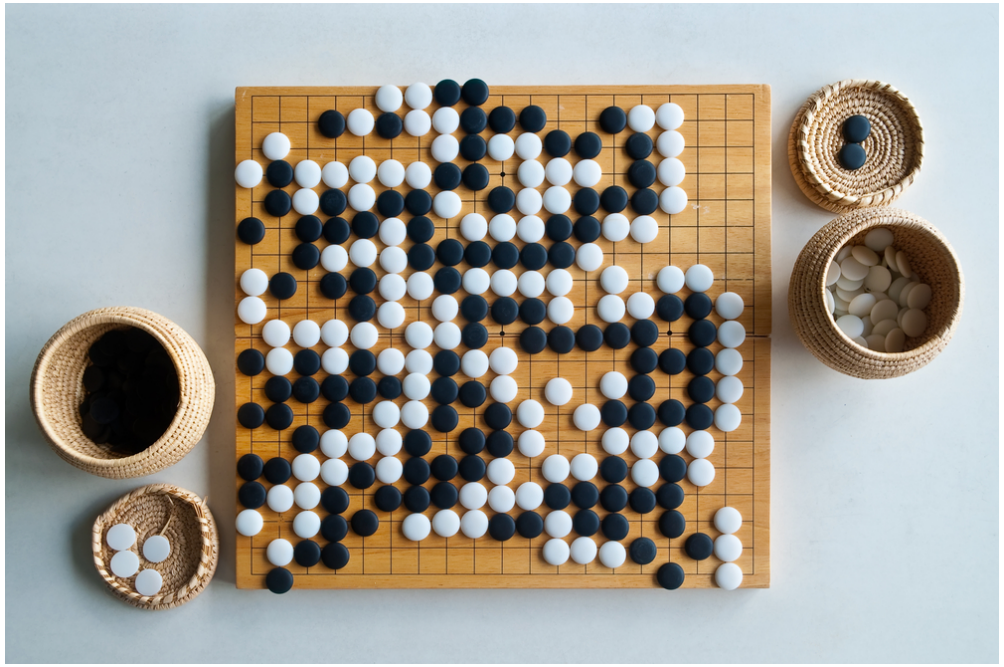
Last improvement in Artificial Intelligence

In France:

- *March 2018*, Rapport Villani - www.aiforhumanity.fr -

The notion of complexity (Go)

GO: 10^{170} positions, 10^{600} games (chess: 10^{120} games)



The notion of complexity (Go)

A classical 3 GHz computer: 3×10^9 op. per second
$\rightarrow$ 2.6×10^{14} op. a day $\rightarrow$ 10^{17} op. a year

Enumerating all games: $O(n)$ with $n = 10^{600}$: arround 10^{583} years.
$\rightarrow$ requires decomposed model and statistics...

Sun life: arround 10^{30} years

Decision Making Problem

How to compute ~~optimal~~ appropriate responces to control dynamical systems ?

Knowing that:

- Model could require very large exploration
- We potentially do not have the model
- Evolution are generally uncertain

Introduction to Decision Under Uncertainty

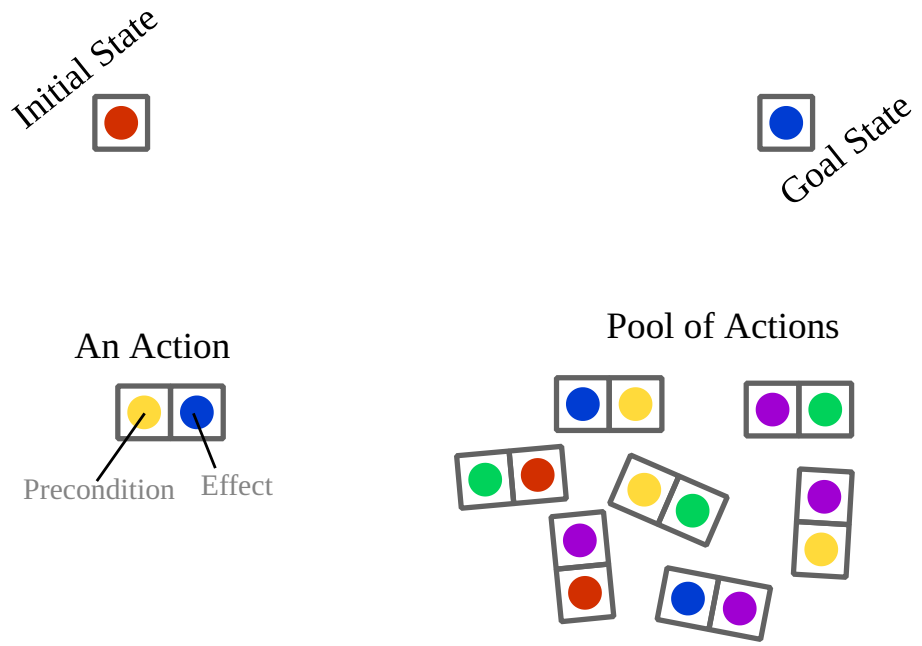
Is an introduction to models and algorithms to perform decision-making at a time step *t*, by considering potential effects.

- 19 hours (5 sessions)
- Mainly as tutorials
- Simple dice games as a playground

1. Introduction
2. Class of problems
3. The notion of Agent
4. Decision Making Process of an agent

Class of problems - Deterministic Planning

Determining *a succession of actions* to drive a system from an initial state to a target state.

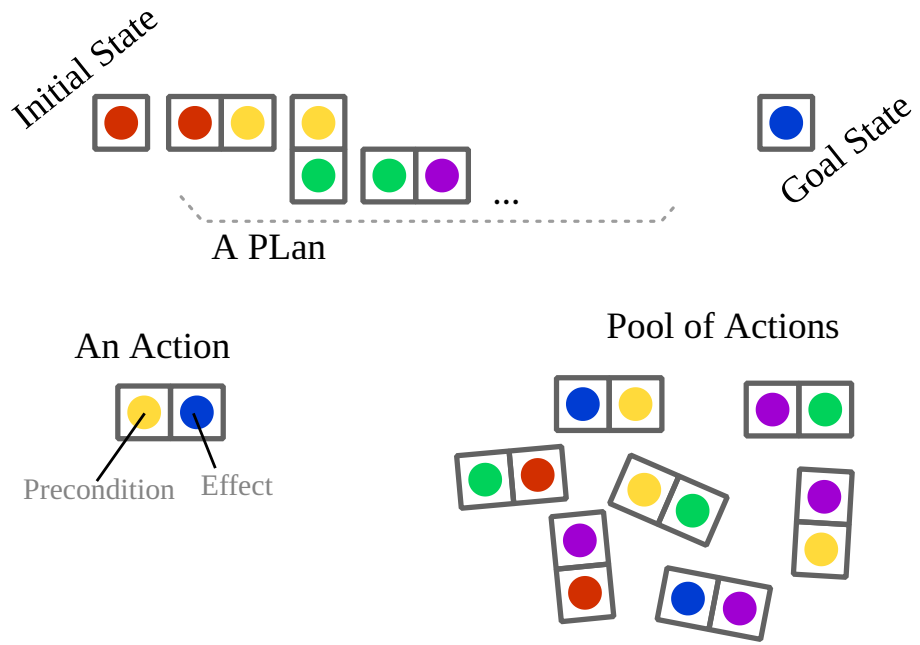


Deterministic case:

- the effects, by doing an action, from a specific state is certain.

Class of problems - Deterministic Planning

Determining *a succession of actions* to drive a system from an initial state to a target state.

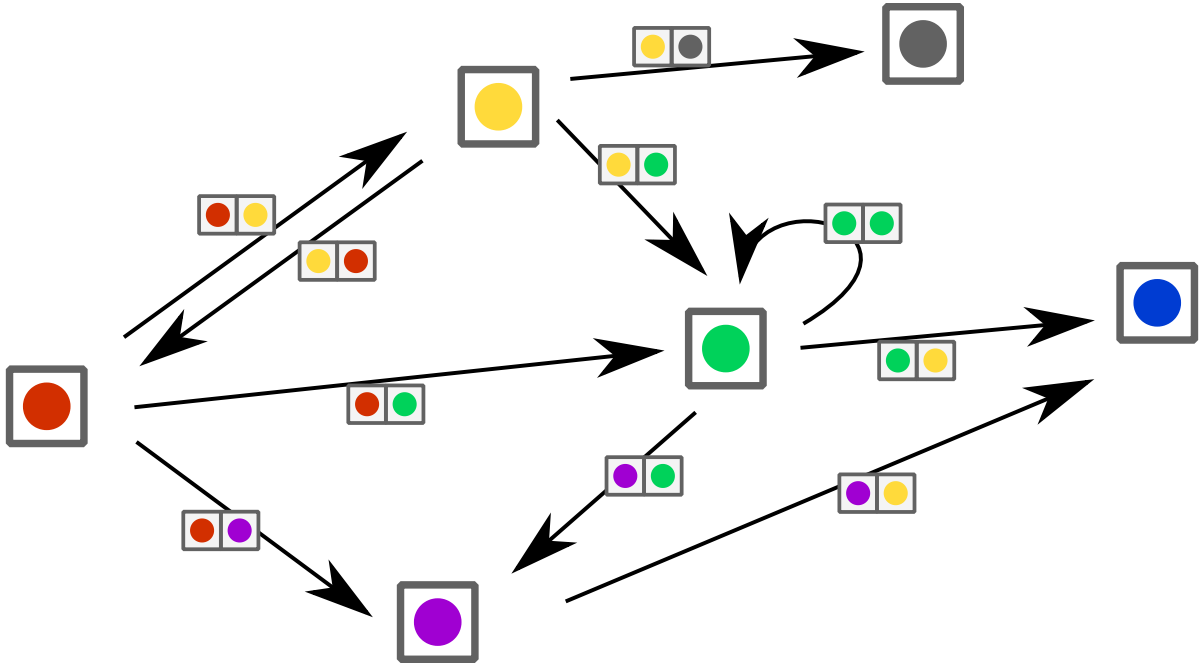


Deterministic case:

- the effects, by doing an action, from a specific state is certain.

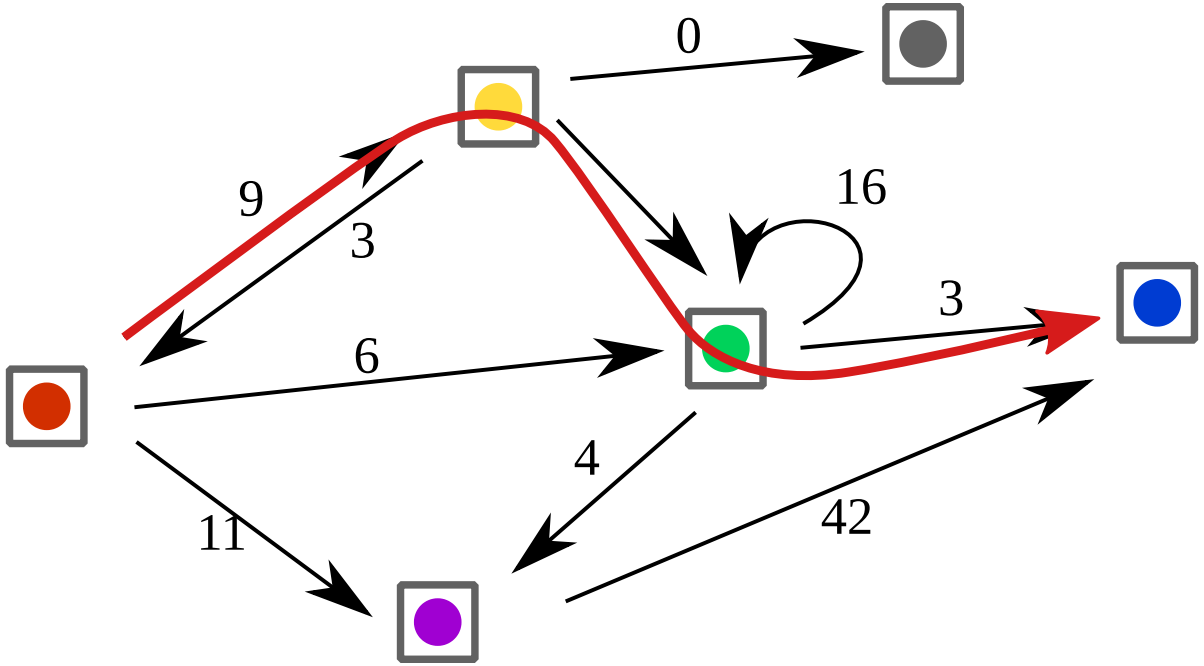
Class of problems - Determine a Plan

Finding a *path* in a *graph* modeling all possible evolutions



Class of problems - Plan Optimization

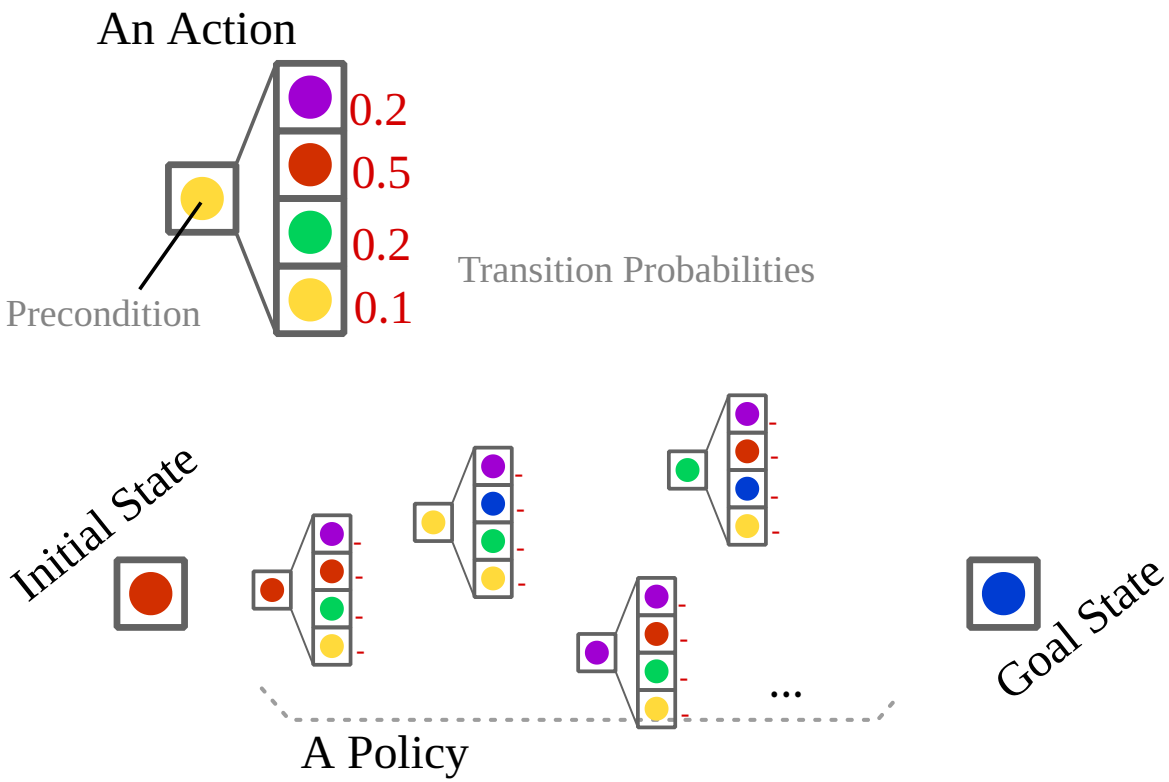
Finding an *optimized* path in a *weighted* Graph



Class of problems - Stokastic Planning

Build a *policy*:

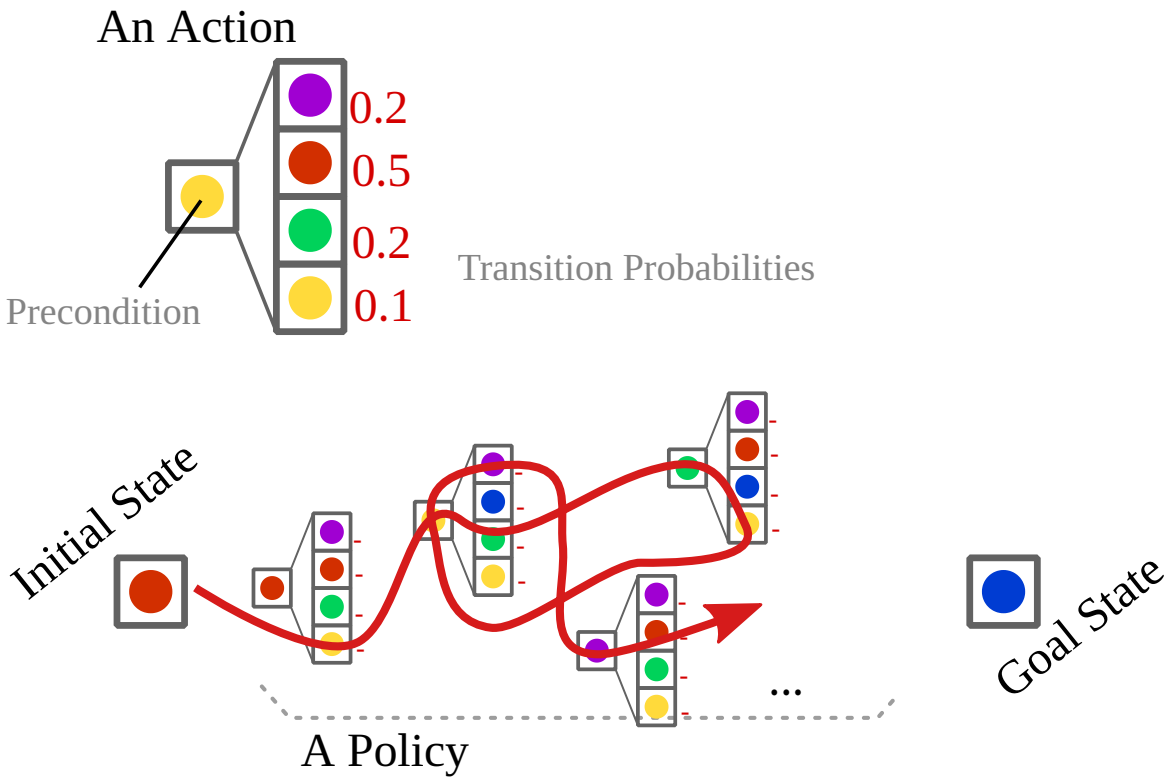
- Associate an *action* to perform *to each* reachable *state*



Class of problems - Stokastic Planning

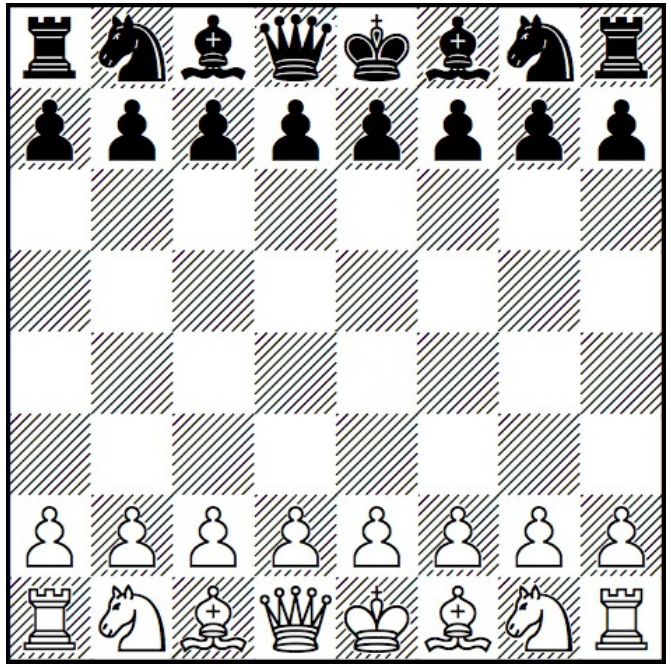
Execute a *policy*:

- Then, the effective succession of actions remains stochastic



Class of problems - Game theory

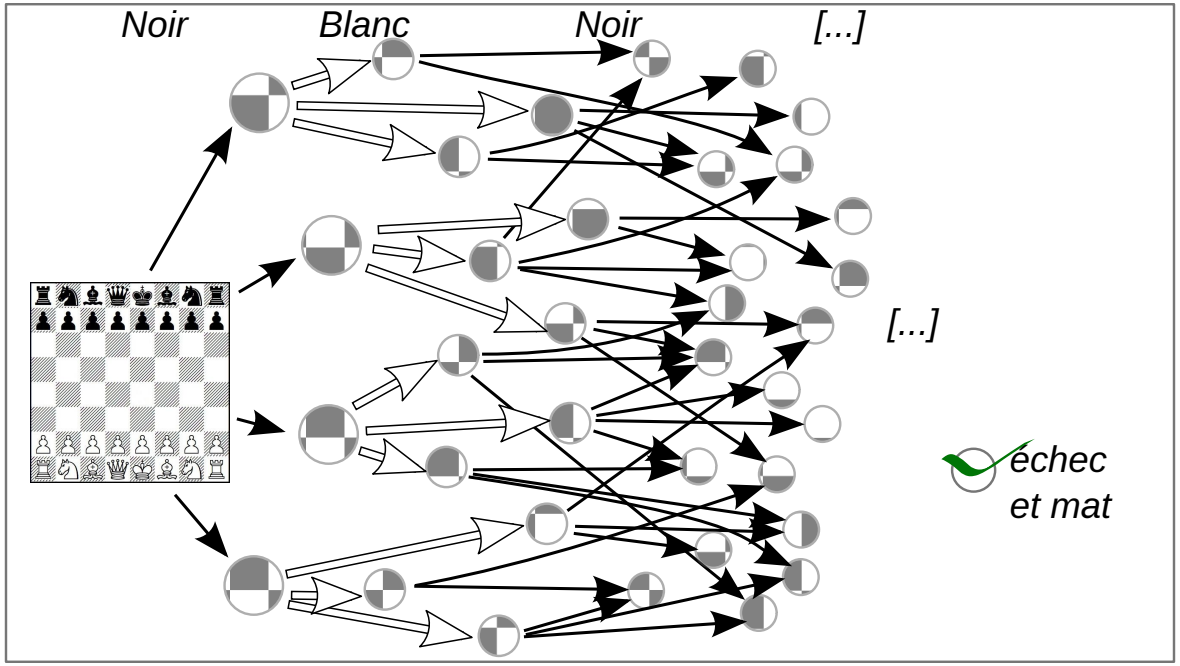
Few entities control the same system (with different goals)



- Which actions for each entity ?
- Which consequences ?

Class of problems - Game theory

Few entities control the same system (with different goals)



- *Uncertainty*: At last on the actions of the other players.

Class of problems - Control Complex systems

Complex systems:

- A lot of entities in interactions

- *Uncertainty*: ...

Vocabulary

- **graph** composed of **node** and **edges**
- **graph** composed of **state** and **action** (State Automata)
- **planning**: finding a valid succession of **actions**
- **determinist** versus **uncertain** / **stochastic**
- **system**, **control** (automation)
- **Multi-Agent System**, **Decision Making** (AI)

Notion of Agent

"I act therefore I am"

- my actions have an effect on the world
- **and** I have the choice to act or not

cf. "BullShit Jobs" - David Graeber (2019)
(p.132-133 fr. in version)

or the joy to be cause - Karl Groos (1901)

Notion of Agent - Simple definition

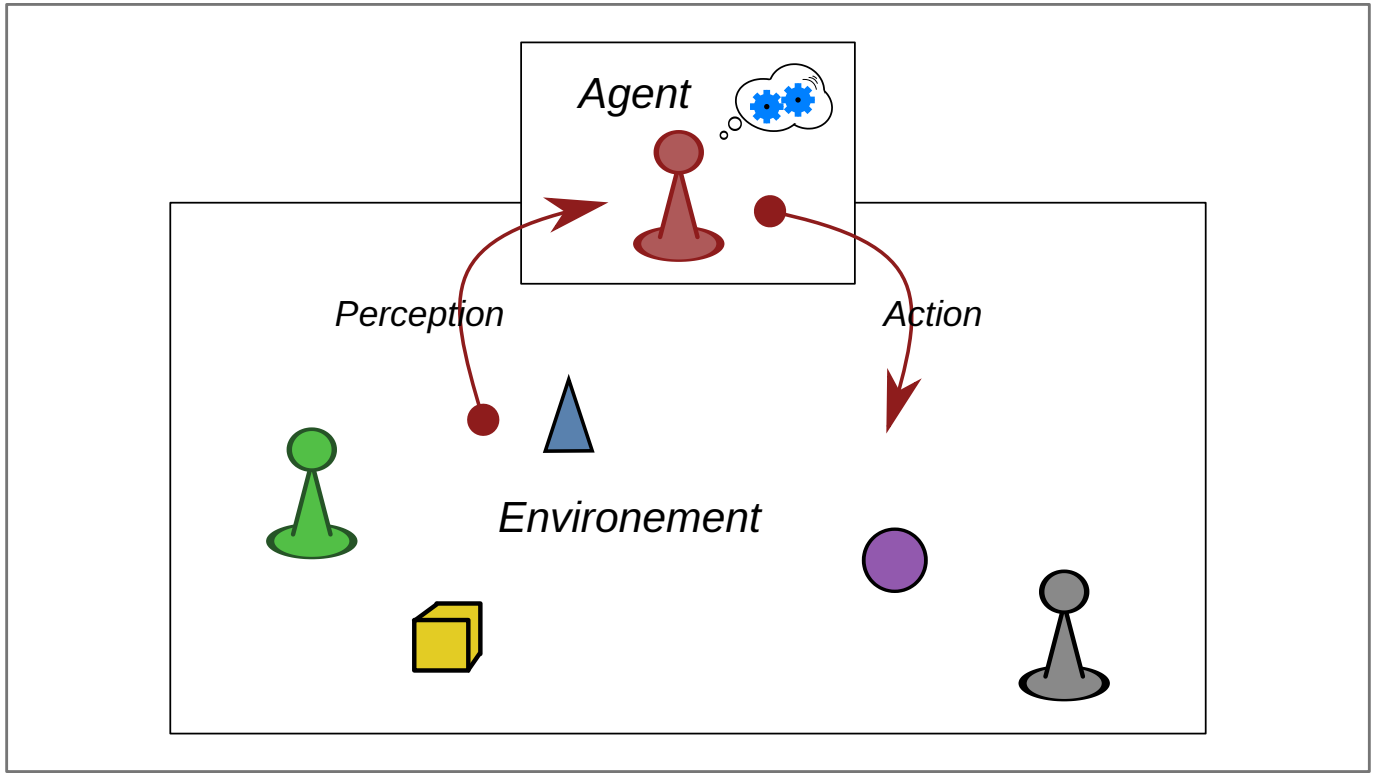
An agent:

An entity capable of perception and action evolving in an environment.

Question:

How to choose appropriate action to perform considering the perception at a each time step ?

Notion of Agent - Simple definition



rarely determinist, mostly uncertain (even stochastic)

Notion of Agent - Complementary Notions

Agent:

- defining by a perception-state, goals and a policy to achieve its goals (*BDI* model: Belief - Desire - Intention)
- with different positions in social structure (*AGR* model: Agent - Group - Role)
- capable of communication
- capable of adaptation (learning)
- driven by emotions
- ...

Course notion to acquire

From *reactive control* **to** *deliberative control*

- Immediate response to stimuli

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Script:
if .... do ...
else if ... do ...
```

versus

- Model and statistical decision-making:

Course notion to acquire

Decision-making under uncertainty

- Script, Policy and Decision Tree
- Reinforcement Learning:
  - Q-Learning (learn the policy)
  - Model-Learning (learn the model, compute the policy)
- Factored Model

Game: 421

- Get the best combination
- by rolling 3 dices

Goal :

- Optimize the 2 re-roll possibility
- by choosing dices to roll again.

Let's go....