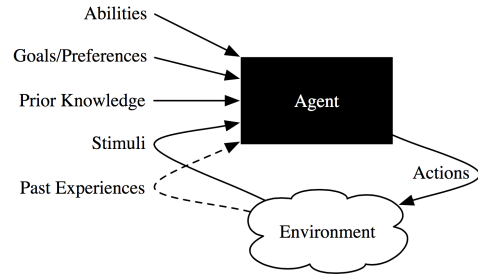


Lecture 2 - Agents and Abstraction

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Readings: Poole & Mackworth 1.3-1.10



- Agent + Environment = world
- Inside black box: belief state

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Knowledge Representation

Defining a Solution

- non-AI:
 - ▶ specify **how** to compute something
 - ▶ specify **what** the next step is
 - ▶ **programmer** figures out how to do the computation
- AI:
 - ▶ specify **what** needs to be computed
 - ▶ specify **how** the world works
 - ▶ **agent** figures out how to do the computation
- **Knowledge**: information used to solve tasks
- **Representation**: data structures used to encode knowledge
- **Knowledge base (KB)**: representation of all knowledge
- **Model**: relationship of KB to world
- **Level of Abstraction**: How accurate is the model

- **Optimal** solution (utility)
- **Satisficing** solution (good enough)
- **Approximately optimal** solution (how far off?)
- **Probable** solution (how likely not?)

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Representations: Symbol Systems

Knowledge Representation

- A **symbol** is a meaningful physical pattern that can be manipulated.
- A **symbol system** creates, copies, modifies and destroys symbols.

physical symbol system hypothesis (Newell & Simon, 1976):

A physical symbol system has the necessary and sufficient means for general intelligent action.

implies that : AI on a computer is possible in theory, but not necessarily feasible in practice

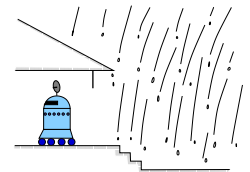
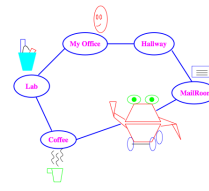
A good representation should be

- **Rich** enough to express the problem
- **Close** to the problem: compact, natural and maintainable
- Amenable to **efficient** computation
- Amenable to **elicitation** from people, data and experiences

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- **Autonomous delivery robot** roams around an office environment and delivers coffee, parcels, . . .
- **Diagnostic assistant** helps a human troubleshoot problems and suggests repairs or treatments. E.g., electrical problems, medical diagnosis.
- **Intelligent tutoring system** teaches students in some subject area.
- **Trading agent** buys goods and services on your behalf.



Let's talk about the Autonomous Delivery Robot

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Autonomous Delivery Robot

What does the Delivery Robot need to do?

- **Abilities:** movement, speech, pickup and place objects, sense weather
- **Observations:** about its environment from cameras, sonar, sound, laser range finders, or keyboards.
- **Prior knowledge:** its capabilities, objects it may encounter, maps.
- **Past experience:** which actions are useful and when, what objects are there, how its actions affect its position.
- **Goals:** what it needs to deliver and when, tradeoffs between acting quickly and acting safely, effects of getting wet.

- **Determine** where user is. Where coffee is . . .
- **Find a path** between locations.
- **Plan** how to carry out multiple tasks.
- Make **default assumptions** about where user is.
- Make **tradeoffs under uncertainty**: should it go near the stairs or outside?
- **Learn** from experience.
- **Sense and act** in the world, avoid obstacles, pickup and put down coffee, deliver mail

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Dimensions of Complexity

Dimensions of Complexity

- Research proceeds by making **simplifying assumptions**, and gradually reducing them.
- Each simplifying assumption gives a **dimension of complexity**
 - ▶ Can be multiple values in a dimension: values go from **simple to complex**
 - ▶ Simplifying assumptions can be **relaxed** in various combinations
- Much of the history of AI can be seen as starting from the simple and **adding in complexity** in some of these dimensions.

- Flat → modular → hierarchical
- **Explicit states → features → objects and relations**
- **Static → finite stage → indefinite stage → infinite stage**
- **Fully observable → partially observable**
- Deterministic → stochastic dynamics
- **Goals → complex preferences**
- **Single-agent → multiple agents**
- Knowledge is given → knowledge is learned from experience
- Perfect rationality → bounded rationality

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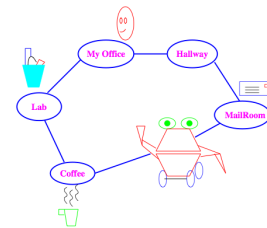
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 - 30 binary features can represent $2^{30} = 1,073,741,824$ states.

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 - 30 binary features can represent $2^{30} = 1,073,741,824$ states.
- **individuals** and **relations**
 - There is a feature for each relationship on each tuple of individuals.
 - Often we can reason without knowing the individuals or when there are infinitely many individuals.



- Explicit: enumeration of all worlds: s_1, s_2, s_2, \dots
- Features: robot location, user location, robot has coffee?, ...
- Relations: robot moves (clockwise + or counter-clockwise -)
 $\forall m \in \{+, -\}, l \in \{1, 2, 3, \dots\} \text{move}(m) : l' \leftarrow (l + m) \% 5$

...how far the agent looks into the future when deciding what to do.

- **Static:** world does not change
- **Finite stage:** agent reasons about a fixed finite number of time steps
- **Indefinite stage:** agent is reasoning about finite, but not predetermined, number of time steps
- **Infinite stage:** the agent plans for going on forever (process oriented)

What the agent can determine the state from the observations:

- **Fully-observable** : the agent knows the state of the world from the observations.
- **Partially-observable** : there can be many states that are possible given an observation.

- **achievement goal** is a goal to achieve. This can be a complex logical formula.
- **maintenance goal** is a goal to be maintained.
- **complex preferences** that may involve tradeoffs between various desiderata, perhaps at different times. Either ordinal or cardinal (e.g., utility)
- **Examples:** coffee delivery robot, medical doctor

Delivery Robot



- Goals may **conflict**
e.g. can't deliver mail and coffee at the same time
- Goals may be **combinatorial**
e.g. user may not want coffee if he doesn't get mail
- Goals may **change**
e.g. when wet, robot can't deliver mail

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Single agent or multiple agents

Next:

- **Single agent** reasoning is where an agent assumes that any other agents are part of the environment. (delivery robot)
- **Multiple agent** reasoning is when an agent needs to reason strategically about the reasoning of other agents. (robot soccer, trading agents)

Agents can have their own goals: cooperative, competitive, or goals can be independent of each other

- Read Poole & Mackworth chapter 2.1-2.3
- Uninformed Search (Poole & Mackworth chapter 3)
- Informed Search (Poole & Mackworth chapter 4)

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