Fundamentals of Artificial Intelligence
Exercise 1: Rational and Intelligent Agents

(Sebastian Mair)
substitute today: Florian Lercher
Technical University of Munich

October 27th, 2023

Tweedback:
twbk.de/zjrq

AnswerGarden:
answergarden.ch/3861518

Organization

Exercise Sessions: Fridays, 13:00 – 14:30 in room MW 2001 (Rudolf-Diesel-Hörsaal) and recorded (Link on Moodle)

Exercise Sheets & Solutions: uploaded to Moodle

Questions: Moodle Forum

Additional tutor hour: Thursdays, 12:00 – 14:00 on BBB (Link on Moodle)

Recap: Rational Agents

Rational Agent

A rational agent should select an action that is expected to maximize its performance measure, given the prior percept sequence and its built-in knowledge.

What is rational depends on:

- the performance measure
- the agent's prior knowledge about the environment
- the possible actions
- the agent's percept sequence up to now

Recap: Properties of Task Envirnoments

Some possible categories for task environments:

- Fully observable vs. partially observable

Class Poli.

Recap: Properties of Task Envirnoments

Some possible categories for task environments:

- Fully observable vs. partially observable
- Deterministic vs. stochastic

Sudoku Dice game

Recap: Properties of Task Envirnoments

Some possible categories for task environments:

- Fully observable vs. partially observable
- Deterministic vs. stochastic
- Single agent vs. multi agent

Maze Chess

Recap: Properties of Task Envirnoments

Some possible categories for task environments:

- Fully observable vs. partially observable
- Deterministic vs. stochastic
- Single agent vs. multi agent
- Static vs. dynamic

Maze Road traffic

⋮

Problem 1.1.1: Rational Agents

Which actions does a rational agent select?

Problem 1.1.1: Rational Agents

Which actions does a rational agent select?

A rational agent selects an action that is expected to maximize its performance measure, given the prior percept sequence and its built-in knowledge.

Problem 1.1.2: Rational Agents

Which of these games would a rational agent always win or draw at and why? Is it physically possible to build such an agent?

(*YES*: a rational agent would always win/draw; *NO*: a rational agent might lose)

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a. Poker

Problem 1.1.2: Rational Agents

Which of these games would a rational agent always win or draw at and why? Is it physically possible to build such an agent?

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a. Poker – *No*

- environment is only partially observable
- game contains randomness

Problem 1.1.2: Rational Agents

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b. Tic-Tac-Toe

Problem 1.1.2: Rational Agents

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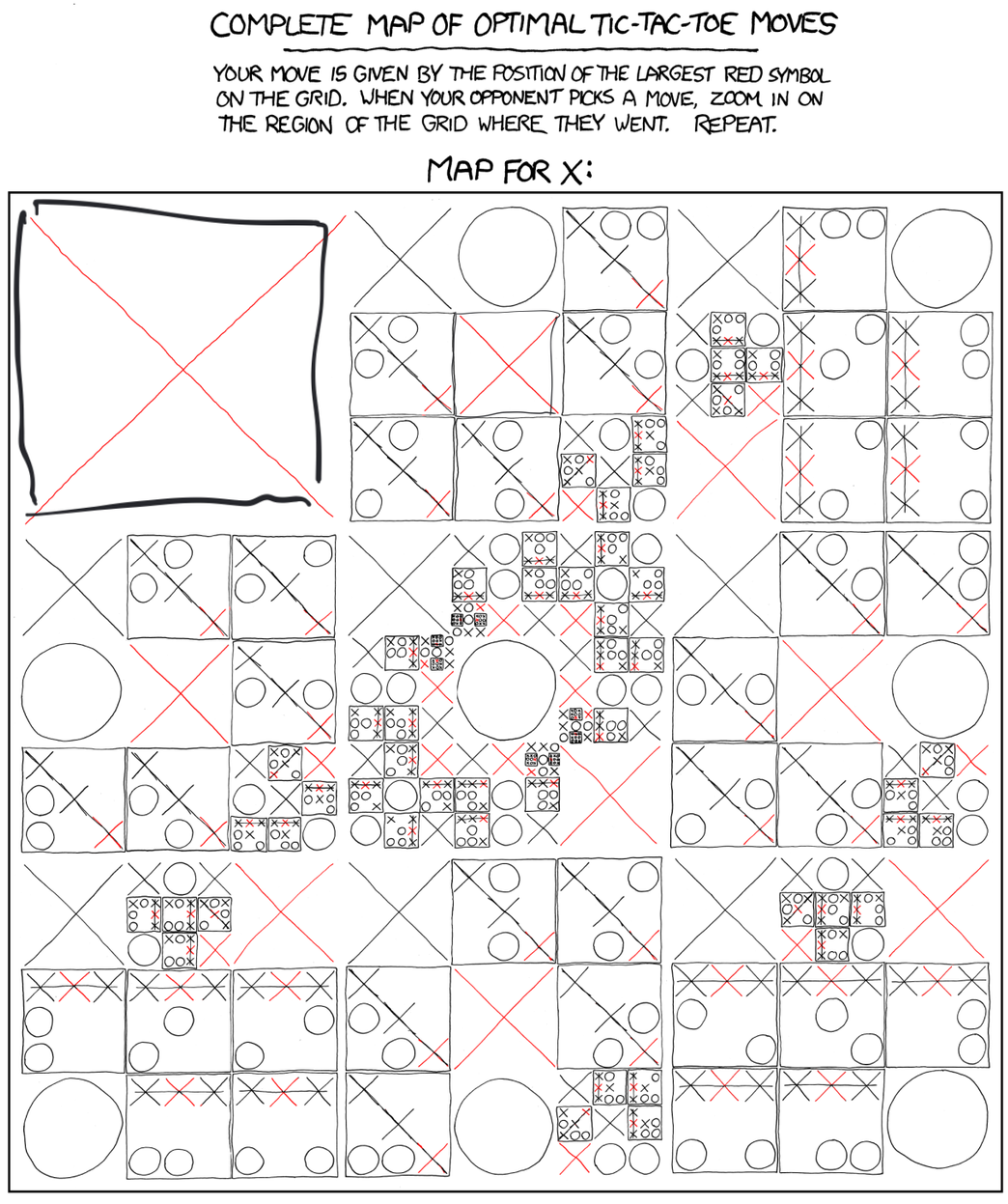
b. Tic-Tac-Toe – *Yes*

- environment is deterministic & fully observable
- an algorithm exists that guarantees win/draw (see xkcd.com/832)

Problem 1.1: Rational Agents

(image: xkcd.com)



Problem 1.1.2: Rational Agents

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c. Chess

Problem 1.1.2: Rational Agents

Which of these games would a rational agent always win or draw at and why? Is it physically possible to build such an agent?

(*YES*: a rational agent would always win/draw; *NO*: a rational agent might lose)

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c. Chess – *Yes (at least for one of the players)*

- environment is deterministic & fully observable
- Zermelo's theorem: either both players can force a draw, or one of the players can force a win
- however: enormous state space (10^{43} board positions, 10^{120} possible games)
- computationally infeasible with current techniques
- currently, it is not known which of the players can enforce a win or if both can enforce a draw

Problem 1.2.1

Suggest performance measures for each of the agents, and which type of agent should be used.

a. GPS route guidance
b. Kettle (*Wasserkocher*)
c. Bi-directional Escalator on Munich Underground

Recap: Categorization of Agents

Agents can be categorized into four categories with increasing generality:

access to information

- **Simple reflex agents**: Actions are based on the current percept
- **Model-based reflex agents**: Handle partial observability using a "world model"
- **Goal-based agents**: Additionally keep track of a goal and choose actions accordingly
- **Utility-based agents**: Try to achieve a goal while maximising the expected utility

utility vs. performance measure

a. GPS route guidance

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Performance measure:

(image: amazon.com)

Type of agent:

a. GPS route guidance

Today's tweedback code: **zjrq** (twbk.de/zjrq)

(image: amazon.com)

Performance measure:

e.g. time to reach goal, fuel expended to reach goal, speed limits on roads, avoiding low bridges (for Heavy Goods Vehicles), toll routes and motorways avoided/preferred, traffic jams avoided etc.

Type of agent:

a. GPS route guidance

Today's tweedback code: **zjrq** (twbk.de/zjrq)

(image: amazon.com)

Performance measure:

e.g. time to reach goal, fuel expended to reach goal, speed limits on roads, avoiding low bridges (for Heavy Goods Vehicles), toll routes and motorways avoided/preferred, traffic jams avoided etc.

Type of agent:

Utility-based Agent

b. Kettle

AnswerGarden: **3861518** (answergarden.ch/3861518)

(image: amazon.com)

Performance measure:

Type of agent:

b. Kettle

Today's tweedback code: **zjrq** (twbk.de/zjrq)

(image: amazon.com)

Performance measure:

Is water boiled?

Type of agent:

b. Kettle

Today's tweedback code: **zjrq** (twbk.de/zjrq)

(image: amazon.com)

Performance measure:

Is water boiled?

Type of agent:

Simple Reflex Agent

c. Bi-directional Escalator on Munich Underground

AnswerGarden: **3861518** (answergarden.ch/3861518)

(image: germannn.tumblr.com)

Performance measure:

Type of agent:

c. Bi-directional Escalator on Munich Underground

Today's tweedback code: **zjrq** (twbk.de/zjrq)

(image: germannn.tumblr.com)

Performance measure:

e.g. does escalator not stop while transporting someone? Waiting time if escalator is empty, waiting time at the bottom might be weighted stronger

Type of agent:

c. Bi-directional Escalator on Munich Underground

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(image: germannn.tumblr.com)

Performance measure:

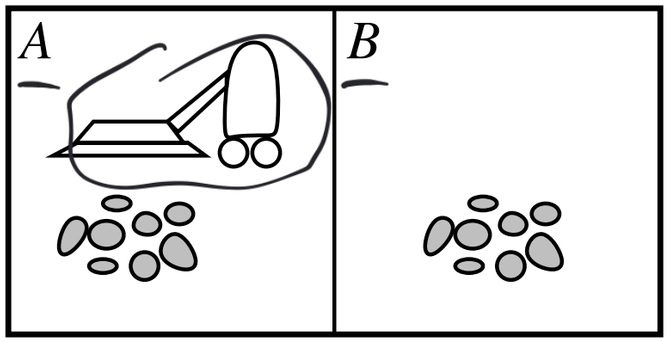
e.g. does escalator not stop while transporting someone? Waiting time if escalator is empty, waiting time at the bottom might be weighted stronger

Type of agent:

Model-based Reflex Agent

Problem 1.2.2

Consider the Vacuum Cleaner environment from the lecture notes.



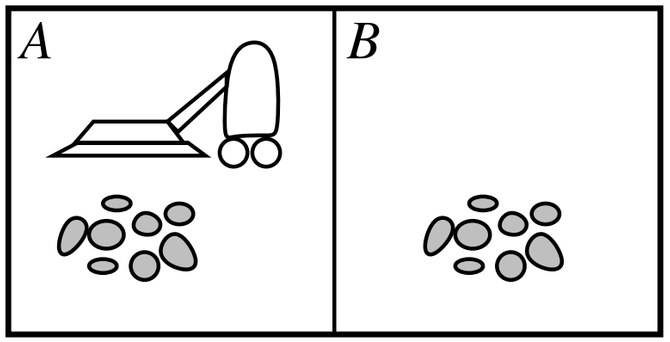
(adapted from *Russell & Norvig*, q. 2.10)

- Floor is dirty or clean with same probability
- Agent can only perceive the floor that it is in, e.g. $[A, \text{Dirty}]$
- Agent starts at each floor with same probability
- Performance measure: +3 points for each cleaned floor, -1 point for each movement

Noop
Suck
Left
Right

Problem 1.2.2

Consider the Vacuum Cleaner environment from the lecture notes.



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a. Can a simple reflex agent be rational for this environment?

Problem 1.2.2

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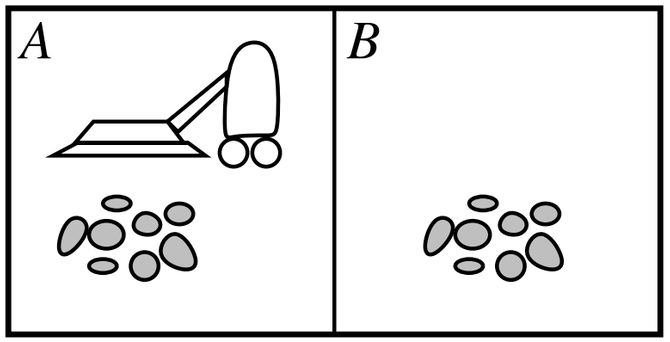

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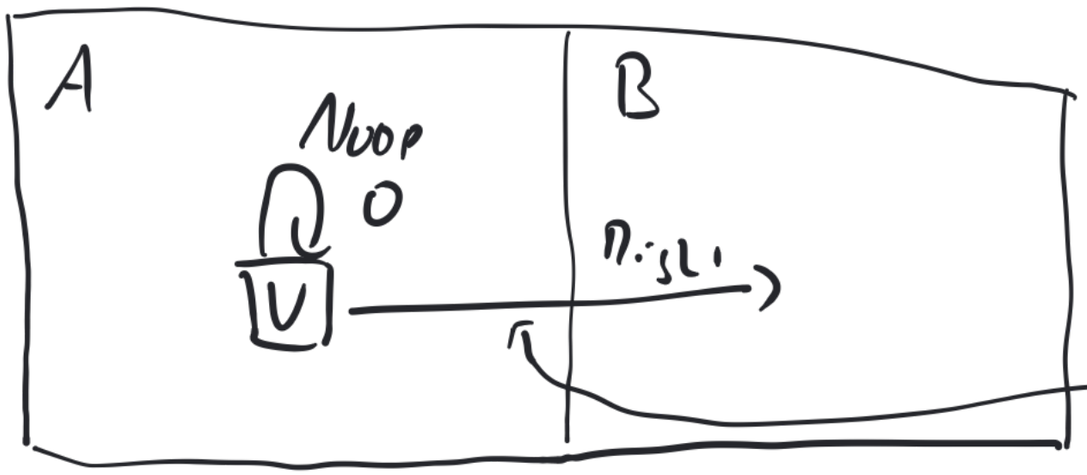
a. Can a simple reflex agent be rational for this environment?
   - **No**

What is rational in the Vacuum Cleaner World?



Assume we are starting in A

$-1 + 0.5 \cdot 3 = 0.5$

Clean A if its dirty

$0.5 \cdot 3 = 1.5$

$1.5 + 0.5 = 2$

Symmetric for B $\quad 0.5 \cdot 2 + 0.5 \cdot 2 = 2$ (in total)

$2 \cdot 0.5 \cdot 3 = 3$

$-1/2$

Designing a simple reflex agent

[A, Dirty] ⇝ Suck

[B, Dirty] ⇝ Suck

[A, Clean] → Noop
→ Right

[B, Clean] → Noop
→ Left

2 · 2 = 4 possible agents (represented by colors below)

Assume we start in A

We start in B

[A, Clean]

	Noop	Right
Noop	0.5·3 = 1.5	0.5·3 + (-1) + 0.5·3 = 2
Left	1.5	-∞

[B, Clean]

	Noop	Right
Noop	1.5	1.5
Left	2	-∞

·0.5

·0.5

	Noop	Right
Noop	1.5	1.75
Left	1.75	-∞

Combined
(50% to start in A
50% to start in B)

1 2 3

50% A, Clean —R→ A, Clean —N→ A, Clean → ... 0

50% A, Dirty —S→ A, Clean —N→ A, Clean 3

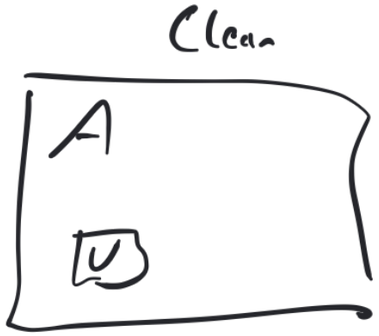
1 2 3

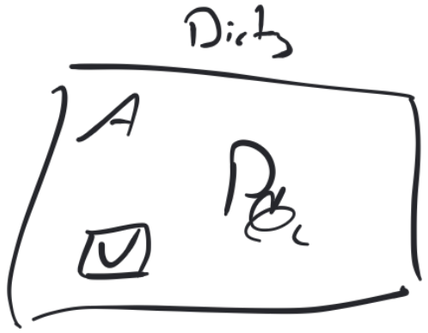
A, Clean —N→ A, Clean —N→ A, Clean → 0

A, Dirty —S, +3→ A, Clean —N→ A, Clean → 3

A, C —R, −1→ B, D —S/N, 0.5·3→ B, C —N→ B, C → ... 0.5

A, D —S, +3→ A, C —R, −1→ B, D —S/N, 0.5·3→ B, C → ... 3.5





Simpler environment
with only one room

Clean → Noop (0)
→ Act (→)

Dirty → Suck (3)

[Dirty]

	Suck
[Clean] → Noop	0.5 · 3 = 1.5
[Clean] → Act	0.5 · 3 − 1 − 1 − 1 ... = −∞

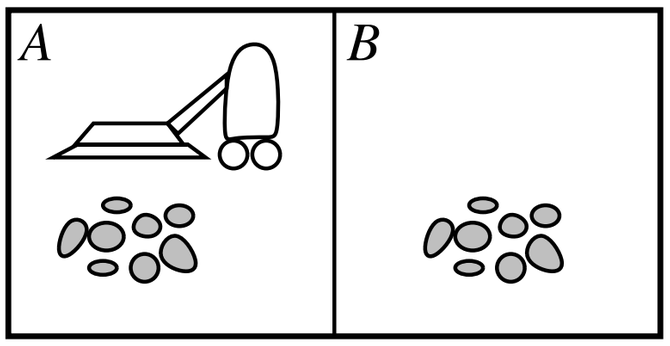
Time

Clean → (−1) Act → Clean → (−1) Act → Cl → (−1) Ag' .. ⇒ −∞

Dirty → (Suck +3) Cle → (Act −1) Clea → (Act −1) ... ⇒ −∞

Problem 1.2.2

Consider the Vacuum Cleaner environment from the lecture notes.



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a. Can a simple reflex agent be rational for this environment?
   - **No**

b. What about a reflex agent with state?

Problem 1.2.2

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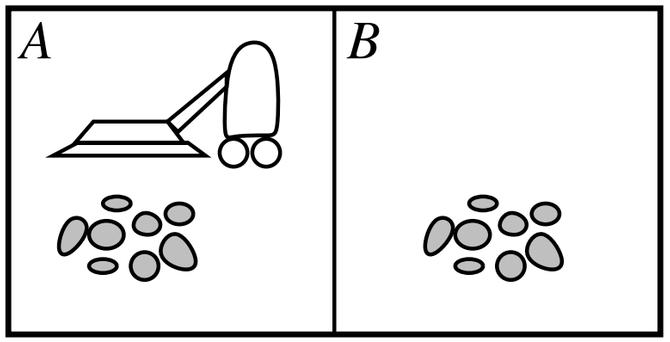

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a. Can a simple reflex agent be rational for this environment?
   - **No**

b. What about a reflex agent with state?
   - **Yes**, it could be

Problem 1.3.1

Today's tweedback code: **zjrq** (twbk.de/zjrq)

Billiards - Who do you agree with?

(image: linux.softpedia.com)

A: "a game of billiards is deterministic: a player's action is determined by the state of the table and where the ball is."

B: "a game of billiards is stochastic, as one player doesn't know what the other player will do."

C: "a game of billiards is stochastic because it is impossible to know exactly where the ball is and what the shape of the ball and the table are. When the player hits the ball, it might go somewhere else than intended"