Rethinking the Intelligent Agent Perceive-Reason-Act Loop

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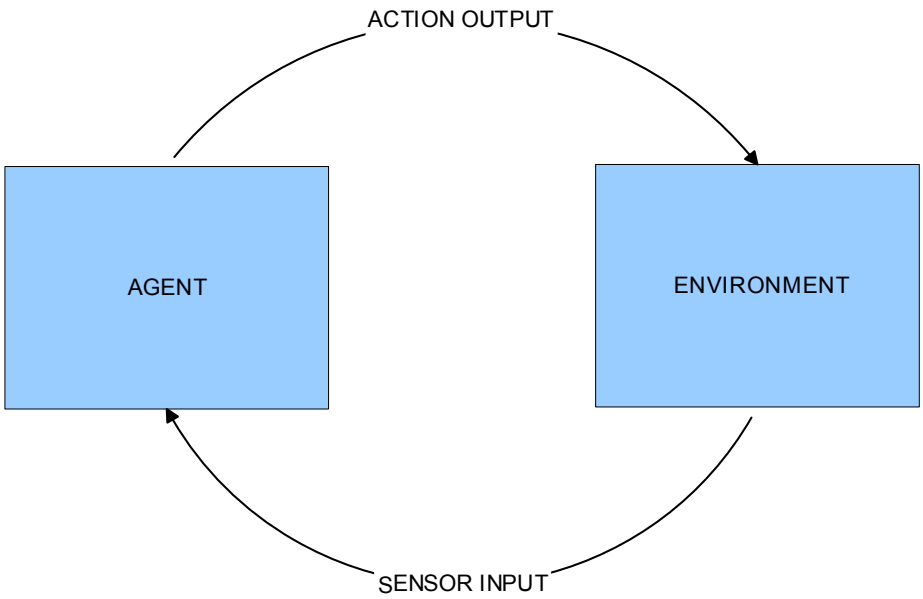
Agent-Environment Interaction

Key issues with current approaches to agent-environment interaction:

- Treat the agent and the environment as separate entities.
- Communication via inputs and outputs.
- Agent-Environment designs do not follow claims about:
  - Agents being situated.
  - The environment being important.

Agent-Environment Interaction Loop



Agent Control Loop...

Pythonic Version of Wooldridge's Agent Control Loop

```
while True:
    observe_the_world()
    update_internal_world_model()
    deliberate_about_which_intention_to_acheive()
    use_means_end_reasoning_to_find_a_plan()
    execute_the_plan()
```

Or the BDI Control Loop...

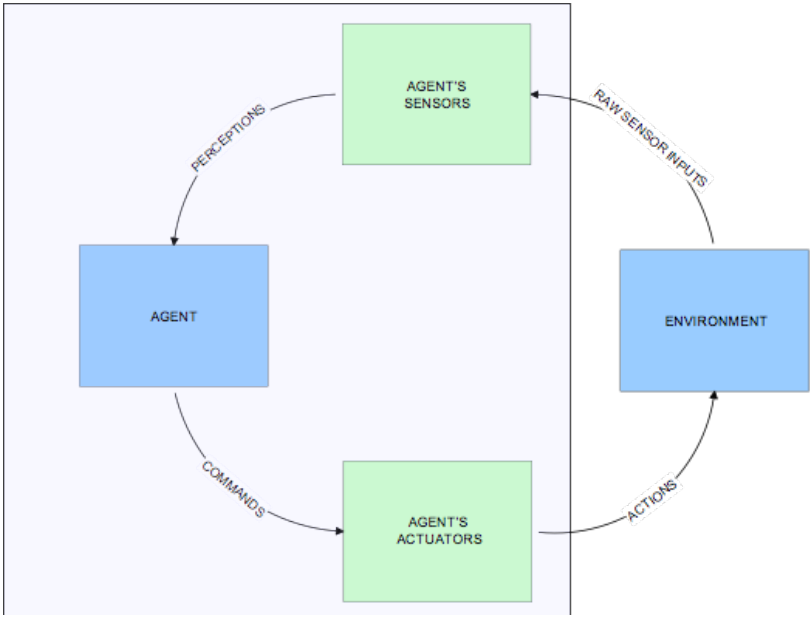
Adapted from Wooldridge...

procedure BDI(B_0, I_0)
  $B \leftarrow B_0$
  $I \leftarrow I_0$
  while True **do**
    $\rho \leftarrow$ `get_next_percept`();
    $B \leftarrow$ `brf`(B, ρ);
    $D \leftarrow$ `options`(B, I);
    $I \leftarrow$ `filter`(B, D, I);
    $\pi \leftarrow$ `plan`(B, I);
    `execute`(π);
  end while
end procedure

Let's dig deeper...

- Begin to look at the agent control loop and the interaction with the environment in more detail.
- The interaction between agent and environment needs to be broken down into components, step by step.
- Start looking at how inputs/outputs are generated... i.e. look at sensors and actuators.

A level down...


AGENT'S SENSORS
PERCEPTIONS
RAW SENSOR INPUTS
AGENT
ENVIRONMENT
COMMANDS
AGENT'S ACTUATORS
ACTIONS

Labels in the Environment

- One of the things that is sent to an agent's sensors is the possibility of pre-labeled entities in the environment.

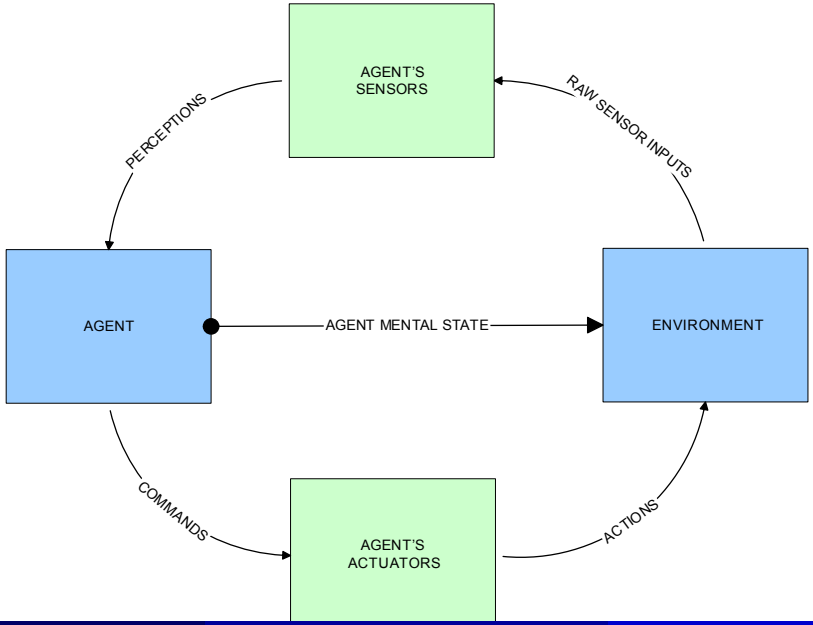
We can begin to formulate a theory...

- In a multi-agent system we have n agents, $A_1 ... A_n$.
- Each agent has m sensors.
- We can specify the i-th agent's j-th sensor as S_{ij}

Agent Mental States

- Each agent A_i can be in a single mental state m_i.
- The mental state may be the agent's beliefs and intentions.
- $m_i = \{B_i, I_i\}$
- Consider the sensing of the environment to be a function of the agent's current mental state.

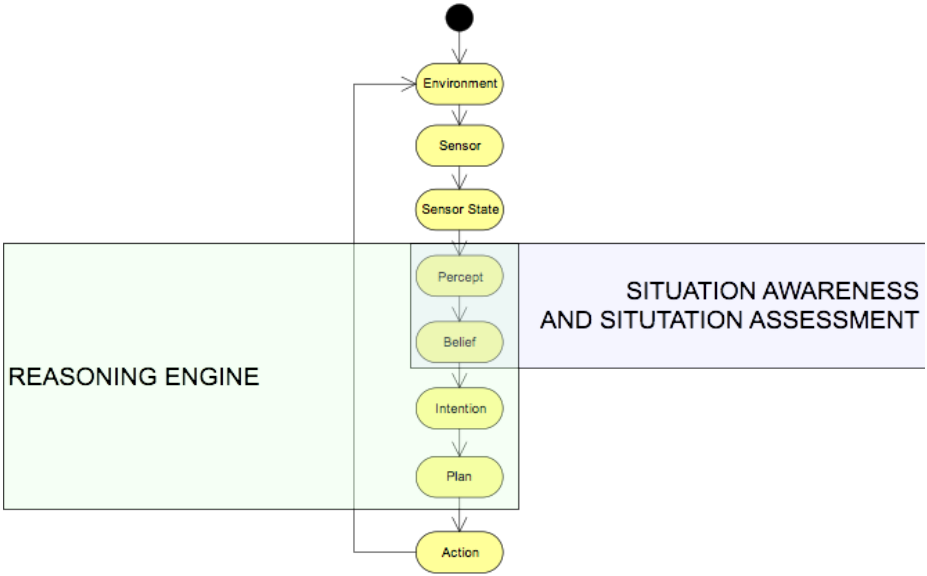
Agent Mental State in the Loop...



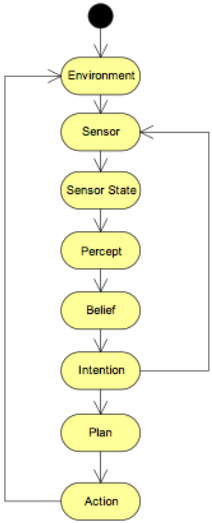
Perception and Mental State

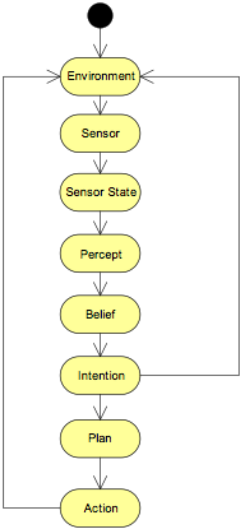
- Implies perception/sensing are a function of an agent's mental state.
- What you perceive as an agent depends on what you are doing and what you believe you are doing (beliefs, intentions).
- This fits in with J.J. Gibsons ideas of direct perception for ecological psychology.
- $\mathsf{Sensor}(\sigma_i, e, m_i) := \sigma_{i+1}$

The Agent-Environment Loop Revisited



Intention Based Feedback Loop





Environmental Representation

- Still need to look at environmental representation options
  - Flat
  - Hierarchical/Relational
  - Labels (Dynamic or Pre-Processed)
  - Intention Oriented Affordances
- Dynamic agent (tailored to the agent)
- Static environment

So what is the goal then?

- To create a *truly* situated agent.
- Affordances: opportunity for action
- Together with a tighter agent-environment feedback loop; might just do the trick.

Affordances

- Affordances are a function:
  - The subset of the environment that the agent is/can perceive using its sensors.
  - The agent's mental state.
  - The agent's current activity...
- Do we need to distinguish between Intention/Activity/Action?

Example: Jumping a Creek

- My intention is to get to Town B from Town A
- I have a plan to *run* from A to B
- I have a plan to *walk* from A to B
- I see a creek
- If I am running the creek *affords* jumping
- Here the affordance is a function of the activity rather than intention.

How do we build such an agent?

- Agent *announces* to the environment what it can see.
- Agent *announces* to th environment what it is doing (activity or action) or maybe even intention.
- Environment/Affordance engine somehow binds what a I can see with what I am doing, generating affordances for the things in the environment.

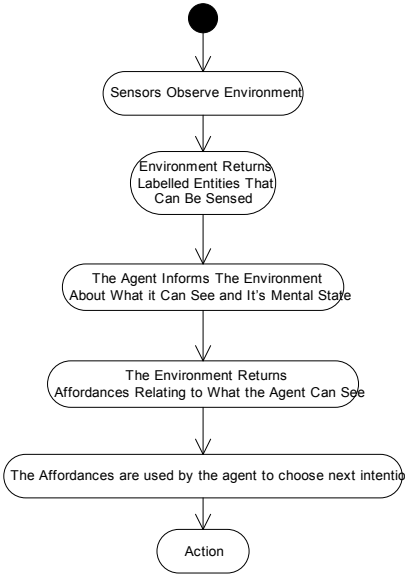
Issues (1)

- How does the agent sense/perceive the affordances?
- Is there an affordance *sensor*?
- Does the agent get affordance percepts (direct percepts) in addition to regular percepts?
- How does the agent then use these affordances in the next deliberation step?

Issues (2)

- What do affordances look like?
  Names, labels, relations?
- `can-jump(creek)` $\rightarrow$ What are these?
- How does having these affordances affect your intention generation process?
- Need more examples...

Example


Sensors Observe Environment
Environment Returns Labelled Entities That Can Be Sensed
The Agent Informs The Environment About What it Can See and It's Mental State
The Environment Returns Affordances Relating to What the Agent Can See
The Affordances are used by the agent to choose next intentio
Action