Foundations of Artificial Intelligence

A5. Introduction: Environments and Problem Solving Methods

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A5.1 Environments of Rational Agents

A5.2 Problem Solving Methods

A5.3 Classification of AI Topics

A5.4 Summary

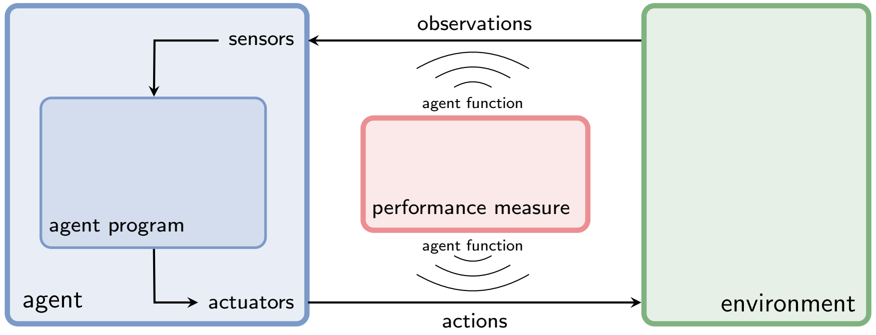
Introduction: Overview

Chapter overview: introduction

- A1. Organizational Matters
- A2. What is Artificial Intelligence?
- A3. AI Past and Present
- A4. Rational Agents
- A5. Environments and Problem Solving Methods

A5.1 Environments of Rational Agents

Environments of Rational Agents



sensors

observations

agent function

performance measure

agent program

agent function

agent

actuators

actions

environment

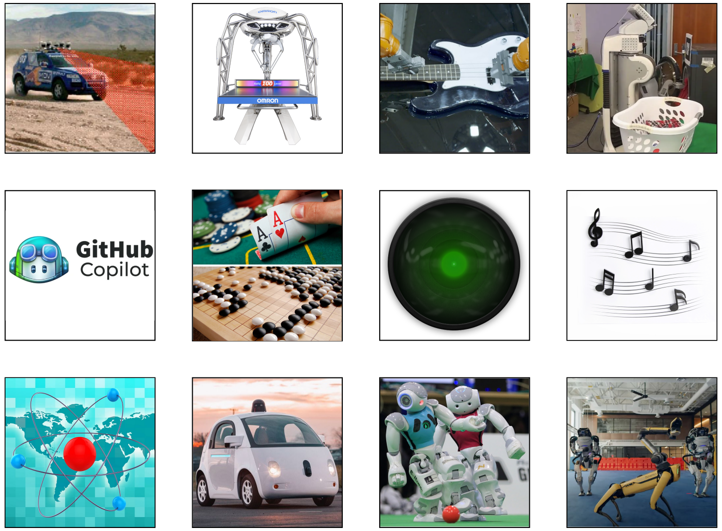
- Which environment aspects are relevant for the agent?
- How do the agent's actions change the environment?
- What does the agent observe?

Properties of Environments

Environment properties determine character of AI problem.

- static vs. dynamic
- deterministic vs. nondeterministic vs. stochastic
- fully observable vs. partially observable
- discrete vs. continuous
- single-agent vs. multi-agent

Properties of Environments

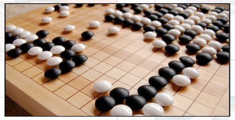
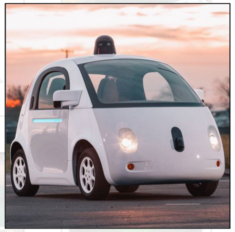


Properties of Environments

static vs. dynamic

Does the state of the environment remain the same while the agent is contemplating its next action?

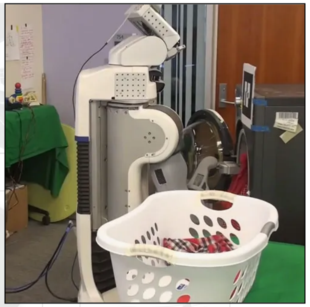
Properties of Environments

deterministic vs. nondeterministic vs. stochastic

Is the next state of the environment fully determined by the current state and the next action? Are probabilities involved?

Properties of Environments

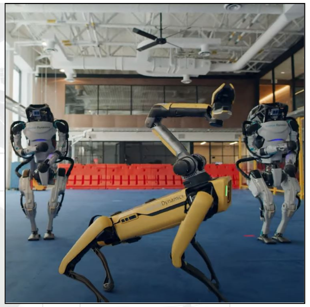


fully observable vs. partially observable

Can the agent fully observe the state of the environment at every decision step or not?

special case of partially observable: unobservable

Properties of Environments



discrete vs. continuous

Is the state of the environment (and actions, observations, time) given by discrete or by continuous quantities?

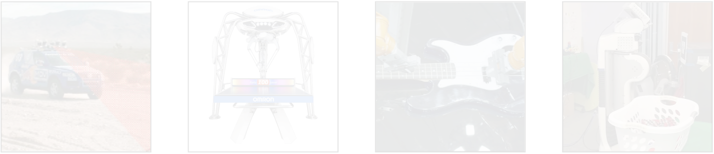
Properties of Environments

single-agent vs. multi-agent

Are other agents relevant for own performance?

subcases of multi-agent: are the other agents adversarial, cooperative, or selfish?

Properties of Environments

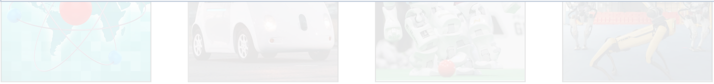


suitable problem-solving algorithms

Environments of different kinds (according to these criteria) usually require different algorithms.

real world

The “real world” combines all unpleasant
(in the sense of: difficult to handle) properties.



A5.2 Problem Solving Methods

Three Approaches to Solving AI Problems

We can solve a concrete AI problem (e.g., playing chess)
in several ways:

Problem Solving Methods

1. problem-specific: implement algorithm tailored to problem
2. general: create problem description as input for general solver
3. learning: learn (aspects of) algorithm from data

problem-specific algorithms:

- designed to solve a specific problem
- allow exploiting problem-specific knowledge
- solve just one (type of) problem

Three Approaches to Solving AI Problems

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in several ways:

Problem Solving Methods

1. problem-specific: implement algorithm tailored to problem
2. general: create problem description as input for general solver
3. learning: learn (aspects of) algorithm from data

general problem solvers:

- user creates model of problem instance in formalism (“language”)
- solver takes modeled instance as input
- solver implements general algorithm to compute solution

Three Approaches to Solving AI Problems

We can solve a concrete AI problem (e.g., playing chess) in several ways:

Problem Solving Methods

1. problem-specific: implement algorithm tailored to problem
2. general: create problem description as input for general solver
3. learning: learn (aspects of) algorithm from data

learners:

- general approach that learns to solve specific problem
- adapts via experience instead of via reasoning
- requires data and feedback instead of model of the AI problems

Three Approaches to Solving AI Problems

We can solve a concrete AI problem (e.g., playing chess) in several ways:

Problem Solving Methods

1. problem-specific: implement algorithm tailored to problem
2. general: create problem description as input for general solver
3. learning: learn (aspects of) algorithm from data

- all three approaches have strengths and weaknesses
- combinations are possible (and common in practice)
- we will mostly focus on general algorithms, but also consider other approaches

A5.3 Classification of AI Topics

Classification of AI Topics

Many areas of AI are essentially characterized by

- the properties of environments they consider and
- which of the three problem solving approaches they use.

We conclude the introduction by giving some examples

- within this course and
- beyond the course ("advanced topics").

Examples: Classification of AI Topics

Course Topic: Informed Search Algorithms

environment:

- static vs. dynamic
- deterministic vs. nondeterministic vs. stochastic
- fully observable vs. partially observable
- discrete vs. continuous
- single-agent vs. multi-agent

problem solving method:

- problem-specific vs. general vs. learning

Examples: Classification of AI Topics

Course Topic: Constraint Satisfaction Problems

environment:

- static vs. dynamic
- deterministic vs. nondeterministic vs. stochastic
- fully observable vs. partially observable
- discrete vs. continuous
- single-agent vs. multi-agent

problem solving method:

- problem-specific vs. general vs. learning

Examples: Classification of AI Topics

Course Topic: Board Games

environment:

- static vs. dynamic
- deterministic vs. nondeterministic vs. stochastic
- fully observable vs. partially observable
- discrete vs. continuous
- single-agent vs. multi-agent (adversarial)

problem solving method:

- problem-specific vs. general vs. learning

Examples: Classification of AI Topics

Advanced Topic: General Game Playing

environment:

- static vs. dynamic
- deterministic vs. nondeterministic vs. (stochastic)
- fully observable vs. partially observable
- discrete vs. continuous
- single-agent vs. multi-agent (adversarial)

problem solving method:

- problem-specific vs. general vs. learning

Examples: Classification of AI Topics

Course Topic: Classical Planning

environment:

- **static** vs. dynamic
- **deterministic** vs. nondeterministic vs. stochastic
- **fully observable** vs. partially observable
- **discrete** vs. continuous
- **single-agent** vs. multi-agent

problem solving method:

- problem-specific vs. **general** vs. learning

Examples: Classification of AI Topics

Course Topic: Acting under Uncertainty

environment:

- **static** vs. dynamic
- deterministic vs. nondeterministic vs. **stochastic**
- **fully observable** vs. partially observable
- **discrete** vs. continuous
- **single-agent** vs. multi-agent

problem solving method:

- **problem-specific** vs. general vs. learning

Examples: Classification of AI Topics

Advanced Topic: Reinforcement Learning

environment:

- **static** vs. dynamic
- deterministic vs. nondeterministic vs. **stochastic**
- **fully observable** vs. partially observable
- **discrete** vs. continuous
- **single-agent** vs. multi-agent

problem solving method:

- problem-specific vs. general vs. **learning**

A5.4 Summary

Summary (1)

AI problem: performance measure + agent model + environment

Properties of environment critical for choice of suitable algorithm:

- static vs. dynamic
- deterministic vs. nondeterministic vs. stochastic
- fully observable vs. partially observable
- discrete vs. continuous
- single-agent vs. multi-agent

Summary (2)

Three problem solving methods:

- problem-specific
- general
- learning

general problem solvers:

- models characterize problem instances mathematically
- formalisms/languages describe models compactly
- algorithms use languages as problem description and to exploit problem structure