1 AI Systems

1.1 What is an AI System?

An AI System can be defined as the study of **rational agents** and **their environments**

1.1.1 Environment

- "The surroundings or conditions in which a person, animal, or plant lives or operates" - Oxford Dictionary
- In AI: The surrounding of an (AI) agent, where the agent operates
- Does not have to be real - Can be artificial
- Example:
  - Selfdriving cars: Street, traffic, weather, road signs, ...
  - Chess: Board, pieces,...

Characteristics of Environments

Discrete vs. Continous

Discrete: Environment has countable number of distinct, well defined states
Continous: Not discrete - Uncountable number of states

For Example:

- Discrete: Chess - Every state of the board is mathematically determinable and defined
- Continous: Selfdriving car - Practically infinite positions and conditions

Observable vs. Partially Observable / Unobservable

Observable: State is completely determinable at each point in time
Partially Observable: State is only partially determinable or only determinable at specific points in time
Unobservable: State is never determinable

Static vs. Dynamic

Static: Environment does **not** change while the agent is acting
Dynamic: Environment can change while the agent is acting

For Example:

- Static: Jigsaw puzzle - State does not change without the agents action
- Dynamic: Driving - State still changes even when the agent stops acting

Single Agent vs. Multiple Agents

Single Agent: Environment contains only one agents
Multiple Agents: Environment can contain multiple agents

Accessible vs. Inaccessible

Accessible: Agent can obtain complete and accurate information about the state
Inaccessible: Agent cannot obtain complete or only inaccurate information

Deterministic vs. Stochastic / Probabilistic

Deterministic: Next state is completely determined by the current state and the actions of the agents
Probabilistic: Next state is also influenced by other factors

Episodic vs. Non-episodic / Sequential

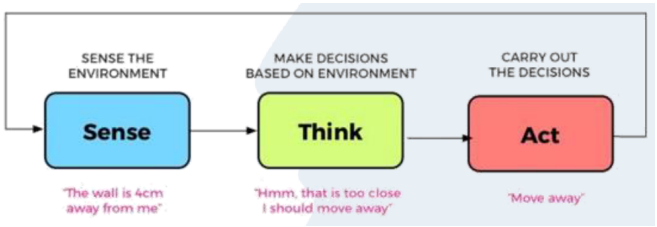
Episodic: Each **episode** consists of the agent perceiving and then acting - every action is dependent only on the episode
Non-episodic: Actions are also dependent on past memory

These characteristics are important, as the environment specifies the specific needs of the agent:

- Different environments require different agent designs
- Not every algorithm works for a specific environment

1.1.2 Agents

- **Sense:** Perceives its environment
- **Think:** Makes decisions autonomously
- **Act:** Acts upon the environments



Rules of AI Agents

1. Must be able to perceive its environment
2. Observations must be used to make decisions
3. Decisions should be used to act
4. (Action should be rational)

Rational Agents

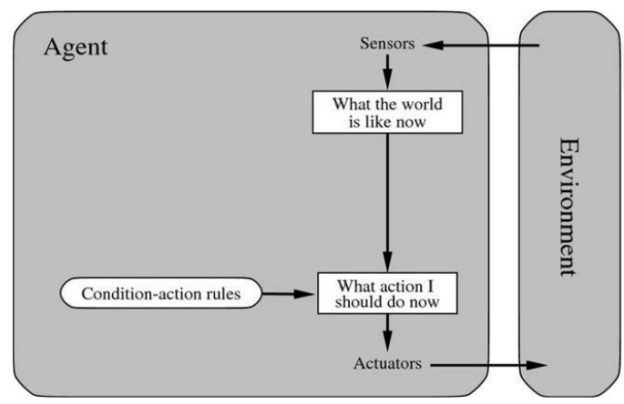
Maximizes the performance and yield the best positive outcome.
Performance is hereby often measured by a function that evaluates a sequence of actions. This function is task-dependent and cannot be generalized.

1.1.3 Types of Agents

Reflex Agent

Act only on the basis of the current percept, ignores past memory

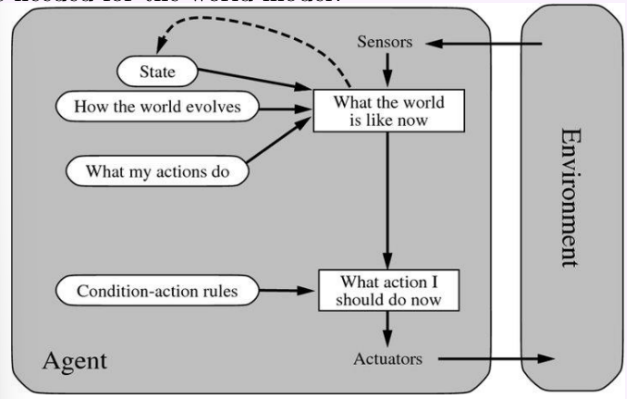
- Implemented through condition-action rules - map state to action
- Problem:
  - Limited decision making
  - No knowledge about anything that cannot be currently perceived
  - Hard to handle in complex environments



Model-Based Agent

Similar decision making to reflex agent, but keep track of the world state

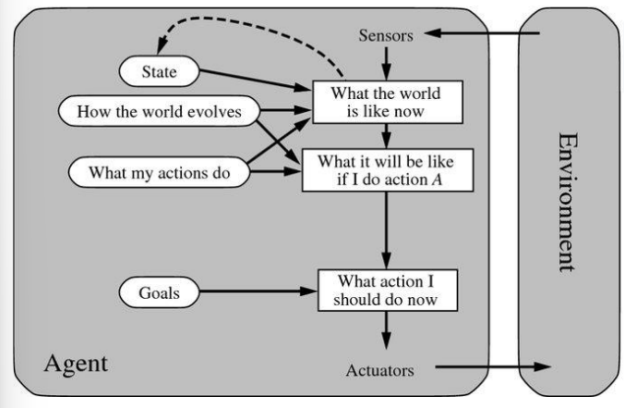
- Input is interpreted and mapped to an internal state representation of the world
- Problem:
  - How do these action affect the internal representation of the world?
  - What details are needed for the world model?



Goal-Based Agent

Essentially a Model-Based Agent with additional functionality that stores desirable states

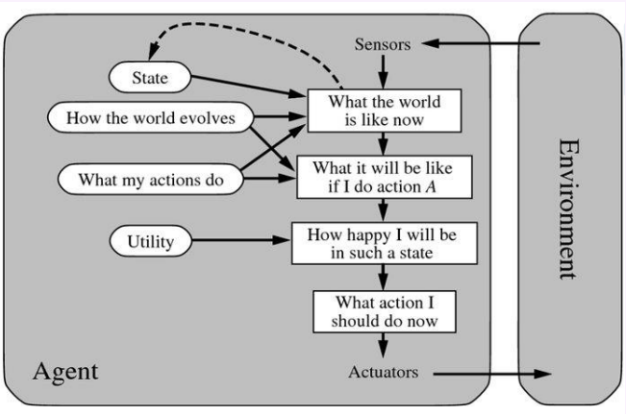
- Knows what states are desirable and acts towards them
- Problem:
  - Difficult to choose actions if a lot of actions are required to achieve a goal



Utility-Based Agent

Similar to Goal-Based Agents, but instead of providing goals it provides a utility function for rating actions and scenarios based on the desirability of the result

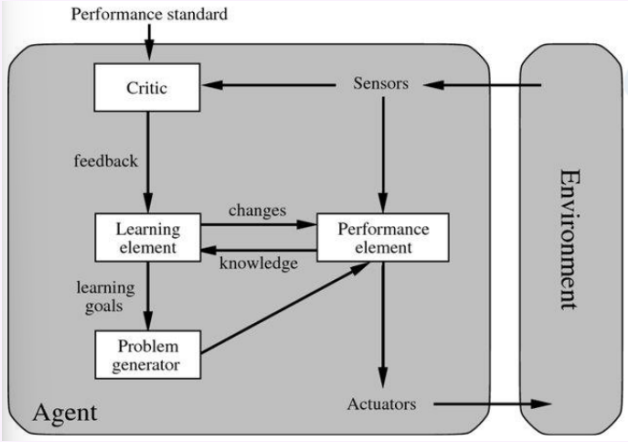
- Goals provide binary distinction, while utility functions provide a continuous measure of desirability
- Can handle selection between two conflicting goals - ”Speed or safety”



Learning Agent

Employs additional learning element to gradually improve and become more knowledgable over time about an environment

- Can learn from past experiences
- Is more robust towards unknown environments
- A learning agent has four conceptual components:
  1. **Learning Element:** Makes improvements by learning from the environment
  2. **Critic:** Gives feedback on the performance of the agent according to a fixed metric
  3. **Performance Element:** Selects the best action according to the critic
  4. **Problem Generator:** Responsible for suggesting actions that will lead to new experiences



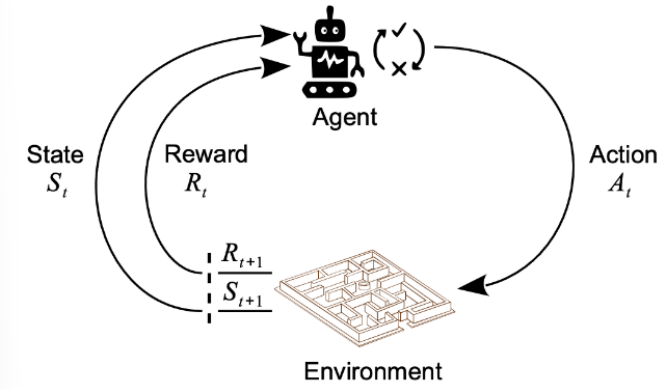
1.2 Creating Intelligent Agents

1.2.1 Search Algorithms

Define "finding a good action" as a search problem and use search algorithm to solve it. Most of these seach algorithms are tree based, altough Bread-First is used often.

1.2.2 Reinforcement Learning

Developed in psychology, Reinforcement Learning essentially is a process of trial and error - Try something out, have a reaction to it, learn wether it was good or bad. Reactions or actions are based on out observations or experiences.



1.2.3 Genetic Algorithms

Inspired by Darwins "Theory of natural selection", this model build multiple different agents and evaluates every one of them. The agent with the highest performance is selected and new models are built based on it. This is done until the performance is good enough.