

Decision Under Uncertainty

An introduction

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Last improvement in Artificial Intelligence

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



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



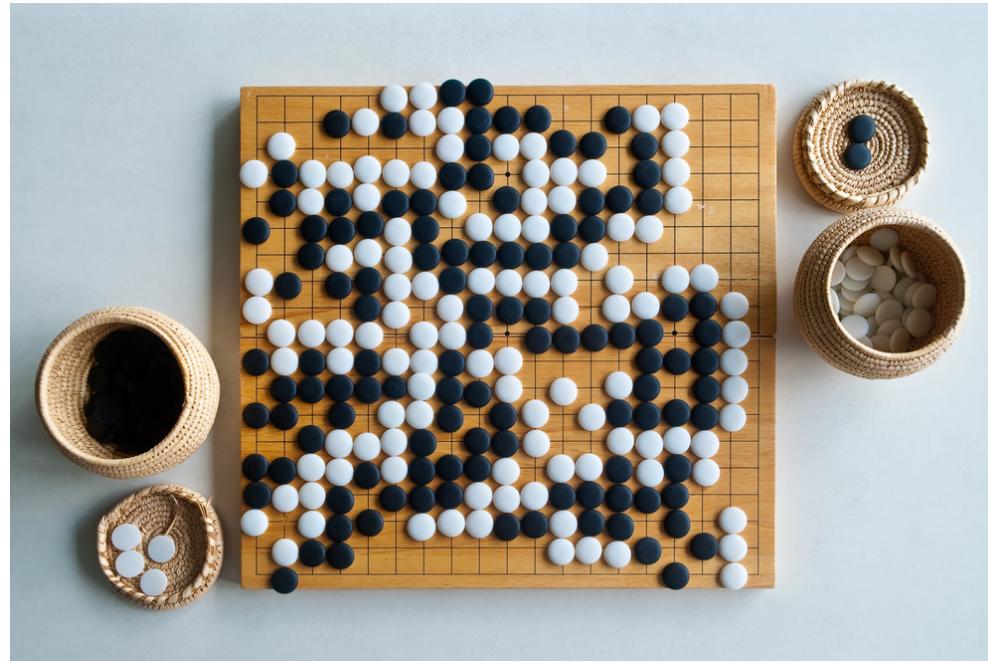
Last improvement in Artificial Intelligence

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
 $\rightarrow 2.6 \times 10^{14}$ 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 responses
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

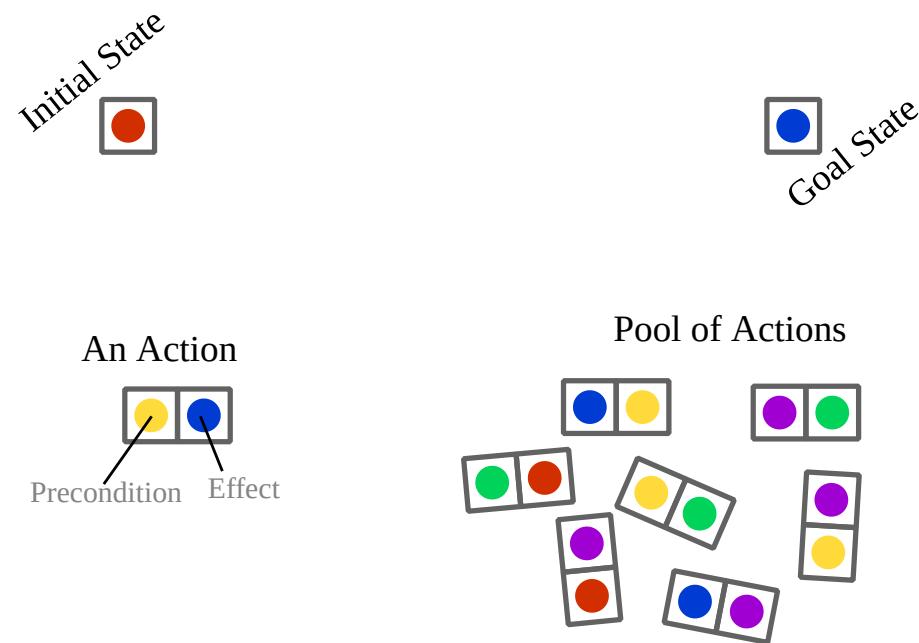
Is an introduction to models and algorithms to perform decision-making at a time step t , by considering potential effects.

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

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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.

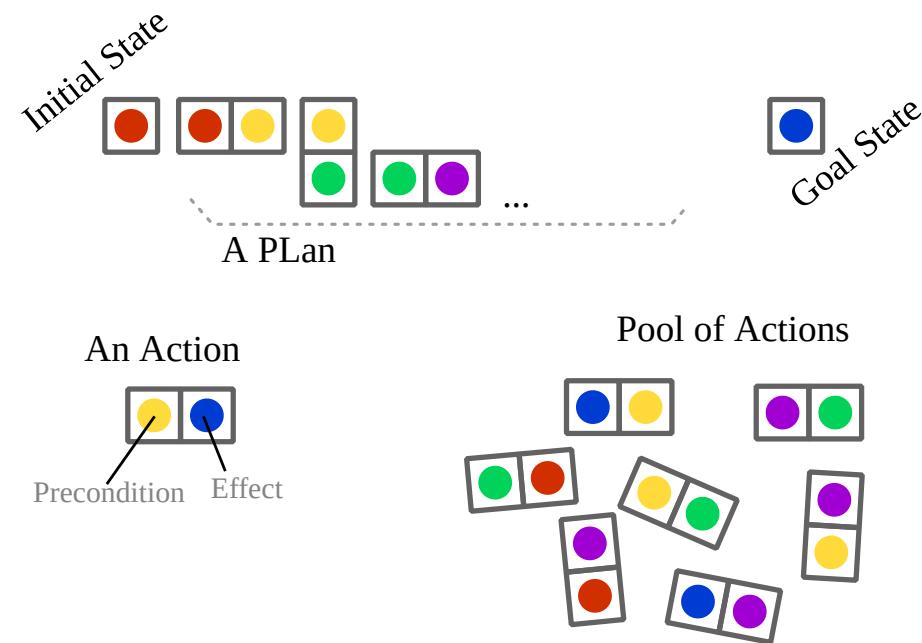


Deterministic case:

- ▶ 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.

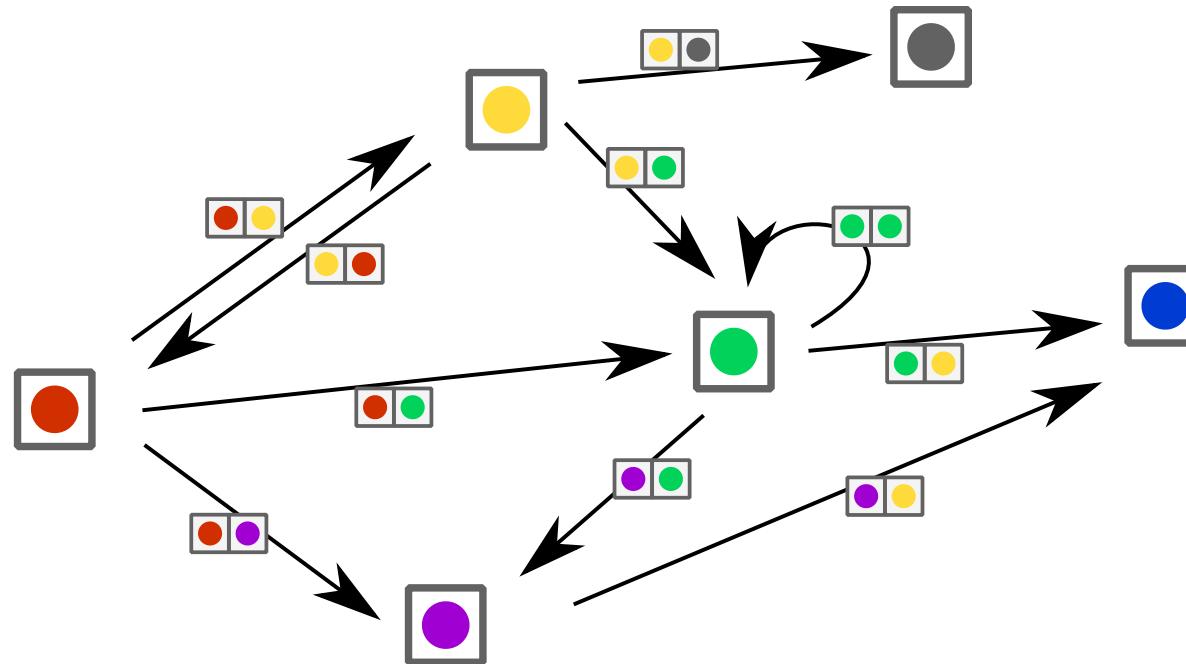


Deterministic case:

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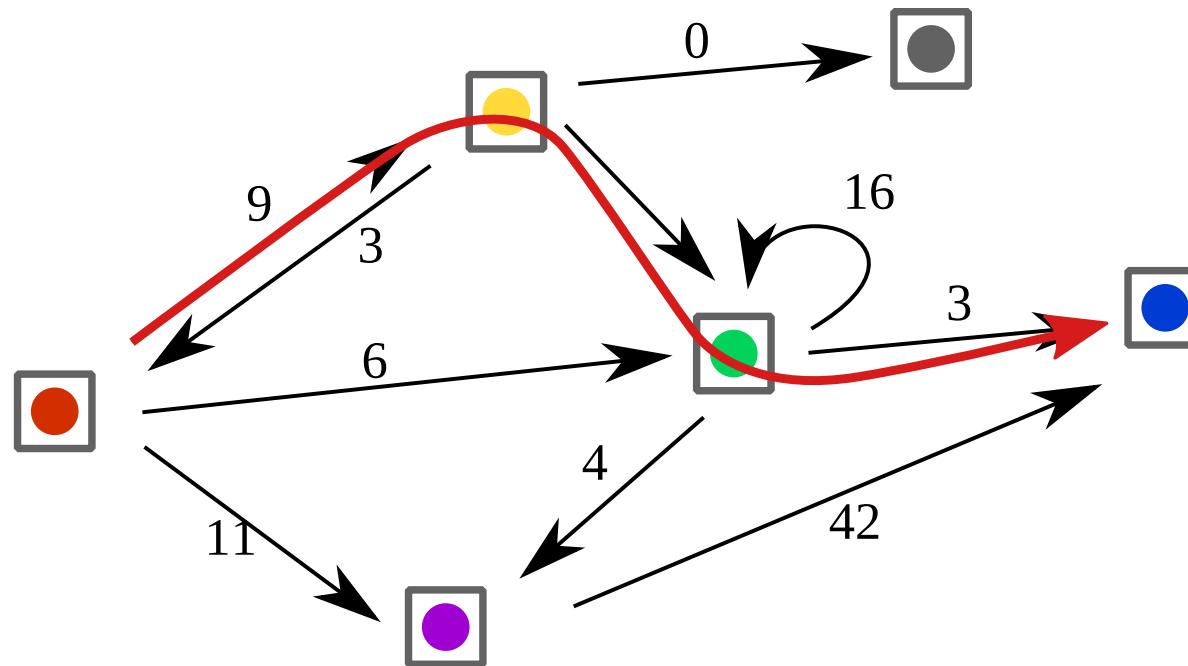
Class of problems - Determine a Plan

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



Class of problems - Plan Optimization

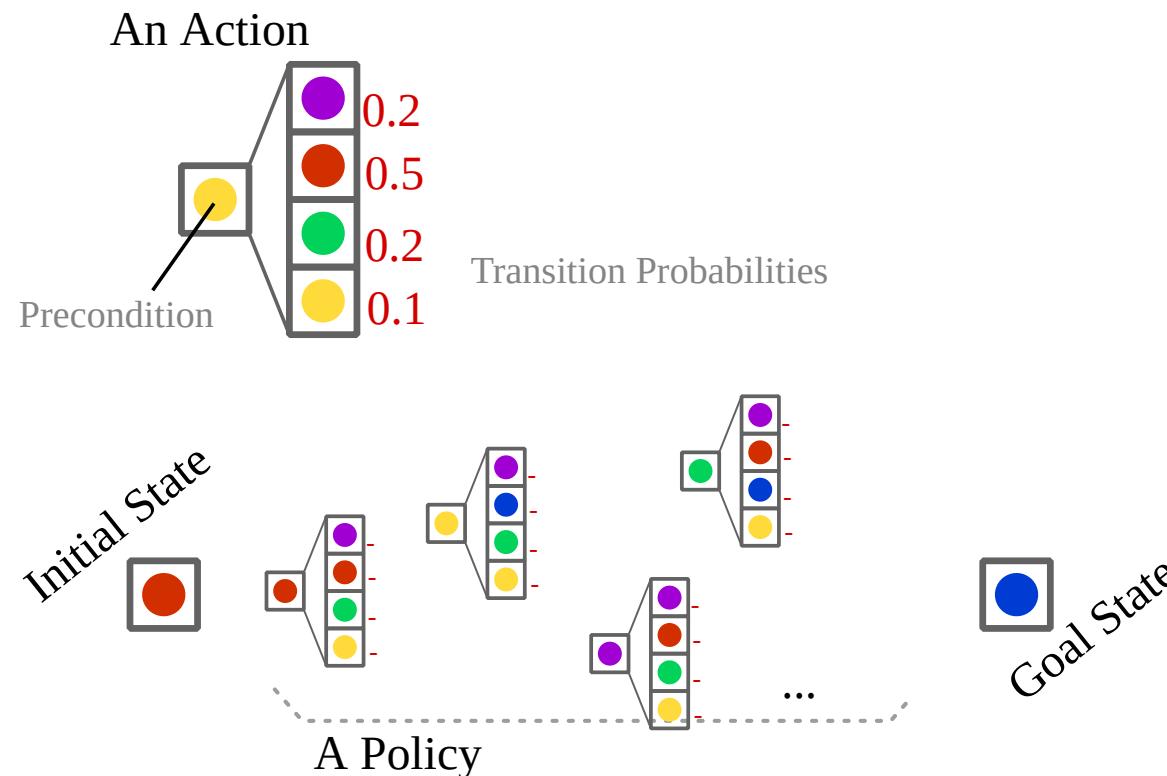
Finding an *optimized* path in a *weighted* Graph



Class of problems - Stochastic Planning

Build a *policy*:

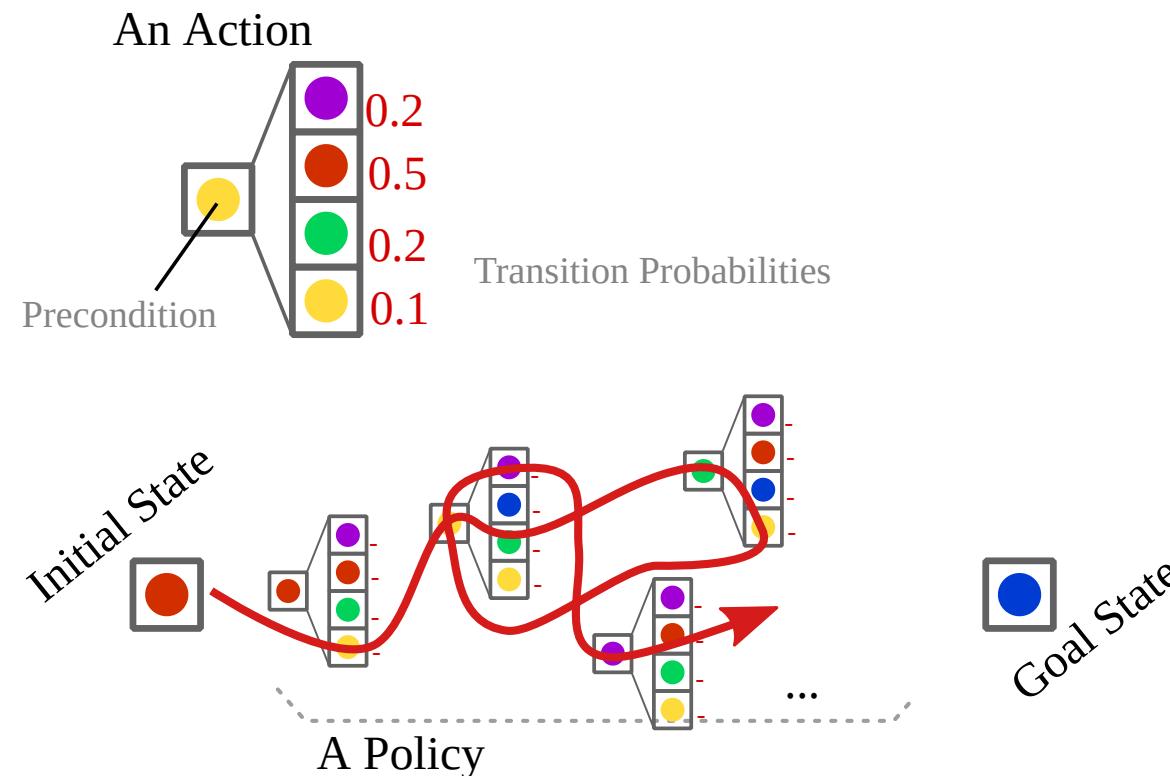
- ▶ Associate an *action* to perform *to each* reachable *state*



Class of problems - Stochastic Planning

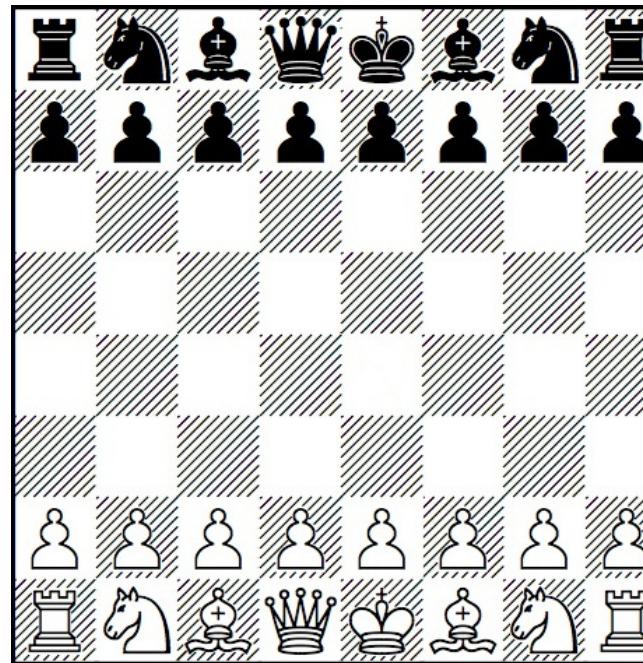
Execute a *policy*:

- ▶ Then, the effective succession of actions remains stochastic



Class of problems - Game theory

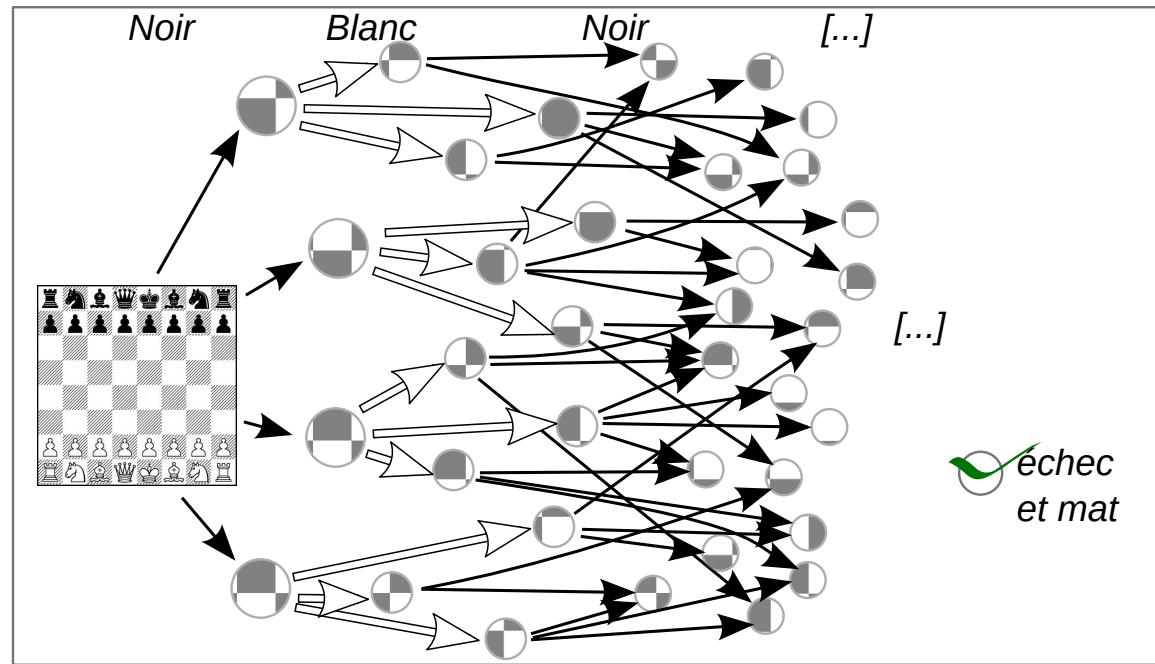
Few entities control the same system (with different goals)



- ▶ 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

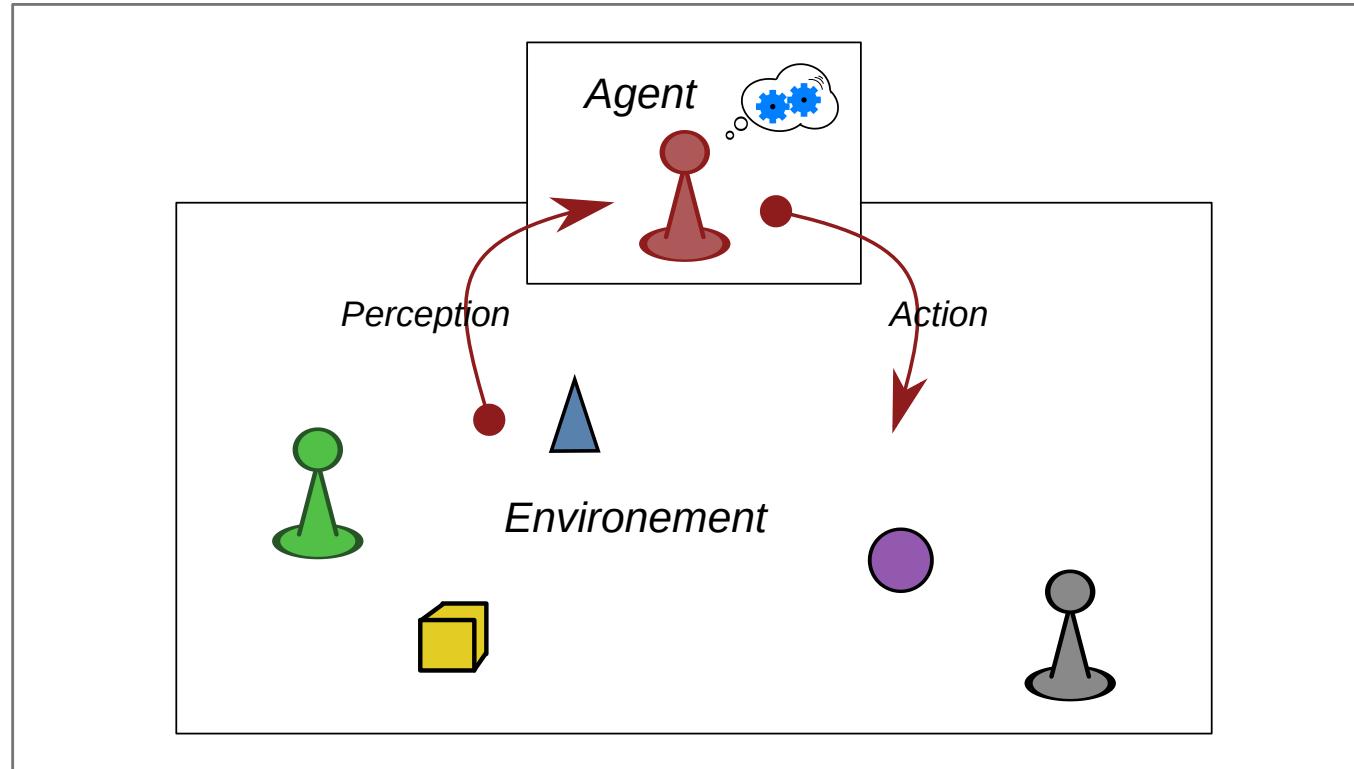
An agent:

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

Question:

**How to choose appropriate action to perform
considering the perception at 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

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.

