CS486/686: Introduction to Artificial Intelligence
Lecture 2 - Agents and Abstraction

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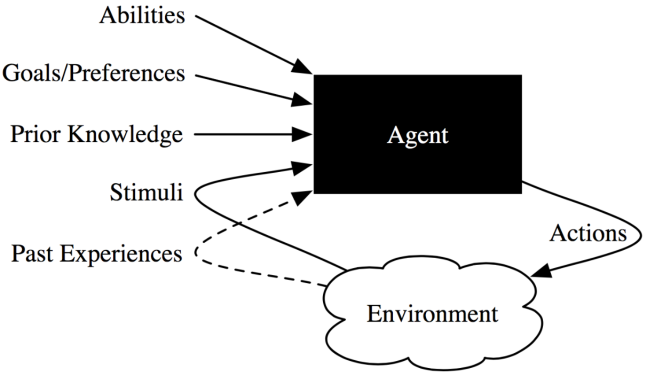
Readings: Poole & Mackworth 1.1

Situated Agent



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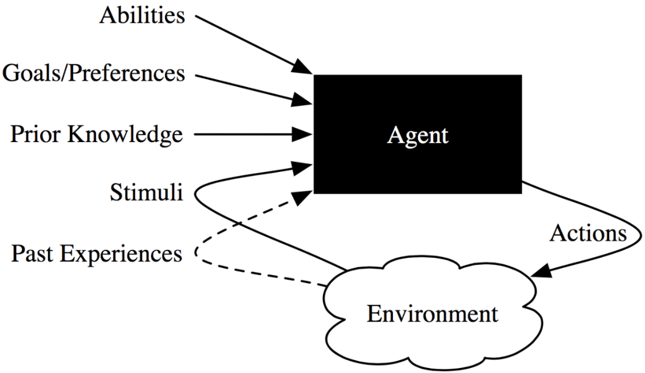

- An **agent** is an entity that performs actions in its **environment**
- Agent+Environment=**world**
- Inside black box: **belief state**

Four Example Application Domains (From Book)

- **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 and medical diagnosis
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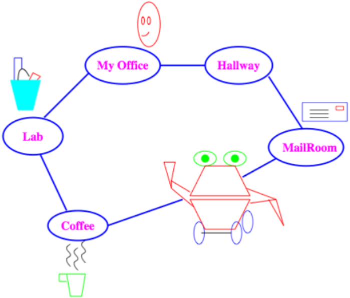
Let's talk about the **autonomous delivery robot**

Domain for Delivery Robot



The robot must:

- Deliver coffee & mail when needed

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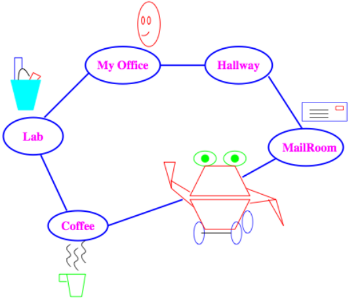

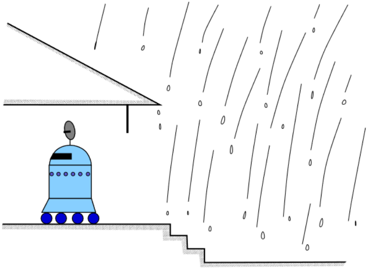

The robot must:

- Deliver coffee & mail when needed
- Avoid getting wet

Autonomous Delivery Robot

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- **Goals:** what it needs to deliver and when, tradeoffs between acting quickly and acting safely, effects of getting wet

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- Learn from experience
- Sense and act in the world, avoid obstacles, pickup and put down coffee, deliver mail

Knowledge Representation

- **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
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- AI:
  - Specify what needs to be computed
  - Specify how the world works
  - **Agent** figures out how to do the computation

Dimensions of Complexity

- The textbook defines 9 “dimensions of complexity” that make up the agent design space
- This is not a complete set (i.e., designing an agent is not as simple as selecting an option for each dimension)
- Can be multiple values in a dimension: values go from simple to complex
- Much of the history of AI can be seen as starting from the simple and adding in complexity in some of these dimensions

Dimensions of Complexity

1. **Modularity**: flat → modular → hierarchical
2. **Planning horizon**: non-planning → finite horizon → indefinite horizon → infinite horizon
3. **Representation**: explicit states → features → individuals and relations
4. **Computational limits**: perfect rationality → bounded rationality
5. **Learning**: knowledge is given → knowledge is learned
6. **Uncertainty**: fully observable → partially observable
   world dynamics: deterministic → stochastic
7. **Preference**: goals → complex preferences
8. **Reasoning by number of agents**: single agent → adversarial → multiagent
9. **Interactivity**: offline → online

Dimension 2: Planning Horizon

How far the agent looks into the future when deciding what to do

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- **Infinite horizon:** the agent plans for going on forever (process oriented)

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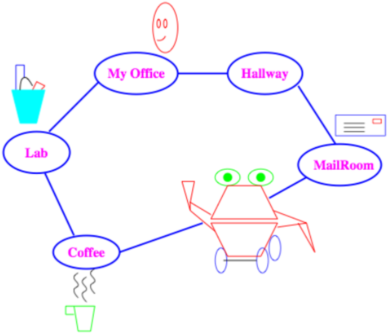
- **Features** or **propositions**
  - It is often more natural to describe states in terms of features
  - 30 binary features can represent $2^{30} = 1,073,741,824$ states
- **Individuals** and **relations**
  - There is a feature for each relationship on each tuple of individuals
  - Often we can reason without knowing the individuals or when there are infinitely many individuals

Example: Delivery Robot



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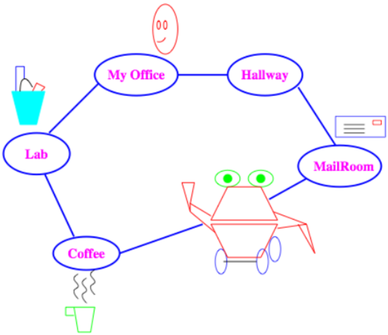

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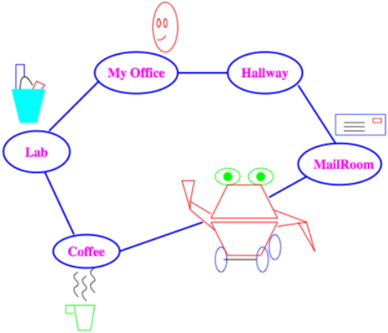

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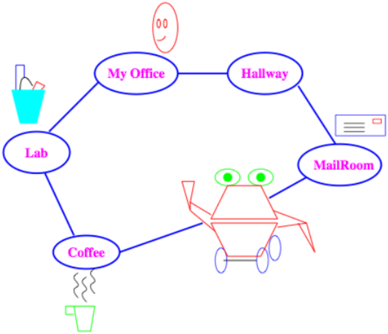

- Explicit: enumeration of all worlds: $s_1, s_2, s_3, \ldots$
- Features: robot location, user location, robot has coffee?, ...
- Relations: robot moves (clockwise + or counter-clockwise -)
  $\forall m \in \{+, -\}, \ell \in \{1, 2, 3...\}, move(m) : \ell' \leftarrow (\ell \; m \; 1)\%5$

Dimension 4: Computational Limits

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Do we have time to calculate exact solutions?

- **Perfect rationality:**
  Agent always chooses the optimal (i.e. highest utility) action
- **Bounded rationality:**
  Agent chooses a possibly sub-optimal action given its limited computational capacity (e.g. chess bots)
  - **Satisficing** solution (good enough)
  - **Approximately optimal** solution (how far off?)

Dimension 5: Learning from Experience

Whether the model is fully specified a priori:

- Knowledge is **given**
- Knowledge is **learned from data or past experience**

Dimension 6: Uncertainty

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

Uncertain World Dynamics

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The dynamics can be:

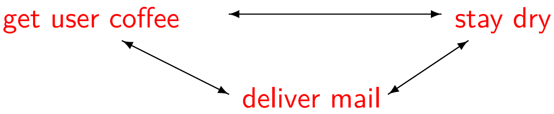
- **Deterministic**: the state resulting from carrying out an action in state is determined from the action and the state
- **Stochastic**: there is uncertainty over the states resulting from executing a given action in a given state

Dimension 7: Goals or Complex Preferences

- **Achievement goal** is a goal to achieve; 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; can be either ordinal or cardinal (e.g., utility)
- Examples: coffee delivery robot, medical doctor

Example: Complex Preferences

Delivery Robot



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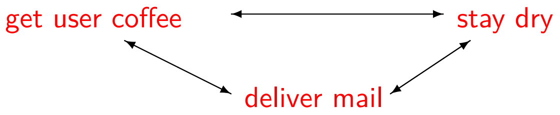

- Goals may conflict

  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

  - user switches from coffee to kale juice

Dimension 8: Reasoning by Number of Agents

- **Single agent** reasoning is where an agent assumes that any other agents are part of the environment (delivery robot)
- **Adversarial** reasoning considers another agent that acts in opposition to our goals (AlphaGo)
- **Multiagent** reasoning is when an agent needs to reason strategically about the reasoning of other agents (robot soccer, trading agents)

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

Next

- Uninformed Search (Poole & Mackworth chapter 3)