Artificial intelligence

Machine learning AI and ML

> Artificial intelligence is the synthesis and analysis of computational agents that act intelligently.

- **Classic**: data processing is consecutive and symbolic (von Neumann-computer).
- **Weak**: computer program whose external behavior is intelligent in a human way.
- **Strong**: system that fulfils weak artificial intelligence, and additionally has internal experiences and a consciousness.
- **Connectionist**: data processing is parallel and distributed.

Defining the options in a decision instance and choosing an option:

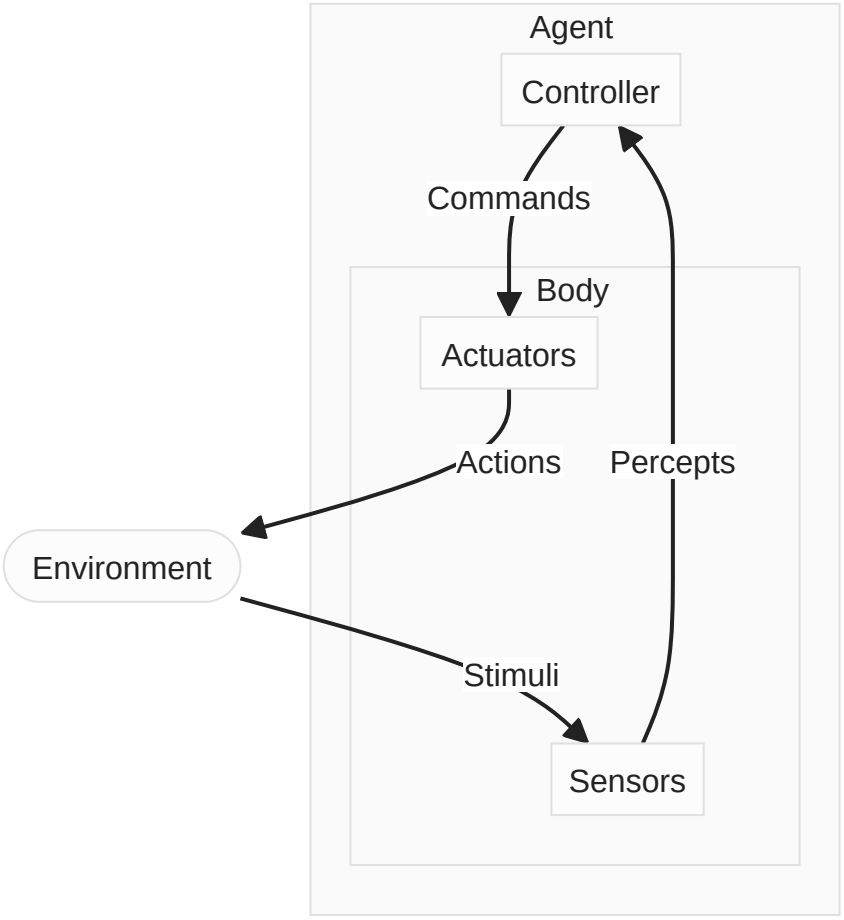
- Solution search
  - Most crucial problem solving technique
  - Options are produced and examined according to some strategy
  - The growing amount of options leads to combinatorial explosion → heuristic search
  - Controlling a search: Indisputable/experimental strategies
  - Directing a search: width/depth/two-way/heuristics
  - Learning solution search strategy: reinforcement learning
- Task planning
  - Producing action queues to reach the goal
  - Initial condition + goals = problem
  - Actions to change the state of the world
  - Requirements: World is predictable + The problem can be divided into sections
- Decision analysis
  - Mathematically choosing the best solution option
  - Probability theory and deduction in uncertainty
  - Utility theory
  - Used for example in support systems for decision making
- Distributed artificial intelligence
  - Using computational models to research individuals' intelligent abilities in relation to their collaboration.
  - Dividing knowledge and problem solving to multiple intelligent agents, and the problems this may lead to in e.g. communication.

Intelligent agent

> A computationally intelligent agent is **an agent which exhibits behaviours typically associated with intelligence in humans and its actions can be explained in terms of computation**.

An agent is something that acts in an environment. An agent acts intelligently if:

- its actions are appropriate for its goals and circumstances
- it is flexible to changing environments and goals
- it learns from experience
- it makes appropriate choices given perceptual and computational limitations
  Input: Abilities, goals/preferences, prior knowledge, stimuli, past experiences, etc.
  Output: Actions.



Search strategies

Type	Strategy	Frontier Selection	Complete	Halts	Space
Uninformed	Depth-first	Stack	No	No	Linear
Uninformed	Breadth-first	Queue	Yes	No	Exp
Uninformed	Heuristic depth-first	Stack ordered by heuristic function value	No	No	Linear

Type	Strategy	Frontier Selection	Complete	Halts	Space
Informed	Best-first	Priority queue ordered by heuristic function value	No	No	Exp
Informed	Lowest-cost-first	Priority queue ordered by path cost	Yes	No	Exp
Informed	A*	Priority queue ordered by sum of path cost and heuristic function value	Yes	No	Exp

Complete — guaranteed to find a solution for graphs with a finite number of neighbours, even for infinite graphs.
Halts — on finite graphs that may have cycles.
Space — as a function of the length of current path.

Logic

Representation and Reasoning System (RRS)

A RRS is made up of:

- syntax: specifies the symbols used, and how they can be combined to form legal sentences
- semantics: specifies the meaning of the symbols
- reasoning theory or proof procedure: a (possibly nondeterministic) specification of how an answer can be produced.

Propositional definite clauses

- An atom is a symbol starting with a lower case letter.
- A body is an atom or is of the form $b_1 \wedge b_2$ where b_1 and b_2 are bodies.
- A definite clause is an atom or is a rule of the form $h \leftarrow b$ where h is an atom and b is a body.
- A knowledge base is a set of definite clauses.

Semantics

- An interpretation I assigns a truth value to each atom.
- A body $b_1 \wedge b_2$ is true in I if b_1 is true in I and b_2 is true in I.
- A rule $h \leftarrow b$ is false in I if b is true in I and h is false in I. Otherwise the rule is true.
- A knowledge base KB is true in $I \iff$ every clause in KB is true in I.

Models and Logical Consequence

- A model of a set of clauses is an interpretation in which all the clauses are true.
- If KB is a set of clauses and g is a conjunction of atoms, g is a logical consequence of KB, written $\mathrm{KB}| = g$, if g is true in every model of KB.
- That is, $\mathrm{KB}| = g$ if there is no interpretation in which KB is true and g is false.

Logical program

Logic programming is based on formulas called Horn rules.

$$\forall_{x_1 \ldots x_k}[A \leftarrow B_1 \wedge B_2 \wedge \ldots B_j], \quad \text{where} \quad k, j \geq 0$$

Non-Horn formulas do not correspond to programs, we need to convert them into Horn form using two methods:

- Logical equivalence
- Skolemization