Biological Vision and Applications
Module 06-04: Deliberative Agents

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Reactive vs. goal-directed behavior

- The AC reacts to the perceived environment states
  - Does not have an explicit representation of goal
  - It's goal (to maintain the room temperature) is implicit in the agent behavior
  - Reactive behavior
- Contrast it with an autonomous car
  - It has an explicit goal: to reach a destination
    - In shortest time, via a scenic route, etc.
  - Proactive / goal-directed behavior needs deliberation
- A practical agent should show both reactive and proactive behavior
  - It should take you to destination ... safely
  - Apply brakes on seeing a pedestrian at front

Reactive vs. Deliberative Agents

What is deliberation

Human mental process: a model for goal-directed behavior

- Deliberation is the act of thinking about or discussing something and deciding carefully (Merriam-Webster dictionary)
  - "I take an umbrella **because** I see that it is raining" (perception)
  - "I give you money **because** I believe that you deserve it" (belief)
  - "I take the school bus **because** I want to go to school" (desire)
- Reasoning happens with percepts, beliefs, desires
- A more complex deliberation process
  - I take taxi **because**
    - I want to go to cinema, and
    - I believe that taxi will take me to cinema, and
    - I see that it is raining
- Deliberation (reasoning) is a property of human mind

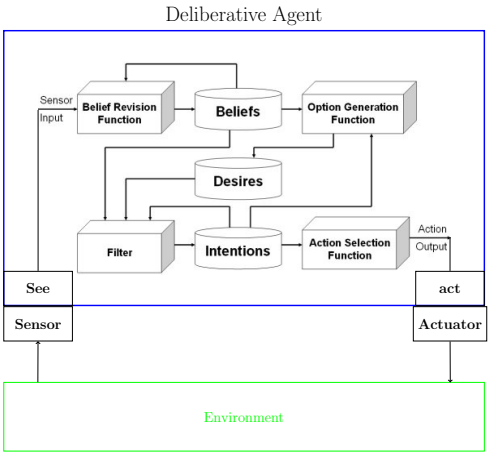
Modeling Deliberative Agents: BDI Architecture

The internal state of the agent is modeled

- **Belief:** An agent's model of the world
  - There is a difference between belief and knowledge
  - Updated with perceptions, communication (additional information)
- **Desire:** The ideal state that an agent wants to accomplish
  - The world is not in that state at the current moment
  - A desire might be realistic or not
  - Relatively static, may change in long-term
- **Intention:** A subgoal required to fulfil the desires
  - Determines it's current activity

Belief vs. knowledge

BDI Architecture



Belief Revision Function:
$brf : B \times P \rightarrow B$

Option generation function:
$options : B \times I \rightarrow D$

A filter function [Deliberation]:
$filter : B \times D \times I \rightarrow I$

Action selection function:
$action : I \rightarrow A$

Example of deliberation in an autonomous agent

- Autonomous car: goal is to reach a destination by 3pm
- Desire: Want to reach a destination by 3pm
- Belief: A map (road network)
- Percept: Current position and orientation
- Intention: Find a feasible path
- Action: Do planning (graph search), with temporal constraints

Example of deliberation in an autonomous agent

Contd.

- Desire: Want to reach a destination by 3pm
- Belief: A map, best path to destination ($X \rightarrow Y \rightarrow Z \ldots$)
- Percept: Current position and orientation
- Intention: take road X
- Action: navigate the car

Example of deliberation in an autonomous agent

Contd.

- After sometime, we are on road Y
- Desire: Want to reach a destination by a certain time
- Belief: A map, best path to destination ($X \rightarrow Y \rightarrow Z \ldots$)
- Percept: Current position and orientation, road-block ahead
- Intention: Current commitment (road Y), Recompute feasible path
- Action: Replan
  1. Alternative found: accept alternate path
  2. Alternative not found: change desire

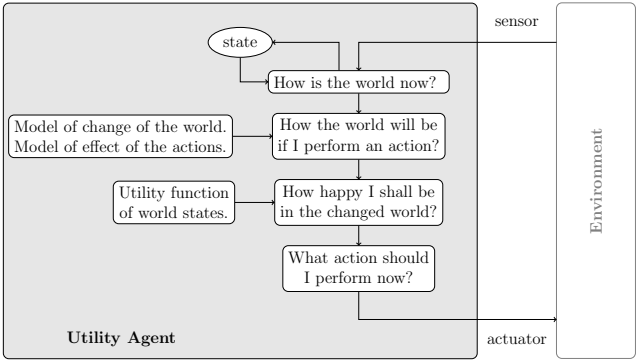
Preferential order of states

- The desire of an agent is to achieve an "ideal" state for itself
  - ... an agent prefers certain states to others
- Let $W = \{w^0, w^1, \ldots w^n\}$ represents the set of the states of the world
- Preferential ordering:
  - $w_i \succsim_A w_j$ means that the agent A either prefers state w_i to state w_j or is indifferent to them
  - $w_i \succ_A w_j$ means that A strictly prefers w_i over w_j by agent A
  - $w_i \approx_A w_j$ means that A is indifferent to w_i and w_j
- Important: Preferential order of states are specific to agents
- Can the preferential states be partially ordered?

Utility of states

- Utility is a mapping from the world states to a numeric value by an agent A
  - $u_A : W \rightarrow \mathbb{R}$
- Consistent with the preferential order of the states for the agent
  - $u_A(w_i) \geq u_A(w_j) \iff w_i \succsim_A w_j$
  - $u_A(w_i) > u_A(w_j) \iff w_i \succ_A w_j$
  - $u_A(w_i) = u_A(w_j) \iff w_i \approx_A w_j$
- Utility values of states are specific to agents
- Rational behavior implies that the agent tries to maximize it's utility

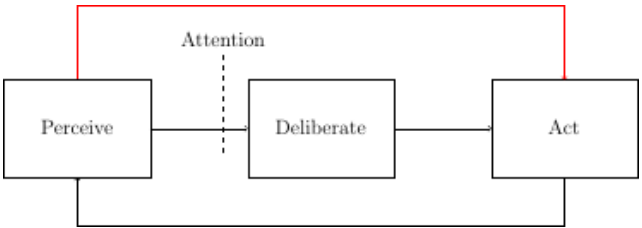
Architecture of a utility based agent



Agent Model

Key Takeaway

- A perpetual loop for it's lifetime



- Reactive behavior is a behavior without deliberation
- Deliberation is the key to goal-directed behavior
- "Mind" of the agent is responsible for the deliberation
  - Mind is modeled with memory, and associated processing

Quiz

Quiz 06-04

End of Module 06-04