Vorlesung

Grundlagen der Künstlichen Intelligenz

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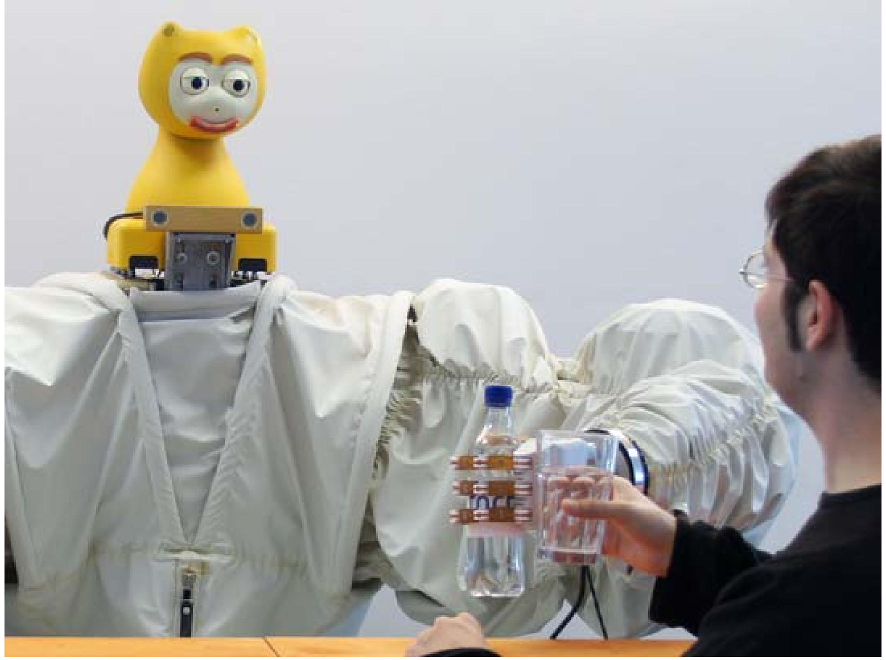

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Recap + Q&A session

Intro / Agents

- An agent is an entity that perceives and acts
- It consists of an architecture and a program
- A ideal rational agent is expected to maximize its performance measure, given the evidence provided by the percept sequence and the built-in knowledge
- There are different types of environments, some are more challenging than others
  - E.g. partially observable, stochastic, sequential, dynamic, continuous
- There are different types of agents
  - Reflex agents, only reacting to the perceipts
  - Goal-based agents, trying to achieve given goal(s)
  - Utility-based agents, maximizing their performance

Search algorithms

- In order to search for a solution, an agent has to define its goal and based on this the agent has to define its problem
- A problem consists of 5 parts: state space, initial state, operators, goal test and path costs. A path from the initial state to a goal state is a solution.
- There exists a general search algorithm that can be used to find solutions. Special variants of the algorithm make use of different search strategies.
- There are optimal and complete search algorithms which are “much better” than blind search
- However, the state spaces and the complexity is still exponential

Search algorithms

- Blind search:

  Depth-first, breadth-first, iterative deepening, ...

- Heuristic search:

  A* always leads to optimal solutions, but space ...

  Different heuristics, addmissible, consistent ones

  Criteria for choosing “good“ heuristics

- All these search algorithms differ in the order in which the expanded nodes are inserted into the „open“ list

Search algorithms

- Local search and optimization
  - Useful if only the final state is of interest
  - Problem: local minima, plateaus, etc.
  - Several algorithms: hill-climbing, simulated annealing, local beam search, genetic algorithms, etc.
- Search with non-deterministic action results
  - Contingency plan instead of action sequence
  - AND-OR-trees

Constraint satisfaction problems (CSPs)

- CSPs: state represented by variable-value pairs
- Set of constraints on variables (unary, binary, and higher-order)
- Backtracking = depth first search + test
- Min-conflicts heuristics are very successful and easy
- Reduction of complexity by reduction to trees instead of graphs

Adversarial search

- Adversarial search needs to take all possible moves of the opponent into account
- Maximise your strategy based on the assumpion that the opponent acts optimally

- Alpha-betra pruning can reduce the search space

- Incomplete real-time decisions need evaluation functions

Logical agents

- Knowledge-based agents with internal representation of knowledge
- Reasoning process to gain new knowledge and to draw conclusions
- Representation schemes (languages)
- A knowledge base is a collection of (formal) sentences
- Syntax and semantics
- Models (possible worlds)

- Two operators on the knowlege base:
  - TELL(*KB*, *sentence*)
  - ASK(*KB*, *sentence*)

Logic

- Logical agents apply inference to a knowledge base to derive new information and make decisions

Basic concepts of logic:

- syntax: formal structure of sentences
- semantics: truth of sentences wrt models
- entailment: necessary truth of one sentence given another
- inference: deriving sentences from other sentences
- soundness: derivations produce only entailed sentences
- completeness: derivations can produce all entailed sentences

- Wumpus world requires the ability to represent partial and negated information, reason by cases, etc.
- Resolution is complete for propositional logic
- Forward, backward chaining are linear-time, complete for Horn clauses
- DPLL and WalkSAT algorithms

Logic

- First-order logic:
  - objects and relations are semantic primitives
  - syntax: constants, functions, predicates, equality, quantifiers
  - Increased expressive power: sufficient to define wumpus world including “hidden properties” such as “hasArrow”
  - Knowledge engineering scheme

- Most every-day sentences can be expressed in FOL

What is Planning

- Generate sequences of actions to perform tasks and achieve objectives.
  - States, actions and goals

- Search for solution over abstract space of plans.

- Assists humans in practical applications
  - design and manufacturing
  - games
  - space exploration
  - Rescue operation (see also RoboCup rescue league)

Planning

- Planning is an area of great interest within AI
- Biggest problem is the combinatorial explosion in states.

- Planning described as set of preconditions, actions, and postconditions
- Use of search strategies to create plans
- Use of theorem proving

- Consideration of limited resources and time

- Hierarchical planning approaches

Knowledge engineering

- Knowledge representation is crucial for efficient reasoning
- Ontologies are a widely used way for representing knowledge
- Upper ontology to describe main concepts and object classes of the world
- Individual ontologies for specific domains needed
- Different ways of reasoning
  - Navigation in semantic networks
  - Formal reasoning using logical representations
- Problem: Handling of default values

Reasoning under uncertainty

- Probability is a rigorous formalism for uncertain knowledge
- Joint probability distribution specifies probability of every atomic event
- Queries can be answered by summing over atomic events
- For nontrivial domains, we must find a way to reduce the joint size
- Independence and conditional independence provide the tools

Bayesian networks

- Bayes nets provide a natural representation for (causally induced) conditional independence
- Topology + CPTs = compact representation of joint distribution
- Generally easy for (non)experts to construct
- Canonical distributions (e.g., noisy-OR) = compact representation of CPTs

Approximate inference

- In general, inference in Bayesian networks is NP-hard
- For polytrees, exact inference has linear time and space complexity.
- For all other network topologies, approximate algorithms are needed

- One promising approach: Sampling (stochastic simulation)
  - Direct sampling
  - Rejection sampling
  - Likelihood weighting

Learning – decision trees

- Learning needed for unknown environments, lazy designers
- Learning agent = performance element + learning element
- Learning method depends on type of performance element, available feedback, type of component to be improved, and its representation
- For supervised learning, the aim is to find a simple hypothesis that is approximately consistent with training examples
- Decision tree learning using an information theoretic approach: entropy and information gain
- Learning performance = prediction accuracy measured on test set