

Foundations of Artificial Intelligence

3. Introduction: Rational Agents

Malte Helmert

University of Basel

March 3, 2021

Introduction: Overview

Chapter overview: introduction

- 1. What is Artificial Intelligence?
- 2. AI Past and Present
- 3. Rational Agents
- 4. Environments and Problem Solving Methods

Agents

Heterogeneous Application Areas

AI systems are used for very **different** tasks:

- controlling manufacturing plants
- detecting spam emails
- intra-logistic systems in warehouses
- giving shopping advice on the Internet
- playing board games
- finding faults in logic circuits
- ...

How do we capture this diversity in a **systematic framework** emphasizing **commonalities** and **differences**?

Heterogeneous Application Areas

AI systems are used for very **different** tasks:

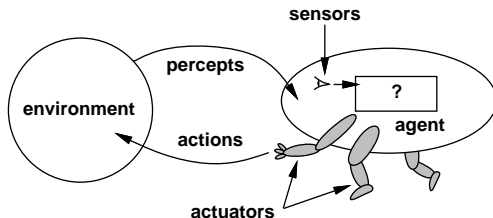
- controlling manufacturing plants
- detecting spam emails
- intra-logistic systems in warehouses
- giving shopping advice on the Internet
- playing board games
- finding faults in logic circuits
- ...

How do we capture this diversity in a **systematic framework** emphasizing **commonalities** and **differences**?

common metaphor: **rational agents** and their **environments**

German: rationale Agenten, Umgebungen

Agents



Agents

- **agent functions** map sequences of **observations** to **actions**:

$$f : \mathcal{P}^+ \rightarrow \mathcal{A}$$

- **agent program**: runs on physical **architecture** and computes f

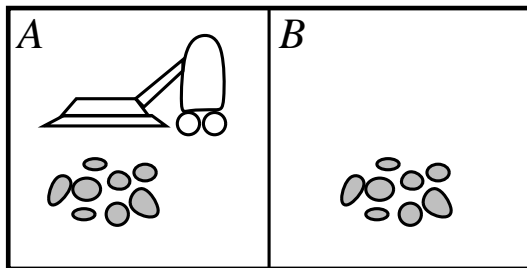
Examples: human, robot, web crawler, thermostat, OS scheduler

German: Agenten, Agentenfunktion, Wahrnehmung, Aktion

Introducing: an Agent



Vacuum Domain



- **observations:** location and cleanness of current room:
 $\langle a, \text{clean} \rangle$, $\langle a, \text{dirty} \rangle$, $\langle b, \text{clean} \rangle$, $\langle b, \text{dirty} \rangle$
- **actions:** left, right, suck, wait

Vacuum Agent

a possible agent function:

observation sequence	action
$\langle a, \text{clean} \rangle$	<i>right</i>
$\langle a, \text{dirty} \rangle$	<i>suck</i>
$\langle b, \text{clean} \rangle$	<i>left</i>
$\langle b, \text{dirty} \rangle$	<i>suck</i>
$\langle a, \text{clean} \rangle, \langle b, \text{clean} \rangle$	<i>left</i>
$\langle a, \text{clean} \rangle, \langle b, \text{dirty} \rangle$	<i>suck</i>
...	...

Reflexive Agents

Reflexive agents compute next action only based on **last observation** in sequence:

- very simple model
- very restricted
- corresponds to Mealy automaton (a kind of DFA) with only 1 state
- practical examples?

German: reflexiver Agent

Example (A Reflexive Vacuum Agent)

```
def reflex-vacuum-agent(location, status):  
    if status = dirty: return suck  
    else if location = a: return right  
    else if location = b: return left
```

Evaluating Agent Functions

What is the **right** agent function?

Rationality

Rationality

Rational Behavior

Evaluate behavior of agents with **performance measure** (related terms: **utility**, **cost**).

perfect rationality:

- always select an action **maximizing**
- **expected value** of **future performance**
- given **available information** (observations so far)

German: Performance-Mass, Nutzen, Kosten, perfekte Rationalität

Is Our Agent Perfectly Rational?

Question: Is the reflexive vacuum agent of the example perfectly rational?

Is Our Agent Perfectly Rational?

Question: Is the reflexive vacuum agent of the example perfectly rational?

depends on performance measure and environment!

- Do actions reliably have the desired effect?
- Do we know the initial situation?
- Can new dirt be produced while the agent is acting?

Rational Vacuum Agent

Example (Vacuum Agent)

performance measure:

- +100 units for each cleaned cell
- -10 units for each *suck* action
- -1 units for each *left/right* action

environment:

- actions and observations reliable
- world only changes through actions of the agent
- all initial situations equally probable

How should a perfect agent behave?

Rationality: Discussion

- perfect rationality \neq omniscience
 - incomplete information (due to limited observations) reduces achievable utility
- perfect rationality \neq perfect prediction of future
 - uncertain behavior of environment (e.g., stochastic action effects) reduces achievable utility
- perfect rationality is rarely achievable
 - limited computational power \rightsquigarrow **bounded rationality**

German: begrenzte Rationalität

Summary

Summary (1)

common metaphor for AI systems: **rational agents**

agent interacts with **environment**:

- sensors perceive **observations** about state of the environment
- actuators perform **actions** modifying the environment
- formally: **agent function** maps observation sequences to actions
- **reflexive** agent: agent function only based on last observation

Summary (2)

rational agents:

- try to maximize performance measure (utility)
- perfect rationality: achieve maximal utility in expectation given available information
- for “interesting” problems rarely achievable
 \rightsquigarrow bounded rationality