Wissensbasierte Systeme (WBS)

18.123 - WS 2002/03

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Sprechzeit Do 16-17h

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Knowledge-based Systems

- **lectures in German, slides in English**
- **lectures and slides based on**

Computational Intelligence

A Logical Approach

David Poole
Alan Mackworth
Randy Goebel

Oxford University Press, 1998

- **PDF versions of slides will be emailed to participants who wish to subscribe**

Exercises, projects, tests

- 1 hour of excercises per week in class
- participation in a project (to be announced) as "schriftlicher Leistungsnachweis"
- oral test in February as "mündlicher Leistungsnachweis"

What is Computational Intelligence?

The study of the design of intelligent agents .

An agent is something that acts in an environment.

An intelligent agent is an agent that acts intelligently:

- **its actions are appropriate for its goals and circumstances**
- **it is flexible to changing environments and goals**
- **it learns from experience**
- **it makes appropriate choices given perceptual limitations and finite computation**

Artificial or Computational Intelligence?

- **The field is often called Artificial Intelligence.**
- **Scientific goal: to understand the principles that make intelligent behavior possible, in natural or artificial systems.**
- **Engineering goal: to specify methods for the design of useful, intelligent artifacts.**
- **Analogy between studying flying machines and thinking machines.**

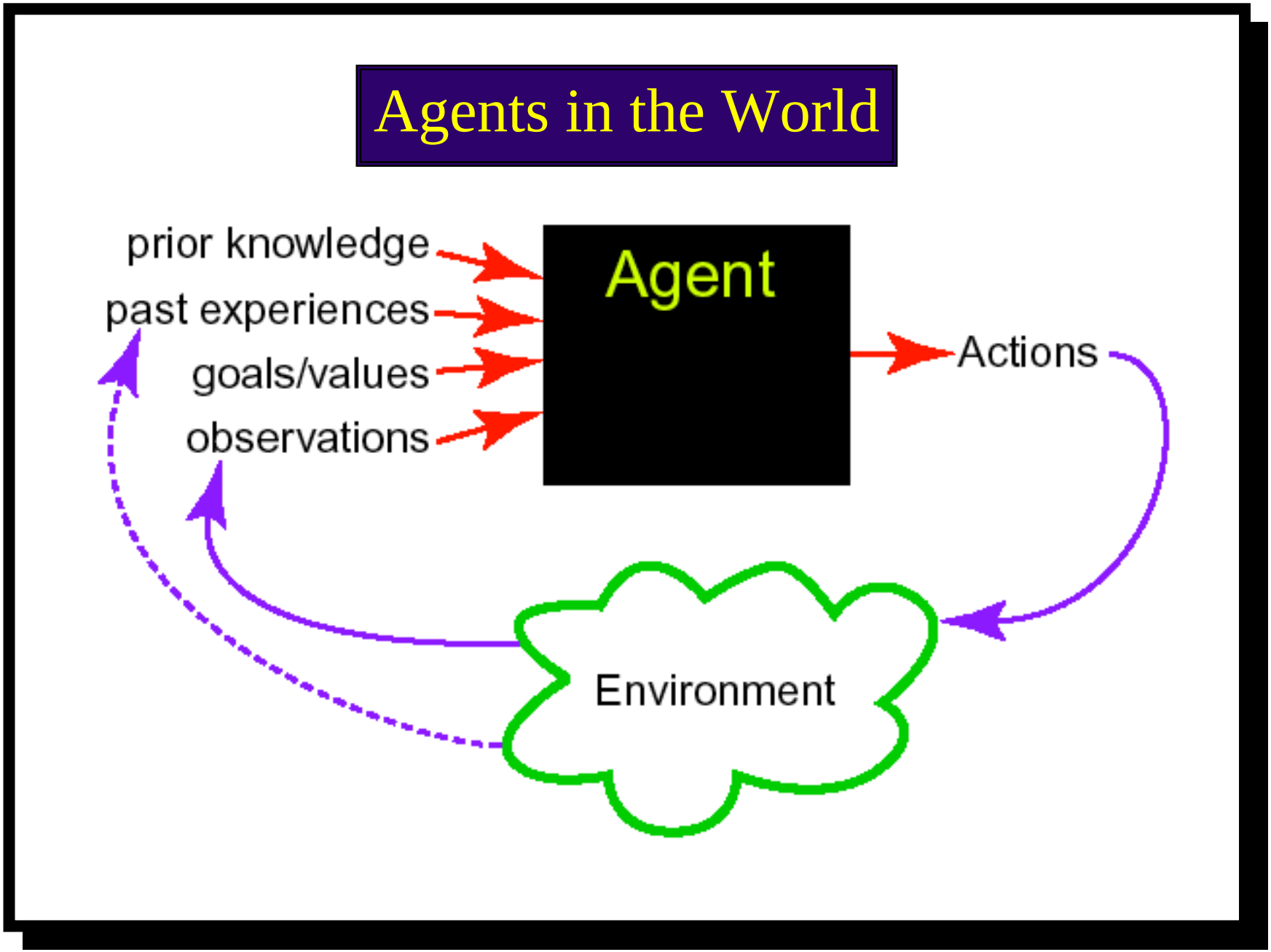
Central hypotheses of CI

Symbol-system hypothesis:

- **Reasoning is symbol manipulation.**

Church–Turing thesis:

- **Any symbol manipulation can be carried out on a Turing machine.**


Agents in the World
prior knowledge
past experiences
goals/values
observations
Agent
Actions
Environment

Representation and Reasoning

To use these inputs an agent needs a representation of them.

=> knowledge

Most common sense tasks rely on a lot of knowledge.

Representation and Reasoning System

Problem => representation => computation

A representation and reasoning system (RRS) consists of

- **Language to communicate with the computer.**
- **A way to assign meaning to the symbols.**
- **Procedures to compute answers or solve problems.**

Example RRSs:

- **Programming languages: Fortran, C++,…**
- **Natural Language**

We want something between these extremes.

Conventional problem solving

Testing a customer for credit-worthiness based on the assumption that professors with a family are credit-worthy

```
PRINT("What is your profession?")
IF READSTR = "professor" THEN
BEGIN
        PRINT("Have you got a family?");
        IF READSTR = "yes" THEN
        PRINT("Congratulations! You are credit-worthy!")
END ELSE ...
```

Knowledge-based problem solving

Knowledge base:

```
professor(john).
has_family(john).
credit-worthy(X) := professor(X), has_family(X).
```

Question:

```
?= credit-worthy(john).
```

Answer: Yes

Knowledge-based diagnosis

Regel 1
Wenn(Anlasser arbeitet normal)
dann (Batterie OK)

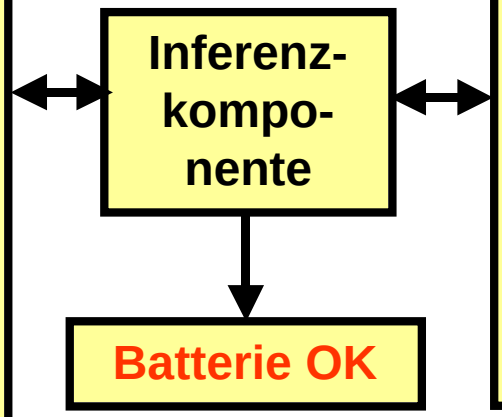
Regel 2
Wenn (Batterie OK)
Und (Wert Tankuhr > 0)
Und (Benzinfilter sauber)
Dann (Problem = Zündanlage)

Regel 3
Wenn (Batterie OK)
Und (Wert Tankuhr > 0)
Und (nicht Benzinfilter sauber)
Dann (Defekt = Benzinzuleitung)

Regel 4
Wenn (nicht Scheibenwischer OK)
Und (nicht Licht OK)
Dann (Defekt = Batterie leer)

Regel 5
Wenn (nicht Wert Tankuhr > 0)
Dann (Defekt = Tank leer)

Regel 6
Wenn (Problem = Zündanlage)
Und (Verteilerdose OK)
Dann (Defekt = Zündspule)



Anlasser arbeitet normal

Scheibenwischer OK

Licht OK

Wert Tankuhr > 0

Benzinfilter sauber

Verteilerdose OK

Your car does not start?

Rule-based expert system infers the cause.

Knowledge-based information retrieval

ARD	ZDF	RTL	SAT.1
20.15	20.15	20.15	20.00
Fußball-WM	China heute	Galactica	Dragonheart
21.45	21.15	21.35	21.00
Sissi	Wetten, daß...	Braveheart	Stirb langsam 2
22.30	22.00	22.45	22.15
Tagesthemen	Heute	Sexshow	Rolling Stones
23.00	22.30	23.30	23.00
The Rock	Terminator 2	Speed	Alien

user selects examples

- Braveheart
- Stirb langsam 2
- Terminator 2

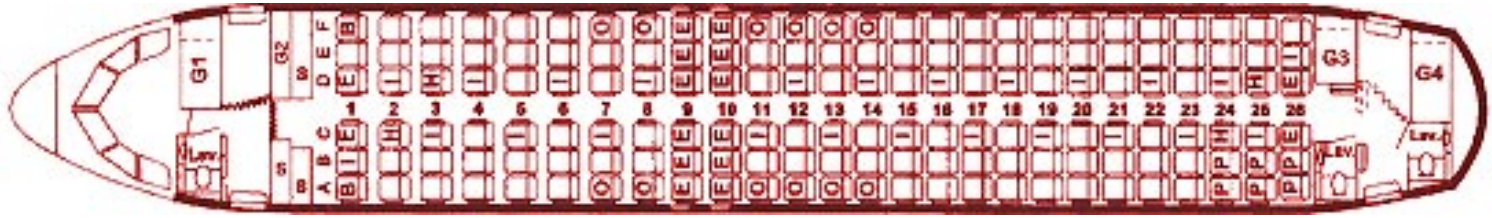
system determines similarity of contents

- Action/Horror
- Kino-Highlights
- bekannte Schauspieler
- Filme neueren Datums

system proposes program items with similar contents

ARD	N3	RTL	PRO 7
20.15	20.15	20.15	20.00
Schatzinsel	Eiskunstlauf	Goldfinger	Psycho II
21.45	21.00	21.30	21.00
Lindenstraße	Sterbehilfe	Dallas	Deep Impact
22.30	22.00	22.15	22.15
Tagesthemen	Extra 3	Titanic	Killerwale
23.00	22.30	23.30	23.00
Armageddon	Achterbahn	Robocop	Arabella

Knowledge-based configuration



Placing cabin equipment (seats, kitchens, lavatories, ...) based on

- **customer wishes**
- **technical facilities**
- **legal constraints**
- **optimality criteria**

Chapters and lectures (1)

Chapter 1: Computational Intelligence and Knowledge

- **Lecture 1 in which we introduce computational intelligence and the role of agents.**
- **Lecture 2 in which we introduce the applications domains.**

Chapters and lectures (2)

Chapters 2 & 3: A Representation and Reasoning System & Using Definite Knowledge

- **Lecture 1 in which we introduce representation and reasoning systems, Datalog, its assumptions, and its syntax.**
- **Lecture 2 in which we present the semantics of ground Datalog.**
- **Lecture 3 in which we introduce variables, queries, answers, recursion, and limitations.**
- **Lecture 4 in which we talk introduce proofs, present the ground bottom-up procedure, and show soundness and completeness.**
- **Lecture 5 in which we introduce a top-down proof procedure (SLD Resolution).**
- **Lecture 6 in which we introduce variables and function symbols and how they are handled in proof procedures.**

Chapters and lectures (3)

Chapter 4: Searching

- **Lecture 1 in which we introduce searching and graphs.**
- **Lecture 2 in which we present some blind search strategies.**
- **Lecture 3 in which we present heuristic search, including best-first search and A* search.**
- **Lecture 4 in which we present various refinements to search strategies, including loop checking, multiple-path pruning, iterative deepening, bidirectional search, dynamic programming.**
- **Lecture 5 in which we introduce constraint satisfaction problems.**
- **Lecture 6 in which we consider consistency algorithms (arc consistency) and hill climbing for solving CSPs.**

Chapters and lectures (4)

Chapter 5: Representing Knowledge

- **Lecture 1 in which we introduce knowledge representation issues and problem specification.**
- **Lecture 2 in which we consider representation languages and mapping from problems into representations.**
- **Lecture 3 in which we present semantic networks, frames, and property inheritance.**

Chapters and lectures (5)

Chapter 6: Knowledge Engineering

- **Lecture 1 in which we introduce knowledge-based systems architectures and the notions of metalanguages and object languages.**
- **Lecture 2 in which we introduce meta-interpreters.**
- **Lecture 3 in which we discuss ask-the-user mechanisms.**
- **Lecture 4 in which we introduce knowledge-based explanation facilities**

Chapters and lectures (6)

Chapter 7: Beyond Definite Knowledge

- **Lecture 1 in which we cover equality, inequality and the unique names assumptions.**
- **Lecture 2 in which we cover the unique names assumption and negation as failure.**
- **Lecture 3 in which we introduce integrity constraints and consistency-based diagnosis.**

Chapters and lectures (7)

Chapter 8: Actions and Planning

- **Lecture 1 in which we introduce actions and planning and the robot planning domain.**
- **Lecture 2 in which we present the STRIPS representation.**
- **Lecture 3 in which we present the situation calculus.**
- **Lecture 4 in which we introduce planning.**
- **Lecture 5 in which we present the STRIPS planner.**
- **Lecture 6 in which we present regression planning.**

Chapters and lectures (8)

Chapter 9: Assumption-based Reasoning

- **Lecture 1 in which we introduce assumption-based reasoning.**
- **Lecture 2 in which we show how to reason with defaults.**
- **Lecture 3 in which we introduce abduction and how it can be combined with default reasoning.**

Chapters and lectures (9)

Chapter 10: Using Uncertain Knowledge

- **Lecture 1 in which we overview uncertainty and the role of probability.**
- **Lecture 2 in which we look at conditional independence and the representation of belief networks.**
- **Lecture 3 in which we look at making decisions under uncertainty.**

Chapters and lectures (10)

Chapter 11: Learning

- **Lecture 1 in which we introduce machine learning and the issues facing any learning algorithm.**
- **Lecture 2 in which we introduce decision tree learning**
- **Lecture 3 in which we introduce neural networks.**
- **Lecture 4 in which we introduce case-based reasoning.**

Chapters and lectures (11)

Chapter 12: Building Situated Robots

- **Lecture 1 in which we introduce agents, robotic systems and robot controllers.**
- **Lecture 2 in which we overview robot architectures and present hierarchical decomposition of robots.**